# CHAPTER 7 DESIGN OF CONTAINER CARGO HANDLING AND FLOATING EQUIPMENT

# CHAPTER 7 DESIGN OF CONTAINER CARGO HANDLING AND FLOATING EQUIPMENT

## 7.1 Design of Quayside Gantry Crane

In the Container Terminal, quayside gantry cranes with an efficient capacity shall be installed to load/unload containers expected in the port. In order to handle containers up to the target year of 2015, two units of quayside gantry cranes for Panamax type container vessels are required to achieve efficient port operation.

### 7.1.1 Outline Performance Specification

The quayside gantry cranes to be installed in the port shall load and unload not only containers but also hatch cover, lashing gear and non-containerized heavy cargo.

The quayside gantry crane is designed to be of rail-mounted type, having a hinged boom on the seaside and fixed girder on the landside. The traversing trolley of the rope-operated type shall be provided on the girders. The main hoist and trolley drives shall be simultaneously fully operational.

In designing principal performance specification of cranes, the average mechanical handling capacity of the cranes was set at 35 boxes per hour.

### 7.1.2 Principal Function and Dimensions

Principal function and dimensions of the cranes are determined as follows and Figure 7.1.1 shows general arrangement and features of the cranes:

1) Type:

Rope trolley type, rail mounted, single lifting gantry, traveling

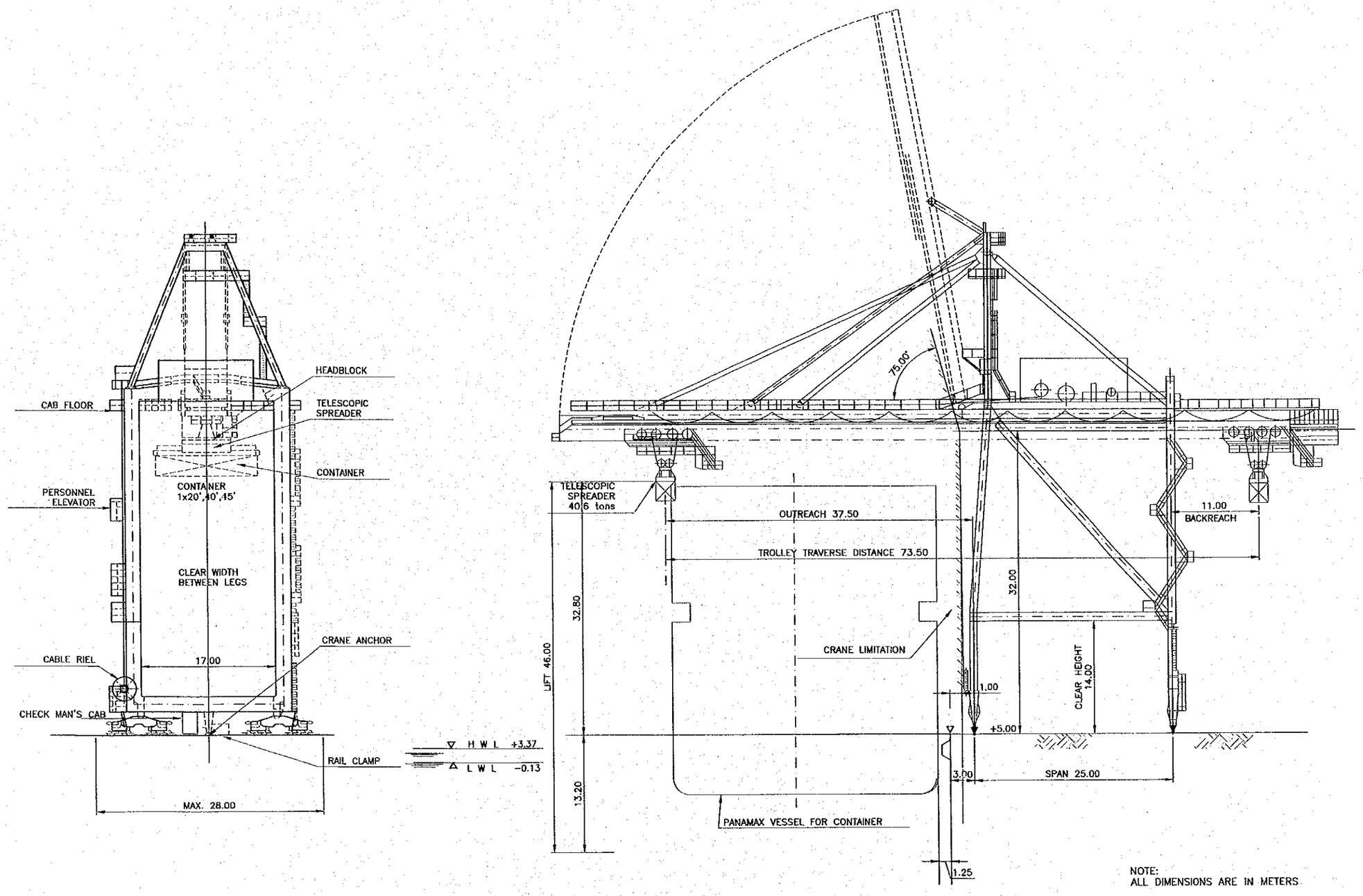
Inverter Control System

Telescopic type (20′, 40′, 45′) spreader

2) Basic Dimensions

| | |
|---|---|
| Hoist capacity (including spreader) | min 50 t |
| (under spreader) | min 40.6 t |
| (under Heavy Lift Hook Beam) | min 45 t |
| Outreach | min 37.5 m |
| Span25 m | |
| Lift (total) | 46 m |
| Lift (above seaside rail surface) | 32.8 m |
| Lift (below seaside rail surface) | 13.2 m |
| Width (buffer to buffer) | max 28 m |
| Portal clearance (under horizontal stays) | min 14 m |

| | | |
|---|---|---|
| | Portal clearance (between seaside leg and seaside leg) | min 17 m |
| | Traveling distance | 430 m |
| | Power supply system | Cable real system |
| 3) | Operating Speed | |
| | Main hoist | |
| | With empty spreader | not less than 150 m/min |
| | With full load (under spreader 40.6 t) | not less than 65 m/min |
| | Trolley | not less than 150 m/min |
| | Gantry | not less than 45 m/min |
| | Boom hoist | not more than 3 degrees |
| | Secondary movement requirements | |
| | - trim | not less than 3 degrees |
| | - list | not less than 3 degrees |
| | - skew | not less than 3 degrees |
| 4) | Ambient Temperature, Wind Load and Earthquake | |
| | Temperature | maximum 45° C |
| | | minimum 10° C |
| | Humidity | |
| | | maximum 99% |
| | Wind Pressure | |
| | Maximum wind speed during operation | 16 m/s |
| | Maximum wind speed during storm wind | 60 m/s |
| | Design seismic coefficient | Kh = 0.2G |
| 5) | Wheel Load and Rail conditions of Gantry rail | |
| | Allowable Wheel Load | |
| | At service conditions (max) Seaside 38.5 t/wheel | Landside 31 t/wheel |
| | At stowed conditions (max) Seaside 50 t/wheel | Landside 58 t/wheel |
| | Wheel pith | not less than 0.9 m |
| | Rail | 73 kg/m |
| | Rail position Seaside rail (from face of berth) | 3 m |
| 6) | Power Source of Crane | |
| | Voltage | 4,160 volt |
| | Phase | 3 |
| | Frequency | 60 Hz |




NOTE:
ALL DIMENSIONS ARE IN METERS

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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

COMISION EJECUTIVA PORTUARIA AUTONOMA (CEPA)

THE DETAILED DESIGN ON PORT REACTIVATION PROJECT IN LA UNION PROVINCE OF THE REPUBLIC OF EL SALVADOR

NIPPON KOEI CO., LTD.

DESIGNED BY :
CHECKED BY :
APPROVED BY :

**Figure 7.1.1 General Feature of Quayside Gantry Crane**

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## 7.2 Design of Tugboats

The about 22 km long approach channel is designed on the basis of one lane traffic. The oceanographic conditions such as current speed and waves are considerably severe in maneuvering the ships entering and leaving the channel of the port and it requires assistance of tugboats. In the design of the channel, a simulation study is conducted and it is concluded that two units of 3,600 PS class tugboats are required to assist in berthing and de-berthing operations.

### 7.2.1 Performance Required

Two tugboats will be used for turning operations but no tugboat will be applied for channel navigation. Tug powering used for the simulations is shown in Table 7.2.1. The powering is derived from the manufacturer bollard pull data considering a reduction of the operational efficiency due to wave height. Those tug boat will be in service in the future.

**Table 7.2.1 Tug Powering (Full out-put)**

| | |
|---|---|
| Tug boat | 3,600 PS Class |
| Wave Height | Under 1.0m |
| Bollard Pull | 45.0 tonF |

Figures 7.2.1 shows typical tugboat assistance for berthing and unberthing operation.

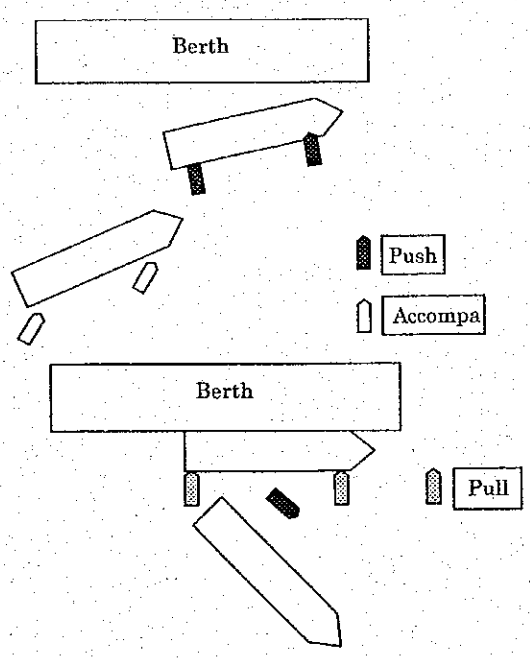



**Figure 7.2.1 Container Ship Unberthing Operation**

### 7.2.2 Outline of Tugboat

The tugboats to be designed and constructed is a steel hulled twin screw type tugboat. It equipped with twin diesel propulsive engines of totaling 2,646 KW (3,600 PS) and two steerable propeller units to engage in mooring work for berthing and unberthing operation of ship. The tugboats shall escort ships in the navigation channel and also to perform towing and pushing ships during berthing and unberthing.

The Vessel shall have suitable towing force, stability and maneuverability for the purpose intended, and enough strength.

The Vessel shall be of flush deck type with sunken f'cle and poop, raked stem and transom stern having deck house amidship as shown in Figure 7.2.2.

### 7.2.3 Classification, Rules and Regulations

The class and notation of tugboat shall be certified by:

Nippon Kaiji Kyokai (NK), NS* (coasting service) Tug, MNS* or
American Bureau of Shipping (ABS), + A1 Towing Vessel, Bureau
Veritas (BV) I³/3E + Tug Coastal Waters or
Lloyd Register of shipping, + 100 A1 Coasting Service Tug LMC, or equivalent.

Rules and Regulations to be followed for design and construction of tugboats are:

- International Convention of Tonnage Measurement of Ship, 1969.
- International Regulation for Preventing Collision at Sea, 1972.
- Rules and Regulations to the Republic of El Salvador.

### 7.2.4 Outline Performance Specification

| | |
|---|---|
| Length, overall | 33.50 m |
| Length, between perpendiculars | 29.00 m |
| Breadth, moulded | 9.40 m |
| Depth, moulded | 4.00 m |
| Designed draft, moulded | 3.10 m |
| Normal trim | 1.00 m |
| Gross Tonnage, International | Approx. 280 Tons |
| Deadweight | Approx. 135 MT |
| Tank capacity (Approximately) | |
| Full oil tank | 80 $m^3$ |
| Lubricant oil tank | 6 $m^3$ |
| Fresh water tank | 25 $m^3$ |
| Water ballast tank | 30 $m^3$ |
| Foam liquid tank | 4 $m^3$ |
| Oil disperse liquid tank | 4 $m^3$ |

### 7.2.5 Propulsion System

Main Engine: 2 sets of diesel engine, non reversible type
Total power 2,646 kW (3,600 PS) in range of 720 –1,000 rpm

Propeller: 2 sets of 360 degrees steerable Z-drive type propellers, 4 bladed, fixed pitch, skewed Kaplan type in propeller duct.
Steering angle, clutch motion and main engine speed shall be controlled remotely form the wheelhouse.

### 7.2.6 Speed and Bollard Pull

Service speed: 12.5 knots on fully loaded draft at 85% rated output of main engines with 15% sea margin.

Bollard pull: 441 kN (45 tonf) on sea trial condition at 100% rated output of main engines.

Endurance: 1,800 nautical miles based on total fuel oil tank capacity and sea speed of 12.5 knots.

Service limitation Coasting service.

### 7.2.7 Complement, etc.

| | | |
|---|---|---|
| Crew | 4 officers and 2 crew members | 6 |
| Passenger | | 12 |
| | Total | 8 |

Accommodation quarter and engine watch room shall be air conditioned.

### 7.2.8 Deck Machinery, etc.

| | |
|---|---|
| Windlass/Rope Winch | 1 x El-hyd. |
| Cable lifter | 29.5 kN (3 tonf) x 12 m/ min |
| Hawser drum | 19.6/9.8 kN (2/1 tonf) x 45/90 m/min |
| Drum rope | 95 mmØ x 100 m/long |
| Brake | 680 kN (70 tonf) |
| Tow Line Reel Winch | 1 x El-hyd. |
| Hawser drum | 19.6/9.8 kN (2/1 tonf)x 45/90 m/ min |
| Drum rope | 95 mmØ x150 m/long |
| Brake | 49 kN (5 tonf) |
| Towing Hook | 1 x 588 kN (60 tonf) |

### 7.2.9 Rubber Fender (Hollow cylindrical)

| | |
|---|---|
| Bow | 1 x 800 mm OD x 12 m long |
| Bow, both sides | 2 x 500 mm OD x 4 m long |
| | 4 x 400 mm OD x 2 m long |
| Stern | 2 x 400 mm OD x 5 m long |

### 7.2.10 Auxiliaries in Engine Room etc.

Electric generator: 2 sets of 450 V, 60 Hz, 100 kVA diesel driven engine.

Fire fighting pump: 1 x 120 $m^3$/h x 120 m driven by diesel engine

Foam fire monitor: 1 x 1,000 l/min on radar mast top

1 x 1.000 l/min on wheelhouse top

Spilled oil dispersion system: 2 x 200 l/min portable type

## 7.3 Maximum Allowable Crane Loads to the Multi-purpose Berth

The cargo handling crane for the multi-purpose berth will be brought by the port user. Though the Specification of crane is not given, the rails itself will be constructed under the project, which has 10m gauge span as a standard sign of multi-purpose quayside crane.

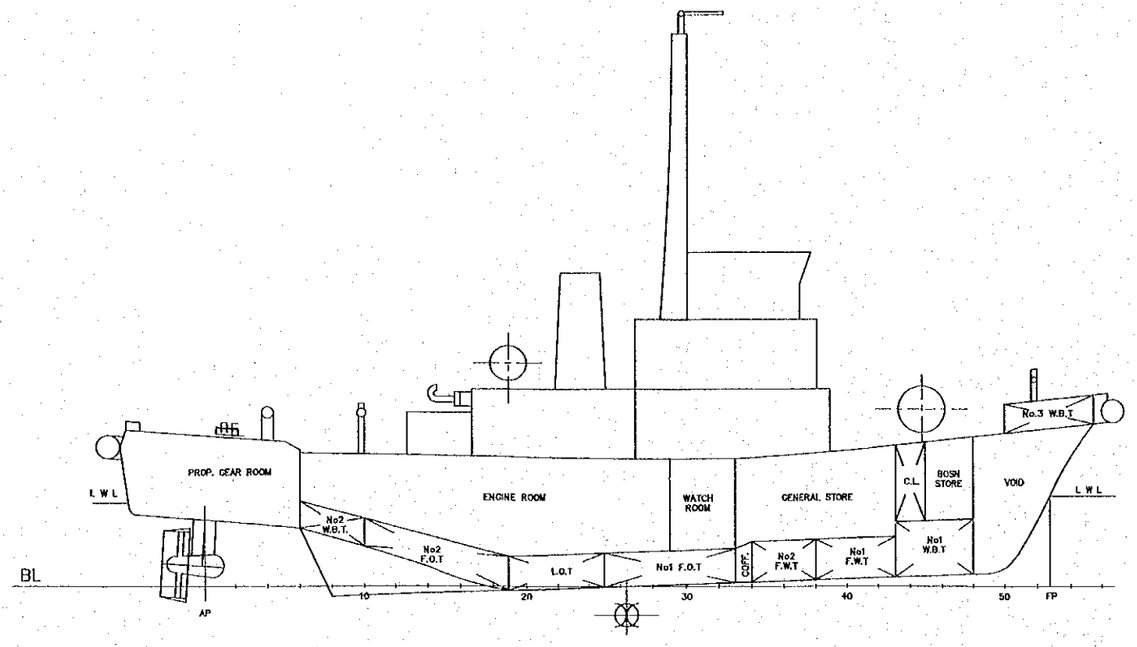
The structural stability of the multi-purpose berth is use with the container berth in future. Then the maximum allowable load of the multi-purpose berth is given as follows.

Principal dimension of quayside crane

| | |
|---|---|
| Lifting capacity | 400kN |
| Total loads of the crane | 6,200kN |
| Rail span | 10.0m |
| Wheel pitch (6 wheels at corner) | 1.0m |

**Table 7.3.1 Maximum allowable crane loads**

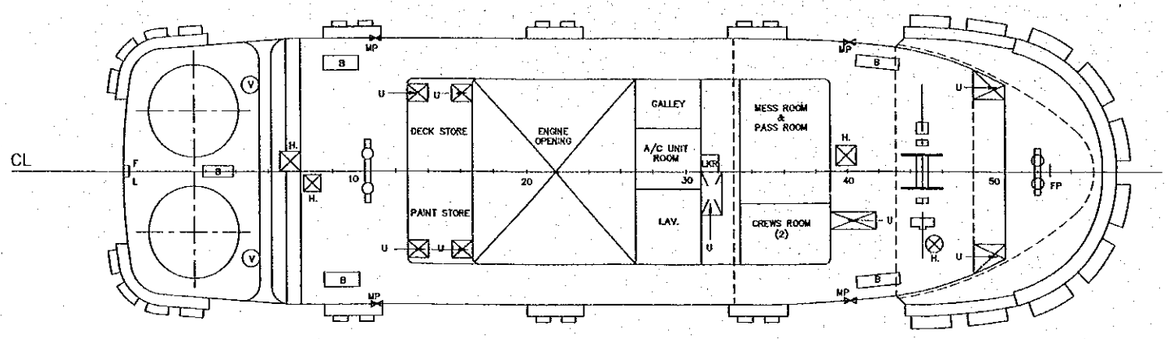
| Condition | | Wheel load | | Note |
|---|---|---|---|---|
| | | Sea side wheel (kN/wheel) | load side wheel (kN/wheel) | |
| Nomal condition | Vertical | 420 | 320 | |
| | Horizontal | 8 | 8 | |
| Seismic condition | Vertical | 604 | 472 | Kh=0.2 |
| | Horizontal | 52 | 52 | |



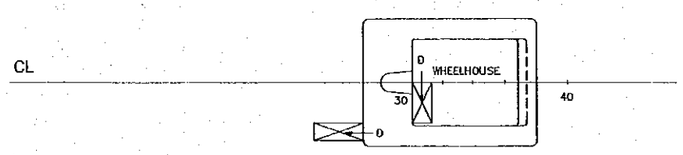

## PRINCIPAL PARTICULARS

| | |
|---|---|
| LENGTH (O.A.) | 33.50 m |
| LENGTH (P.P.) | 29.00 m |
| BREADTH (MLD) | 9.40 m |
| DEPTH (MLD) | 4.00 m |
| DRAFT (MLD) | 3.10 m |
| GROSS TON | 280 ton |
| MAIN ENGINE | 2X1,323 kW (2x1,800=3,600 PS) |
| SERVICE AREA | COASTING SERVICE |

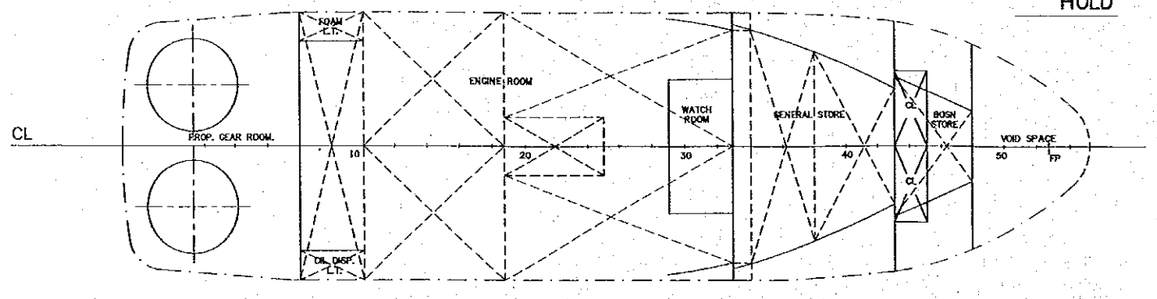
## UPPER DECK



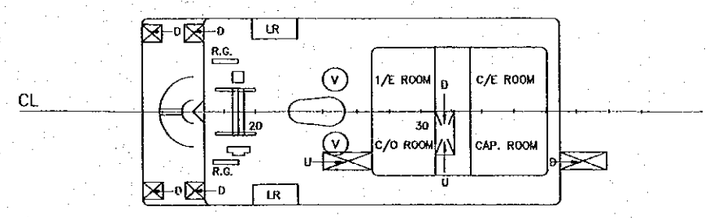

## NAV. BRIDGE DK.




## HOLD




## ENGINE CASING TOP & BRIDGE DECK

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DESIGNED BY :

CHECKED BY :

APPROVED BY :

Figure 7.2.2 General Arrangement of tugboat

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# CHAPTER 8 CONSTRUCTION AND IMPLEMENTATION SCHEDULE

# CHAPTER 8 CONSTRUCTION AND IMPLEMENTATION SCHEDULE

## 8.1 General Scope of Construction

Bidding for the Project work components will be made under the following three (3) packages:

Package A : Civil and Building Works

Package B : Procurement of Cargo Handling Equipment (two units of gantry crane)

Package C : Procurement of Floating Equipment (two units of tugboat)

Table 8.1.1 shows the major work items with their quantities for the Package A works.

**Table 8.1.1 Major Work Items for Civil Works**

| Work Item | | Unit | Quantity | Remarks |
|---|---|---|---|---|
| 1. | Dredging | | (11,489,000) | |
| 1.1 | Outer Channel | $m^3$ | 4,160,000 | (-14.5m),(B=137m) |
| 1.2 | Inner Channel | $m^3$ | 4,469,000 | (-14.0m),(B=140m) |
| 1.3 | Turning Basin | $m^3$ | 2,860,000 | (-14.0m),(-9.5m) |
| 1.4 | Navigation Aids | LS | 1 | |
| 2. | Demolition of Existing Facilities | LS | 1 | Jetty, sheds & others |
| 3. | Container Berth | m | 340 | |
| 4. | Multi-purpose Beth | m | 220 | |
| 5. | Passenger Berth | m | 240 | |
| 6. | Revetment | | | |
| 6.1 | Revetment | m | 650 | |
| 6.2 | Temporary Revetment & Bund | m | 1,640 | |
| 7. | Reclamation | | | |
| 7.1 | Reclamation | $m^3$ | 3,005,000 | |
| 7.2 | Removal of Soft Soil | $m^3$ | 481,000 | |
| 8. | Pavement | | (169,600) | |
| 8.1 | Concrete Pavement | $m^2$ | 8,600 | RTG lane & apron |
| 8.2 | Concrete Pavement | $m^2$ | 71,200 | Container yard |
| 8.3 | Asphalt Concrete Pavement | $m^2$ | 19,000 | Port road, etc. |
| 8.4 | Macadam Pavement | $m^2$ | 72,000 | Open storage, etc. |
| 9. | Drainage | | | |
| 9.1 | Pipe | m | 3,500 | |
| 9.2 | Trench | m | 6,020 | |
| 10. | Building | | | |
| 10.1 | Port Administration | $m^2$ | 2,540 | |
| 10.2 | Container Freight Station | $m^2$ | 2,420 | |
| 10.3 | Maintenance & Repair Shop | $m^2$ | 1,440 | |
| 10.4 | Container Gate | L.S | 1 | 6 lanes |
| 10.5 | Cargo Gate | L.S | 1 | 3 lanes |
| 10.6 | Power Supply Station | L.S | 1 | |
| 11. | Utility | | | |
| 11.1 | Electrical System | LS | 1 | |
| 11.2 | Water Supply & Sewerage | LS | 1 | |

## 8.2 Site Condition

### 8.2.1 Workable Days

The number of workable days for civil and building works is estimated assuming that Sunday, National Holiday and the days of bad weather due to wave, rain, and wind are non-workable days.

The number of workable days is estimated for the following three major categories of work.

**(1) Channel Dredging**

The number of workable days for channel dredging was estimated based on the wave height data at Punta El Chiquirín as shown in Table 8.2.1. The limit of workable wave height for dredgers is 1.5 m, the number of workable days for channel dredging is estimated at 96.4% of working days. The actual number of working days is 293 days a year taking into consideration 72 Sundays and National holidays. The rate of workable days is estimated at 77.4% ((365days - 72days)/ 365days x 96.4%). The factors of rain and wind that do not affect the dredging work were not considered in the analysis of non-workable days.

**Table 8.2.1 Wave Height Record at Punta El Chiquirín**

| Wave Height (m) | Frequency | |
|---|---|---|
| | No. | % |
| 0 – 1.5 | 4,746 | 96.4 |
| 1.5 – 3.0 | 176 | 3.6 |
| Total | 4,922 | 100.0 |

**(2) Construction of Structures**

The number of workable days for structural works in the harbor area is estimated considering the effects of wave and holidays. Table 8.2.2 shows the result of wave height analysis by the Sverdrup Munk Bretschneider (SMB) method. The limit of workable wave height for construction of structural works is 0.5 m, therefore, the number of workable days for structural works is assumed to be 99.9% of working days. With regard to the factors of rain and wind, no consideration is given because most rains, generally considered as tropical showers, fall is only for a short time (less than 1 hour). The rate of workable days is estimated at 80.2% ((365days - 72days)/ 365days x 99.9%).

**Table 8.2.2 Rate of Appearance of Wave Height in Harbor Area**

| Wave Height (m) | Rate of Appearance (%) |
|---|---|
| 0.0 m – 0.3 | 98.0 |
| 0.3 m – 0.5 | 1.9 |
| 0.5 m – 0.75 | 0.1 |

### (3) Earthworks

The number of workable days for earthworks considering the significance of rainfall is studied using rainfall data at La Unión (1996 to 2000) provided by the Ministry of Agriculture and Cattle.

Table 8.2.3 shows the monthly average rainy days for each range of rainfall.

**Table 8.2.3 Monthly Average Rainy Days for Each Range of Rainfall (1996 to 2000)**

(Unit: days)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainy Days | 0.4 | 0.6 | 1.0 | 1.8 | 11.6 | 17.8 | 16.0 | 16.2 | 23.0 | 16.4 | 6.8 | 1.0 | 112.6 |
| Below 1mm | 0.2 | 0.2 | 0.2 | 0.4 | 2.2 | 3.2 | 3.0 | 2.8 | 2.8 | 2.2 | 2.4 | 0.4 | 20.0 |
| 1mm-10mm | 0.2 | 0.4 | 0.8 | 1.2 | 3.6 | 6.8 | 6.2 | 8.8 | 8.4 | 7.8 | 2.4 | 0.6 | 47.2 |
| 10mm-30mm | - | - | - | 0.2 | 3.0 | 4.4 | 4.0 | 2.6 | 6.4 | 4.4 | 1.6 | - | 26.6 |
| 30mm more | - | - | - | - | 2.8 | 3.4 | 2.8 | 2.0 | 5.4 | 2.0 | 0.4 | - | 18.8 |
| Monthly Ave. Rainfall (mm) | 1 | 3 | 4 | 8 | 256 | 315 | 244 | 170 | 448 | 239 | 88 | 1 | 1,777 |

[Source: Ministry of Agriculture]

Table 8.2.4 shows the number of annual rainy days based on the rainfall data limiting to the day time record (8:00 to 17:00 hours) with its rate of appearance. It shows the rainfall during daytime is much lower than that in Table 8.2.3.

**Table 8.2.4 Yearly Rainy Days at Daytime and its Rate of Appearance During 1996 to 2000**

| Description | Unit | 1996 | 1997 | 1998 | 1999 | 2000 | Average |
|---|---|---|---|---|---|---|---|
| Rainy Days | Days | 18 | 22 | 26 | 21 | 16 | 20.6 |
| Rainfall | mm | 231.2 | 270.7 | 254.6 | 320.9 | 96.2 | 234.7 |
| Rate *1) | % | 4.9 | 6.0 | 7.1 | 5.8 | 4.4 | 5.6 |

[Source: Ministry of Agriculture, Note: Rate of appearance shows the percentage against rainy days during daytime]

In estimating the number of workable days for structural works, only the daytime rainy days are considered. Thus, the annual average of non-workable days due to rain is estimated at 20.6 days. The ratio of workable days is assumed at 94.4%. The rate of workable days is estimated at 75.8% ((365days - 72days)/ 365days x 94.4%).

The workable days for the three major categories of work are summarized below:

Dredging Work : 77%
Structural Work : 80%
Earthwork : 76%

## 8.3 Availability of Construction Materials and Equipment

### 8.3.1 Availability of Construction Materials

An availabiliby of local construction materials are investigated throughout the country. Also local products such as cement, precast concrete block, and recady mix concrete and asphalt mixture for pavement, were investigated.

**(1) Local Construction Materials**

1) Sand and Gravel

Sand and gravel to be used mainly for concrete are available at both Laguna de Aramuaca and Sirama River, approximately 42 km and approximately 27 km from the project site, respectively.

(Laguna de Aramuaca)

The sand and gravel at Laguna de Aramuaca is volcanic sand and gravel. The sand from this area is required to be washed and screened in order to get well graded materials.

A quarry was developed and quite large amount of sand and gravel is available.

(Sirama River)

The Sirama River is a narrow width of about 30 m and is not sufficient to exploit borrowing operation.

2) Rock

Rock material for revetment and structural foundations is available in the vicinity of the project site sufficiently.

No quarry is opened yet in this area, however, potential quarry sites exist in the areas owned by both the Government and private.

In the project site there is hill covered by natural forest. According to the geological investigation, it reveals a rock hill with overburden of an average thickness of 4 to 5 m. Prior to quarry opening, it is necessary to remove such overburden and rock material can be produced.

Rock material is also available in the La Colorada area, approximately 8 km from the project site. The quarry has an estimated deposit volume of approximately 2,000,000 $m^3$. However, it is required to open quarry operation and quality area.

3) Reclamation Soil

Reclamation soil is available in the vicinity of the project site and its quantity good enough. Also the dredged materials from the proposed access channel would be utilized for reclamation soil.

4) Sub-base Material for Pavement

Sub-base material is available at the La Colorada district, approximately 8 km from the project site. However, in order to secure well graded material to fit the specification, sieve treatment would be required.

5) Cement

One of the major suppliers of cement has a base factory in San Miguel City. They supply cement either by bulk or in bag. They also could arrange bulk transporters for a large transaction. As to the Type-V cement (partland blast furnaces slag cement), it is not available in the country.

6) Ready Mixed Concrete

A ready mixed concrete manufacture exists in the vicinity of San Miguel City, approximately 47 km from the project site. It is necessary to improve its productivity for the project use.

7) Asphalt Concrete Mixture

An asphalt concrete mixing plant exists in San Miguel City owned by the Ministry of Public Works.

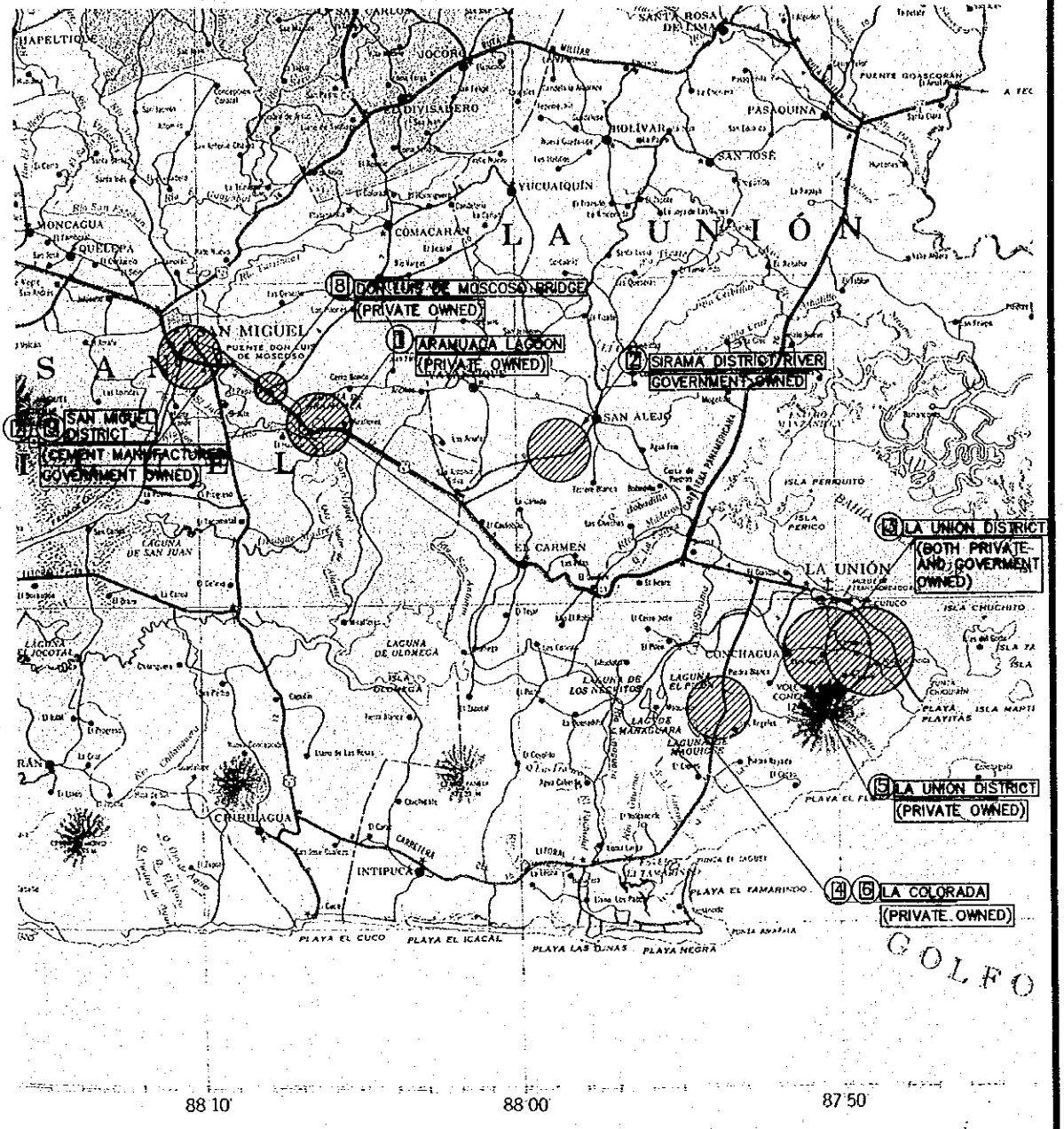
**(2) Sources of Local Materials**

Table 8.3.1 and Figure 8.3.1 show the location and information on the local materials stated in the above.

**Table 8.3.1 Sources of Local Materials**

| Description | Locations | Ref. No. | Approx. Distance from the Site | Remarks |
|---|---|---|---|---|
| Sand and Gravel | Laguna De Aramuaca | ① | 42 km | Private owned |
| -ditto- | Rio Sirama District | ② | 27 km | Government owned |
| Rock | La Unión District | ③ | within 5 km | Private and Government owned |
| -ditto- | La Colorada | ④ | 8 km | Private owned |
| Soil for Reclamation | La Unión District | ⑤ | within 5 km | Private owned |
| Sub-base Material | La Colorada | ⑥ | 8 km | Private owned |
| Cement | San Miguel District | ⑦ | 50 km | Cement manufacturer |
| ICB (Interlocking Concrete Block) | Puente Don Luis De Moscoso | ⑧ | 47 km | Private owned |
| Asphalt Mixture | San Miguel District | ⑨ | 50 km | Government owned |

Note: Ref. No. means the number indicated in the Figure 8.3.1




| Japan International Cooperation Agency (JICA) | Figure | Title |
|---|---|---|
| The Detailed Design on Port Reactivation Project in La Union Province of the Republic of El Salvador | 8.3.1 | SOURCES OF LOCAL MATERIALS |

### (3) Materials to be Imported

Steel products and other furnished products shall be imported from abroad.

### (4) Sources of Major Materials

The sources of major materials incorporated into the Project are as follows:

**Table 8.3.2 Sources of Major Materials**

| Description | Source |
|---|---|
| Cement | Local |
| Sand and Gravel for Concrete | Local |
| Reclamation Soil | Local |
| Rock for Structural Foundation | Local |
| Steel Pipe Pile | Foreign |
| Steel Reinforcement | Local |
| Steel Products (shaped steel, etc.) | Foreign |
| Geotextile Sheet | Foreign |
| Wharf Fixtures | Foreign |
| Sub-base & Base Materials | Local |
| Asphalt Concrete Mixture | Local |
| Concrete Products | Local |

## 8.3.2 Availability of Equipment

The equipment employed for the Project is investigated either from local or foreign sources.

Ordinary construction equipment are available in El Salvador for on-land works, though sufficient number is not available. Concrete mixing plant, asphalt mixing plant, mobile crane, dump truck, bulldozer, backhoe, etc. are available in El Salvador. The marine floatings equipment such as dredgers, floating barges, have to be mobilized from abroad.

The sources of major construction equipment are listed in Table 8.3.3.

**Table 8.3.3 Major Construction Equipment and Sources**

| Description | Source |
|---|---|
| [Floating Construction Equipment] | |
| Cutter Suction Dredger or Trailer Suction Hopper Dredger | Foreign |
| Grab Dredger Fleet | Foreign |
| Pile Driving Barge | Foreign |
| Gutt Barge | Foreign |
| Crawler Crane Barges | Foreign |
| Flat Barges | Foreign |
| Tugboat | Foreign |
| Diver boat | Foreign |
| [Construction Plant] | |
| Concrete Mixing Plant | Local or Foreign |
| Asphalt Mixing Plant | Local |
| Crushing Plant | Local |
| [On-land Construction Equipment] | |
| Crawler Crane | Local or Foreign |
| Truck Crane | Local or Foreign |
| Bulldozer | Local or Foreign |
| Backhoe | Local or Foreign |
| Dump Truck | Local or Foreign |
| Transporter | Local or Foreign |

## 8.4 Major Works Volume and Construction Equipment

### 8.4.1 Major Works Volume

**1) Major Works Volume be incorporated into the Civil Works are as follows:**

| Item | Unit | Quantity | Remarks |
|---|---|---|---|
| Concrete | $m^3$ | 83,400 | Caisson, cope, pavement, etc. |
| Steel Reinforcement | ton | 6,400 | - ditto - |
| Rubble Stone | $m^3$ | 267,000 | Caisson foundation, revetment |
| Armor Stone | $m^3$ | 24,700 | - ditto - |
| Geotextile Sheet | $m^2$ | 64,700 | Behind caisson, revetment |
| Steel Pipe Pile | ton | 553 | Crane foundation (112 nos.) |
| Steel Pipe Pile | ton | 315 | Passenger Berth (37 nos.) |
| Rubber Fender | nos. | 60 | |
| Bollard | nos. | 38 | |
| Crane Rail | m | 1,328 | With accessories |
| Reclamation Fill | $m^3$ | 3,005,000 | |
| Sub-base Course | $m^3$ | 37,280 | |
| Base Course | $m^3$ | 30,720 | |
| Asphalt Mixture | ton | 2,760 | |
| Concrete Pipe | m | 3,510 | Drainage |
| Navigation Aids | sum | 1 | Lighthouse x 1<br>Light Beacon x 3<br>Light Buoy, etc |

**2) Major Working Volume to be incorporated into the Building Works are as follows:**

| Item | Unit | Quantity | Remarks |
|---|---|---|---|
| Concrete | $m^3$ | 3,700 | |
| Steel Reinforcement | ton | 650 | |
| Structural Steel | ton | 410 | |
| Fixings | LS | 1 | |

### 3) Major Working volume to be incorporated into the Utility Works are as follows:

| Description of Work | Unit | Quantity | Remarks |
|---|---|---|---|
| Electrical System | LS | 1 | |
| Water Supply & Sewerage Treatment System | LS | 1 | |

## 8.4.2 Major Construction Equipment

| Equipment | Spec. | No. | Expected Output | Referenced Work Item |
|---|---|---|---|---|
| Suction Dredger Fleet (Imported) | 8,000ps to 10,000ps | 1 | 500,000$m^3$/mo. | Dredging work |
| Grab Dredger Fleet<br>Grab Dredger<br>Hopper Barge<br>Pusher Boat<br>Anchor Boat (Imported) | <br>20$m^3$<br>3,5000$m^3$<br>3,000ps<br>480ps | <br>1<br>2<br>1<br>1 | 247,000$m^3$/mo. | Excavation works |
| Floating Dock<br><br>Anchor Boat (Imported) | 6,000ton<br><br>480ps | 1<br><br>1 | 2nos of caisson per cycle | Caisson production |
| Gutt Barge (Imported) | 1,000 $m^3$ | 3 | 1,200$m^3$/day<br>900 $m^3$/day<br>600 $m^3$/day<br><br>100 $m^3$/day | Sand replacement<br>Rubble mound<br>Revetment,<br>Filling sand & backfilling<br>Armor stone |
| Pile Driving Barge (Imported) | 4.2ton | 1 | 5nos/day<br>8nos/day | Passenger Berth<br>Crane foundation |
| Crawler Crane Barge (Imported) | 900ton, 45ton | 4 | | Berth structure & revetment |
| Flat Deck Barge (Imported) | 900ton | 4 | | -ditto- |
| Tugboat (Imported) | 250ps | 2 | | -ditto- |
| Diver Boat (Imported) | 100ps | 5 | | -ditto- |
| Survey Boat (Local) | 100ps | 1 | | Survey work |
| Concrete Mixing Plant (Local) | 75$m^3$/hr | 1 | 350$m^3$/day max. | Concrete work |
| Asphalt Mixing Plant (Local) | 100ton/hr | 1 | | Pavement work |
| Crawler Crane (Local) | 100ton<br>45ton | 1<br>3 | | Concrete block<br>General use |
| Trailer Truck (Local) | 50ton | 1 | | |
| Concrete Pump (Local) | 70$m^3$/hr | 2 | | Caisson production & concrete placing |
| Bulldozer (Local) | D-6 to D-9 | 10 | | Earthworks |
| Dump Truck (Local) | 10ton to 20ton | 50 | | |
| Wheel Loader (Local) | 1.5$m^3$ to 2.5$m^3$ | 5 | | Stone & Earth works |
| Backhoe (Local) | 0.7 $m^3$ to 1.5$m^3$ | 5 | | Stone & Earthworks |
| Agitators Truck (Local) | 5$m^3$ | 5 | | Concrete work |
| Tire Roller (Local) | 10ton | 2 | | Earthworks |
| Macadam Roller (Local) | 10ton | 2 | | Earthworks |
| Concrete Finisher (Local) | w=6.5m | 1 | 550$m^2$/day | Concrete pavement |
| Asphalt Finisher (Local) | w=6.5m | 1 | 2,000$m^2$/day | As. con. pavement |

## 8.5 Construction Method

### 8.5.1 Temporary Works

Immediately after the possession of construction site, the following preparatory work will be commenced.

- Mobilization of personnel, construction equipment and materials.
- Setting out of the site boundary.
- Construction of temporary site facilities such as office, services, yard for plant and materials stockpiling, etc.
- Preparation of temporary construction facilities such as material loading jetty.
- Processing of rock and soil quarry opening and operation.

1) Setting out

The reference point of the project will be checked. The benchmarks of the project coordinates will be established within the site based on a local coordinate (Local Lambert NAD-27) established by CNR (Centro Nacional de Registros). Simultaneously, an elevation survey of benchmarks refering to the project datum will be carried out.

2) Contractor's work yard

A construction work yard located on the east side of the site will be granted to the Contractor as indicated in Figure 8.5.1. Approximately 11 ha of yard area will be provided for the following yards.

| | | |
|---|---|---|
| Office area | : | 0.5 ha |
| Concrete batching plant area | : | 0.5 ha |
| Material stockpiling area | : | 5.0 ha |
| Re-bar and formwork area | : | 2.0 ha |
| Pre-cast concrete production area | : | 3.0 ha |
| | Total | 11 ha |

3) Handling facility of construction materials

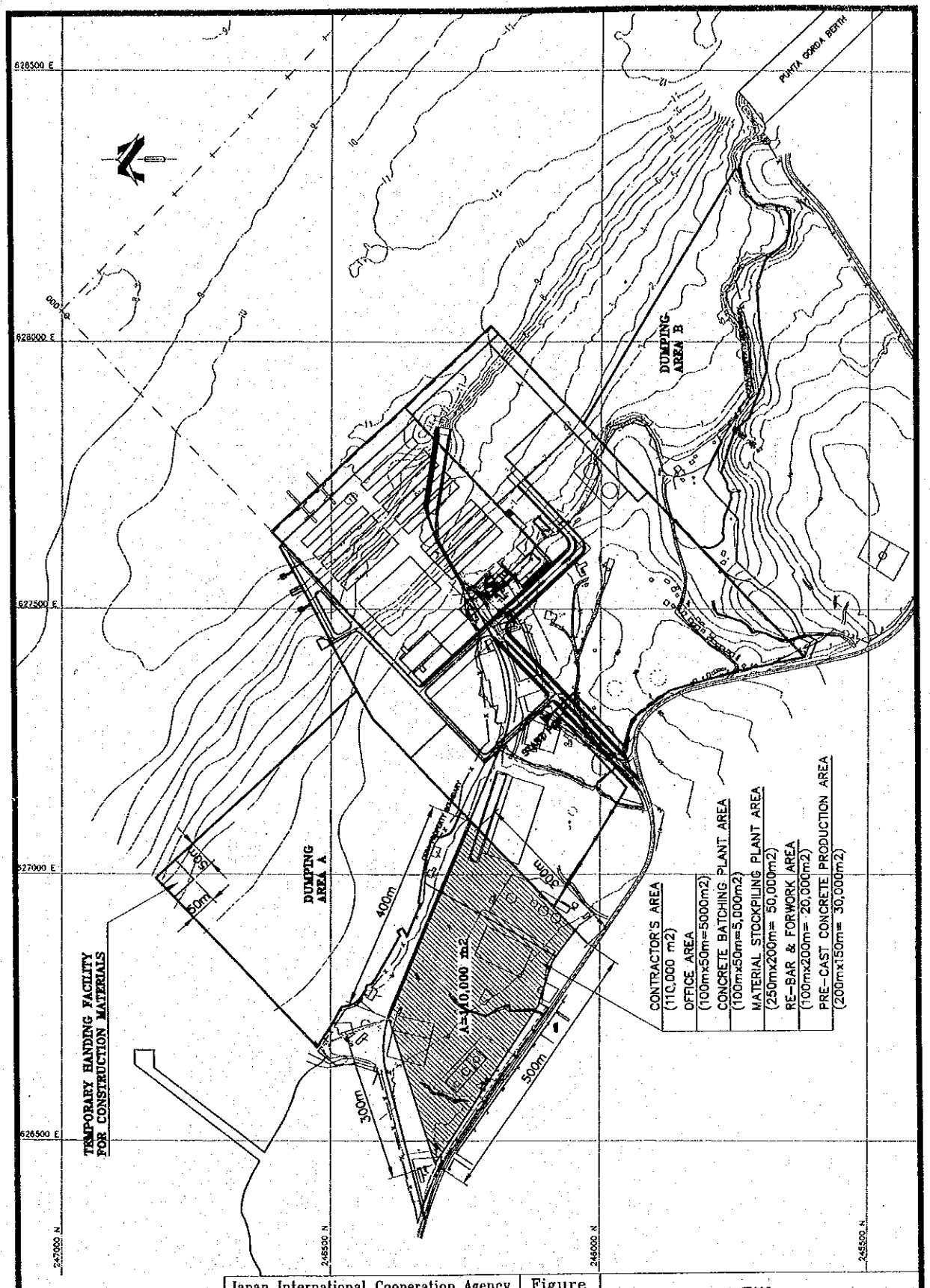
A temporary jetty for handling materials material will be constructed at the corner of the dumping area A indicated Figure 8.5.1. A loading platform of 50m x 50m will be constructed and connected to on-shore which will be constructed in the line of temporary revetment of the dumping area A.

4) Access road for construction from outside

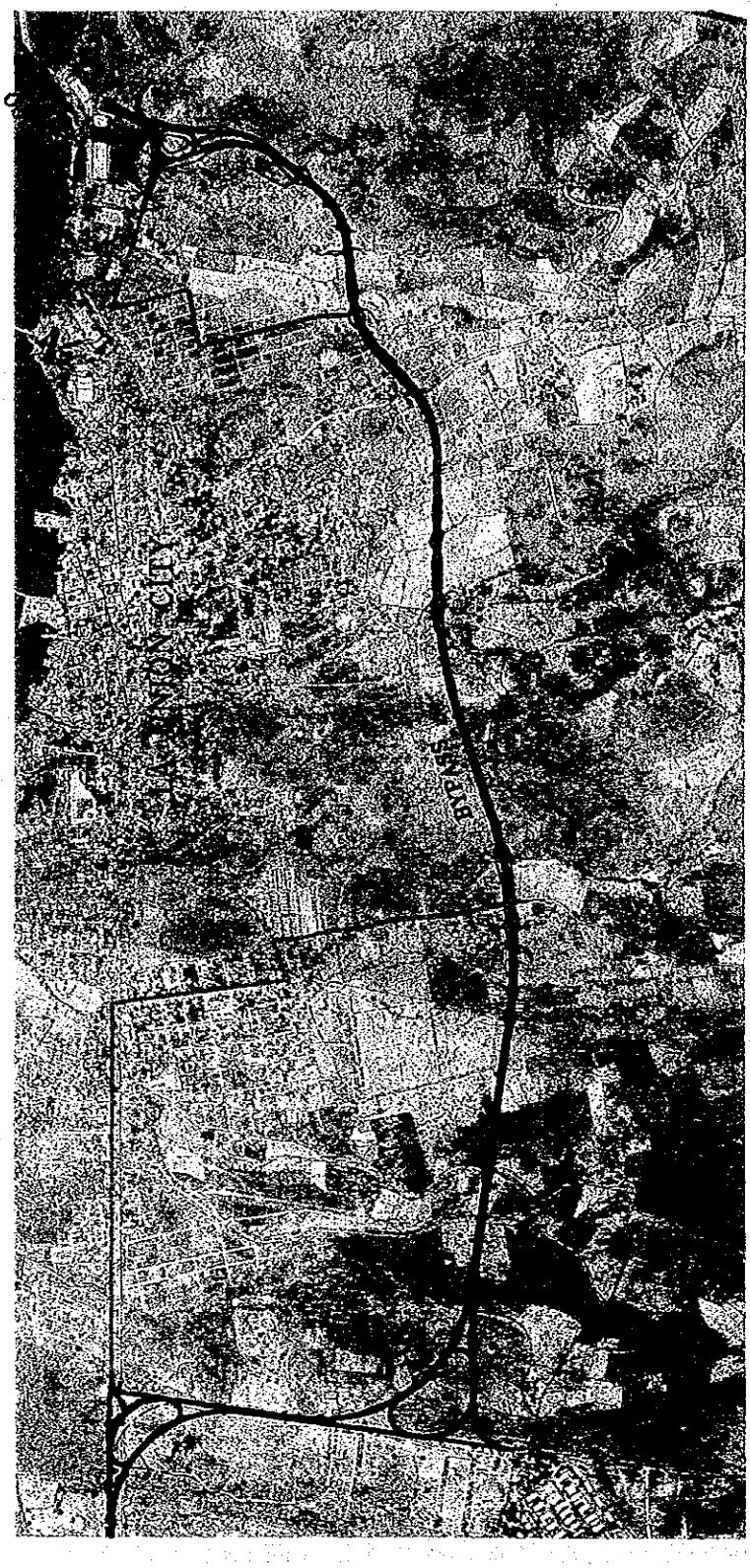
An access road to the project site will be conservated for hauling construction materials and equipment. This access road shall be completed prior to commitment of the Project in order to moderate disturbance to the city by the traffics during and after conservation. This was set up as one of environmental

permit conditions for the project by MARN.

The alternative route is shown in Figure 8.5.2. That is aligned so as to de-route outside the city with a part of the newly planned bypass road.




| Japan International Cooperation Agency (JICA) | Figure | Title |
|---|---|---|
| The Detailed Design on Port Reactivation Project in La Union Province of the Republic of El Salvador | 8.5.1 | CONTRACTORS AREA AND TEMPORARY HANDING FACILITY |




| Japan International Cooperation Agency (JICA) | Figure | Title |
|---|---|---|
| The Detailed Design on Port Reactivation Project in La Union Province of the Republic of El Salvador | 8.5.2 | ACCESS ROAD TO CONSTRUCTION YARD |

### 8.5.2 Environmental Countermeasures for the Project Works

During the construction period, the following mitigation measures and permit conditions shall be considered;

1) Environmental management during borrow operation
Air pollution from dust and vehicular emissions, and water pollution from runoff shall be avoided.

2) Management of waste from borrow operation
Excess vegetation and topsoil generated by the borrow operation shall be disposed to the locations agreed by the La Union Municipal Authority.

3) Dismantling and disposal of existing infrastructure
Harm to human health and pollution of land and sea shall be prevented. Demolished material including asbestos from Warehouse No.5 shall be disposed to the locations agreed by the La Union Municipal Authority.

4) Environmental protection during dredging
In order to reduce water pollution from the diffusing muddiness produced by dredging and disposal works, turbidity and SS will be monitored daily for one month at 12 monitoring stations (locations are mentioned below) before commencement of dredging works. From the data collected, an interrelation between turbidity and SS and the average background value of SS will be analyzed. Turbidity will then be monitored every 24 hours during the dredging working of 50cm below the surface at 12 monitoring stations. The measured value will be converted to SS and if its values reach to the trigger levels dredging operation will be suspended until levels return to background or countermeasure will be taken. Monitoring and trigger levels (increases above ambient) are:

| | | | | |
|---|---|---|---|---|
| Stations 1, 2 | : | near Perico Island mollusk beds | : | 60mg/ltr |
| Stations 3, 4, 5 | : | southern edge of mangrove area | : | 100 mg/ltr |
| Stations 6 | : | north of inner channel, near north-eastern mangroves | : | 200 mg/ltr |
| Stations 7 | : | 500m from reclamation area | : | 200 mg/ltr |
| Stations 8, 9 | : | west of outer channel, near inshore fishing grounds | : | 200 mg/ltr |
| Stations 10,11,12 | : | disposal site | : | 200 mg/ltr |

### 8.5.3 Dredging Works

The dredging work involves the turning basin, inner channel and outer channel. The turning basin is located in front of the container berth with an area of approximately 657,000 $m^2$. The approximately 5 km long inner channel runs parallel to the shoreline between the turning basin and El Chiquirín Point. The approximately 16 km long

outer channel extends from the Zacatillo Island to offshore.

A volume of 2,790,000 $m^3$ will be dredged in turning basin, 4,469,000 $m^3$ in the inner channel and 4,160,000 $m^3$ in the outer channel. The finishing profiles of the dredged area will be -14.0 m both in the turning basin and inner channel and -14.5 m in the outer channel, and the slope will be 1 to 5.

Dumping areas are situated offshore at a distance of 25 km from the Cutuco Port (called offshore dumping area) and onshore on both sides of the terminal (called onshore dumping areas A and B). Figure 8.5.3 shows the location of dredging area and dumping areas.

Dredged material will be categorized as suitable material for reclamation and unsuitable material for disposal. Dredged sand material which is classified as suitable material for reclamation will be filled into the reclamation area. From the dredging materials, a volume of 1,487,000 $m^3$ of sand material is expected to be filled in the reclamation area, and 934,000 $m^3$ and 434,000 $m^3$ of sandy material will be filled in the onshore dumping area A and B respectively. The remaining volume of 8,564,000 $m^3$ will be disposed of at the offshore dumping area even if such volume includes suitable material.

For the dredging operation, two alternative methods is considered: dredging by means of cutter suction dredger and dredging by trailer suction hopper dredger, taking into consideration the result of diffusion simulation and environmental study. Both alternative methods are discussed in this section.

**(1) Preparation and Mobilization**

As soon as possible after the commencement, preparation works for dredging such as setting out for coordinates and pre-dredging survey work will be carried out. Based on the coordinates fixed, sounding survey for confirmation of existing sub-surface profile of the dredging area including tide observation will be carried out in order to determine the volume to be dredged. An echo sounder with GPS (Global Positioning System) will be employed for the sounding survey. At the same time, the designated 12 locations of turbidity monitoring stations will be established and the measurement of turbidity and SS will be carried out at these stations for at least one month before the commencement of operation, in order to determine background levels and the relationship between the parameters.

The mobilization of dredger will be commenced at an appropriate time during the progress of the works.

In the course of preparation of dredging operation, calibration between the position and

depth of the cutter head will be carried out in order to confirm the dredged depth indicator.

**(2) Dredging and Dumping Operation**

For dredging and dumping operation of the Project, the following method is considered by means of trailer suction hopper dredger taking into consideration of the result of diffusion simulation and environmental study.

1) Dredging

The suitable material for reclamation exists most likely in the outer channel area, and less possibility in turing basin and inner channel judging from the results of geological survey. Then, the following operation method will be taken.

The trailer suction hopper dredger having a hopper capacity of approx. 8,000 $m^3$ class will be employed. The operation will be expected in average of 500 hours per month (day and night operation).

During the dredging operation, dredging alignment will be kept by leading of GPS.

Taking into consideration of environmental protection especially for the diffusion of turbidity during dredging operation and obtaining the suitable material for reclamation from outer channel, the following operation will be taken.

i) During the rising tide, dredging operation shall be limited to the Outer Channel in order to minimize the turbidity water go into the upstream of the Fonseca Gulf.

ii) During the ebb tide, the dredging operation in the Turning Basin and Inner Channel will be carried out because the turbidity diffusion is not expected toward the upstream of the Fonseca Gulf. If turbidity diffusion arises and observes more than standard value at designated points during the dredging operation, necessary counter measures shall be taken such suspension of dredging operation provision of silt curtain as auxiliary measure.

2) Dumping and Reclamation

- Onshore Dumping at areas A and B, and Reclamation:

Only the suitable material shall be dumped to the onshore dumping areas.

The temporary bunds and revetment for enclosing the reclamation area and onshore dumping areas will be constructed before commencement of site clearance and dumping operation of suitable materials. Spillway will be prepared to the temporary bund and temporary revetment in order to control the diffusion of silt particles.

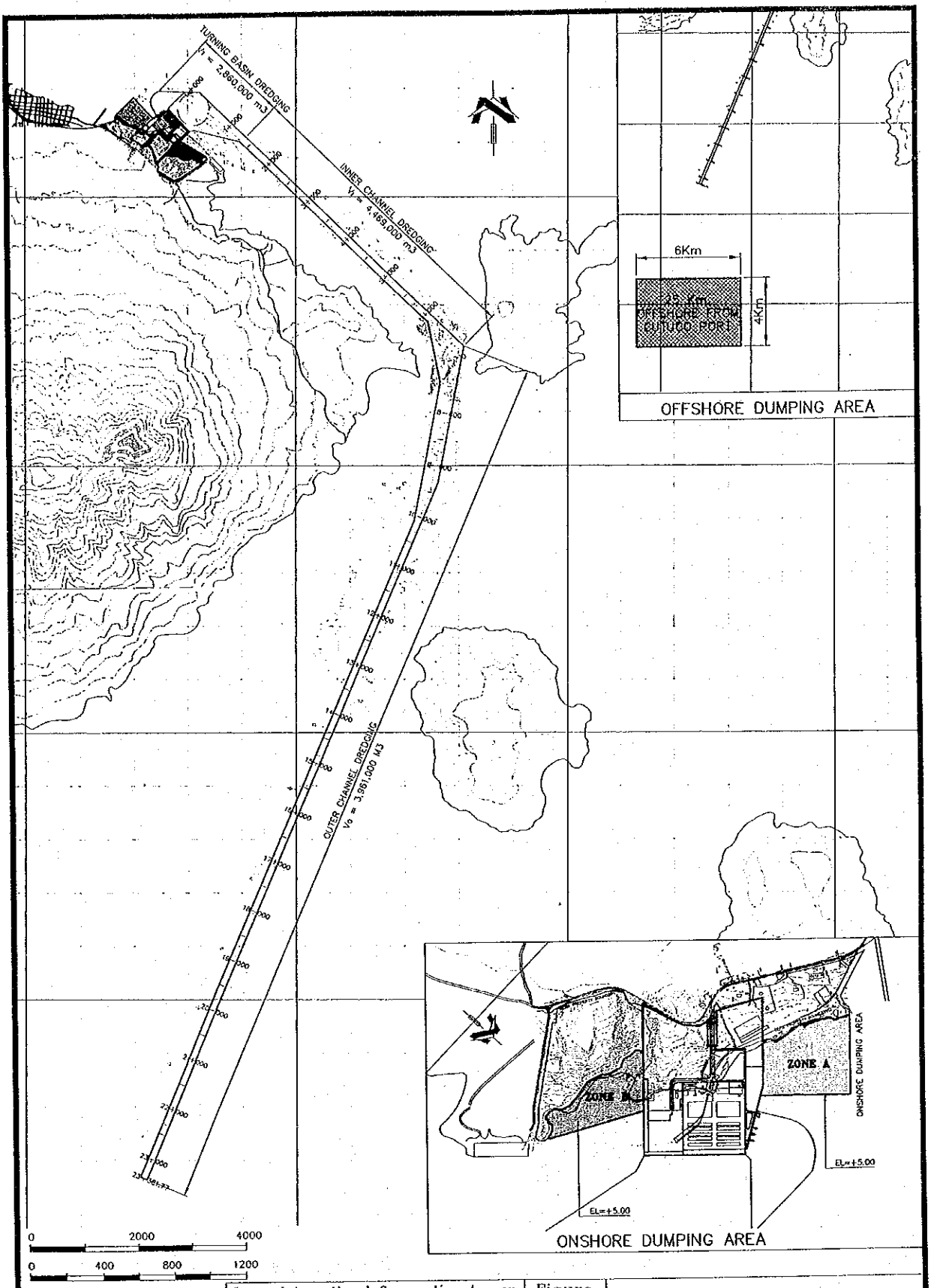
In both onshore dumping areas, appropriate buffer area will be kept in order to settle sediment of silt particles as much as possible. In addition, the silt curtains will also be provided so as to minimize the turbite water from the outler as much as possible of every spillway.

Dumpling operation will be carried out by means of hydraulic discharge directly from trailer suction hopper dredger. Discharge pipes will be arranged on land in the dumping area in advance. Once the suitable material appeared during dredging operation in the outer channel, the trailer suction hopper dredger will be moved to the onshore dumping area and the discharge mouth of dredger will be connected with the fixed discharge pipe. Then, the discharge operation will be commenced. Discharge operation shall be carried out with utmost care to reduce the amount of flow from spillway so as to control the amount of flowing dredger material out.

During the operation, water quality shall be observed at the frequency and locations designated in the Specifications.

- Offshore dumping

The dumping area is located at 25 km (with a depth of –29 m and area of 6 km by 4 km) away from the project site. Dredged material will be transported to the dumping area and dumped within the designated area. Dumping operation will be carried out by opening the bottom of trailer suction hopper dredger. The traveling of dredger will be expected 5 times a day. While the dumping, the trailer suction hopper dredger is running through a wide range of the dumping area with a maximum navigation speed in order to spread the material widely.




| Japan International Cooperation Agency (JICA) | Figure | Title |
|---|---|---|
| The Detailed Design on Port Reactivation Project in La Union Province of the Republic of El Salvador | 8.5.3 | LOCATION OF DREDGING AND DUMPING AREA |

### 8.5.4 Berths

Berth facilities will consist of a Container Berth (L=340 m), a Multi-purpose Berth (L=220 m) and a Passenger Berth (L=240 m). Berth structures will be of Concrete Caisson Type for the Container Berth and Multi-purpose Berth, and Vertical Steel Pipe Pile Type for the Passenger Berth.

During the construction of the Container Berth and Multi-purpose Berth, the following procedures and work sequence will be taken:

1) Excavation of trench for rubble foundation
2) Placing of rubble rock for caisson mound including compaction
3) Caisson manufacturing including launching and placing
4) Sand filling into caisson including cover concrete
5) Backfilling behind caisson
6) Coping concrete and fittings
7) Crane beam (foundation and beam) including fixtures

#### (1) Excavation of Trench for Rubble Foundation

A grab dredger fleet composed a 20 $m^3$ grab dredger, 3,500 $m^3$ hopper berge, 3,000 ps class tugboat and anchor boat, will be employed for the excavation of soft material. 500 hours operation per month in average is scheduled (day and night operation). The probable output of the dredger estimated at 247,000 $m^3$ per month. The grab dredge shall be of water tight type for diffusion prevention.

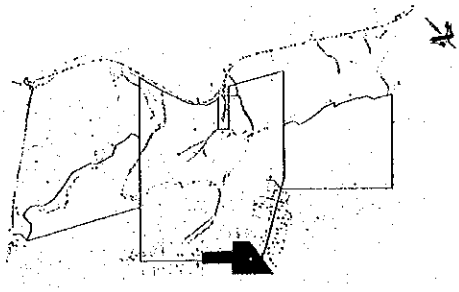
Since the soil excavated is very fine and soft, countermeasure shall be taken to minimize the muddiness water to diffuse. Details is discussed in the Section 8.5.6 (1).

After the completion of the bathymetric survey in the project area, excavation of trench for rubble foundation will be commenced. The excavated material will be loaded onto hopper barges, and disposed at the offshore dumping area. The excavation operation shall be carried out with utmost care to prevent the diffusion of particles of dredged material.

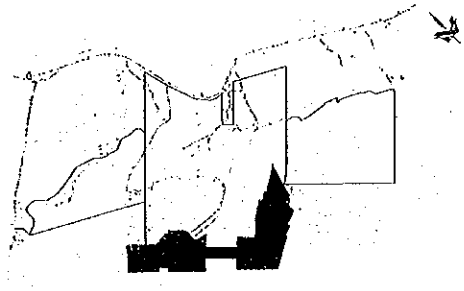
The excavation will be carried out to reach the firm layer having a N-value of not less than 30 in order to obtain the desired bearing capacity of the caisson foundation. Figure 8.5.4 shows the procedure for excavation of rubble foundation.

#### (2) Placing of Rubble Stone for Caisson Mound including Compaction

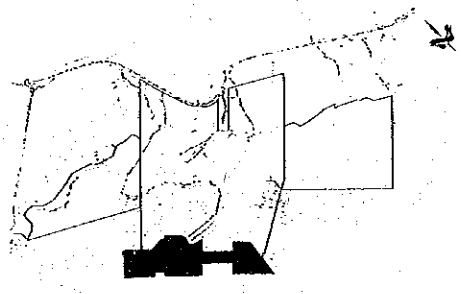
The rubble stone of caisson mound shall be of sound stone material in a range of 10 kg to 250 kg. Produced stone material will be transported to the temporary stockpile yard provided nearby the site.



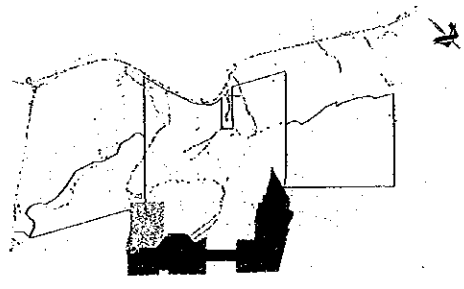
1 ST STEP
CONTAINER BERTH



3 TH STEP
WEST REVETMENT



2 ND STEP
MULTI-PURPOSE BERTH



4 TH STEP
EAST REVETMENT

| Japan International Cooperation Agency (JICA) | Figure | Title |
|---|---|---|
| The Detailed Design on Port Reactivation Project in La Union Province of the Republic of El Salvador | 8.5.4 | PROCEDURE FOR EXCAVATION OF RUBBLE FOUNDATION |

A Gutt Barge having a loading capacity of 1,000 $m^3$ and equipped with a grab bucket having a capacity of 3 $m^3$ will be employed for the rubble stone placing work. The expected output of the gutt barge for this work is 900 $m^3$ per day. Stone materials will be loaded onto the gutt barge from a temporary loading jetty constructed in advance at the location shown in Figure 8.5.1. The placing operation will be done by divers, as well as leveling mound surface. Figure 8.5.5 shows the procedure of rubble mound construction both on berths and revetment works.

Compaction of rubble mound will be carried out by vibration or similar method. In order to confirm the extent of compaction, a compaction test on land will be carried out in advance.

**(3) Caisson Production including Launching and Placing**

Seventeen numbers of concrete caissons for the Container Berth and 12 numbers of concrete caissons for the Multi-purpose Berth will be produced on the floating Dock. Two numbers of caissons will be produced at same the cycle. A 6,000 ton loading class floating dock will be employed for producing caissons, taking into consideration the concrete caisson dimensions. The floating dock shall have dimensions of L=50 m x W=38 m x H=19 m (d=4.0 m) at least.

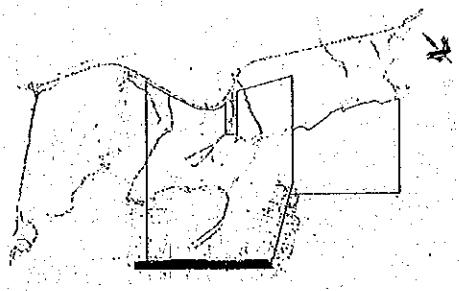
To allow earlier concrete caisson production, a floating dock will be moored alongside the existing Cutuco Jetty until the temporary jetty is constructed at the corner of the Temporary Revetment A-West and A-North as shown in Figure 8.5.6. The floating dock will be shifted to the new temporary jetty just before completion by enclosing revetments. Loading of materials such as shuttering, formworks, reinforcing bars, etc. will be carried out through the jetty. A reinforcement processing and formwork assembling yard will also be provided in the temporary onshore yard.

The following procedures will be applied for producing concrete caissons.

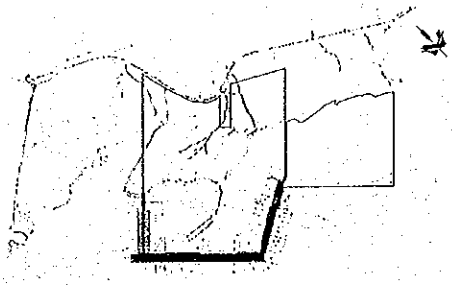
Concrete will be placed in six steps, taking into consideration the maximum height of concrete placing for wall in one time (Hmax.=3.0 m) for the concrete caisson.

1) Preparation of platform for concrete caisson

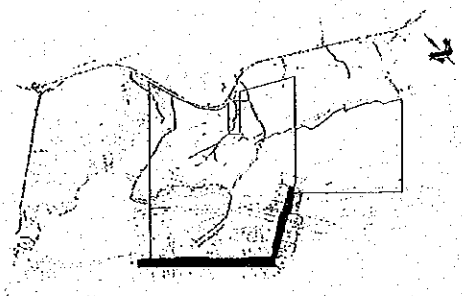
A sand mat and asphalt roofing will be placed underneath the caissons in order to easily detach the caissons from the deck of the floating dock while launching.



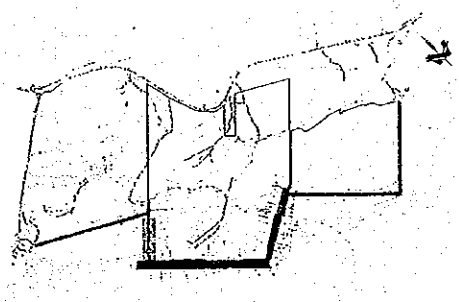
1 ST STEP
CAISSON MOUND



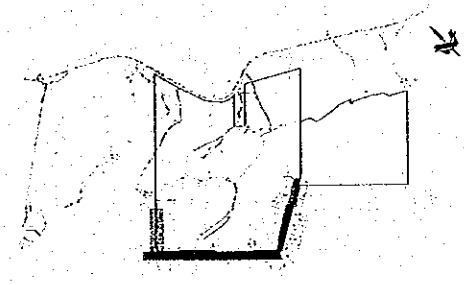
4 TH STEP
TEMPORARY BUND
EAST & WEST



2 ND STEP
WEST REVETMENT

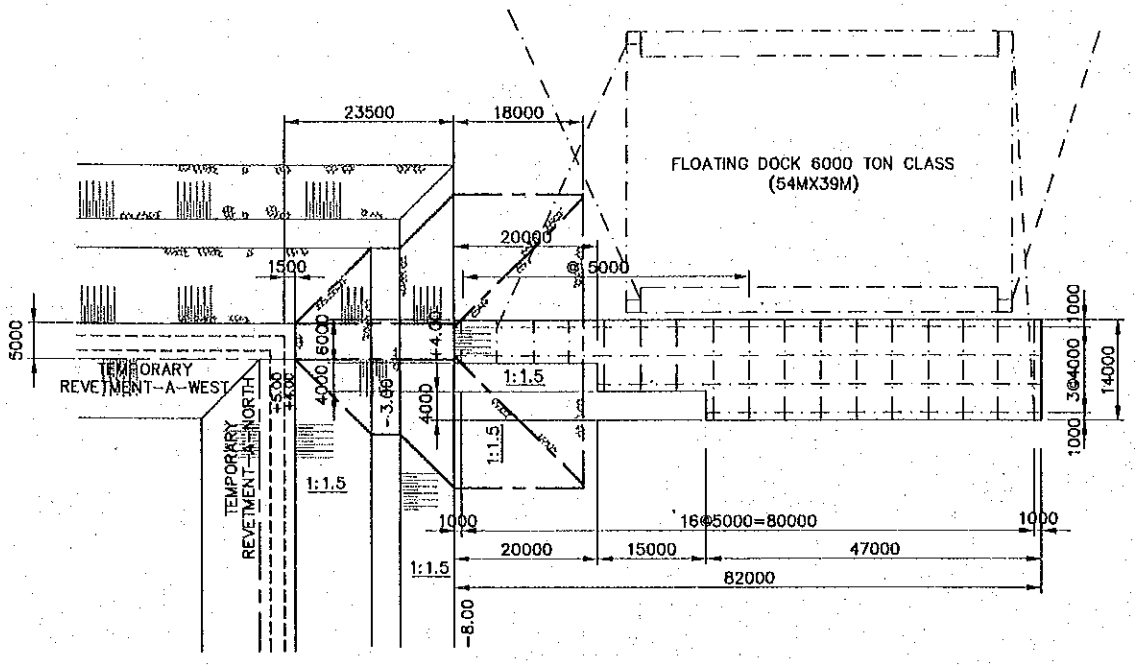


5 TH STEP
TEMPORARY REVETMENT
A-NORTH, A-WEST
AND B.

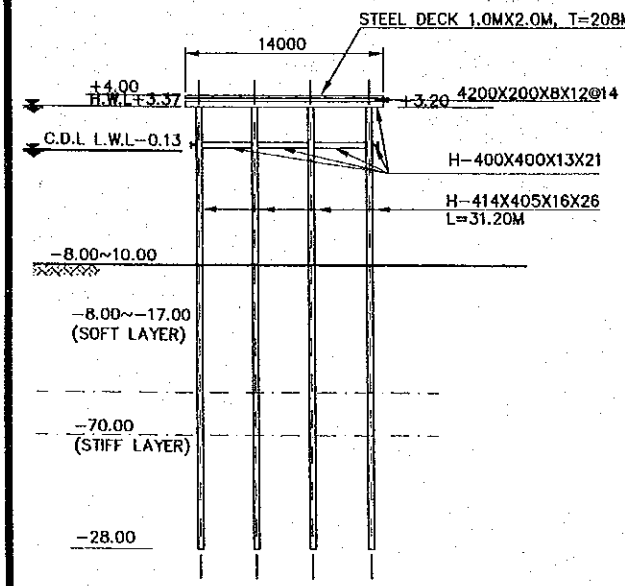


3 ND STEP
EAST REVETMENT

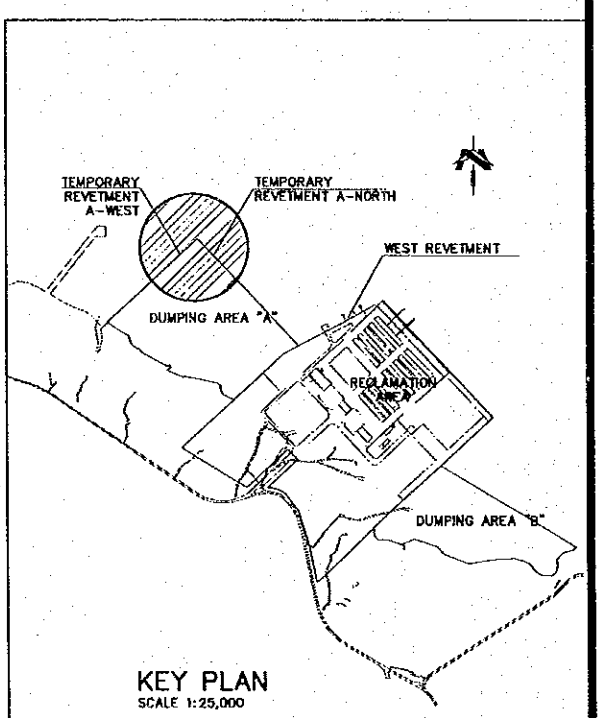
| Japan International Cooperation Agency (JICA) | Figure | Title |
|---|---|---|
| The Detailed Design on Port Reactivation Project in La Union Province of the Republic of El Salvador | 8.5.5 | PROCEDURE OF RUBBLE MOUND FOR BERTH AND REVETMENT |




PLAN OF TEMPORARY JETTY
SCALE 1:1000




SECTION OF TEMPORARY JETTY
SCALE 1:500




KEY PLAN
SCALE 1:25,000

| Japan International Cooperation Agency (JICA) | Figure | Title |
|---|---|---|
| The Detailed Design on Port Reactivation Project in La Union Province of the Republic of El Salvador | 8.5.6 | TEMPORARY JETTY |

2) Arranging of reinforcement bars, formwork and shuttering.
Reinforcement bars will be cut and bent at the temporary yard.

Shuttering and formwork will also be assembled in several parts at the temporary yard in advance. Assembled parts and reinforcing bars will be loaded by crane onto the floating dock.

3) Concrete placing
Concrete will be ready-mixed at the concrete mixing plant established in the Contractor's work yard.

After inspection of reinforcing bars and formworks, concrete will be placed by using concrete pump through discharge pipes. Concrete placing will be carried out with utmost care to prevent segregation. Compaction of concrete will be carried out by using immersion type vibrator. Curing of concrete will follow soon after the concrete placing.

During the producing concrete caissons, safety precautions such as safety net, safety belt, etc. shall be assured for labors, because of operations at high place.

4) Launching and temporary placing of concrete caissons
The concrete caisson has stability without ballast afloat. So the floating dock will be towed to the launching location having a water depth not less than -12.0m (draft of caisson; 7.1 m + depth of floating dock: 4.0 m + allowance) and the concrete caisson will be launched.

Then caissons will be towed to the temporary storage location. Caissons will be placed in position temporarily by pouring seawater into each chamber of the caisson with submerged pumps.

5) Placing of concrete caissons
Upon completion of the rubble mound construction, caissons will be placed in the final position. A flat barge with winches and a crawler crane barge will be employed for the final placing of caissons. The exact position of caissons will be guided by surveyor from the fixed point.

The first caisson re-floated will be towed to the approximate position and placed temporarily by pouring of seawater into it. The second caisson will be placed correctly to the position in the same manner as the first one.

After placing of the second caisson, the first caisson will be re-floated and placed to the correct position. Caissons in position will be filled with seawater.

**(4) Sand Filling into Caisson and Cast Cover Concrete**

A Gutt Barge at 1,000 $m^3$ loading capacity with a 3 $m^3$ grab bucket will be employed for filling sand into caissons. The probable output of the gutt barge for this work is 600 m3 per day. Material for filling is sea sand borrowed from approved borrow pit s. The sand filling shall be within a grading limit specified in the Specifications.

During sand filling operation, the filling height difference between the next chambers shall be not more than 1.0 m in order to prevent excessive pressure to the inner wall of the caisson. A concrete pump will be employed to cast concrete covers. After completion of joints between caisson to protect the backfilling materials from leakage will be fixed between caissons.

**(5) Backfilling behind Caisson**

After completion of joint, backfilling behind caissons will be carried out. Rubble stone for backfilling shall be rock material with a size of less than 100 kg. Produced rock material will be transported to the temporary stockpile yard to be provided nearby the site.

The same equipment as described in item (4) above will be employed for the backfilling work. The expected output of the gutt barge for this work is 600 $m^3$. Rock materials will be loaded onto the gutt barge from the temporary jetty. The placing operation will be carried out by divers with utmost care to prevent damage to caisson s. After placing of backfill rock a filter fabric will be placed by divers on the slope surface of backfill rock.

**(6) Coping Concrete and Fittings**

After settlement of caissons cease, coping concrete and fittings works will be done. The required reinforcement is assemble together with fixing the anchor bolts of fittings in place. Setting the formworks, concrete will be cast.

**(7) Crane Rail Foundation (Foundation and Beam)**

Before placing backfill rock behind caissons, steel pipe piles for crane rail foundation will be driven. A pile a driving barge will be employed for driving steel pipe piles. The expected output of pile driving work is 8 numbers per day.

Driven piles will be fixed and tied temporarily to the caisson top by H-shaped steel in order to prevent deformation of the piles during placing backfill rock. Beam concrete will be executed after completion of reclamation works. Judgment for required pile penetoration will be done by applying the Hiley Formula which gives the ultimate bearing capacity of driven piles.

### 8.5.5 Revetment

The revetment will be constructed to confine the reclamation materials and disposal materials. Based on a comparison study, the suitable revetment structure is decided as rock mound type with armor stone. This work sequence are summarized as follows.

**(1) Soil Improvement**

The same dredger as described in Item 8.5.4 (1) will be employed for excavation of soft material. The probable output of the dredger is 247,000 $m^3$ per month. The procedure of excavation is illustrated in Figure 8.5.4.

Utmost care shall be taken to minimize dispersion of muddiness water applying the countermeasure mentioned in the Section 8.5.6 (1).

Immediately after finishing the excavation of soft soil, replacing material will be filled into the dredged trench by the same type of gutt barge as described in Item 8.5.4 (2). The probable output of the gutt barge is 1,200 $m^3$ per day.

Considering the designs seismic conditions, the replacing material shall be of well graded, which has unti-liquefaction failure.

**(2) Revetment Construction**

The core of revetment shall be composed of rock material with a size of 10 kg to 250 kg. Produced rock material will be transported to the temporary stockpile yard which to be provided nearby the site.

Placing of rock material will be carried out from both landside and offshore taking into consideration the site and structure conditions as well as the construction schedule. In order to control diffusion of muddiness during the reclamation work, revetment construction shall be executed in advance, which will confine the reclamation area.

Placing of Core Rock Material:

In placing core rock material, the following combined methods will be employed.

a) Placing of core rock material from land
Rock materials will be placed with end-on method, dumped directly by dump trucks and rush by bulldozers. Backhoes will be employed for leveling of slopes. After leveling of slopes, filter fabric will be placed on the interior slope by divers.

b) Placing of core rock material from sea.
Gutt Barge will be employed for stone placing core rock in the offshore portion. Rock materials will be loaded onto the gutt barge from a temporary jetty in advance. Placing operation will be carried out by assistance of divers, and then leveling slopes and placing filter fabric on the interior slope will be done continuously.

c) Placing of armor stone material and coping concrete.
After completion of core rock placing, armor stone will be placed on the outer slope. Placing operation will be carried out by crawler crane on a flat barge with assistance of divers.

### 8.5.6 Reclamation

Soft stratum in the reclamation area shall be excavated in order to avoid consolidating settlement.

#### (1) Excavation of Soft Stratum

The same dredging procedure as described in Item 8.5.4 (1) will be employed for excavation of soft stratum. The probable output of the dredger is 247,000 $m^3$ per month. The same procedure as described in Item 8.5.5 (1) will be applied for this work.

The removal of soft stratum along the revetment has to carried out initially under the coundition of open sea. Then dispersion of muddiness would affect to the marine environment. So it is recommended to introduce the closed silt curtain method at the location of excavation work as shown in figure 8.5.7 that is widely used in the dredging work in Japan.

#### (2) Reclamation

Reclamation material will be obtained from both sources, i.e. cutting of a hill at the hill-side of the project area and dredged materials from the proposed access channel. Site clearance in the hilly area of the project site will be carried out at initial stage of the reclamation works.

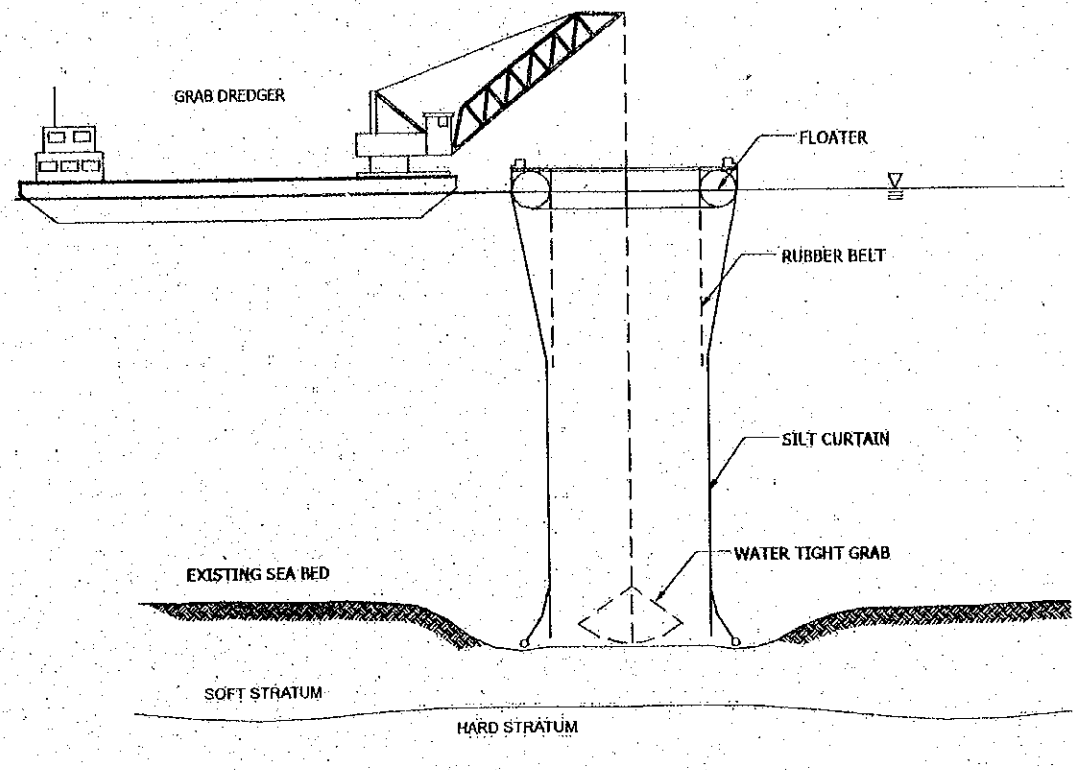



**Figure 8.5.7 Closed Silt Curtain Method**

After finishing removal of soft stream from the reclamation area, reclamation works will be commenced. Excavated material from the hilly area will be hauled and ended on directly to the reclamation area. Dredged suitalbe materials will be filled by means of hydraulic fill from a suction dredger through discharge pipes to the reclamation area. The layer above mean sea level will be compacted by every 30 cm thickness using compaction rollers to attain the required density.

During the reclamation operation, appropriate environmental protection measures will be provided around the operation area.

### 8.5.7 Pavement Works

The types of pavement will consist of concrete pavement for the container yard, RTG traffic lane, gravel pavement for the container stacking area, asphalt pavement for the road area and macadam pavement for the parking area. The work will be carried out following the reclamation works, compacting and leveling.

#### (1) Sub-grade Preparation

Sub-grade will be leveled and compacted until the required CBR value is achieved.

Compaction rollers such as tire roller, macadam roller and/or vibration rollers will be employed. Compaction will be carried out by such equipment together with sprinkling

water in order to obtain the optimum water content of the compaction soil, and leveled to the specified elevation by bulldozer or motor grader.

**(2) Sub-base and Base Course**

After completion of sub-grade preparation, sub-base and base course will be rolled and compacted until the required CBR value is achieved. Compaction will be carried out at every 30 cm thickness using compaction rollers in an appropriate manner. Compaction will be carried out with sprinkling water in order to obtain the optimum water content of the compaction soil, and then leveled to the specified elevation by motor grader. Materials for sub-base and base course shall be well graded.

**(3) Asphalt Concrete**

Asphalt concrete will be used for the binder course and surface course. After completion of the base course, a prime coat and tack coat will be applied for obtaining good contact between base course and asphalt binder course, and asphalt binder course and asphalt surface course. Asphalt mixture will be produced and transported from an asphalt plant in San Miguel. During transporting, asphalt mixture shall be kept at the specified temperature.

Asphalt-finisher will be employed for paving works. After rolling out of asphalt mixture, compaction by tire roller and macadam roller will follow.

**(4) Concrete Pavement**

Concrete pavement including concrete beam for the RTG track lane will be of cast-in-place in-situ reinforced concrete type. After compaction of the base course, the surface will be cleaned. Reinforcement bars, formworks are placed and concrete will cast. Construction joints will be arranged by tie bars and slip bars.

### 8.5.8 Building Works

Building works will include the Port Administration Building, Container Freight Station, Maintenance and Repair Shop, Container Gate, Cargo Gate, Power Supply Station, and Guide House.

**(1) Foundations**

The Buildings, will have reinforced concrete continuous beam foundation with/without vertical concrete pile foundation. Locally produced concrete piles (40 cm x 40 cm to 50 cm x 50 cm and a length of 5 m to 10 m) will be driven by crawler-based pile driver. Pile driving length will be judged by applying the Hiley Formula that shows the ultimate bearing capacity of driven piles.

Concrete will be placed using concrete pump in order to avoid construction joints.

**(2) Structures**

The Port Administration Building and Power Supply Station will be of reinforced concrete structure, the Container Freight Station and Maintenance and Repair Shop will be of steel structure, and the Container and Cargo Gate will be of combined reinforced concrete and steel structure. Concrete will be placed using mobile crane with concrete bucket, considering the small quantity of each structural member. Steel structure will be manufactured locally. Processing and assembling will be done by local manufacturers. The maximum weight of assembled steel members will be 3 tons and jointing and fixing will be carried out using mobile crane.

In parallel with structures works, plumbing and electrical conduits works, etc. will be carried out.

**(3) Finishes and Utilities**

Upon completion of structural works, finishing works both interior and exterior and fixing work of utilities will proceed. Finishing works will be carried out in accordance with the finishing schedule specified on the Drawings. Utility works such as plumbing and electrical will follow.

An elevator for the Port Administration Building, an overhead traveling crane with 5 ton loading capacity for the Repair Shop, a weighing scale with 5 ton capacity for the CFS and 4 weigh bridges with 50 ton capacity for both Container and Cargo Gates will be installed. Upon completion of installation, commissioning of these equipment will be carried out in the presence of the personnel concerned.

## 8.6 Construction Schedule

### 8.6.1 Package A: Civil and Building Works

**(1) General**

The overall construction period of the Civil and Building Works is scheduled 36 months.

**(2) Preparation Works**

Preparations for construction including obtaining rock quarry opening permission and quarry operation, mobilization of equipment and materials, preparation of temporary facilities, etc. will be completed within 7 months from the date of commencement of the works.

**(3) Dredging Works (Turning Basin and Approach Channel Dredging)**

Dredging of the turning basin and approach channel will be completed within 6 months and 17 months respectively from the commencement of the Works.

**(4) Berth Structures**

Excavation of trench for caisson foundation will be commenced at earlier stage. Berth structures will be completed within 27 months from the commencement of the Works. The Container Berth will be constructed first, and then construction of the Multi-purpose Berth and Passenger Berth will follow.

**(5) Revetment Works**

Revetment work will be commenced at an earlier stage of construction and shall be completed within 22.5 months from the commencement of the Works in order to enclose the construction site.

**(6) Reclamation Works**

Reclamation work is divided into two phases: soil improvement by means of displacement, and reclamation fill work. Removal of soft stratum by dredging will be completed within 2.5 months from the commencement of the Works. Following the removal of soft stratum, reclamation work will be carried out and completed within 16.5 months from its commencement.

**(7) Pavement and Drainage Works**

In the final stage of reclamation works, pavement and drainage works will be commenced and completed within 14 months and 9.5 months from the commencement of the Works respectively.

Figure 8.6.1 shows the construction schedule of Package A works showing the timing and duration of each work item.

### 8.6.2 Package B: Procurement of Cargo Handling Equipment

**(1) General**

The overall period of Procurement of Cargo Handling Equipment including Bidding Procedure is 29 months.

**(2) Bidding Procedure**

The bidding procedure will take 9 months (3 months for Prequalification and 6 months for Bidding/Evaluation and Contract conclusion).

**(3) Design and Manufacture in the Factory**

Design and manufacture in factory of the equipment will take 15 months from the commencement.

**(4) Sea Transportation**

Sea transportation from the factory will take for 1 month.

**(5) Installation and Performance Test**

Installation and performance test will take 2 months.

**(6) Training on Crane Operation and Maintenance**

Training on crane operation and maintenance will take 2 months.

### 8.6.3 Package C: Procurement of Floating Equipment

**(1) General**

The overall period of Procurement of Floating Equipment including Bidding Procedure is 25 months.

**(2) Bidding Procedure**

Bidding procedure will take 9 months (3 months for P requalification and 6 months for Bidding/Evaluation and Contract conclusion).

**(3) Design and Manufacture in Factory and Performance Test**

Design and manufacture in factory and performance test of the equipment will take 14 months from the commencement (including 2 months of training).

**(4) Sea Transportation**

Sea transportation from the factory will take 1 month.

**(5) Performance Trial and Final Inspection**

The performance trial and final inspection will take 1 month .

| No. | Description | Qty | Unit | Remarks |
|---|---|---|---|---|
| A | CIVIL WORKS | | | |
| a | Preparatory Works | | | |
| -1 | Preparation of Quarry | 1 | sum | |
| -2 | Mobilization | | | |
| | Mobilization of Equipment | 1 | sum | |
| | Mobilization of Materials | 1 | sum | |
| -3 | Preparation of Temporary Facilities | | | |
| | Preparation of Temp. Facilities | 1 | sum | |
| | Concrete Plant Erection | 1 | sum | |
| | Temporary Jetty | 1 | sum | |
| | Setting Out, etc. | 1 | sum | |
| | Removal of Existing Jetty | 1 | sum | |
| b | Dredging Works | | | |
| -1 | Outer Channel Dredging (-14.5m) | 4,160,000 | m3 | |
| -2 | Inner Channel Dredging (-14.0m) | 4,469,000 | m3 | |
| -3 | Turning Basin Dredging (-14.0m) | 2,860,000 | m3 | |
| | Dumping to Area A & B | 1,368,000 | m3 | |
| -4 | Navigation Aids | 1 | sum | |
| c | Berths | | | |
| -1 | Container Berth | | | |
| | Excavation of Foundation | 243,000 | m3 | |
| | Rubble Mound of Caisson | 54,600 | m3 | |
| | Armor Stone | 3,820 | m3 | |
| | Caisson Production & Placing | 17 | nos | |
| | Sand filling into Caisson | 84,500 | m3 | |
| | Cover concrete | 2,780 | m3 | |
| | Backfilling behind Caisson | 49,100 | m3 | |
| | Cope Concrete | 5,460 | m3 | |
| | Apron Concrete Pavement | 7,200 | m2 | |
| | Driving SPP for Crane Beam | 68 | nos | |
| | Crane Beam Concrete | 1,160 | m3 | |
| | Ancillary Works | 1 | sum | |
| -2 | Multi-purpose Berth | | | |
| | Excavation of Foundation | 279,000 | m3 | |
| | Rubble Mound of Caisson | 65,700 | m3 | |
| | Armor Stone | 4,350 | m3 | |
| | Caisson Production & Placing | 12 | nos | |
| | Sand filling into Caisson | 59,700 | m3 | |
| | Cover concrete | 1,960 | m3 | |
| | Backfilling behind Caisson | 37,200 | m3 | |
| | Cope Concrete | 6,430 | m3 | |
| | Apron Concrete Pavement | 1,980 | m2 | |
| | Driving SPP for Crane Beam | 44 | nos | |
| | Crane Beam Concrete | 750 | m3 | |
| | Ancillary Works | 1 | sum | |
| -3 | Passenger Berth | | | |
| | Steel Pipe Pile Driving | 37 | nos | |
| | Superstructure (Pier-1) | 141 | m3 | |
| | -Do- (Pier-2) | 305 | m3 | |
| | -Do- (Breasting Dolphin) | 371 | m3 | |
| | Ancillary Works | 1 | sum | |
| d | Revetment Works | | | |
| -1 | West Revetment | 400 | m | |
| | Excavation of Soft Material | 385,000 | m3 | |
| | Sand Replacement | 156,400 | m3 | |
| | Placing of Rubble Stone | 119,000 | m3 | |
| | Placing of Armor Stone | 12,400 | m3 | |
| | Concrete Block | 149 | nos | |
| | Cope Concrete | 2,290 | m3 | |
| -2 | East Revetment | 250 | m | |
| | Excavation of Soft Material | 198,000 | m3 | |
| | Sand Replacement | 83,600 | m3 | |
| | Placing of Rubble Stone | 48,500 | m3 | |
| | Placing of Armor Stone | 6,300 | m3 | |
| | Cope Concrete | 980 | m3 | |
| -3 | Temporary Revetment A-North | 515 | m | |
| | Placing of Rubble Stone & Sand | 48,370 | m3 | |
| -4 | Temporary Revetment A-West | 440 | m | |
| | Placing of Rubble Stone & Sand | 24,550 | m3 | |
| -5 | Temporary Revetment B | 530 | m | |
| | Placing of Rubble Stone & Sand | 46,240 | m3 | |
| -6 | West Bund | 200 | m | |
| | Placing of Rubble Stone & Sand | 9,500 | m3 | |
| -7 | East Bund | 50 | m | |
| | Placing of Rubble Stone & Sand | 3,220 | m3 | |
| e | Reclamation Works | | | |
| -1 | Land Reclamation (Land Cutting) | 1,518,000 | m3 | |
| | -Do- (Borrowed from Dredging) | 1,437,000 | m3 | |
| -2 | Removal of Soft Soil | 481,000 | m3 | |
| f | Pavement Works | | | |
| | 1 Concrete Pavement (RTG) | 8,600 | m2 | |
| | 2 Concrete Pavement | 71,200 | m2 | |
| | 3 As-con Pavement | 19,000 | m2 | |
| | 4 Macadam Pavement | 72,000 | m2 | |
| | 5 Gravel Pavement | 20,250 | m2 | |
| | 6 -do- Concrete Plate | 1,614 | nos | |
| | 7 Walkway | 2,600 | m2 | |
| g | Drainage Works | | | |
| -1 | Pipe Culvert | 3,510 | m | |
| -2 | U-Trench with Cover | 6,020 | m | |
| B | BUILDING WORKS | | | |
| -1 | Port Administration Building | 2,500 | m2 | |
| -2 | Container Freight Station | 2,200 | m2 | |
| -3 | Maintenance & Repaire Shop | 1,200 | m2 | |
| -4 | Container Gate | 245 | m2 | |
| -5 | Cargo Gate | 205 | m2 | |
| -6 | Power Supply Station | 450 | m2 | |
| -7 | Other Buildings | 3 | sum | |
| C | UTILITY WORKS | | | |
| | Electrical Works | 1 | sum | |
| | Water Supply, Sewerage & Others | 1 | sum | |

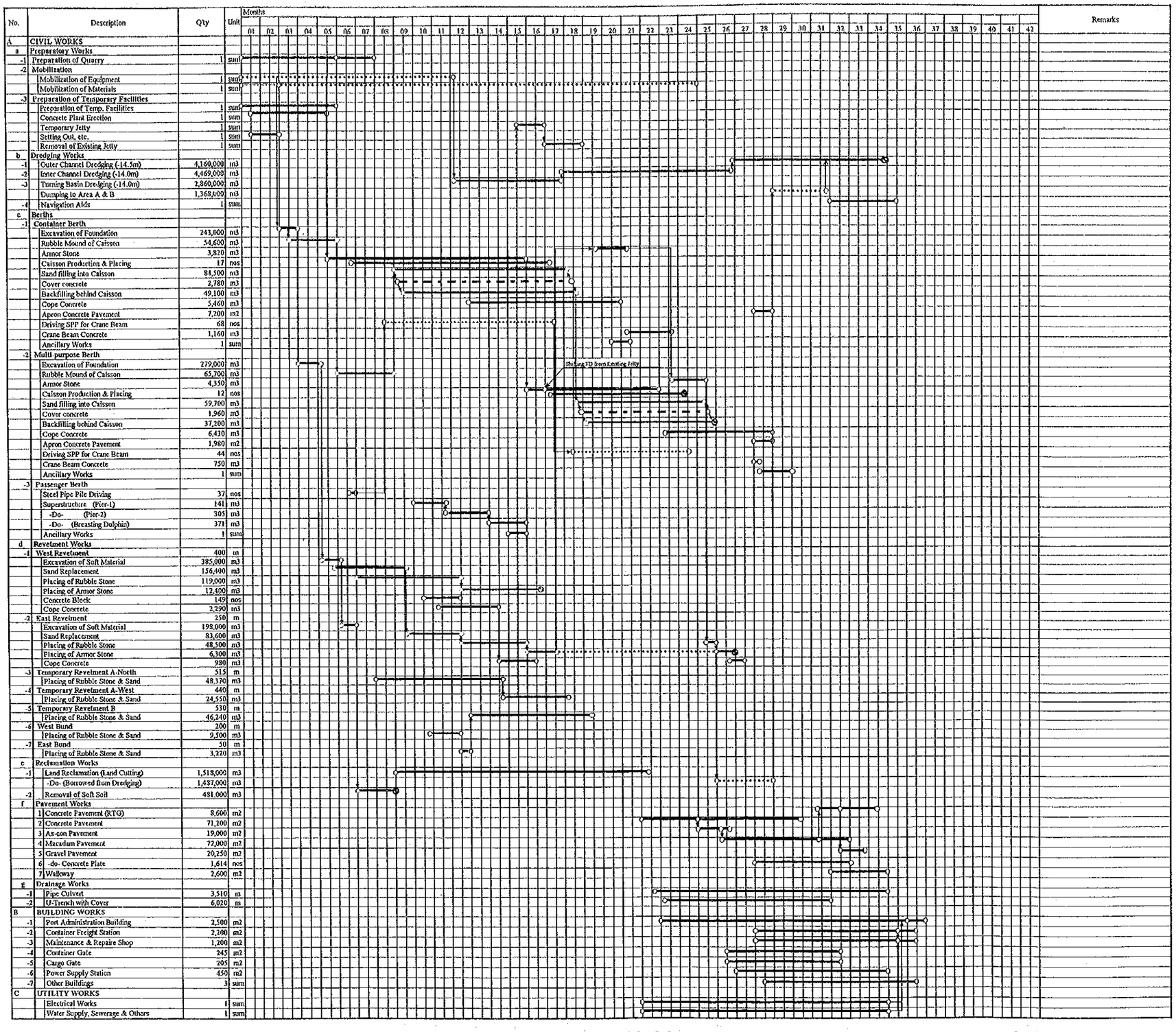



**Figure 8.6.1 Civil Works Construction Schedule**

## 8.7 Maintenance Dredging

A sedimentation simulation study is conducted as discussed in Section 5.5. Based on the results, the annual sedimentation volume is estimated at about 1.2 million cubic meters per year. Since this is significant volume, maintenance dredging shall be carried out constantly in order to keep the nominal water depth of access channel.

For maintaining the channel water depth, there would be two options:

1) Maintenance dredging will be performed on a contract basis through bidding; and
2) Maintenance dredging will be performed by CEPA will procure own dredging fleet.

The infill volume for three years is estimated with an assumption that it will be reduced to 80% of the former year as tabulated below:

**Table 8.7.1 Estimated Infill Volume in 3 years** (Unit : $m^3$)

| Area | First Year | Second Year | Third Year | Total |
|---|---|---|---|---|
| Turning Basin | 480,000 | 380,000 | 300,000 | 1,160,000 |
| Inner Channel | 450,000 | 360,000 | 290,000 | 1,100,000 |
| Outer Channel | 310,000 | 240,000 | 190,000 | 740,000 |
| Total | 1,240,000 | 980,000 | 780,000 | 3,000,000 |

The average infill thickness of the deposit in each area is estimated as shown in Table 8.7.2. Infill might occur in the particular location as seen in the figures presented in Section 5.5, and the average thickness of deposit in the turning basin after 3 years is estimated at 1.75 m. Judging from the table below the allowable frequency of maintenance dredging shall be at least once in every 3 years, but it is desirable to perform it in every 2 years considering the infill rate and efficiency of dredging work.

**Table 8.7.2 Estimated Average Thickness of Deposit**

| Area | Approx. Area ($m^3$) | In First Year | In Second Year | In Third Year |
|---|---|---|---|---|
| Turning Basin | 657,000 | 0.73 m | 1.30 m | 1.76 m |
| Inner Channel | 626,000 | 0.72 m | 1.29 m | 1.75 m |
| Outer Channel | 1,660,000 | 0.18 m | 0.33 m | 0.44 m |

In the case CEPA undertakes the maintenance dredging by itself, it is most suitable to procure a smaller trailer suction hopper dredger of 2,000 $m^3$ or 3,000 $m^3$ class, since the idling time will be longer for larger dredgers. On the other hand, the dredger to be used under the contract is most likely of 5,000 $m^3$ to 8,000 $m^3$ class as these are commonly owned by dredging companies.

The operation cost in the case of using CEPA's own dredger, including fuel, crew, repair, and depreciation cost is estimated as shown in Table 8.7.3.

**Table 8.7.3 Cost of Maintenance Dredging in Case of CEPA Own Dredger**

| Area | Operation Cost per Year | Unit Cost per $m^3$ | Operating Duration per Time |
|---|---|---|---|
| 1) In Case of Maintenance every 2 years | | | |
| TSH Dredger 2,000 $m^3$ | 4.3 mill. US$ | 4.3 US$ | 8.7 months |
| TSH Dredger 2,000 $m^3$ | 6.0 mill. US$ | 5.4 US$ | 6.3 months |
| 2) In Case of Maintenance every 3 years | | | |
| TSH Dredger 2,000 $m^3$ | 4.7 mill. US$ | 4.7 US$ | 11 months |
| TSH Dredger 2,000 $m^3$ | 6.0 mill. US$ | 6.0 US$ | 9.4 months |

In the case of dredging on a contract basis, the costs including mobilization and operation are estimated as shown in Table 8.7.4.

**Table 8.7.4 Cost of Maintenance Dredging on a Contract Basis**

| Area | Contract Cost per Time | Unit Cost per $m^3$ | Operating Duration per Time |
|---|---|---|---|
| 1) In Case of Maintenance every 2 years | | | |
| TSH Dredger 5,000 $m^3$ | 5.4 mill. US$ | 2.4 US$ | 4.0 months |
| TSH Dredger 8,000 $m^3$ | 5.3 mill. US$ | 2.4 US$ | 2.9 months |
| 2) In Case of Maintenance every 3 years | | | |
| TSH Dredger 5,000 $m^3$ | 7.5 mill. US$ | 2.5 US$ | 6.0 months |
| TSH Dredger 8,000 $m^3$ | 7.1 mill. US$ | 2.4 US$ | 4.3 months |

The detailed costs are shown in Figure 8.7.1 and 8.7.2.

In the case of maintenance dredging by CEPA' own dredger, the depreciation cost is the biggest factor in the dredging cost because of the two-year idling period.

Judging from the figures in terms of cost, it is recommended that maintenance dredging be made on a contract basis utilizing larger dredger which is most appropriate. The shorter duration between the maintenance dredging times is favorable not only in the cost aspect but also in better port service. However, this will ultimately depend on the infill volume.

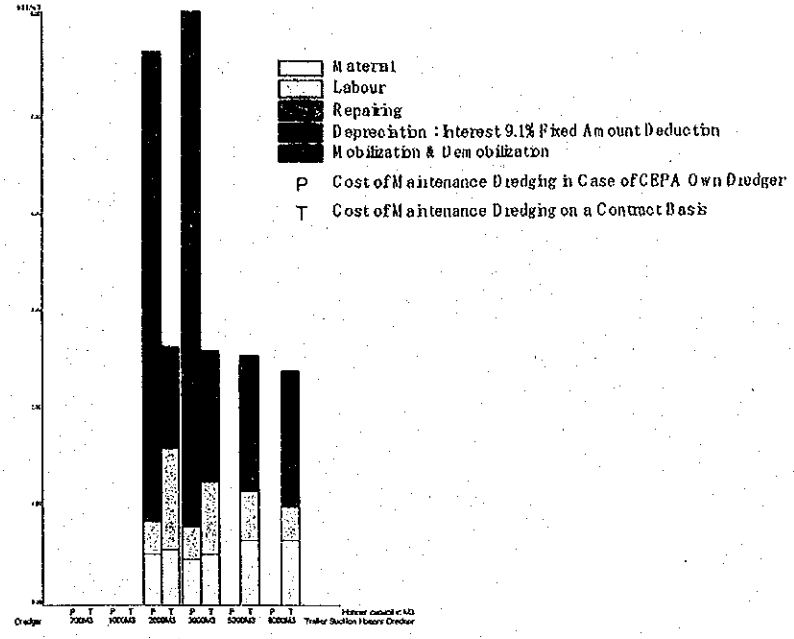



**Figure 8.7.1 Comparison of Operation Cost for Maintenance Dredging 1 time per 3 years Dredging Productivity 3,000,000m$^3$ (25km Offshore Dumping)**

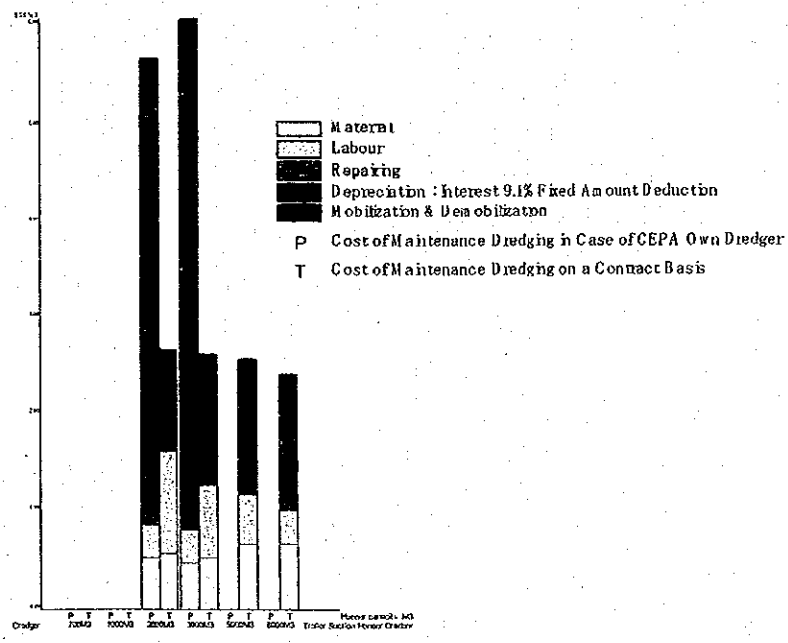



**Figure 8.7.2 Comparison of Operation Cost for Maintenance Dredging 1 time per 2 years Dredging Productivity 2,000,000m$^3$ (25km Offshore Dumping)**

## 8.8 Implementation Plan

### 8.8.1 Financing of Project Costs

The financing of the project costs is expected to be made by JBIC and BCIE with the following financing percentage at maximum.

| | | JBIC | BCIE |
|---|---|---|---|
| - | Consultancy Services | 100% | - |
| - | Civil and Building Works (Package A) | 75% | 25% |
| - | Procurement of Cargo Handling Equipment (Package B) | 100% | - |
| - | Procurement of Floating Equipment (Package C) | 100% | - |

The procurement of services and goods will be proceeded basically in accordance with the JBIC Guidelines on Procurement.

### 8.8.2 Procurement Method

CEPA will procure a consulting firm for the construction supervision through the shortlisting method. The services to be provided include assistance in bidding process, construction supervision of Package A works, supervision of procurement of equipment for Packages B and C, and assistance during the defects liability period. The total contract period is expected to be about 70 months including the service during the defects liability period.

A contractor will be selected based on the JBIC guidelines through international competitive bidding (ICB). The bidding process for Package A works will start with the prequalification of prospective bidders followed by bidding by the prequalified bidders. The construction period of this package is expected to be 36 months plus a 12-month defects liability period.

Same as Package A, manufacturers will be selected through international competitive bidding (ICB). Bidding for Packages B and C will be proceeded separately as these contracts will be concluded individually. The bidding process will be the same as for Package A, i.e. through prequalification of prospective bidders and bidding by the prequalified bidders. The contract period of Package B is 20 months and that of Package C is 16 months. The defects liability period of both packages is 24 months.

### 8.8.3 Implementation Schedule

Figure 8.8.1 shows the overall project implementation schedule. The total project period excluding the defects liability period is estimated at about 50 months.

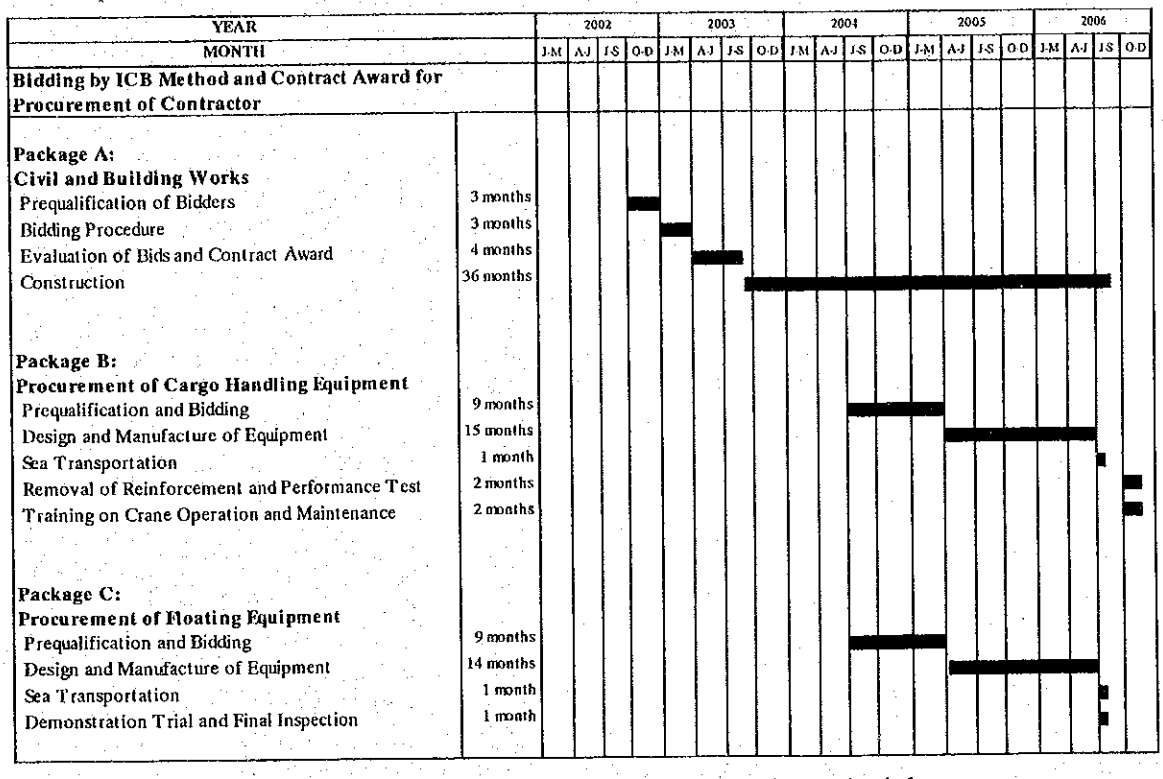



Figure 8.8.1 Overall Project Implementation Schedule