# CHAPTER 3 FACILITY AND EQUIPMENT PLAN

## 3-1 Conventional Berths

① QEQ

The No.5 berth in the Queen Elizabeth Quay is at least temporarily used as a container berth until the Master Plan is completed, but its container crane is retained there in expectation of temporary needs for handling heavy cargo or containers even after completion of the Master Plan. Five births in the Queen Elizabeth Quay are planned as general cargo berths with cargo handling capacity of 750 thousand freight tons altogether.

② BQ

Five berths, including the north end berth of the Bandaranaike Quay, are planned to be used as general cargo berths with cargo handling capacity of 650 thousand freight tons altogether.

③ CB

Two berths of the coaster Berths are planned to be used as general cargo berths with cargo handling capacity of 100 thousand freight tons altogether.

④ PVQ

Two berths in the Prince Vijaya Quay are planned as general/bulk cargo berths with cargo handling capacity of 300 thousand freight tons altogher. Considering the decreasing tendency in foods cargo, the widened North Pier can handle the substantial amount of foods. Thus, the Prince Vijaya Quay can be transferred gradually to a quay for general cargo handling by making use of the existing transit sheds on it.

⑤ NP

Foods currently handled at the Prince Vijaya Quay are discharged directly to the lorries. This foods handling method is best suited for the North Pier after the completion of widening to 50 m to allow for lorries' U-turn. Two berths with the water depth of −9m can be prepared in the North Pier. 400 thousand freight tons of foods can be asssigned to these two berths.

⑥ NGP and SP

The North Guide Pier and the South Pier are planned to be transferred to ship repair berths.

⑦ Midstream Berths

Abolition of cargo handling at the midstream berths is strongly suggested to ensure the safety of navigation inside the Port. Considering, however, that 400 to 500 vessels annually call the Port exclusively for bunker, some of the midstream berths must be retained excluding the sea area to be reserved as the waterway and the turning/mooring basin.

Above results are shown in Table-IV.3.1.

## 3-2 Container Berths

As already stated in Part III "Cargo Traffic Forecast", it is considered that the demand for containers in the Port of Colombo will increase to 1,144,000 tons (approx. 80,000 TEU) in 1983 and to 2,806,000 tons (approx. 197,000 TEU) in 1988, including transhipped containers, if sufficient container handling facilities and equipment are provided.

It can be said that the containerization of sea transport in its second stage, where it is in-progress in the developing countries while it is nearly completed in the developed countries. In many ports of Asian, Middle East and African countries, container berths capable to accept full container ships have been constructed or are being planned, and the movement of containers to/from these ports is quickly increasing.

Also in the Port of Colombo, the amount of containers handled has rapidly increased in recent years with 5,281 containers handled in 1978 (Statistics by the Sri Lanka Ports Authority) though available port facilities and equipment for containers are limited, and the demand for containers is increasing. The Sri Lanka Ports Authority indicates that there is a strong demand for containerization and some shipping lines offer to tranship containers at the Port of Colombo.

In order to cope with the container demand in the Port of Colombo and to catch up with the progress of world containerization, the construction and arrangement of container berths and container handling equipment capable to accept full container ships are urgently required.

In the circumstances, the construction and arrangement of three container berths are planned for 1988, as stated in the foregoing Chapter, by constructing the Korteboam Container Quay near the old Coaling Jetties. Since the Korteboam Quay construction work will take a long time and therefore can not respond to the present urgent demands for containerization, a container berth is also provided at the Queen Elizabeth Quay No. 5 as the part of the Urgent Plan, which can be readied by the end of 1981. The conversion of the Queen Elizabeth Quay No. 5 from a container berth to a conventional berth, subject to the progress of containerization and the demand for containers when the Korteboam Quay is constructed, shall be studied.

### 3-2-1 Container Terminal

A container terminal is the junction point between the marine and land transport of containers. It performs the stevedoring and storing of containers and the delivery/receiving of containers and container cargo, and its efficiency will govern the overall efficiency of the container transportation. An arrangement of facilities and equipment for the effective and quick handling of large numbers of containers in the terminal must be carefully studied and determined. After considering the various conditions existing and anticipated in the Port of Colombo, the straddle carrier system is adopted as the optimum terminal container handling method (refer to the following Paragraph "Selection of the Container Handling Method") and layout of the container terminal is illustrated in Fig.-IV.3.1 and Fig.-IV.3.4.

(1) Queen Elizabeth Quay No. 5 Container Terminal (Fig.-IV.3.1)

As an emergency measure to cope with the rapidly increasing container demand, the Queen

Elizabeth Quary No. 5 is employed for a container terminal, but it is somewhat narrow with a berth length of 300 meters and width of 118 meters. In order to obtain a maximum container slot number (the number of containers can be placed) by securing a large container yeard in this narrow site and also to utilize effectively the existing facilities, the north part of the Queen Elizabeth Quay No. 4 transit shed is remodeled for a container terminal office (2nd story, 735 m²) and for a maintenance shop for equipment and containers (1st story, 735 m²). In addition, the Queen Elizabeth Quay No. 4 transit shed is utilized as a container freight station (CFS) as well as transit shed for conventional cargo. An area (50-m wide) behind the Queen Elizabeth Quay No. 1 to 4 transit sheds, presently being used as an open storage yard for cago or as a port road, is reserved as a road and freight handling facility for a width of 30 meters from the transit sheds but the remaining width of 20 meters is allocated for an open storage yeard and/or empty/loaded containers storage yard for the sudden increase of containers.

Due to the narrow width of this terminal and to its structural design for the container crane foundation (refer to V-3-2 Crane Foundation of Queen Elizabeth Quay No. 5), a narrow rail span of 16 m is employed for the container crane, which provides a wide container yard but, instead, sufficient crane backreach shall be provided for the convenience in operation. Meantime, since the movable range of the crane (length of rail) is limited to 200 m of the total berth length of 300 m (refer to V-3-3 Crane Foundation of Queen Elizabeth Quay No. 4), only one crane is provided.

As the result, 840 slots can be utilized, by which it is assumed that about 50,000 TEU (maximum) of containers can be handled yearly in this container terminal.

Remarks: The number of containers handled at the container terminal will be influenced by the various factors such as the intervals of container ships' calls, the amount of containers loaded/unloaded by each ship, the duration of containers' stay in the terminal and so forth, and it cannot be accurately forecasted. However, it can be assumed by the following formula:

$$C = \frac{L \times H \times W \times K}{D}$$

where, C: Number of containers handled, TEU (maximum)/year

L: Number of containers stored (slots), TEU

H: Number of stacking layers of containers (stacking height), 3 high stacking for straddle carrier

W: Operational margin, 0.7 to 0.8 for straddle carrier

K: Total days; 365 days (per year)

D: Days of container's stay in terminal

Therefore, if L = 840 slots, H = 3 layers, W = 0.75, and D = 14 days (maximum days of stay of conventional cargo at present) in case of the Queen Elizabeth Quay No. 5,

$$C = \frac{840 \times 3 \times 0.75 \times 365}{14} = 49{,}275 \text{ TEU/year}$$

Thus, about 50,000 TEU (max.) can be handled yearly, but the actual number of containers handled might be around 40,000 TEU/year, in-out being subject to the frequency of container ships' arrivals, the number of containers loaded/unloaded, etc.

Since about 50,000 TEU(max.)/year of containers can be handled at the Queen Elizabeth Quay No. 5, the current increasing container demand can be met until the Korteboam container terminal is completed. However, as already stated above, the Queen Elizabeth Quay No. 5 has a narrow width of 118 m, its container crane can be moved only for a discance of 200 m even though the total length of berth is 300 m, and water depth of this berth is partly 11.0 m, all of which are not sufficiently large enough for the existing "container ships of the third generation" (ship's length: 250 to 290 m, full draft: 11.0 to 12.0 m). In addition, this berth has no space for future expansion, and its access road leading to the outside of the port through which a large quantity of containers must be transported is too long, which may cause traffic congestion. Therefore, while watching the progress of containerization of the Port, moving the container facilities and equipment of the Queen Elizabeth Quay No. 5 to the Korteboam terminal should be studied for integrating all container handling in the Korteboam terminal in future when this terminal is completed. Because of this, it is planned to minimize the investment for fixed facilities and therefore plugs for reefer containers and container weight scales are not provided. When the container facilities and equipment are shifted to the Korteboam terminal, the Queen Elizabeth Quay No. 5 can be utilized as a conventional berth with an open storage area for long and heavy cargo such as steel and plants.

(2) Korteboam Container Terminal (Fig.-IV.3.4)

The Basic layout of the Korteboam container terminal is shown in Fig.-IV.3.4. However, further review on this layout will be required based upon the results and records of actual operation of the Queen Elizabeth Quay No. 5 and the Korteboam No. 1 container terminal which are planned in the Urgent Plan.

The number of containers stored in the three berths is assumed to be about 4,900 slots in total, which makes it possible to handle about 290,000 TEU (max.) or practically 230,000 TEU (80%) annually. Thus, even though the container facilities and equipment of the Queen Elizabeth Quay No. 5 are transferred to the Korteboam Quay and is used as a conventional berth, the three berths of the Korteboam will be capable of handling all containers expected for 1988. In addition, three berths arranged together assure the flexibility of container cranes operation, to increase efficiency of the berthing operation for large and small container ships, and to reduce waiting time for berthing of container ships which operational cost is very high compared with conventional ships, all of which are factors to attract more container ships to the Port.

When this container terminal is fully operated, about 230,000 TEU of containers annually or about 3,200,000 tons of cargo (14 tons per TEU including empties) will be transported through the Korteboam Quay, which will be more than one-half of all cargo handled in the Port of Colombo (according to the forecast for 1988, 2,195,000 tons for conventional general cargo, and 2,806,000 tons for container cargo). Accordingly, port administration facilities including customs and quarantine are required around the terminal; the site for these facilities is secured near the entrance of the terminal.

(3) Container Equipment

On basis that the straddle carrier system is employed, the required container equipment and their approximate costs are shown in Table-IV.3.2. It is needless to say that the optimum type of equipment and/or the required number of equipment should be studied when the Master Plan is carried out.

### 3-2-2 Selection of the Container Handling Method

Efficiency of operation and quality of the terminal service are governed by the selection of the container handling method and kinds and numbers of equipment assembled at the container terminal.

Container handling methods in general use are classified by handling equipment used such as the chassis system, straddle carrier system and transfer crane system. In the chassis system, each container is placed on a chassis and stored in the container yard. In the two other systems, containers are stacked in the container yard in several layers, 3 layers maximum using a straddle carrier and normally 5 layers with a transfer crane, which enables the efficient use of land area.

There are some other stacking equipment for containers such as forklift and side loader (side forklift), but they are mostly used as auxiliary equipment for terminal container handling.

The chassis system requires a large terminal land area, a large number of chassises and a lot of initial investment for them since containers are stored in single layer. Thus, this method is unsuitable not only to the narrow Queen Elizabeth Quay No. 5 terminal but also to the Konteboam container terminal which is to be constructed by reclamation within the rather narrow port area. The merits and demerits of the straddle carrier, transfer crane and side loader system for the Queen Elizabeth Quay No. 5, the first container terminal in the Port of Colombo, were studied and the results are shown in Tables-IV.3.3 and IV.-3.4 and Figs-IV.3.1., IV.3.2 and IV.3.3.

Since the container terminal in the Port of Colombo is offered for the use by different users, a system capable to meet various demands of different users, that is, one which is flexible will be required. In addition, the Port of Colombo is strategically located at an intermediate point on the main ocean routes connecting the Far East to Europe, Middle East and Africa or connecting Europe to Australia and New Zealand, so that a high service level must be maintained to entice container ships taking these routes and transhipment cargo.

Considering these various elements required for the Port of Colombo and the results of comparison stated above, it is determined to adopt the straddle carrier system that is widely being used at container terminals for multi-users throughout the world.

NOTES: Though the use of a side loader is suggested by the Sri Lanka Ports Authority, this is not recommended for the following reasons:

① Cost of the equipment is high and the number of containers which can be handled is rather small (number of containers that can be stored in the terminal is small, and terminal area cannot be used effectively).

② The cycle time of a standard operation of unloading a container from a chassis, transporting and stacking it is 1.5 to 2.0 minutes for the straddle carrier and 2.0 to 3.0 minutes for the side loader, which means that the side loader is slightly inferior in operational efficiency. A feature of the side loader is its function of transporting containers on truck as well as lifting them, but the former is not an important function for a container handling machine in a terminal. A side loader system might be most effective where containers must be transfered between two distant points such as between a container terminal within a port and an inland container depot, if both of which have no container handling equipment. (However, its total weight is from 70 to 80 tons when fully loaded, so that the strength of road surface becomes critical in the countries where the road conditions are generally poor.)

③ Because of the above reasons, a side loader has not been used as main container handling equipment in terminals, but is used only as auxiliary equipment at container depot or freight station of container terminals.

## 3-3 Tanker Berth

### 3-3-1 General

At present, crude oil and its products are handled mainly on the North Pier. As there are facilities such as the dock yard and the work shop very close to North Pier, there has been fear for the danger of an accident. In the meantime, to meet an increasing demand for oil products, the refinery is being expanded, and this necessitates the increased capacity of crude oil handling facilities. Bearing these two points in mind, the installation of a buoy berth outside the Port is being considered. This paragraph describes the technical consideration of future crude oil handling facilities.

### 3-3-2 Import and Export Plan of Crude Oil, etc.

The quantities of crude oil and refined oil planned to be imported and exported are as shown in Table-IV.3.5, according to the plan of Ceylon Petroleum Corporation.

If tankers are assumed to carry 30,000 tons of crude oil and 20,000 tons of refined oil, the number of tankers required to transport the above cargo will be 78 tankers for crude oil plus 43 tankers for others totaling 121 tankers in 1990, about double the present number of tankers. If crude oil handling is assumed to be done only on the North Pier, with 2.5 berthing days, the berth occupancy will be 78 x 2.5/365 = 0.64, which is rather high. However, if the North Guide Pier is also used, the present facilities will allow the handling of the above quantities.

The capacity of the refinery is scheduled to be increased from the present 38,000 barrels/day to 51,000 barrels/day by October, 1979 in line with the above plan, to process 2,350,000 tons of crude oil.

### 3-3-3 Future Plans of Oil Handling Facilities

#### (1) General

The present oil handling facilities in the Port will, from the consideration above, be congested if they handle the planned 2,350,000 tons of crude oil and 900,000 tons of refined oil in 1990. Furthermore, apart from the cargo handling capacity, the present facilities adjacent to the dock yard, work shop, etc. should best be moved to a safer location. This will also provide a space for the expansion of other Port functions, and therefore must be considered comprehensively in relation with other facilities. In addition, if large tankers can be accepted, an economic effect accruing from the reduction of transport cost can be expected.

(2) Short History

With regard to the transfer of the oil handling facilities, NEDECO*, ADB**, IMCO***, etc. have already carried out studies. They all pointed out the danger of oil handling at the present location, and proposed relocating the facility. Fig.-IV.3.5 shows the layout of the oil berth proposed by NEDECO. According to it, a 550 m long breakwater is to be constructed from the west end of Prince Vijaya Quay toward the north, and a mooring basin with 10.8 m water depth secured behind it, to accept a 40,000 DWT class tanker. While this plan provides satisfactory functions from the view of safety, it has demerits such as i) the construction cost is high due to construction of a new breakwater, ii) since the berthing route runs from north to south, ship operation in the SW monsoon season is difficult (stopping distance is not considered), iii) shltering in the NE monsoon season is not good, iv) tanker size is small, without high economic benefit expected, etc. The problems of ii) to iv) can be solved by elongating the breakwater and creating a mooring basin of sufficient water depth, but in this case, the construction cost rises, and increasing the depth of the mooring basin may require the removal of bed rock. However, the existing oil handling facilities can be relocated collectively, and the pipeline can be easily extended.

Fig.-IV.3.6 shows the berth proposed by ADB. This is to construct a buoy berth for 60,000 DWT class tankers behind the NW breakwater. On selecting this plan, an offshore buoy berth and a new oil harbour in front of the NW breakwater were examined as alternatives, but they were not adopted in view of the working efficiency, maintenance work, high construction cost, etc. This plan began to be constructed under ADB loan, but was suspended due to technical problems involving the submarine pipeline, dredging etc.

The IMCO mission studied the general future plans of oil handling facilities, and recommended an offshore buoy berth in combination with the use of the Port of Trincomalee. With regard to the idea of constructing an oil berth in the Port, they pointed out the difficulty of ship operation, rock removal along the channel and mooring basin, smaller acceptable tanker size, etc.

Under these circumstances, this study takes up the offshore buoy berth and the dolphin berth behind the NW breakwater which are highly appropriate both technically and economically, and carefully compares them by considering the natural conditions, etc. about which data were newly analyzed this time.

(3) Offshore buoy Berth

This plan is to construct a buoy berth for large tankers for a drastic increase of cargo handling capacity. The structure, working efficiency, construction cost, etc. of the buoy berth

* Report on The Operations and Development of the Port of Colombo and Certain Outports of Ceylon; NEDECO, 1961

** Appraisal of Colombo Port Tanker Berth Project in Ceylon; Asian Development Bank, 1970

*** Mission Report; United Nations, Inter-Governmental Maritime Consultative Organization, 1977 are examined below.

With regard to the tanker size, 100,000 DWT class tankers are selected here, since the savings in transport cost by larger tankers of more than 100,000 DWT are not so great for this Port, due to the relatively short transport distance.

1) Location of Construction

The location of the buoy berth must be seperated* by at least 5 x L (L = ship length) for the critical minimum depth (h) line(h > 1.25 x full draft) or the nearest breakwater for safe berthing, unberthing and operation of the tanker and emergency drifting.

The standard size of tankers are shown in Table-IV.3.6.**

The possible buoy locations corresponding to respective tanker sizes off the Port can be obtained as shown in Fig. IV.3.7, by using the above factors. The buoys were located 5L apart from the offshore shoal (Kelani Gala), and the pipeline was designed to be minimum in length. The buoy may be installed to the north or south of the Colombo Port. Lengths of the pipeline for each buoy location are shown in Table-IV.3.7.

If the buoy is installed to the north of the Port, the submarine pipeline will cross the channel, and the length will be about double to what it would be in the south. The south buoy berth involves the difficult work of new installation of a pipeline on land through an urban area (along the lake and the railway), but is more advantageous for the shorter total length of the pipeline.

2) Buoy

Buoys presently used for offshore berths can be classified into the different types shown in Fig.-IV.3.8. Of them, the multi-point type, though the construction cost is low, is not suitable for installing off the Port where the predominant wind direction changes seasonally, and therefore the difficult berthing, leaving and operation of the tanker, are expected. Of the single-point types, types b, c and d are fixed to the sea bottom by piles, and are not proper where the sea bed is rocky. Therefore, for this port, type (a) which has been most popularly used is judged to be most appropriate.

3) Pipeline

With the increase of tanker size and pipeline length, the capacity of the existing pipeline becomes insufficient, and must be rised. The capacity of pipeline by tanker size is examined below.

i) Calculation of Pipeline Capacity

The pipeline capacity should be calculated such that the total of the static pressure head due to height difference, the head loss due to pipe friction, etc. does not exceed the normal pressure of oil pipe.

The head loss due to friction of a straight pipe is given by the following equation of Darcy Weisbach.

* Report on Buoy Berth at Mutsu-Ogawara Harbour

** Guides on Design of Port Facilities: Port and Harbours Bureau, Ministry of Transport, JAPAN 1978

$$h_f = f\frac{\ell}{d} \cdot \frac{v^2}{2g}$$

where $h_f$: Head loss due to friction (m)

$f$: Friction coefficient

$\ell$: Length of the pipe (m)

$d$: Inner diameter of the pipe (m)

$v$: Mean velocity of oil (m/sec)

$g$: Acceleration of gravity (m/sec²)

ii) Capacity of Existing Pipeline

With regard to the existing pipeline, the possibility for increasing the capacity will be examined below.

The dimensions of the existing pipeline are as follows.

| | |
|---|---|
| Inner diameter | 24" |
| Length | 42, 653 feet |
| Normal pressure | 150 psi |
| Discharging capacity | 1,300 tons/hour |

By the above equation, when $k/d = 5 \times 10^{-4}$ (k roughness of pipe), oil temperature is 20°C and specific gravity of crude oil is $\sigma = 0.855$, then the total pressure P inside a pipe discharging 1,300 t/hr is

$P = 1.1 \times P_f + P_h$ ($P_f$: Friction loss $P_h$: Static loss)

$= 5.6 + 3.4 = 9.0$ kg/cm²

The normal pressure inside a pipe is usually taken at 10 to 15 kg/cm² and the above value is almost critical. Therefore, an additional pipeline is required for dealing with an increased tonnage of crude oil.

iii) Additional Capacity Required

Assuming the cargo handling time to be 30 hours or less (see Table-IV.3.8) and the normal pipe pressure 10 kg/cm² or less, then the diameter of pipeline required additionally, to meet the future increase of tanker size is as shown in Table-IV.3.9, including the pipeline for the dolphin berth described later.

The buoy berth is to be constructed for large tankers in the open sea under severe sea conditions, and is used only for crude oil handling. Therefore, for safety reasons, the bunkering and refined oil handling now done at the North Pier must be transferred. In this study, they are moved to behind the Nort-West breakwater.

iv) Buried Depth of Pipeline

The buried depth of the pipeline is determined by considering the force acting on it when an anchor dropped. Table-IV.3.10 shows the standard value presently used in Japan for various ship sizes.

Taking a ship size of 100,000 DWT for the buoy berth and 65,000 DWT ship aimed by the Colombo Dock Yard Ltd. for the dolphin berth (and with an allowance of 0.6 m for future dredging), the buried depths required can be obtained as follows.

Buoy berth 2.14m
Dolphin berth 1.90 + 0.6 = 2.5m

4) Communication and Disaster Prevention Facilities and others

It is indispensable to provide special fireboats equipped with chemical extinguishers against a possible accident. To prevent spreading of spilled oil, an oil boom of the length of $2\pi L$ (L: ship length) is required. Furthermore, spilled oil must be removed by an oil disposing agent or recovery boats, to prevent sea pollution.

Weather and sea conditions greatly affect berthing and unberthing and cargo handling. Marine weather information must be given to ships through proper communication system.

5) Maintenance

The following maintenances are required, for the buoy berth.

(1) Rubber hoses: To be changed once a year and checked regularly.
(2) Oil pipes: To be checked once a year at a pressure of 1.5 times the normal pressure.
(3) Buoy: To be checked once a year and be in dock once every four or five years.
(4) Anchor chains: To be checked half a year after installation and then once a year
(5) Mooring ropes: To be changed every four or six months.

For the above operations, an experienced diver team must be arranged.

6) Working Efficiency

As described in the Chapter on Natural Conditions, in the SW monsoon season from June to September, westerly waves are predominant off the Port. The working efficiency of the buoy berth is greatly affected by sea conditions. The critical wave height and wind velocity for operations at a berth are as shown in Table-IV.3.11 according to the standard* used in Japan.

From Table-I.3.7 of the Chapter on Natural Conditions, the frequencies of the occurrence of 1.2 m or higher waves (critical wave height) by month are shown in Table-IV.3.12.

Whole cargo handling operation can be completed in three successive calm days of waves 1.2 m or lower, and workable days are as shown in Table-IV.3.13. According to the table, in the SW monsoon season, approximately only half of a month is workable and this will possibly hamper a smooth supply of crude oil. Therefore, to cope with this, spare storage tanks becomes necessary. The workable days are 234/year, and given 3 berthing days a tanker, the berth occupancy is $3 \times 23.5/234 = 0.30$, giving a considerable allowance against the critical value of about 60%.

(4) Dolphin Berth

This plan is to transfer the oil handling facilities including the bunkering facilities, collectively to the area behind the North-West breakwater. Compared with the buoy berth, the

*; Sea berths and Submarine pipelines; Tsuruta, Ueda and Nakayama, 1975

acceptable tanker size is smaller, but it has advantages of higher working efficiency and lower construction cost.

IMCO mission pointed out various technical difficulties on the plan of constructing an oil berth inside the Port, including danger in manouvering large tankers, bed rock removal which may be encountered in dredging, pollution, the possible danger of a fire accident.

In conclusion, they propose constructing an offshore buoy berth for crude oil handling, and to use the existing facilities for handling crude oil and refined oil at the same location as present.

As for the points mentioned above, in this study, safety of ship operation is secured by widening and deepening the channel and the mooring basin (see the Paragraph of Approach Channel), and the existing facilities are concentrated, including those of refined oil and bunkering, considering the danger in the present location. With regard to rock removal, there are no detailed data available at present, and final judgement should be made based on the results of future survey.

The pollution and disaster prevention measures are recommended based on the standard used in Japan.

a) Location of Berth

The dolphin berth is a facility for handling large quantities of crude oil and its products, therefore the location should be determined through consideration of the traffic volume of ships, the ship sizes and the condition of the anchorage in the adjacent water areas. The water area behind the North-West breakwater is separated apart from both the channel and the turning basin and judged to be the optimum location for the berth.

Furthermore, it is necessary that ships in the vicinity can take shelter when an accident arises, and a moored tanker must be separated from the nearest channel by about 1L, least it should be affected by the waves and drag force due to navigation nearby. The safety distances from other port facilities are determined by considering the danger circles of ignition and poisoning, for the area behind the NW breakwater, the safety distances from other facilities are sufficiently secured. The area behind the North-West breakwater is favorably calm, and the waves diffracting from the head of breakwater propagate along its rear side in the bow-stern direction of the tanker, without any serious rollling and pitching of the tanker.

b) Structural Type

Since the area behind the North-West breakwater is shallow and may be rocky, a pile type dolphin berth is not suitable, and a fixed type dolphin is taken up.

The structural types now used for a fixed-type berth are as follows:

- o Dolphin type
  - Pile type
  - Jacket type
  - Cell type (Steel sheet pile)
  - Caisson type
- o Piled pier type

At present, behind the NW breakwater, a concrete cellular type dolphin constructed by the ADB project is left incomplete. The detailed condition of this structure are unknown, and must be investigated before the execution of the future plan. A section of the North-West breakwater is shown in Fig.-IV.3.9. In this study, a caisson type dolphin berth is to be constructed.

Standard arrangement of dolphins is shown in Fig.-IV.3.10. There must be breasting dolphins on both side of a working platform.

The working platform must be installed backwards from the front face-line of the breasting dolphins, to avoid collision with the tanker. For mooring, bollards should be laid out on the crown of the North-West breakwater.

The size of caisson for the breasting dolphins is about 10 × 10 × 17 m, when the reaction force on a rubber fender is taken at 400 tons. If the interval of the breasting dolphins is taken at 80 m, the structure can be used also for smaller tankers of 5,000 DWT class. Tankers of less than 5,000 DWT can be directly berthed behind the breakwater (water depth at the rubble mount –7.6 m). In the Port, more than 1,000 ships per year are supplied with oil, by anchoring at the midstream berths. If these ships are supplied with oil from the above dolphin berth and the bunkering facilities, most of the midstream buoys can be removed.

Based on the above, the arrangement of dolphins is shown in Fig.-IV.3.11.

c) Pipeline

Many pipelines are laid on the South Pier and South Jetty for refined oil handling and bunkering, in addition to that for crude oil. These facilities should be transferred together with the crude oil handling facilities, form the above-mentioned safety considerations and effective use of land within the limited port area.

The pipelines installed on the respective piers are as follows.

| | |
|---|---|
| South Pier | |
| White Oil | 10" |
| Water | 10" |
| Fuel Oil | 10" |
| " | 14" |
| Gas Oil | 10" |
| Fuel Oil | 12 3/4" |
| Marine Diesel Water | 8" |
| Gas Oil | 8" |
| North Pier | |
| Crude Oil | 24" |
| Fuel Oil | 14" |
| Gas Oil | 10" |
| Naphtha | 12 3/4" |
| Fuel Oil | 10" |

| | |
|---|---|
| Water | 10" |
| White Oil | 10" |

When facilities related to the handling of crude and other oils are collectively relocated, the following pipes are necessary to be laid to the planned berth.

| | |
|---|---|
| Crude Oil | ϕ24" |
| Naphtha | 14" |
| Petrol | 10" |
| Fuel Oil | 10" |
| Kerosene | 10" |
| Five Main | 8" |
| Water | 6" |

For oil handling, metal arms (loading arms) is recommended instead of the rubber hoses presently used, for higher working efficiency and safety.

d) Tugboats

Berthing and unberthing must be assisted by tugboats. The required hose-power is usually 6 to 7% of DWT of ship considered. Tables-IV.3.14 and -IV.3.15 show the required thrust and number of tugboats.

When current congestion in the Port is considered, 2 tugboats of about 3,000 HP are required for safety. There is one 2,500 HP tugboat available at present, and so one more 3,000 HP tugboat must be purchased to meet the above requirement. For finding the berthing velocity of tanker, the breasting dolphins should be equiped with a berthing velocity indicator, and the information should be given to ship operators, to secure the stability of the dolphins, and to avoid the damage on a ship's hull.

Mooring facilities should be provided with a power winder for pulling the mooring ropes, and the use of quick release type hooks is recommended for quicker emergency unberthing.

e) Dredging, Raising of Breakwater,

The channels and the mooring basin should be dredged respectively to 51.5 feet and 46 feet, to accept 60,000 DWT class tankers, as described in the Paragraph on Approach Channel. Furthermore, to secure the safety of cargo handling the breakwater should be raised, together with wave absorber put in front, to prevent wave overtopping. The armour blocks in front of the breakwater reduces the waves reflected from it and is to improve the clamness along the channel. A section of a planned breakwater is shown in Fig.-IV.3.12. Disaster prevention facilities, etc. are required to be almost the same as those of the buoy berth. Maintenance work is easy compared with the buoy berth, and the number of unworkable days per year is 10 or less to give a sufficient efficiency of crude oil handling.

### 3-3-4 Conclusion

When the crude oil handling facilities are transferred, tankers of larger size will bring economic benefit. For safety, both of the above plans are judged to have almost equal functions; here they are compared in view of the economic benefit.

(1) Benefit

The relationship between tanker size and transportation cost is shown in Fig.IV.3.13. The sailing distance between Colombo and Ras Tanura is 4,300 miles, and the annual saving of transport cost due to the increase of tanker size are as shown in Table-IV.3.6.

In this Port with relatively short transportation distance, the benefits brought from tankers up to 100,000 DWT class are considerable, but from large tankers of more than 150,000 DWT it is not large.

However, since the buoy berth for 100,000 DWT class tankers involves the problem of waiting due to inclement weather as mentioned before, the above-mentioned reduction of transport cost is decreased. The average number of waiting days due to rough weather is about 1 day/tanker, and this increases the transportion cost of a 100,000 DWT tanker by about 5%, to decrease the annual saving to $\$5,510 \times 10^3$.

(2) Construction cost

The construction costs of the buoy berth (100,000 DWT tanker) and the dolphin berth (60,000 DWT tanker) are estimated as shown in Table-IV.3.17, including related facilities.

Choice of tanker size:

The deliberation made up to the previous paragraph was for 60,000 DWT tankers, which are expected bring the maximum effect by constructing the dolphin berth. If the tanker size is decreased to less than 60,000 DWT, then the economic benefit decreases, but the initial investment required for construction also decreases greatly. At present, some of the soil data, etc required for calculation of construction cost are not available, and do not allow accurate economic comparison by difference of tanker size. The cost comparison can be made approxiamtely, as follows:

Facilities for 40,000 DWT tankers does not involve a construction of additional pipeline or much dredging work (channel depth 47.5', mooring basin depth 42'), therefore the initial investment is the smallest. Furthermore, very little widening work of the approach channel is required (breadth of tanker 27.3 m for 30,000 DWT, 29.9 m for 40,000 DWT). This scheme will be able to be effectively set out also as a first step of the whole plan aiming at 60,000 DWT tankers. For 50,000 DWT and 60,000 DWT tankers, the development plan should be made only after survey results on the bed soil are obtained.

(3) Comparison

Based on the above, the buoy berth will be compared with the dolphin berth from various viewpoints.

a) Economy

The buoy berth can accept large tankers, with large economic benefit by scale merit.

On the other hand, it involves large initial investment and high maintenance cost.

b) Working Efficiency

In the case of the buoy berth, operations are difficult due to waves, especially in the SW monsoon season, hampering the smooth supply of crude oil.

c) Safety

The buoy berth is located outside of the harbour and is highly safe against an accident, etc., but in view of the difficult working conditions, the dolphin berth will be safer against oil leakage.

d) Matching with other Facilities

For a refinery capacity of 8,100 tons/day, the supply of crude oil by 100,000 DWT tankers is rather large. And even if the buoy berth is constructed, there remain the problems of reined oil handling and bunkering operations from the safety viewpoint in the Port. Therefore, the dolphin berth is preferable since the oil handling facilities can be integrated.

e) Maintenance

The buoy berth requires frequent checks of the rubber hoses, making maintenance troublesome.

f) Effective Utilization of Water Area

The dolphin berth occupies a wide water area for maneuvering and cargo handling of the tanker and requires dredging, being inferior to the buoy berth.

g) Ease on the Execution

The construction of the buoy berth in the open sea is difficult, but does not involve any problem in the NE monsoon season. The installation of the submarine pipeline is not technically difficult.

The above is summarized in Table-IV.3.19

Thus an overall examination was made using the data available at present. Due to lack of data concerning natural conditions, especially soil conditions, a further detailed survey must be made before deciding on a final plan. In this study, the dolphin berth is judged to be highly suitable both technically and economically. For the overall development of the Port of Colombo, the oil handling facilities should be quickly transferred, and therefore the detailed study must be done at the earliest opportunity.

## 3-4 Inside-port Road

### 3-4-1 General

An inside-port road must be laid out adequately to ensure safe and effective transport and alignment with a peripheral road network.

The Port of Colombo is surrounded by the densely populated urban area. Particularly, in the Pettah and Fort sections which are the center of the city, where a road network of heavy traffic volume is developed. The Port of Colombo handles about 90 percent of the total export and import cargo of the country, and the related cargo transport is as much as about 20 percent of the cargo transport in the city. 90% of Port cargo are dependent on road transportation, with the remainder moving by rail. The number of trucks in the city occupies an average of 9 percent (maximum about 50 percent) of the total number of vehicles. Thus, the Port cargo transport effects the urban traffic considerably, while the traffic capacity of the city is not enough to cope with the increasing population and a considerable congestion is caused by inadequate road control and insufficient road capacity and parking space.

In order to relieve the current traffic congestion in the city and to cope with the increasing traffic volume in the future, the Urban Development Authority* is studying a drastic road network redevelopment plan.

According to the plan, the adverse effect on urban traffic, which is caused by the transportation of port cargo, will be reduced by transferring the warehouses presently spotted over the city to the Warehouse Complex in the northwestern part (along Kelani Ganga) of the city. Further, as the north-south traffic passes through the Fort and Pettach sections, a trunk line through the suburban area is proposed to detour these congested sections.

In this report, the inside-port road is planned, assuming the road is constructed along the railway from the eastern side of the dry dock as proposed by UDA.

3-4-2 Inside-Port Road Plan

Transport of cargoes generated from within the Port of Colombo is dependent largely on roads. There may be developed means of transport by railway or canal in the future, but the importance of road transport will scarecely be affected by them.

At present, the roads in the port are considerably congested on account of inadequate control and insufficient capacity, and thus will be unable to cope with increasing traffic volume and greater size of vehicles dealing with container transportion in the future. Therefore, an adequate redevelopment should be planned.

On the service area of the Port of Colombo it is similarlly congested, therefore the inside-port roads should be connected to the road network in the environ, considering the future traffic condition. Here, the future insideport traffic volume will be forecasted from the Port cargo volume to determine an adequate scale and layout of inside-port roads.

(1) Forecast of Traffic Volume**,***

In Japan, a traffic volume generated in a port is forecasted by a cargo volume using the formula given below. The future traffic volume in the Port of Colombo is assumed to be of a similar pattern as that in Japan and will be estimated using the same formula.

Hourly traffic volume = Annual cargo volume (freight ton/year) $\times \alpha/\omega \times \beta/12 \times \gamma/30 \times (1 + \delta)/\epsilon \times \sigma$

* Colombo Urban Area Development Plan: Urban Development Authority

** Port Facility Design Manual: Bureau of Port and Harbour, Ministry of Transport, JAPAN

*** Report on Forecast Procedure of Port Traffic Volume: Planning Division, Bureau of Port and Harbour, and Planning Division, First Port Construction Bureau, Ministry of Transport, JAPAN; March 1979.

where $\alpha$ : Automobile share = Automobile transport/Whole transport;
$\omega$ : Actual truck loading (ton/truck);
$\beta$ : Monthly variation = Peak monthly cargo volume/Mean monthly cargo volume;
$\gamma$ : Daily variation = Peak daily cargo volume/Mean daily cargo volume;
$\delta$ : Related vehicle rate = Number of related vehicles/Number of trucks;
$\epsilon$ : Loaded truck rate = Number of loaded trucks/Number of trucks; and
$\sigma$ : Hourly variation = Peak hourly traffic volume/Daily traffic volume

For the above coefficients, the following values are standardly used in Japan at present.

$\omega = 10t$, $\beta = 1.2$; $\gamma = 1.5$; $\delta = 0.5$; $\epsilon = 0.5$; and $\sigma = 0.12$.

For $\alpha$, the transport by barge and railway of about 3 percent is neglected, and value of 1.0 is tanken. For the related vehicle rate, it is assumed that one half of is passes through the existing gates. Then, from the formula:

Hourly traffic volume = $1.5 \times 10^{-4}$ x Annual cargo volume.

The forcasted cargo and traffic volumes are given in Table-IV.3.20

(2) Road Width

Similarly, according to the standard used in Japan, the road width of 2 lanes is enough when the traffic volume is of a value less than those listed in Table-IV.3.21.

Accordingly, as shown in Fig.-IV.3.14 the width of the inside-port road will have to be 2 lanes until 1983 and 4 lanes thereafter.

(3) Layout of Inside-Port Road (Fig. IV.3.15)

Upon the foregoing examination, the layout of the inside-port road is planned and shown in Fig. IV.3.15.

1) Access Road

The port is to be connected to the outside area by a newly constructed road running from the central part of Korteboam Container Quay along the railway, under the Alutmawatte Road through the marshland and to Wales Avenue and then to Victoria Bridge. As an alternative, the road along the south side of the dry dock may be taken instead of the new road along the railway. But, the layout shown in Fig. IV.3.15 is considered to be more adequate in (i) it is difficult to widen the road leading to Point G because of the dock facilities and its works there, (ii) it is extremely difficult to secure the required road width at or about Point G and (iii) it is relatively easy to secure the land along the railway. The planned access road includes tunnel crossings with the Graving Road and Alutmawatte Road and is of a width of 4 lanes.

2) Queen Elizabeth Quay Section

The existing road on the Queen Elizabeth Quay has a sufficient width but is not used properly due to cargo and container yard operations being uncoordinated. In the future, the road in this section will be 15 m wide along the parapet on the western side, and run to the

North West Gate.

3) North West Gate – Korteboam Quay

This section is not of sufficient width nor adequate alignment with several sharp bends, so that substantial improvement is required. It will be widened to 20 m in the future (at the stage of Master Plan). But, for the Urgent Plan only 2-lane will be paved and the bends at Point E will be straightened, by removing the existing facilities.

4) Korteboam Quay – Prince Vijaya Quay

The road in this section is 10 m wide at present, and is of sufficient capacity even for future traffic volume, so it will not be widened but connected to the access road at Point G. The existing road shall be marked clearly, and some obsolete portions will be repaired for effective and safe transportation. Standard cross-sections of the inside-port road are shown in Fig. IV.3.16 and the construction cost in Table IV.3.22.

## 3-5 Approach Channel and Turning Basin

The approach channel for a tanker of 60,000 DWT class tanker, which is anticipated to be the largest to call on this Port must permit safe and smooth navigation. The existing and planned channels and the turning basin are shown in Fig. I .3.17.

### 3-5-1 Channel Alignment

It is desirable to separate an approach channel for tanker from a channel and mooring basin for other kinds of ships for safety. But in this port, safe navigation could be secured by restricting the sailing of other ships when a tanker enters or departs the Port and by removing as many midstream buoys as possible.

A pilot is compulsory, and embarks on a tanker at about 1.5 km off the port entrance. After passing the end of the Sough-West breakwater, a tanker is to be assisted by tugboats. The entrance is about 150 m wide, and four light beacons are installed at the tips of Sough-West and North-West breakwaters. The navigation in this channel seems difficult to some extent for a 30,000 ton class tanker, the largest ship now entering the port, which must be supported by the pilot, tugboats, etc. For 60,000-ton tankers, the present channel width and stopping distance are insufficient. In Fig. IV.3.17 (b) is shown a planned channel.

The approach channel is designed almost as same as the present one, but is widened to 200 m (about 5,8B) over the entire length by removing about 75 m from the tip of the North-West breakwater. While the Sough-West breakwater is extended by 150 m, to secure sufficient stopping distance and a sufficient degree of calmness at the entrance and inside the port.

### 3-5-2 Channel Width

A channel width is determined by a traffic volume of ships, winds, waves, etc. For this port, the traffic volume is relatively small, and two entrance channels are provided, and therefore the channel will be designed for one lane. Factors determining the channel dimensions are shown in

Table-IV.3.23.

Ship positioning ... The positioning accuracy by a single beacon is about 0.02D (D ... distance between a ship and a beacon) at right angle to a channel. When a transit beacon is provided it is improved to 0.014D. Therefore, in this port where the widening of the channel adversely affects the calmness inside, it is desirable to install proper beacons and channel buoys.

Yawing ... Deviation of a ship from a target course due to unequal water pressures acting on a ship's hull, unskilled steering, etc.

Deviation due to wind and current ... Width allowance required for correcting a ship under lateral force of wind, current, etc. Thus, if the largest of ships calling this port is a 60,000 DWT tanker, a required channel width W is

$$W = 5.8B = 5.8 \times 34.0 = 197.2m$$

At present, the width of the main channel is about 150m between the ends of the foundation mounds of both breakwaters, and this corresponds to the width required for a 30,000 DWT class tanker. To secure the above-mentioned width, the present channel must be widened by about 50m. Furthermore, it is desirable that the tip of the older Queen Elizabeth Breakwater at which the pilot station is built be removed to secure and smooth navigation.

3-5-3 Water Depth of Channel and Mooring Basin

The channel depth should be determined by considering a loaded draft of the largest ship to call the port, tidal level, squat, pitching & rolling, empirical factors, etc.

1) Loaded draft

If the largest ship considered is a 60,000 DWT tanker, the loaded draft is 13.0m.

2) Squat

A relation between ship speed and squat are shown in Fig. IV. 3. 18. There are no data for a 60,000-ton class tanker, but since there is not much difference in squat by ship size, 0.3m can be obtained, with h/d = 1.1 to 1.2 and V = 6.0 knots.

3) Pitching & Rolling

As there is no established method for calculating hull sinkage due to waves, 2/3 of wave height is adopted for a medium size ship, and 1/2 for a large ship. At present, the wave height of 8 feet is adopted as the limit for embarking of the pilot, and based on this, the sinkage due to waves is derived as 4 feet, for a large ship.

4) Empirical Factors

An allowance is usually taken as 2 to 4 feet, when the sea bottom is sandy a smaller value is adopted. As a channel survey show it to be rocky at some portions, so here 4 feet is adopted.

51.5 feet is obtained as the required channel depth by adding the above values. As for the water depth of the mooring basin, 1 foot is added to the presently adopted keel clearance of 2 feet, considering the increase of ship size, to give 46 feet as the total depth.

### 3-5-4 Stopping Distance and Turning Basin

The distance from the point where a ship reaches the area sheltered by a breakwater, etc. to the point where it stops is about 4L when approaching at 6 knots, usually 1 L is added to it, giving 5L. The turning basin shall be a circle with a diameter of 2L, when tugs are used.

### 3-5-5 Required Volume of Spoil to be dredged

The volume of spoil to be dredged for the above mentioned mooring basin is listed in the Table IV.3.24.

The dredging work possibly involves rock removal, the extent of which cannot be calculated, due to lack of data. The bed rock elevation inside and outside the Port must be surveyed in detail. The final layout of the channel should be made based on the results of the survey and on economic considerations.

## 3-6 Summary of Facility/Equipment in the Master Plan

The summary of facility and equipment in the Master Plan are shown in Table-IV.3.25.

Table-IV.3.26 shows the summary of dry cargo berths including container berths.

Table – IV.3.1 List of Conventional Berths, Master Plan

| Quays, Piers & Berths | Length in Meters (Feet) | | Depth in Meters (Feet) | Max. Vessel (DWT) | Cargo | |
|---|---|---|---|---|---|---|
| | Waterfront | Berth | | | Kind | Capacity (F. tons) |
| QEQ | 1,150 (3,773) | 1,080 (3,543) | | | | |
| #1 | | 210 ( 689) | 11.0 (36.1) | 20,000*1 | General Cargo | 150,000 |
| #2 | | 210 ( 689) | 11.0 (36.1) | 20,000 | do | do |
| #3 | | 210 ( 689) | 11.0 (36.1) | 20,000 | do | do |
| #4 | | 210 ( 689) | 11.0 (36.1) | 20,000 | do | do |
| #5 | | 240 ( 787) | 11.0 (36.1) | 30,000 | do | do |
| BQ | 940 (3,084) | 805 (2,641) | | | | |
| #1 (West) | | 165 ( 541) | 9.0 (29.5) | 10,000 | General Cargo | 150,000 |
| #2 (West) | | 165 ( 541) | 9.0 (29.5) | 10,000 | do | do |
| #3 (North) | | 105 ( 344) | 6.0 (19.7) | 3,000 | do | 50,000 |
| #4 (East) | | 185 ( 607) | 10.0 (32.8) | 15,000 | do | 150,000 |
| #5 (East) | | 185 ( 607) | 10.0 (32.8) | 15,000 | do | do |
| CB | 200 ( 656) | 140 ( 459) | | | | |
| #1 | | 70 ( 230) | 5.0 (16.4) | 1,000 | General Cargo | 50,000 |
| #2 | | 70 ( 230) | 5.0 (16.4) | 1,000 | do | do |
| PVQ | 370 (1,214) | 330 (1,083) | | | | |
| #1 | | 165 ( 541) | 9.0 (29.5) | 10,000 | General/Bulk Cargo | 150,000 |
| #2 | | 165 ( 541) | 9.0 (29.5) | 10,000 | do | do |
| North Quay | 370 (1,214) | 330 (1,083) | | | | |
| #1 | | 165 ( 541) | 9.0 (29.5) | 10,000 | Bulk Cargo | 200,000 |
| #2 | | 165 ( 541) | 9.0 (29.5) | 10,000 | do | do |
| Korteboam Quay | 2,025 (6,644) | 900 (2,953) | | | | |
| #1 (Container) | | 300 ( 984) | 12.0 (39.4) | Full Container Vessel | Container | 1,000,000 |
| #2 ( do ) | | 300 ( 984) | 12.0 (39.4) | do | do | do |
| #3 ( do ) | | 300 ( 984) | 12.0 (39.4) | do | do | do |
| Conventional Total | 3,575 (11,729) | 2,870 ( 9,416) | | | | 2,200,000 |
| Container Total | 2,025 ( 6,841) | 900 ( 2,953) | | | | 3,000,000 |
| Grand Total | 5,600 (18,373) | 3,770 (12,369) | | | | 5,200,000 |

Table – IV.3.2 Container Equipment and Cost Estimates for Master Plan

(Unit: $1,000 USD)

| Equipment | | QEQ | | Korteboam | | Total | |
|---|---|---|---|---|---|---|---|
| | | Quantity | Cost | Quantity | Cost | Quantity | Cost |
| Container Crane | | 1 | 3,017 | 6 | 18,102 | 7 | 21,119 |
| Straddle Carrier | | 3 | 960 | 22 | 7,040 | 25 | 8,000 |
| Yard-use Tractor | | 2 | 52 | 15 | 390 | 17 | 442 |
| Yard-use Trailer Chassis | 40' | 2 | 18 | 20 | 180 | 22 | 198 |
| " | 20' | 8 | 56 | 30 | 210 | 38 | 266 |
| Forklift Truck 15 ton | | 2 | 274 | – | – | 2 | 274 |
| " 1.5 ton | | 6 | 84 | 36 | 504 | 42 | 588 |
| Weighing Scale | | – | – | 5 | 205 | 5 | 205 |
| Total | | | 4,461 | | 26,631 | | 31,092 |

Table – IV.3.3 Comparison Table for Container Handling Equipment at QEQ #5 Container Terminal

| Item | Straddle Carrier | Transfer Crane (Tyre-mounted, 75 feet span) | Side loader |
|---|---|---|---|
| Handling Capability<br>Ground Slot<br>Storage Capacity (Max.)<br>Expected throughput annum. | <br>840 TEU<br>2,520 TEU (3 high)<br>50,000 TEU Approx. | <br>648 TEU<br>2,592 TEU (3 high)<br>55,000 TEU Approx. | <br>680 TEU<br>2,040 TEU (3 high)<br>49,000 TEU Approx. |
| Equipment's Cost Total (See Table – IV.3.4) | US$ 4,461,000 | US$ 5,761,000 | US$ 4,879,000 |
| Running Cost per unit/year (percent of capital cost) | Approx. 10% USD ($32,000/unit/year) | Approx. 5% USD ($34,300/unit/year) | Approx. 10% USD ($43,200/unit40'/year) |
| Pavement of terminal | Heavy pavement | Not sor heavy pavement except crane track | Heavy pavement |
| Operational Factor | *Very flexible to operational demands and/or trade expansion<br>*Efficient, Productive | *Not flexible<br>*Slow operation due higher stacking density<br>*Reliable, less maintenance | *Unknown due no use of the machine for major handling of containers at terminals. Likely the same as or slightly lower in efficiency than straddle carrier |

(Note) Please refer Table – IV.3.4 and Fig. – IV.3.1, IV.3.2 and IV.3.3 for the details.

Table – IV.3.4 Comparison of Equipment/Cost required for QEQ #5 Container Terminal

($1,000 USD)

| Equipment | Cost per unit | Straddle Carrier System | | Transfer Crane System | | Sideloader System | |
|---|---|---|---|---|---|---|---|
| | | Quantity | Cost | Quantity | Cost | Quantity | Cost |
| Container Crane | 3,017 | 1 | 3,017 | 1 | 3,017 | 1 | 3,017 |
| Straddle Carrier | 320 | 3 | 960 | – | – | – | – |
| Transfer Crane | 686 | – | – | 3 | 2,058 | – | – |
| Sideloader 20' | 299 | – | – | – | – | 2 | 598 |
| 40' | 432 | – | – | – | – | 2 | 864 |
| Yard-use Tractor | 26 | 2 | 52 | 8 | 208 | 1 | 26 |
| Yard-use Trailer Chassis | | | | | | | |
| 40' | 9 | 2 | 18 | 4 | 36 | 1 | 9 |
| 20' | 7 | 8 | 56 | 12 | 84 | 1 | 7 |
| Forklift Truck 15 tons (Stacking empty container) | 137 | 2 | 274 | 2 | 274 | 2 | 274 |
| Forklift Truck 1.5 tons (CFS operation) | 14 | 6 | 84 | 6 | 84 | 6 | 84 |
| Total | | | 4,461 | | 5,761 | | 4,879 |

Table – IV.3.5 Oil Import & Export (Thousand T/M)

* Fuel Oil Export

| | Crude Oil | Kerosene | Gas Oil | Fuel Oil | Chemical Naphtha | Refined Oil Total |
|---|---|---|---|---|---|---|
| 1980 | 2,350 | – | – | *263 | 30 | 293 |
| 1981 | 2,350 | 4 | 12.6 | *243 | 30 | 289.6 |
| 1982 | 2,350 | 137 | 44.5 | *220 | 30 | 431.5 |
| 1983 | 2,350 | – | – | 371 | 30 | 401 |
| 1984 | 2,350 | – | – | 398 | 30 | 428 |
| 1985 | 2,350 | – | – | 428 | 30 | 458 |
| 1986 | 2,350 | – | – | 462 | 30 | 492 |
| 1987 | 2,350 | – | – | 499 | 30 | 529 |
| 1988 | 2,350 | 87.2 | – | 518 | 30 | 635.2 |
| 1989 | 2,350 | 164.2 | – | 537 | 30 | 731.2 |
| 1990 | 2,350 | 243.1 | 30 | 557 | 30 | 860.1 |

Table – IV.3.6 Standard Tanker Size

| Type | DWT (t) | Overall Length (m) | Molded Width (m) | Molded Depth (m) | Draft in Full Load (m) |
|---|---|---|---|---|---|
| Oil Tanker | 700 | 50 | 8.5 | 4.0 | 3.7 |
| | 1,000 | 57 | 9.4 | 4.5 | 4.2 |
| | 2,000 | 73 | 11.4 | 5.6 | 5.1 |
| | 3,000 | 85 | 12.8 | 6.4 | 5.9 |
| | 5,000 | 102 | 14.7 | 7.6 | 6.9 |
| | 10,000 | 139 | 19.0 | 9.9 | 8.1 |
| | 15,000 | 157 | 21.7 | 11.3 | 9.0 |
| | 20,000 | 171 | 23.8 | 12.4 | 9.8 |
| | 30,000 | 194 | 27.2 | 14.1 | 10.9 |
| | 40,000 | 211 | 29.9 | 15.4 | 11.7 |
| | 50,000 | 226 | 32.1 | 16.5 | 12.5 |
| | 70,000 | 250 | 35.9 | 18.4 | 13.6 |
| | 100,000 | 270 | 39.0 | 19.2 | 14.6 |
| | 150,000 | 291 | 44.2 | 23.0 | 17.9 |
| | 200,000 | 325 | 47.2 | 24.5 | 19.0 |
| | 250,000 | 348 | 51.8 | 25.6 | 20.0 |

Table – IV.3.7 Length of Pipeline

| North buoy | | | | South buoy | | |
|---|---|---|---|---|---|---|
| Tanker Size (D.W.T) | Installation water depth | Pipeline length | | Installation water depth | Pipeline length | |
| | | Submarine | Land | | Submarine | Land |
| 80,000 | -19 m | 5,200 m | 13,300 m | -21 m | 3,000 m | 15,180 m |
| 100,000 | -21 | 6,800 | 13,300 | -24 | 3,650 | 15,180 |
| 120,000 | -22 | 7,150 | 13,300 | -24 | 3,800 | 15,180 |

Table – IV.3.8 Average Working Time (100,000 ~ 200,000 D.W.T)

(Unit: hr)

| | Tanker Size | 10~15 (10^x4) D.W.T. | 11~20 (10^x4) D.W.T. |
|---|---|---|---|
| Dolphine | a. Pilotage ~ Berthing | 1.8 | 2.1 |
| | b. Berthing ~ Unloading | 1.2 | 2.2 |
| | c. Unloading | 27.0 | 27.5 |
| | d. Unloading ~ Unberthing | 3.6 | 2.5 |
| | e. Unberthing | 1.1 | 0.2 |
| | Total | 37.9 | 34.4 |
| Buoy | a. Pilotage ~ Berthing | 2.7 | 1.3 |
| | b. Berthing ~ Unloading | 1.8 | 3.0 |
| | c. Unloading | 30.8 | 48.0 |
| | d. Unloading ~ Unberthing | 2.1 | 5.0 |
| | e. Unberthing | 1.4 | 0 |
| | Total | 40.3 | 57.3 |
| Average | a. Pilotage ~ Berthing | 1.9 | 1.8 |
| | b. Berthing ~ Unloading | 1.36 | 2.5 |
| | c. Unloading | 28.1 | 34.3 |
| | d. Unloading ~ Unberthing | 3.2 | 3.3 |
| | e. Unberthing | 1.6 | 0.2 |
| | Total | 38.6 | 42.0 |

Table – IV.3.9 Pipeline Dimension

| | Total Length (m) | Diameter (inch) |
|---|---|---|
| 30,000 DWT | 13,000 | – |
| 40,000 | 14,400 | – |
| 50,000 | 14,400 | 16 |
| 60,000 | 14,400 | 20 |
| 80,000 | 18,180 | 32 |
| 100,000 | 18,830 | 36 |
| 120,000 | 18,980 | 38 |

Table – IV.3.10 Standard Buried Depth

| Ship size (D.W.T) | Weight of anchor (t) | Penetration of anchor (m) | Bite by anchoring before stopping (m) | Buried depth (m) |
|---|---|---|---|---|
| 10,000 | 4.0 | 1.87<br>0.58 | 0.9<br>0.9 | 2.77<br>1.48 |
| 20,000 | 5.4 | 2.21<br>0.63 | 1.0<br>1.0 | 3.21<br>1.63 |
| 50,000 | 8.2 | 2.69<br>0.70 | 1.16<br>1.16 | 3.85<br>1.76 |
| 80,000 | 10.9 | 3.15<br>0.77 | 1.26<br>1.26 | 4.41<br>2.03 |
| 100,000 | 12.4 | 3.39<br>0.81 | 1.33<br>1.33 | 4.72<br>2.14 |
| 200,000 | 18.0 | 4.20<br>0.93 | 1.50<br>1.50 | 5.70<br>2.43 |
| 300,000 | 22.0 | 4.83<br>1.02 | 1.59<br>1.59 | 6.42<br>2.61 |

Note: Upper values are for silty soil and lower values are for sandy soil.

Table – IV.3.11 Critical Wave Heights and Wind Velocities for Operation

(100,000-DWT class)

| | Buoy berth | Dolphin berth |
|---|---|---|
| Pilot embarking | | |
| Wave height | 1.5 m | 1.3 m |
| Wind velocity | 15 m/sec | 13 m/sec |
| Berthing | | |
| Wave height | 1.2 m | 1.3 m |
| Wind velocity | 15 m/sec | 15 m/sec |
| Cargo handling | | |
| Wave height | 1.5 m | 1.3 m |
| Wind velocity | 15 m/sec | 10 m/sec |

Table – IV.3.12 Nos. of Days of Wave Height 1.2m and over

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency (days) | 2.5 | 1.6 | 0.6 | 1.6 | 4.3 | 9.4 | 8.3 | 8.0 | 7.1 | 5.6 | 2.5 | 0.7 | 52.2 (14%) |

Table – IV.3.13 Workable Days for Buoy Berth (H 1/3<1.2m)

| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % | 0.794 | 0.770 | 0.760 | 0.715 | 0.636 | 0.456 | 0.521 | 0.568 | 0.472 | 0.554 | 0.637 | 0.826 | 0.642 |
| Nos. of Days | 24.6 | 21.6 | 21.5 | 23.6 | 19.7 | 13.7 | 16.2 | 17.6 | 14.2 | 17.2 | 19.1 | 25.6 | 19.6 |

Note: Three successive calm days are necessary for a whole operation.
(Analyzed from wind records furnished by CPC.)

Table – IV.3.14 Required Thrust of Tugboat

(In tons)

| Ship size (D.W.T) | Fully Loaded | | | | On Ballast | |
|---|---|---|---|---|---|---|
| | (Water depth)/(draft) | | | | Wind velocity | |
| | 1.1 | 1.2 | 1.3 | 1.5 | 10 m/sec | 15 m/sec |
| 50,000 | 70 | 60 | 50 | 45 | 35 | 65 |
| 100,000 | 110 | 90 | 80 | 70 | 60 | 115 |
| 150,000 | 140 | 120 | 100 | 85 | 70 | 135 |
| 200,000 | 160 | 140 | 120 | 100 | 80 | 160 |
| 250,000 | 185 | 160 | 140 | 120 | 95 | 185 |
| 300,000 | 210 | 180 | 155 | 130 | 115 | 210 |

Table – IV.3.15 Number of Tugboats Required

| Ship size (D.W.T) | Number of tugboats for entry | Number of tugboats for departure |
|---|---|---|
| 40,000 ~ 60,000 | 2 | 2 |
| 60,000 ~ 80,000 | 2 ~ 3 | 2 ~ 3 |
| 80,000 ~ 100,000 | 3 | 3 |
| 100,000 ~ 130,000 | 3 ~ 4 | 3 |
| 130,000 ~ 160,000 | 4 | 3 |
| 160,000 ~ 200,000 | 4 ~ 6 | 3 ~ 4 |

Table -- IV.3.16 Transportation Cost by Tanker Size (10,000 DWT)

| Tanker Size | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|
| Trans. Cost ($/t) | 5.6 | 5.0 | 4.5 | 4.1 | 3.8 | 3.5 | 3.3 | 3.1 | 2.8 | 2.3 |
| Trans. Cost (0000$/year) | 1316 | 1175 | 1058 | 964 | 893 | 823 | 776 | 729 | 658 | 501 |
| Saving (0000 $) | 0 | 141 | 258 | 352 | 423 | 493 | 540 | 587 | 658 | 815 |

Table – IV.3.17 Construction Cost

(Unit: Million US$)

| Buoy Berth | Cost | Dolphin Berth | Cost |
|---|---|---|---|
| Buoy | 5.23 | Dolphin | 0.91 |
| Pipeline | 15.68 | Pipeline | 8.86 |
| Storage Tank | 3.95 | Tug Boat | 1.92 |
| Assist Boat & Others | 0.57 | Armour Block | 3.49 |
| Bunkering | 5.16 | Bunkering | 5.16 |

Table – IV.3.18 Cost Difference

(Unit: Million Rs.)

| Item \ Tanker Size | 60,000 DWT | 50,000 DWT | 40,000 DWT |
|---|---|---|---|
| Pipeline | 8.86 | 8.86 (approx) | ≒ 0 |
| Saving | 3.52 | 2.60 | 1.42 |

Table -- IV.3.19 Comparison of Buoy & Dolphin Berth

| | Item | Buoy Berth | Dolphin Berth |
|---|---|---|---|
| 1 | Economy | X | O |
| 2 | Working Efficiency | X | O |
| 3 | Safety | O | Δ |
| 4 | Matching | Δ | O |
| 5 | Maint. | X | O |
| 6 | Port water area | O | X |
| 7 | Easiness of work | Δ | O |

Table – IV.3.20 Traffic Volume Forecasted

| Year | 1980 | 1982 | 1984 | 1986 | 1988 | 1990 |
|---|---|---|---|---|---|---|
| Cargo volume (000t) | 3,086 | 3,237 | 3,565 | 4,069 | 4,573 | 3,077 |
| Traffic volume (/hr.) | 463 | 486 | 535 | 610 | 686 | 762 |

Table – IV.3.21 Hourly Traffic Volume

| Type of Road | Hourly Traffic Volume |
|---|---|
| Road connecting the port with highway, etc. | 650 Vehicles/hour |
| Other roads | 500 |

Table – IV.3.22 Cost of Road Improvement

| Section | Particular | Length (m) | Width (m) | Area ($m^2$) | Unit Cost($) | Total Cost ($10^6$ $) |
|---|---|---|---|---|---|---|
| I | Improvement | 850 | 15 | 12,750 | 4.8 | 0.058 |
| II | Improvement | 3,000 | 10 | 30,000 | 5.9 | 0.178 |
| | Removal | | | 1,362 | 319.8 | 0.436 |
| III | Construction | 700 | 20 | 14,000 | 15.0 | 0.224 |
| | Tunnel Work | 13 | 9 | 117 | 1050.8 | 0.107 |
| | | 17 | 20 | 340 | 913.7 | 0.311 |
| IV | Improvement | 1,150 | 10 | 11,500 | 18.3 | 0.210 |
| | | | | | Total | 1.524 |

Table – IV.3.23 Calculation of Channel Width

| Factor | | Width |
|---|---|---|
| Required channel width (1/2) | Ship position holding accuracy of ship | 1B |
| | Yawing (full load, 6 knots) | 0.2B |
| | Correction of deviation due to wind (15 m/sec) | 0.2B |
| | Correction of deviation due to current (0.5 knots) | (1B) |
| | 1/2 of beam | 0.5B |
| | Sub-Total | 2.9B (4.4B) |
| Required channel width | | 5.8B |

Note B Ship's Beam.

## Table – IV.3.24 Volume of Spoil to be Dredged

| | Water depth ft | Area m² | Required Dredging volume of spoil m³ | Remarks |
|---|---|---|---|---|
| Channel | 51.5' | 390,000 | $1.24 \times 10^6$ | Outbreak 2' |
| Mooring basin | 46.0' | 900,000 | $2.0 \times 10^6$ | Outbreak 1' |

## Table – IV.3.25 Summary – Master Plan

| Item | Unit | Q'ty | Cost: Value (1,000 US$) | Cost: Share (%) | Target Year | Note |
|---|---|---|---|---|---|---|
| Conventional Berths | | | | | | |
| KQ #2 (New Berth, Temporary) | Berth | 1 | – | | 1983 | Modified to CINR Berth after 1988 |
| NP (Widening, 1 Berth → 2 Berths) | Berth | 2 | 3,538 | 2.7 | After Removal of Oil Dock | Widening of 50m, Two –9m Berths |
| NGP/SP (Cargo Berth → Ship Repair Berth) | Berth | 3 | – | | 1983 (1B) After Completion of NP (2B) | |
| QEQ #5 (Container → Conventional) | Berth | 1 | – | | 1988 | |
| Cargo Handling Equipment | Set | 1 | 7,537 | 5.8 | 1980 | |
| Sub Total | | | 11,075 | 8.5 | | |
| Container Berths | | | | | | |
| QEQ #5 (Crane Foundation, etc.) | Set | 1 | 1,628 | 1.2 | 1981 | |
| KQ #1/#2/#3 | Berth | 3 | 47,736 | 36.6 | 1983 (#1) 1988 (#2/#3) | #2 (Conventional + Container) |
| Dredging | Mn.m³ | 1.5 | 2,880 | 2.2 | 1983, 1988 | |
| Container Equipment | Set | 1 | 31,092 | 23.9 | 1981,1983, 1988 | |
| Sub Total | | | 83,336 | 63.9 | | |
| Oil Berth* | | | | | | *A feasibility study including an in situ survey of the bed-rock depth along the approch channel should be carried out. |
| Dolphines | Set | 1 | 937 | 0.7 | Set by F/S* | |
| Pipelines, etc. | Set | 1 | 11,515 | 8.8 | • | |
| Bunkering Facilities | Set | 1 | 686 | 0.5 | • | |
| Improvement of Port Entrance | Set | 1 | 12,011 | 9.2 | • | |
| Extension of SW Breakwater | (m) | (150) | (6,171) | | | |
| Removal of the Southwest End of NW Breakwater | (m) | (75) | (514) | | | |
| Seawall/Wave Dissipation Work along NW Breakwater | (m) | (700) | (5,326) | | | |
| Dredging | M.m³ | 3.24 | 6,900 | 5.4 | • | |
| Tug Boat | No. | 1 | 1,919 | 1.5 | • | |
| Sub Total | | | 33,968 | 26.1 | | |
| Road | km | 5.7 | 1,981 | 1.5 | 1982 (2 Lanes) 1988 (4 Lanes) | |
| Grand Total | | | 130,360 | 100.0 | | |

Note: Engineering fee and physical contingency are not included in the Table.

Table – IV.3.26 Number of Alongside Berths (Dry Cargo)

| | Exsisting | | Planned | | Transferred | | Balance | |
|---|---|---|---|---|---|---|---|---|
| | Large*1 | Small*1 | Large | Small | Large | Small | Large | Small |
| Alongside Berths | 14 | 3 | 5 | 0 | 3*3 | 0 | 16 | 3 |
| Conventional | 14 | 3 | 2*2 | 0 | 3 | 0 | 13 | 3 |
| Container | 0 | – | 3 | – | 0 | – | 3 | – |

Note: *1 "Large" denotes for quaywalls with the water depth of -7.5m or deeper and "small" for quaywalls with that shallower than -7.5m.

*2 North Pier

*3 2 berths at North Guide Pier and 1 berth at South Pier.

Fig. – IV.3.1 Layout of QEQ #5 Container Terminal (Straddle Carrier System)

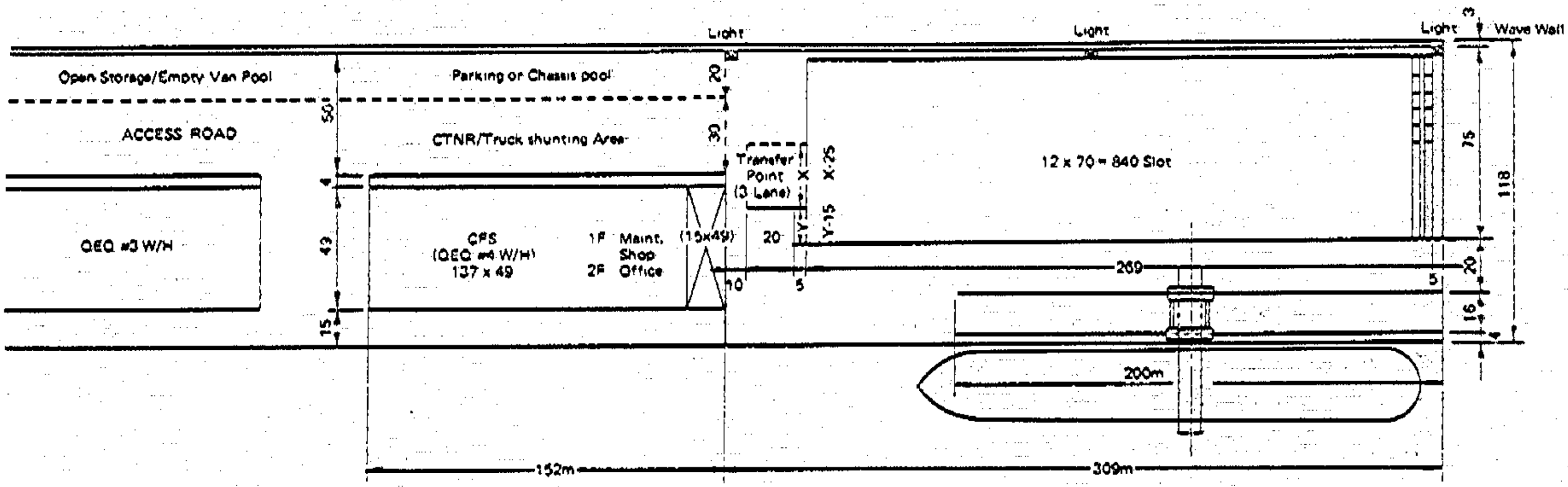


Fig.-IV.3.2 Layout of QEQ #5 Container Terminal (Transfer Crane System)

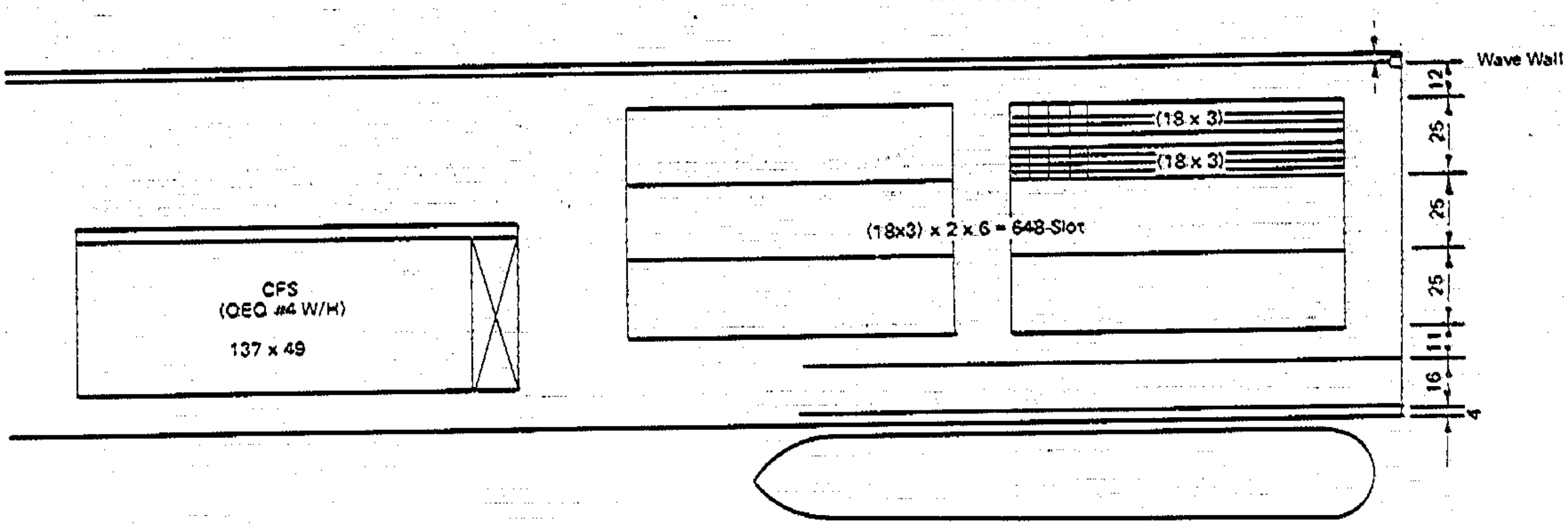


Fig. – IV.3.3 Layout of QEQ #5 Container Terminal (Sideloader System)

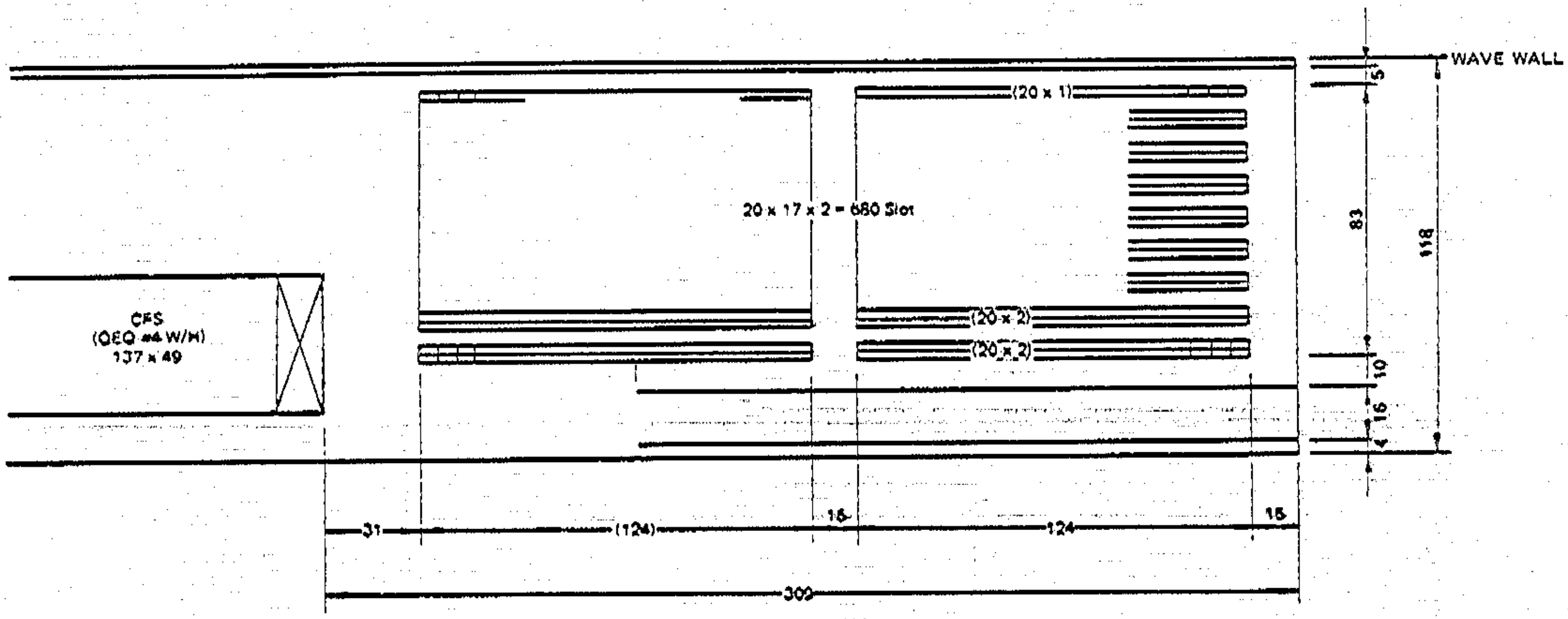
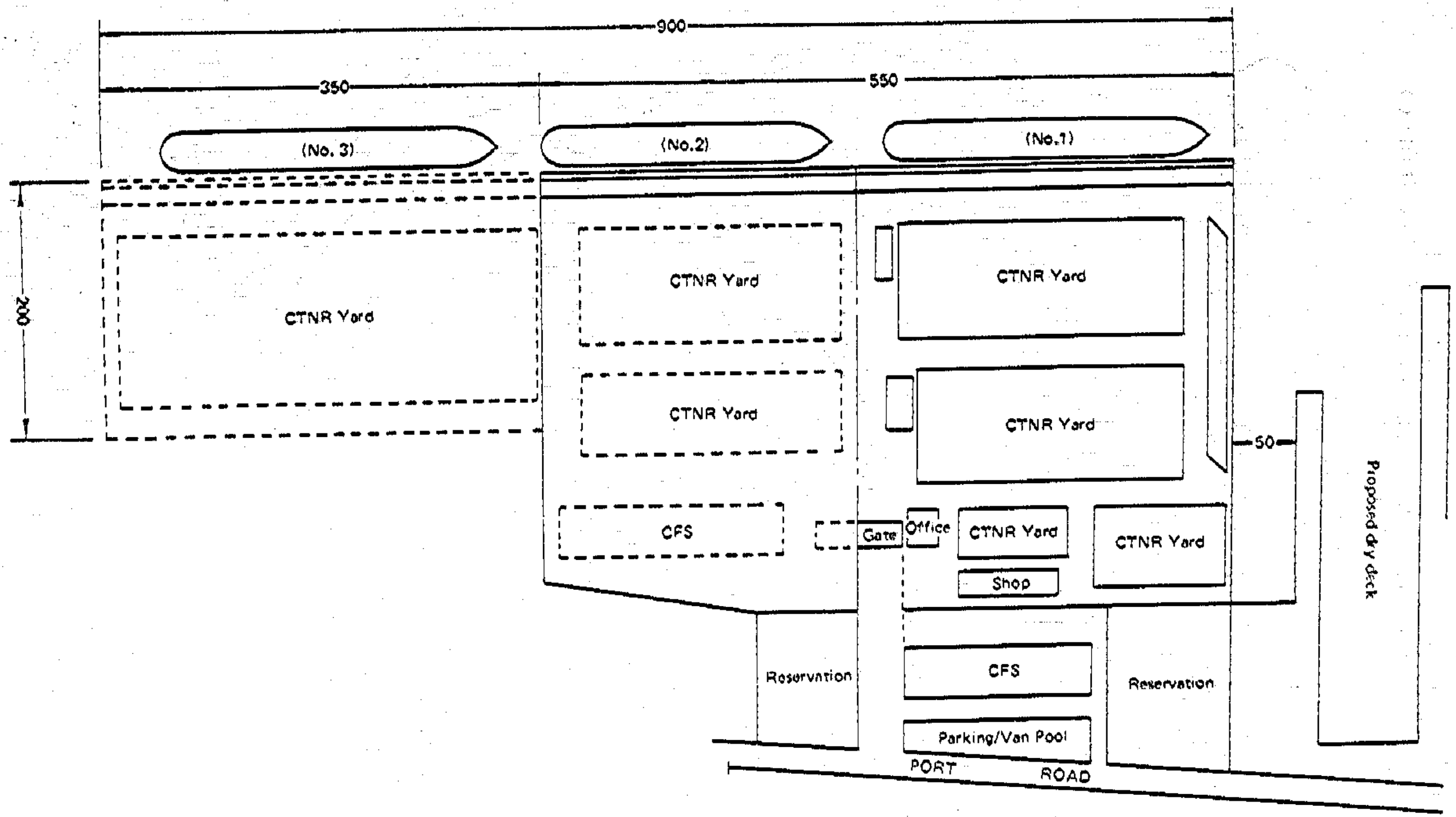


Fig. – IV.3.4 Basic Layout of Korteboam Container Quay (Master Plan)




—— Urgent Plan ---- Master Plan

Fig. – IV.3.5 New Oil Harbour (Proposed by NEDECO)

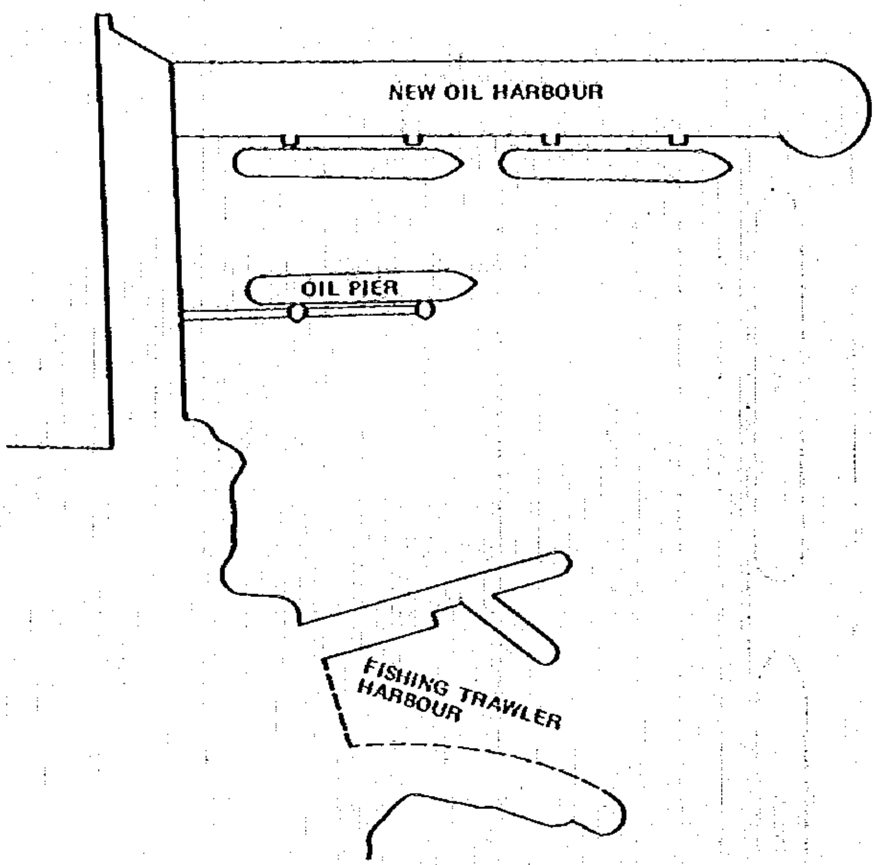
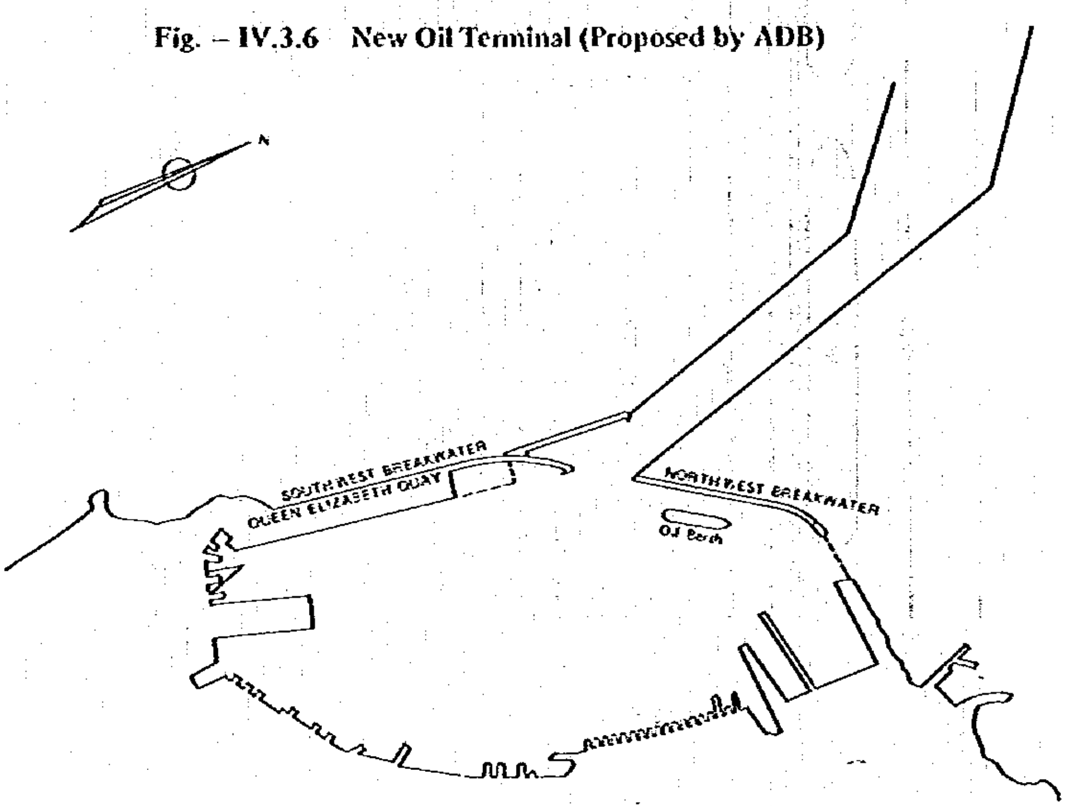



Fig. – IV.3.6 New Oil Terminal (Proposed by ADB)



## Fig. – IV.3.7 Buoy & Pipe Line

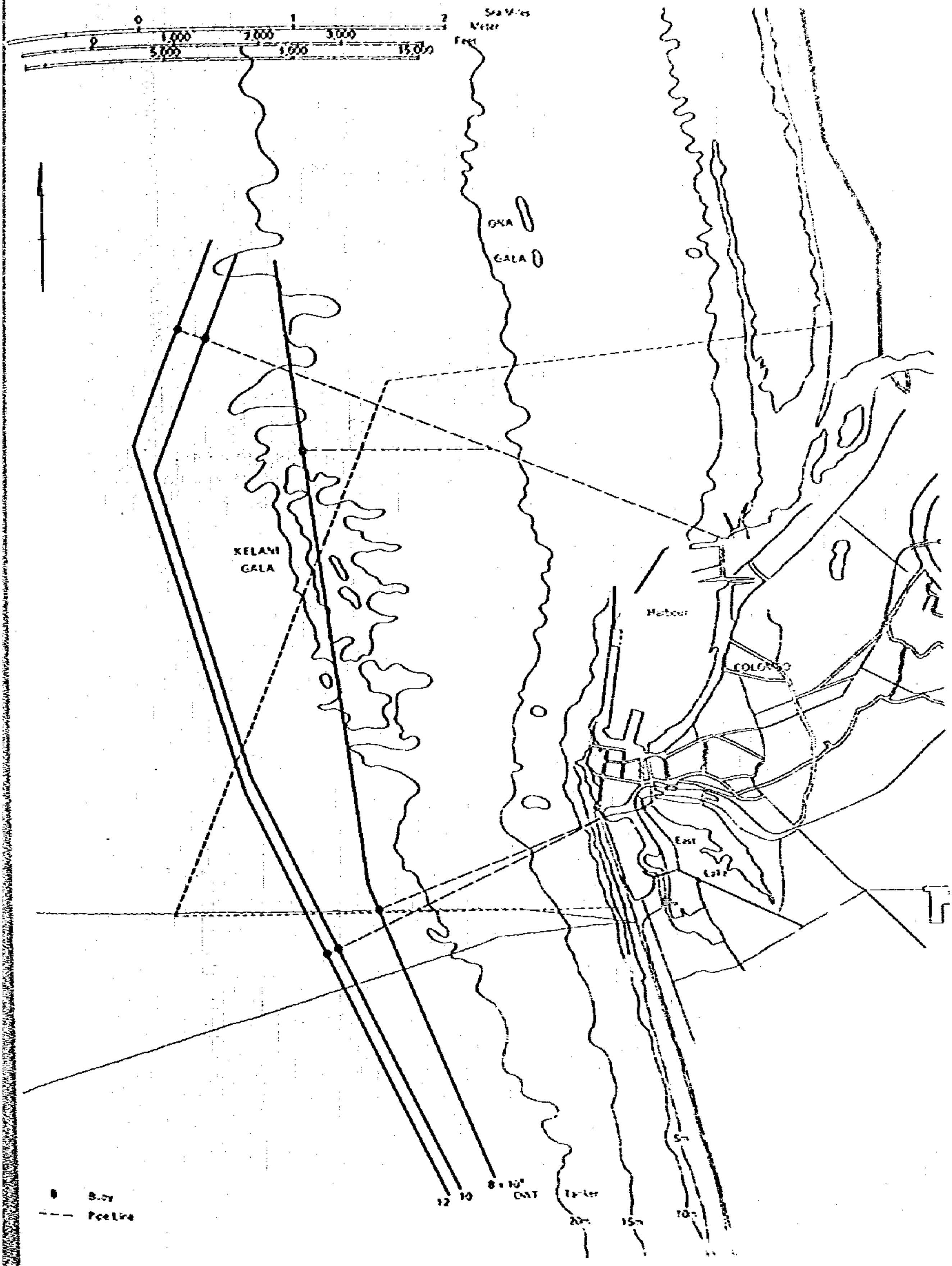
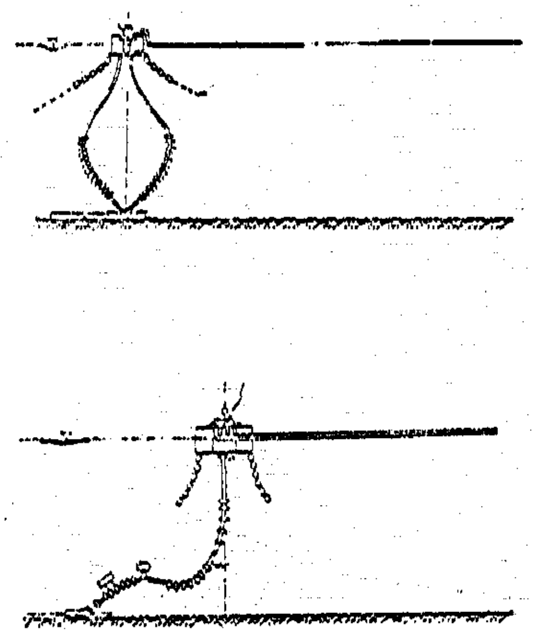
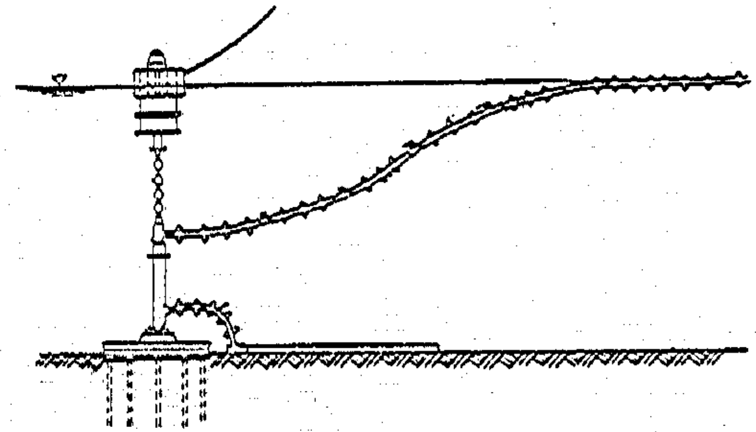


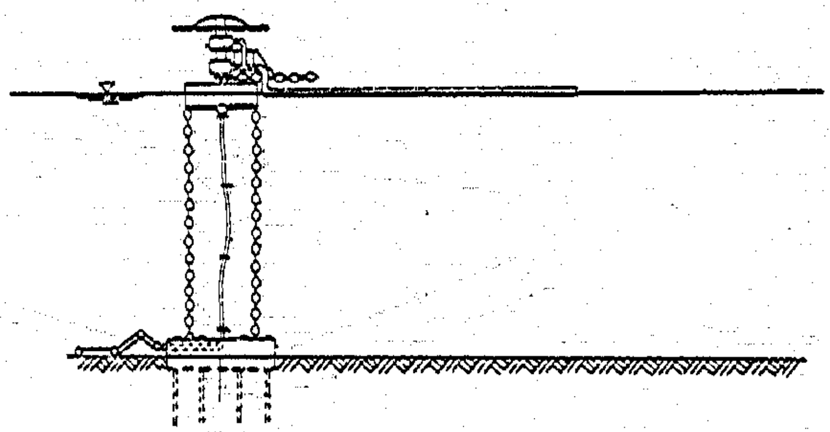
Fig. – IV.3.8 Types of Buoy



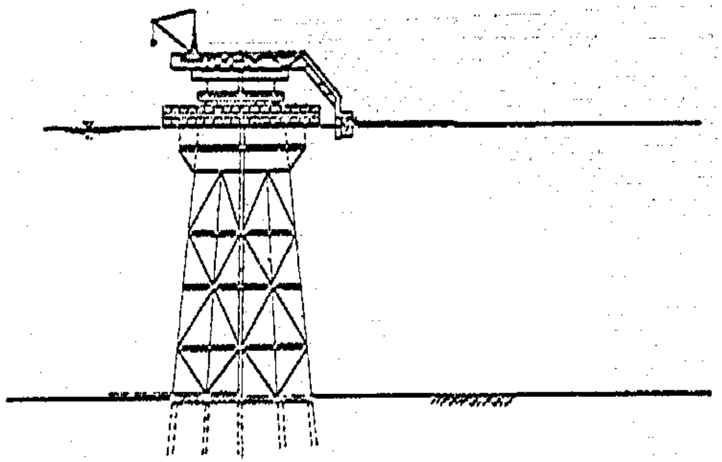
(a) S.P.M. C.A.L.M. Type



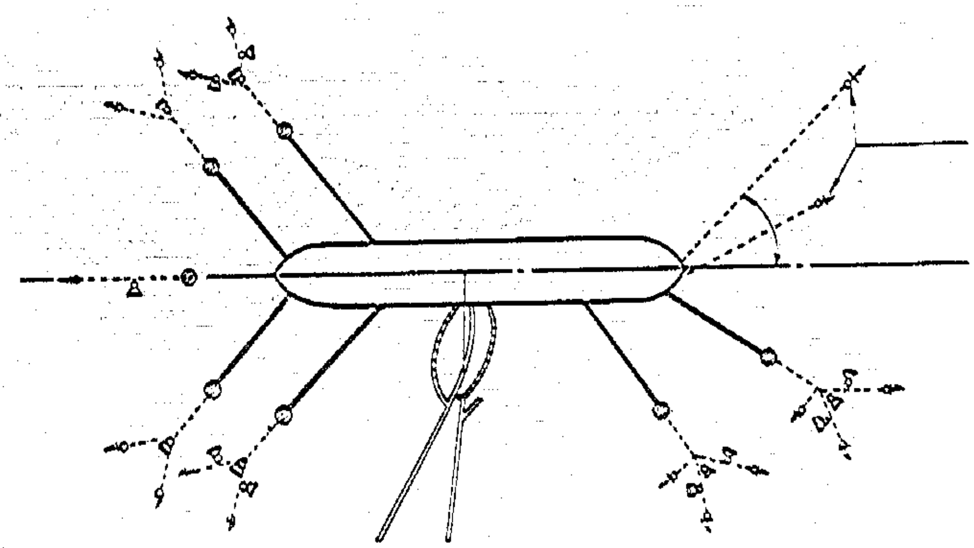
(b) S.P.M. S.A.L.M. Type



(c) S.P.M. V.A.L.M. Type



(d) S.P.M. Tower Type



(e) M.P.M.

Fig. – IV.3.9 Cross Section of NW Breakwater

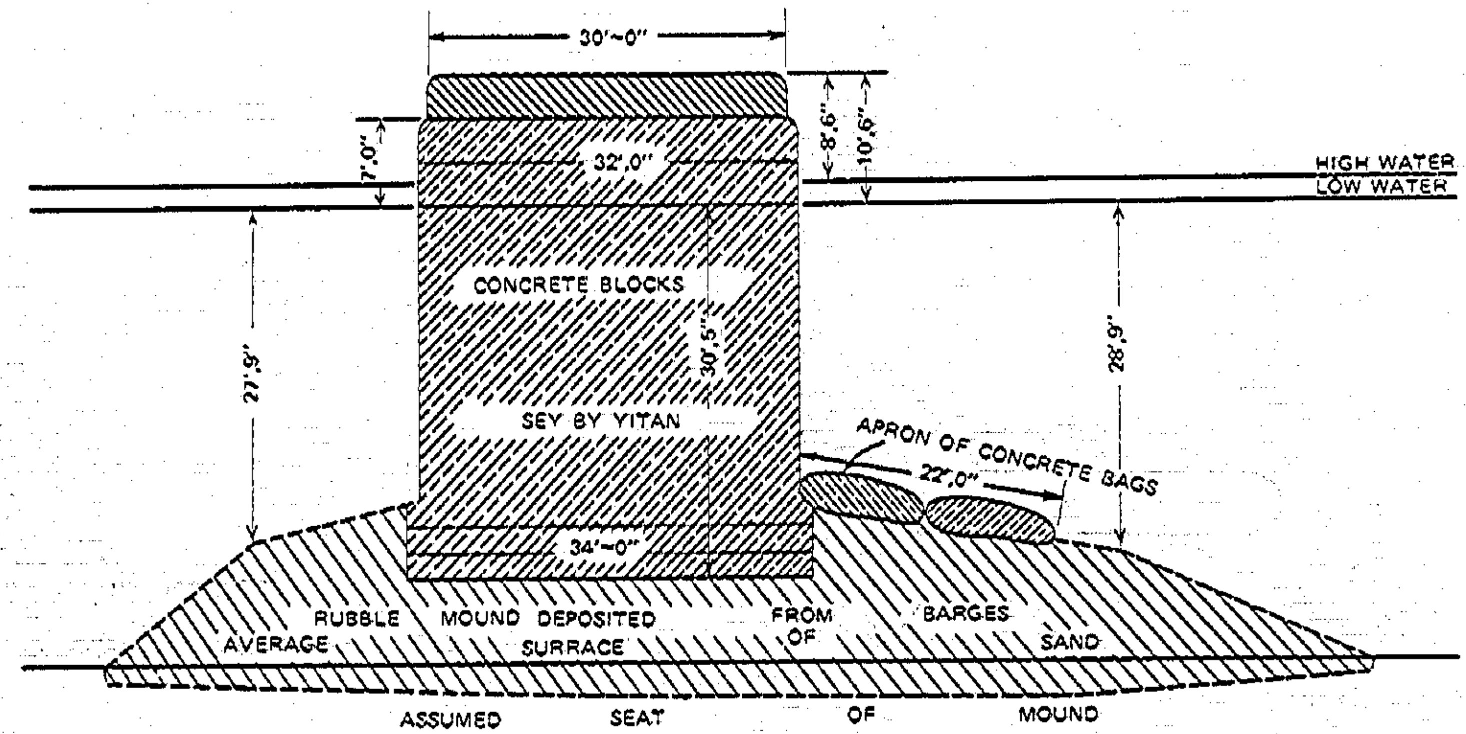
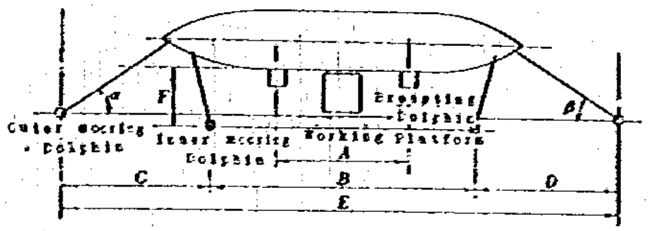


Fig. – IV.3.10 Standard Layout (Dolphin Berth)




| Size \ Factor | A (m) | C (m) | E (m) | F (m) | α (°) | β (°) |
|---|---|---|---|---|---|---|
| 100000 DWT Class | ~90~ | ~110~ | ~450~ | ~30~ | 45° or less | 〃 |
| 200000 | ~105~ | ~120~ | ~450~ | ~40~ | 〃 | 〃 |
| 300000 | ~120~ | ~130~ | ~530~ | ~50~ | 〃 | 〃 |
| 500000 | ~130~ | ~145~ | ~583~ | ~60~ | 〃 | 〃 |

Fig. – IV.3.11 Oil Cargo Handling Facilities (m)

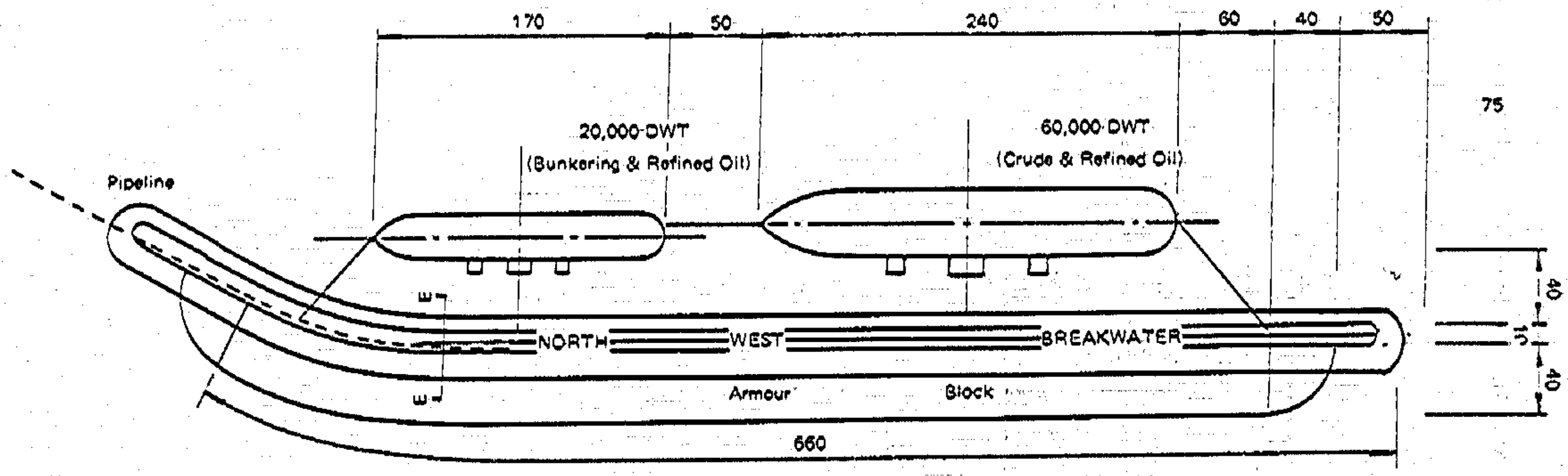


Fig. – IV.3.12 Cross Section, NW Breakwater

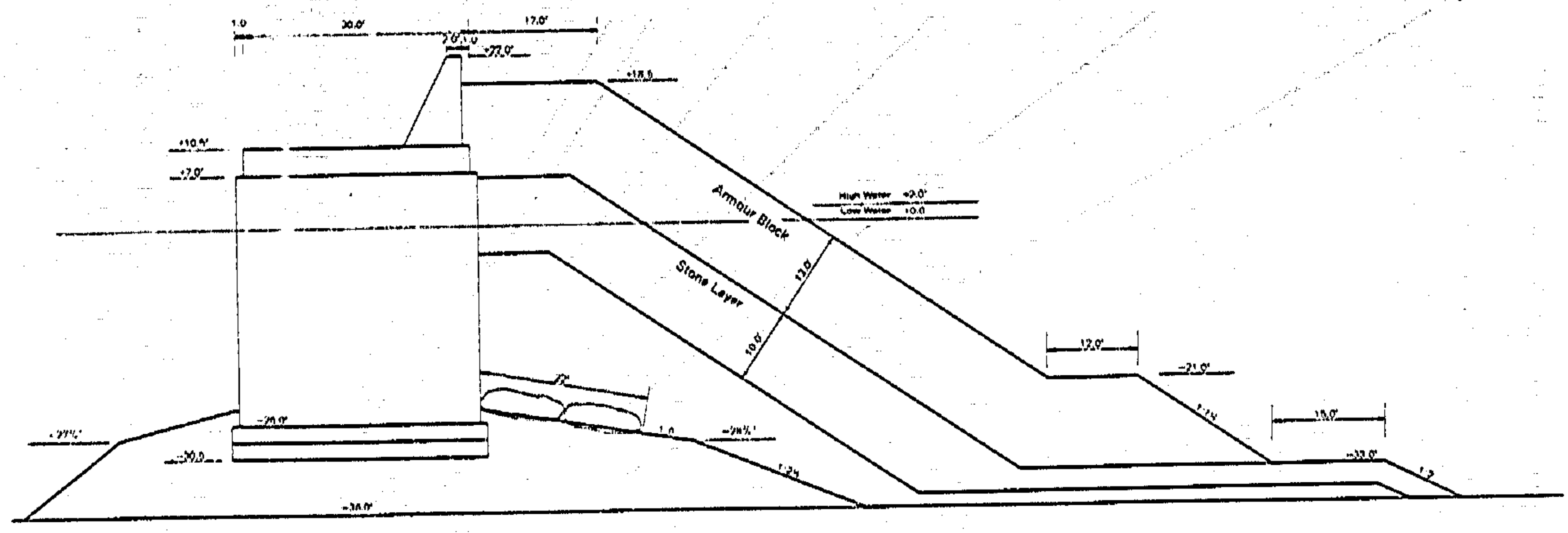
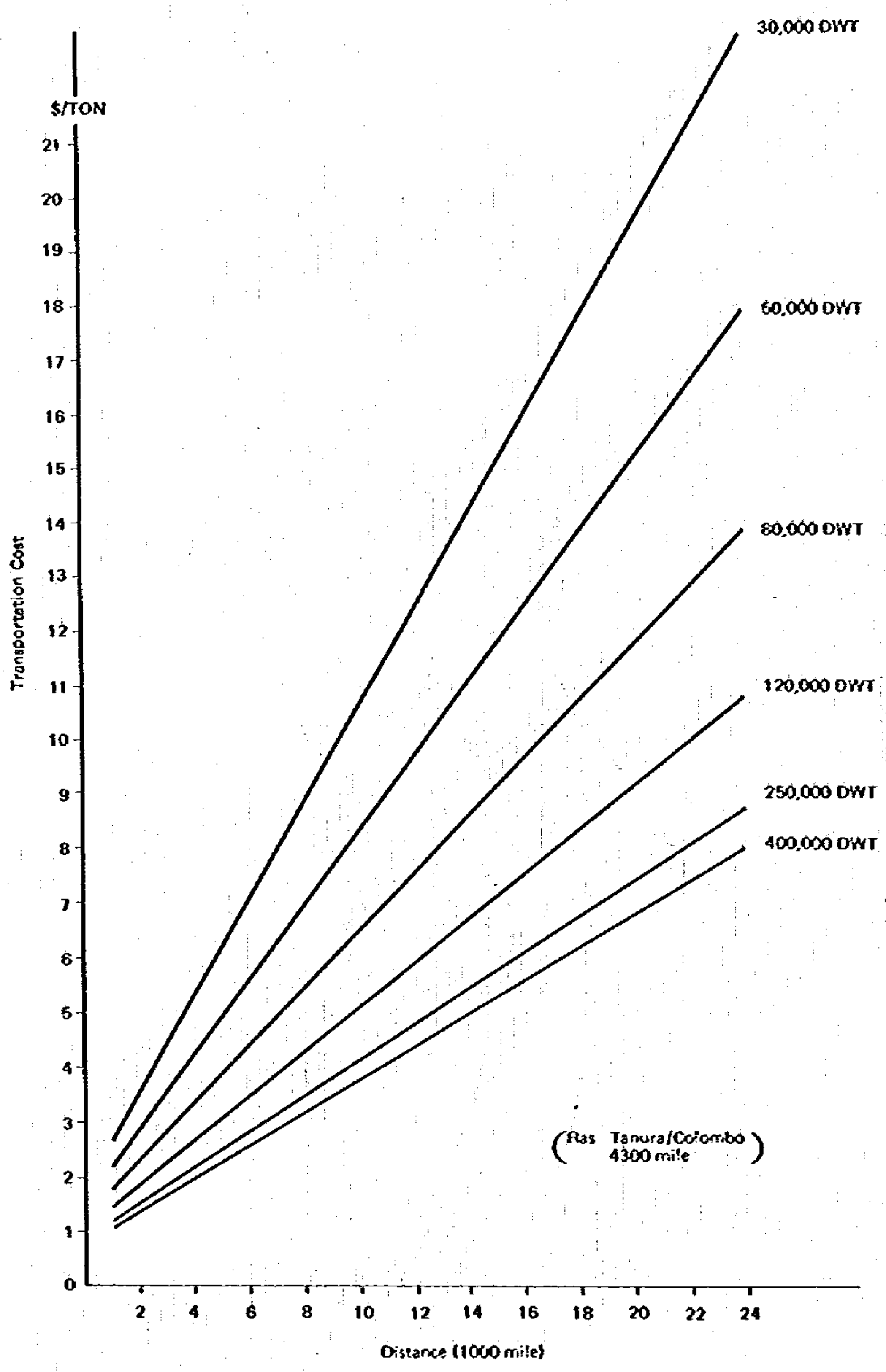


Fig. – IV.3.13 Transportation Cost of Crude Oil



## Fig – IV.3.14 Traffic Volume

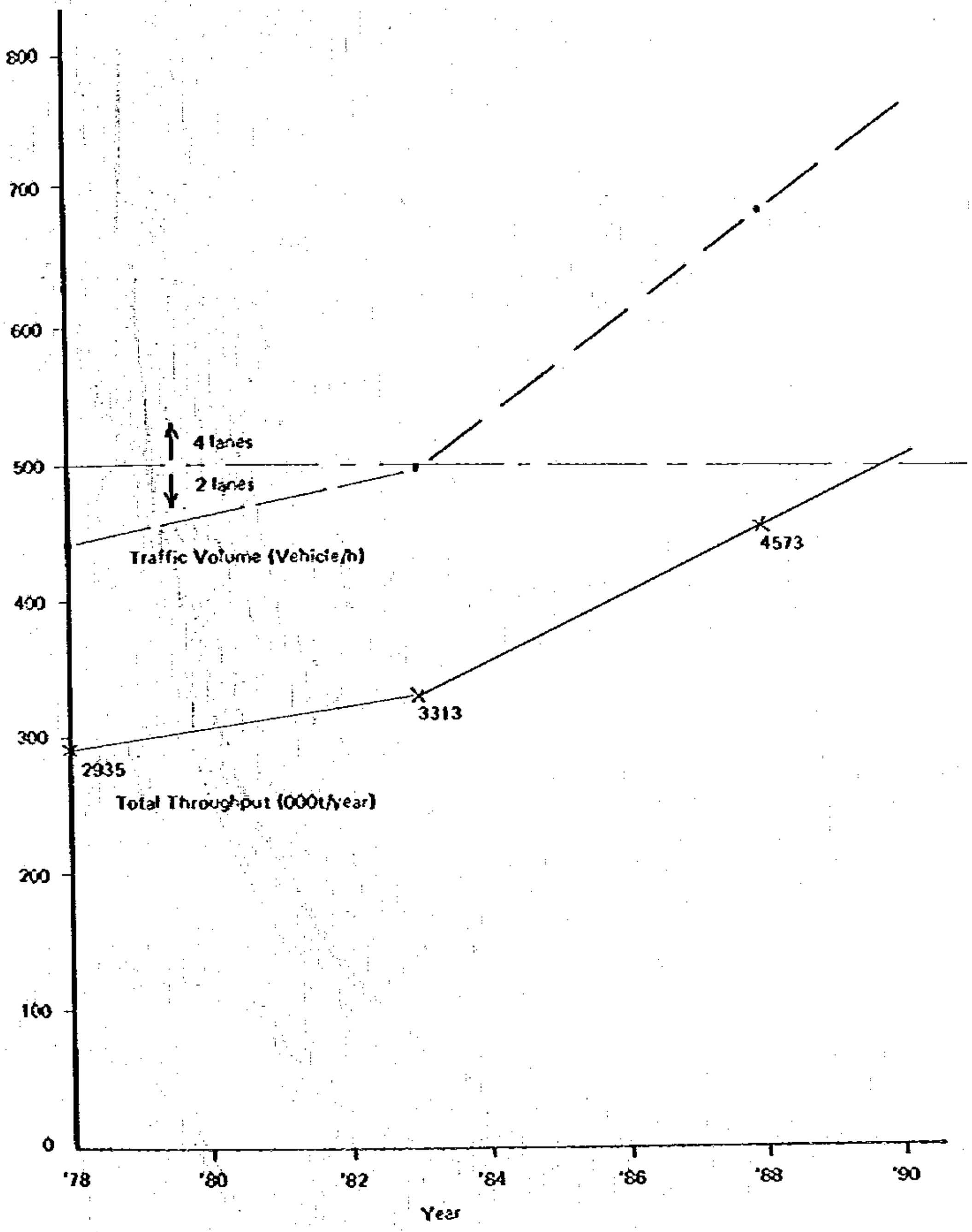


Fig – IV.3.15 Layout of Road, Tunnel and Bridge Planned

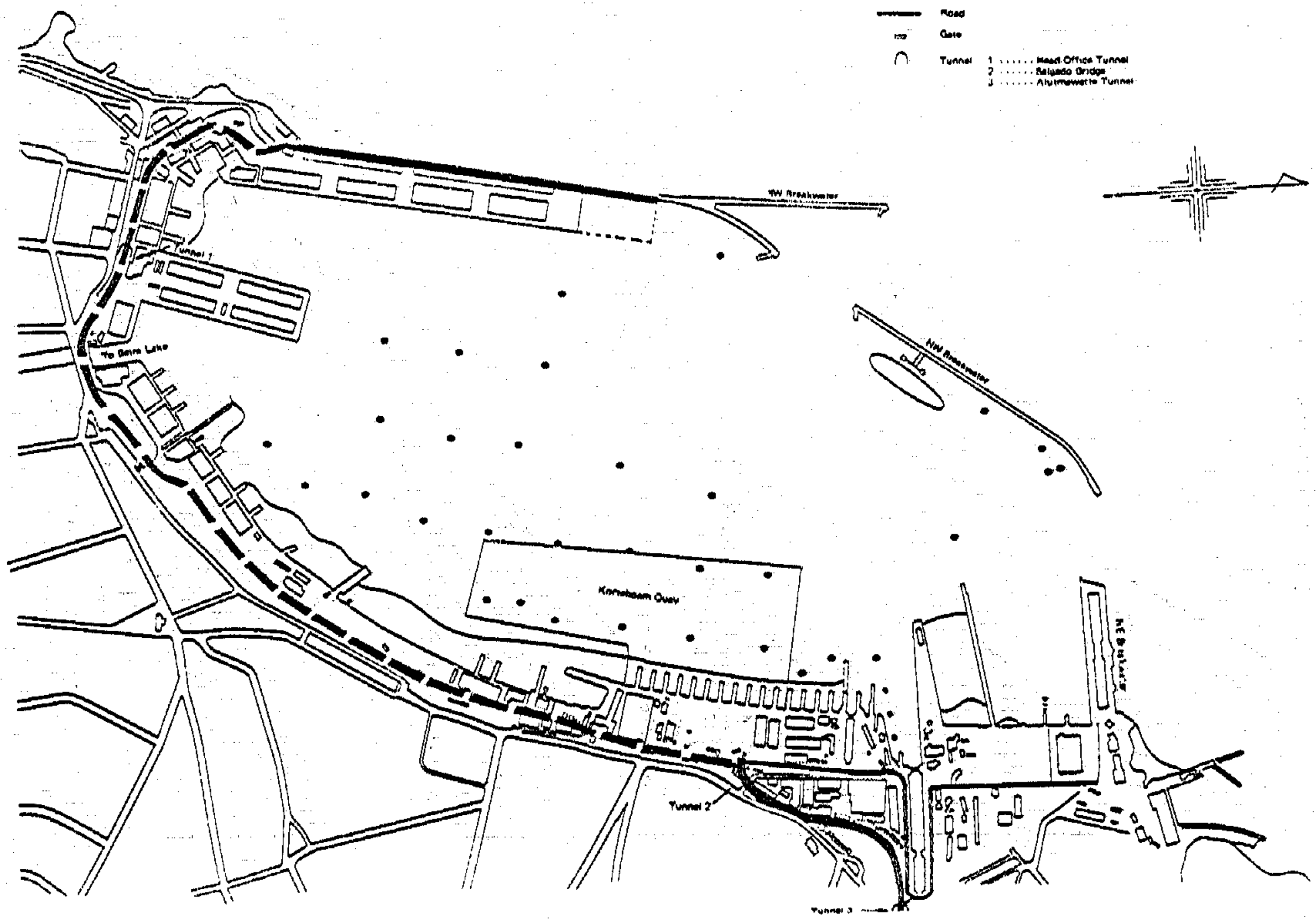
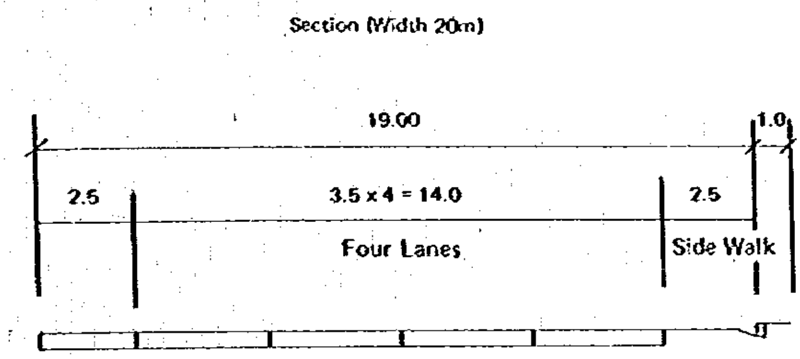


Fig – IV.3.16 Cross Section of Road (m)



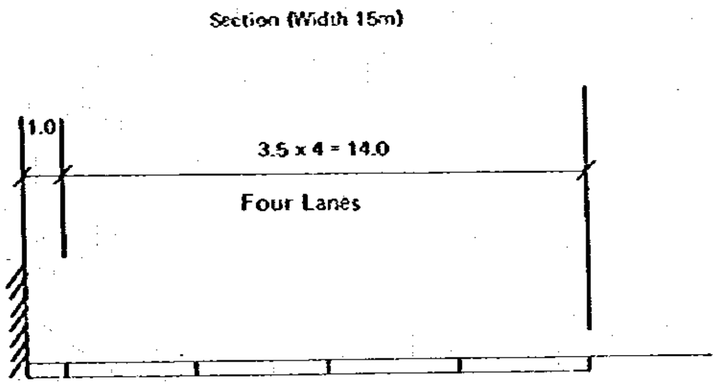



Fig. IV.3.17(a) Approach Channel (Existing)

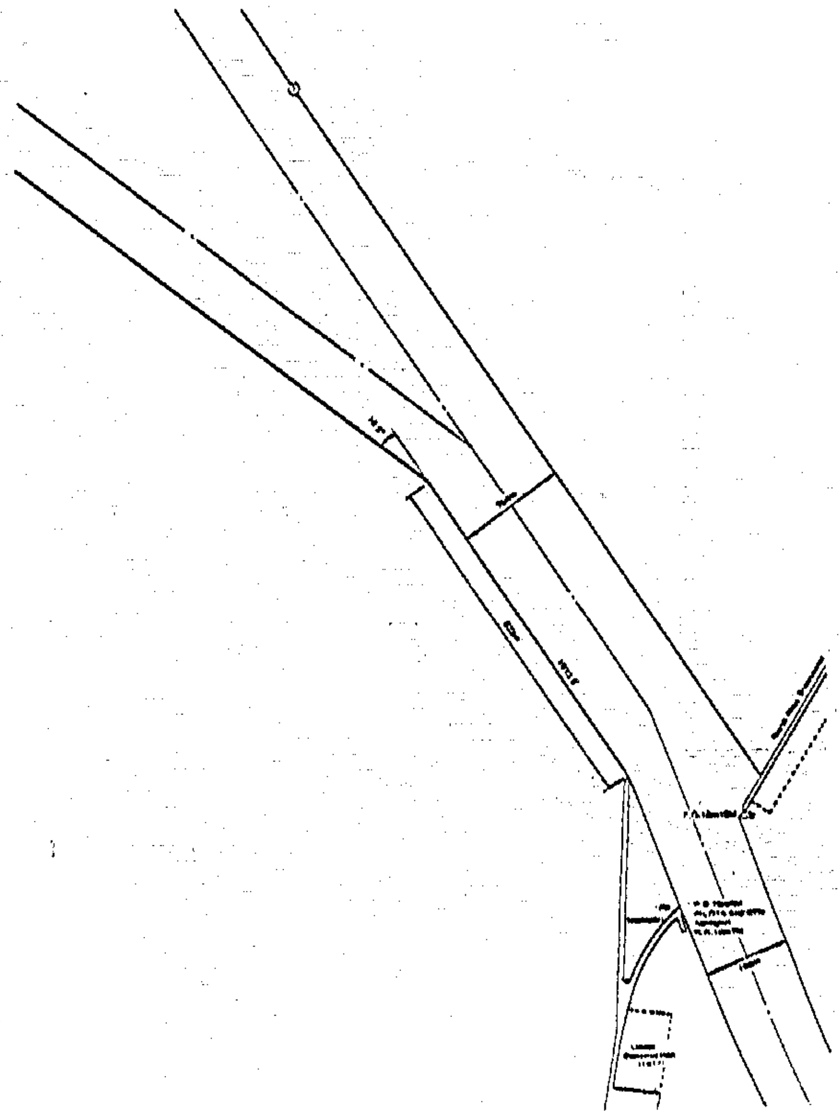


Fig. IV.3.17(b) Approach Channel (Planned)

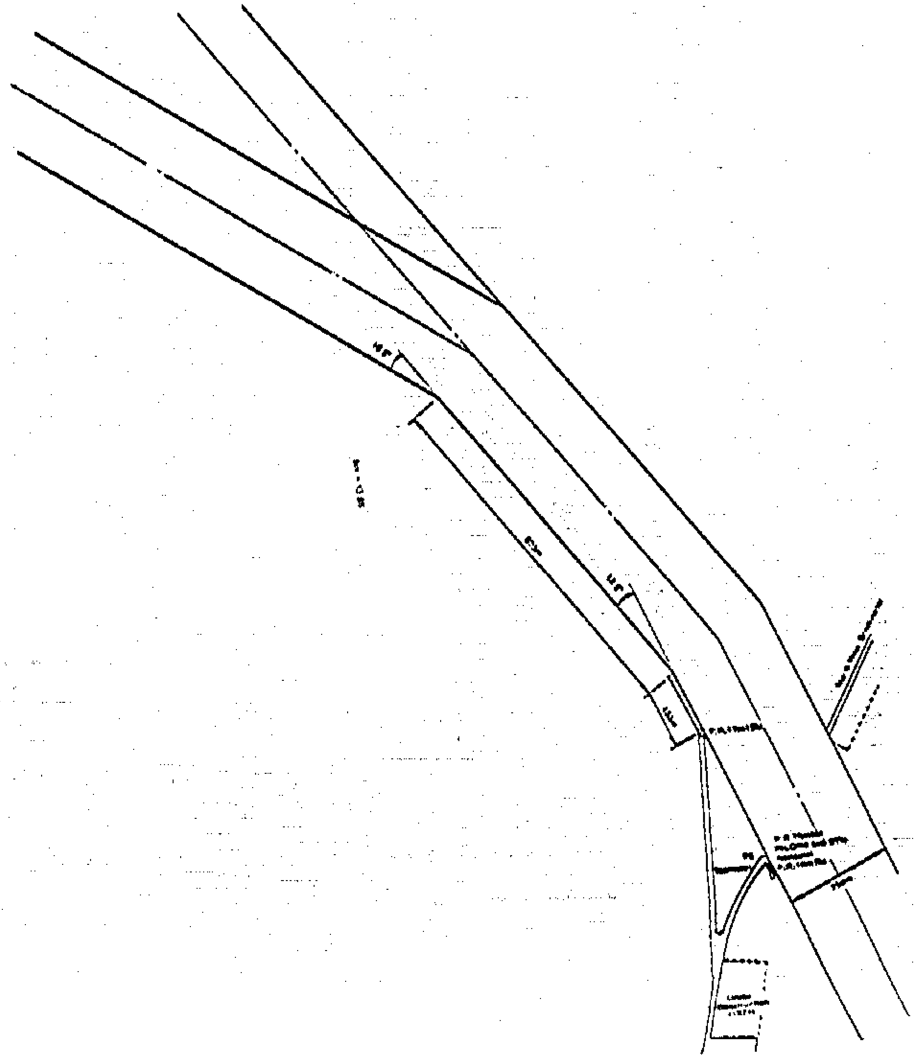
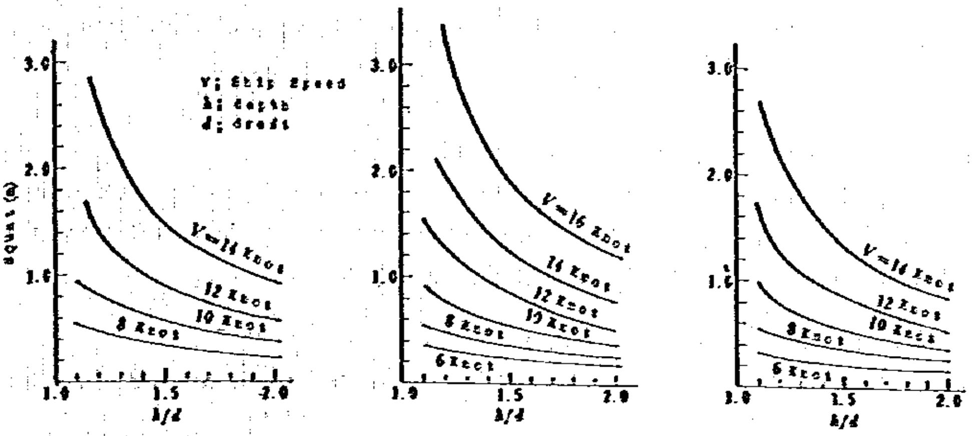


Fig.-IV.3.18 Squat




(a) 100,000DWT (b) 150,000DWT (c) 200,000DWT

# CHAPTER 4 BASIC DESIGN OF STRUCTURES

## 4-1 Types of Structures

Basic design of main port structures required in the planning process for the development project of the Port of Colombo will be stated in Chapter 4. The types of structures for which the basic design has been performed are shown below.

① Basic Design for Seawall for Reclaimed Land
The basic design is performed based on the plan for creating new back-up yard with a 200 m width, to construct the new seawall behind the South-West Breakwater, and to reclaim the space between the breakwater and the seawall.

② Basic Design for New Container Wharf
This is the basic design for the new container wharf to be constructed in the water area in front of the Coaling Jetties.

③ Basic Design for Seawalls
This is the design for seawalls required to widen the north side of the North Quay. Both caisson type seawall (design water depth of −10.0m), and rubble mound type seawall (design water depth of −7.0m) are designed.

④ Basic Design of Breakwater
The South-West Breakwater is expanded by 150 m along the existing channel, and 75 m long existing portion of the North-West breakwater is removed. Basic design is conducted for a 150 m long breakwater to be newly constructed.

## 4-2 New Container Wharf

### 4-2-1 Reclamation Plan and New Wharf Plan

In order to examine the construction costs and construction feasibility which are the determinating factors when establishing the location of a new container wharf, the basic design was made for both (1) Reclamation Plan and (2) New Wharf Plan. The both plans were compared to each other to decide which design has much advantage. The Reclamation Plan stated in this chapter means the plan for reclaiming the area behind the existing South-West Breakwater and to change the Queen Elizabeth Quay into the new container wharf. The New Wharf Plan means the construction of the new container wharf in the water area in front of the Coaling Jetties.

Based upon the results of the survey on the natural conditions at the Port of Colombo, the following design conditions were determined:

(1) Reclamation Plan

| | |
|---|---|
| Design water depth: | −10 m below LWOST |
| Design wave height: | 4.0 m (5-year wave) |
| Allowable over topping: | $6 \times 10^{-2}$ $m^3/m/sec$ |
| Gradient of seabed: | Approx. 1/50 |
| Tide levels: HWOST: | +0.72 m |
| LWOST: | ±0.00 m |
| Soil conditions: | Rock or dense sand |
| Bulk density of concrete: | 2.3 $t/m^3$ |
| Bulk density of rubblestone: | 2.65 $t/m^3$ |

(2) New Wharf Plan

| | |
|---|---|
| Design water depth: | −12.0 m below LWOST |
| Tide levels: HWOST: | +0.72 m |
| LWOST: | ±0.00 m |
| Crown height: | +2.7 m |
| Design load: | Surcharge, 3.0 $t/m^3$ |
| Gross weight of container crane: | 660-ton class |
| Wheel load (quay side): | 38.2 tons/wheel |
| Number of wheels (No. of wheels/leg times leg): | 8 x 4 = 32 wheels |
| Soil conditions: | |
| Sand: | 0 m to −15 m below LWOST |
| Rock: | −15 m below LWOST |

Under the design conditions stated above, 5 alternative designs ranging from Design A to Design E were performed to be compared with each other.

(1) Reclamation Plan

Design A : Gravity-type caisson seawall for reclaimed land (Fig.-IV.4.1)

Design B : Rubble mound-type seawall for reclaimed land (Fig.-IV.4.2)

(2) New Wharf Plan

Design C : Gravity-type caisson quaywall (Figs. -IV. 4.3 (a), (b))

Design D : Steel sheet pile cellular cofferdam type quaywall (Figs. -IV. 4.4 (a), (b))

Design E : Gravity-type cellular concrete block quaywall (Figs.-IV. 4.5 (a), (b))

Though sheet pile-type quaywall, steel sheet pile quaywall with relieving platform and open-type quaywall on piles can be also considered as structures for the New Wharf Plan in addition to the above, the gravity-type quaywall mainly was considered in making comparisons, since the depth of bed rock in this proposed site is shallow as already stated in I-2-4 Soil Condition.

4-2-2 Comparison of Designs

In Tables-IV.4.1 and IV.4.2, main factors that affect the determination of structural types were listed and designs were compared to each other for both the Reclamation Plan and the New Wharf Plan respectively.

As shown in Table-IV.4.1, there is no apparent overall difference between Design A and B. The cost for Design A is slightly lower than the other so that in the Reclamation Plan, Design A was selected as the preferable design for the seawall.

On the other hand, in the New Wharf Plan, Design D is slightly inferior to Design C and E. The construction cost of Design C is higher than that of Design E and the construction work period of Design C is shorter than that of Design E. If ample time is available, Design E is superior than Design C, however, Design C is more appropriate if construction work had to be completed with great urgency, especially in the Urgent Plan.

For the above mentioned reasons, Design A and Design C are selected to examine the construction cost and construction feasibility of the Reclamation Plan and the New Wharf Plan which are included in the Urgent Plan as well as the Master Plan. The overall comparison between the Reclamation Plan and the New Wharf Plan is given in IV-2 Planning of Port Layout and Land Use.

4-3 Revetment for the North Quay Extension

The north side of the existing 10.10 m wide North Quay is not being used at present since wave height in the Port is high during the monsoon season. In order to widen the quay width from 10.10 m to 50.0 m, a new bulkhead will be constructed at the north side of the North Quay. Though the existing revetment is made of rubbles, a caisson-type bulkhead structure will be adopted at the front end section of the North Quay (design water depth: −10.0 m) to prevent the disturbance to sailing ships. But the remaining extent of 300 m (design water depth: −7.0m) will have a rubble mound-type revetment.

The typical section is shown in Fig.-IV.4.6 for the caisson-type bulkhead and in Fig. -IV.4.7 for the rubble mound-type revetment respectively.

4-4 Extension of the South-West Breakwater

Basic design for the South-West Breakwater was made under the following design conditions:

| | | |
|---|---|---|
| Design wave height: | | 6.1 m (25-year wave) |
| Period: | | 9.1 sec. |
| Wave direction: | | Normal to breakwater |
| Coefficient of friction: | | 0.6 |
| Gradient of seabed: | | 1/100 |
| Tide levels: | HWOST: | +0.72m |
| | LWOST: | ±0.00m |

| | |
|---|---|
| Soil condition: | Sand |
| Design water depth: | −13.00 m LWOST |

The typical cross-sectional view of the extended South-West Breakwater is shown in Fig.-IV.4.8.

Table – IV.4.1 Comparison between Designs A & B

| Item | | Design A: Gravity type caisson seawall | Design B: Rubble mounted type seawall |
|---|---|---|---|
| Natural conditions | Soil type (sand or rock) | Proper | Proper |
| | Water depth (-10m) | Proper | Proper |
| Construction work condition | Degree of difficulty of construction method | Difficult | Easy |
| | Necessity for production yard for wave-breaking concrete blocks | Unnecessary | Necessary |
| | Necessity for concrete caisson yard | Necessary | Unnecessary |
| | Scale of concrete plant | Large | Small |
| | Scale of rubblestone storage | Small | Large |
| Construction cost | Rough estimate ($1,000 USD/m) | 22 | 24 |
| Construction period of time | | Slightly shorter than Design B | Slightly longer than Design A |
| Materials | Quantity of concrete used | Small | Large |
| | Supply of concrete | Short supply if only domestic product is used | Short supply if only domestic product is used |
| | Quantity of rubbles used | Small | Large |
| | Supply of rubbles | Development of new quarry is required | Development of new quarry is required |
| Maintenance & repair | Degree of difficulty | Difficult | Easy |
| | Frequency | Low | High |

Table – IV.4.2 Comparison between Designs C, D & E

| Item | | Design C: Gravity type caisson quaywall | Design D: Steel sheet pile cellular cofferdam type quaywall | Design E: Gravity type cellular concrete block quaywall |
|---|---|---|---|---|
| Natural conditions | Soil type (rock or weathered rock) | Proper | Proper | Proper |
| | Water depth (-12m) | Proper | Proper | Proper |
| Construction work conditions | Degree of difficulty of construction method | Easy | Difficult | Easy |
| | Scale of work base | Large | Small | Intermediate |
| | Scale of concrete plant | Large | Small | Large |
| | Work experience (in Japan) | Many | Small | Small |
| Construction cost | Rough estimate ($1,000 USD/m) | 21 | 27 | 20 |
| Construction period of time | | Short | Long | Intermediate |
| Materials | Quantity of concrete used | Large | Small | Intermediate |
| | Supply of concrete | Short supply if only domestic product is used | Domestic product is available in sufficient quantity | Short supply if only domestic product is used |
| | Quantity of sheet piles used | None | Large | None |
| | Supply of sheet piles | Unused | From abroad | Unused |
| Maintenance and repair | Degree of difficulty | Difficult | Difficult | Difficult |
| | Frequency | Low | Low | Low |

Fig. – IV.4.1 Cross-Section of Gravity-Type Caisson Seawall (Design A)

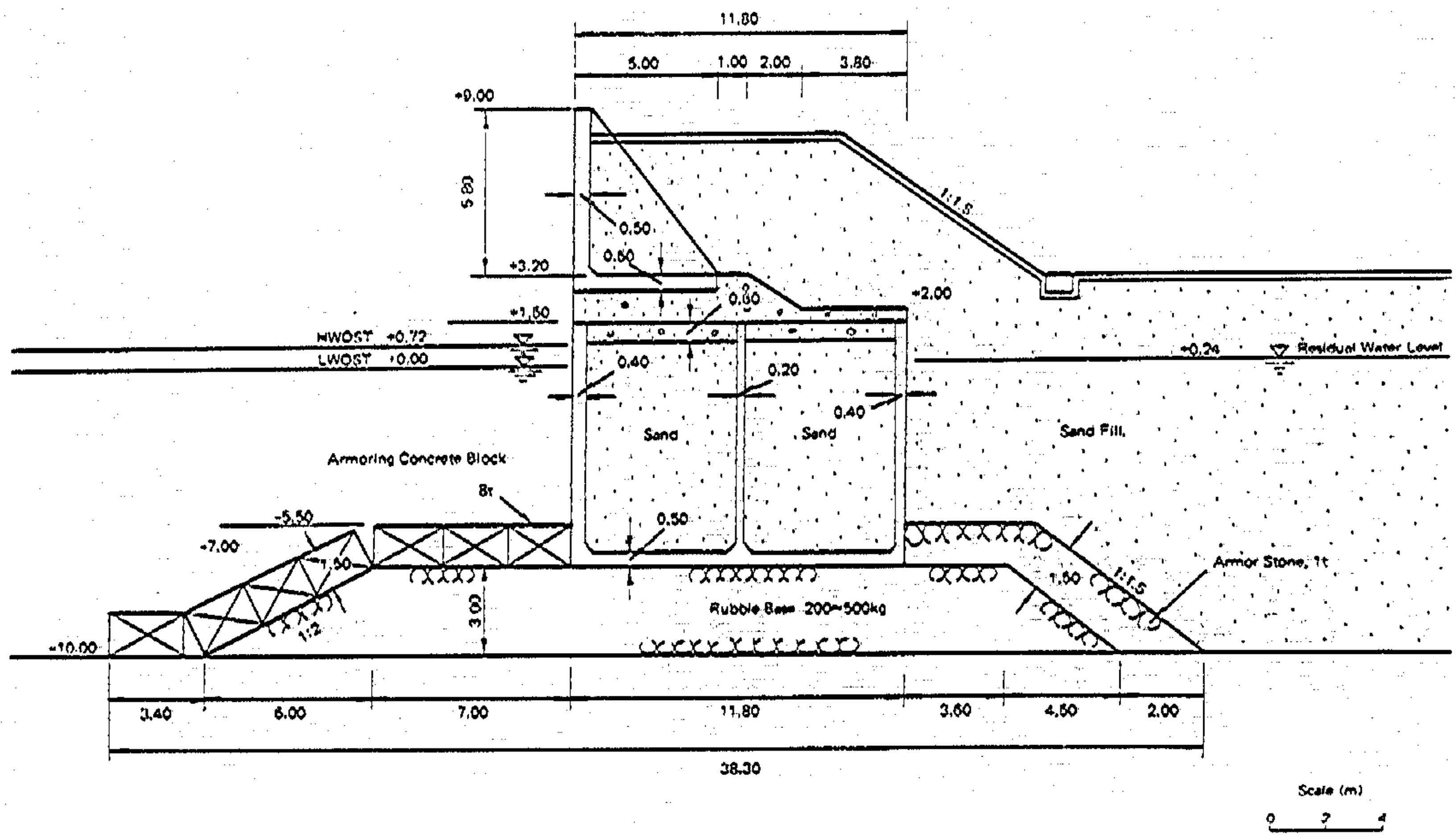


Fig. – IV.4.2 Cross-Section of Rubble Mound-Type Seawall (Design B)

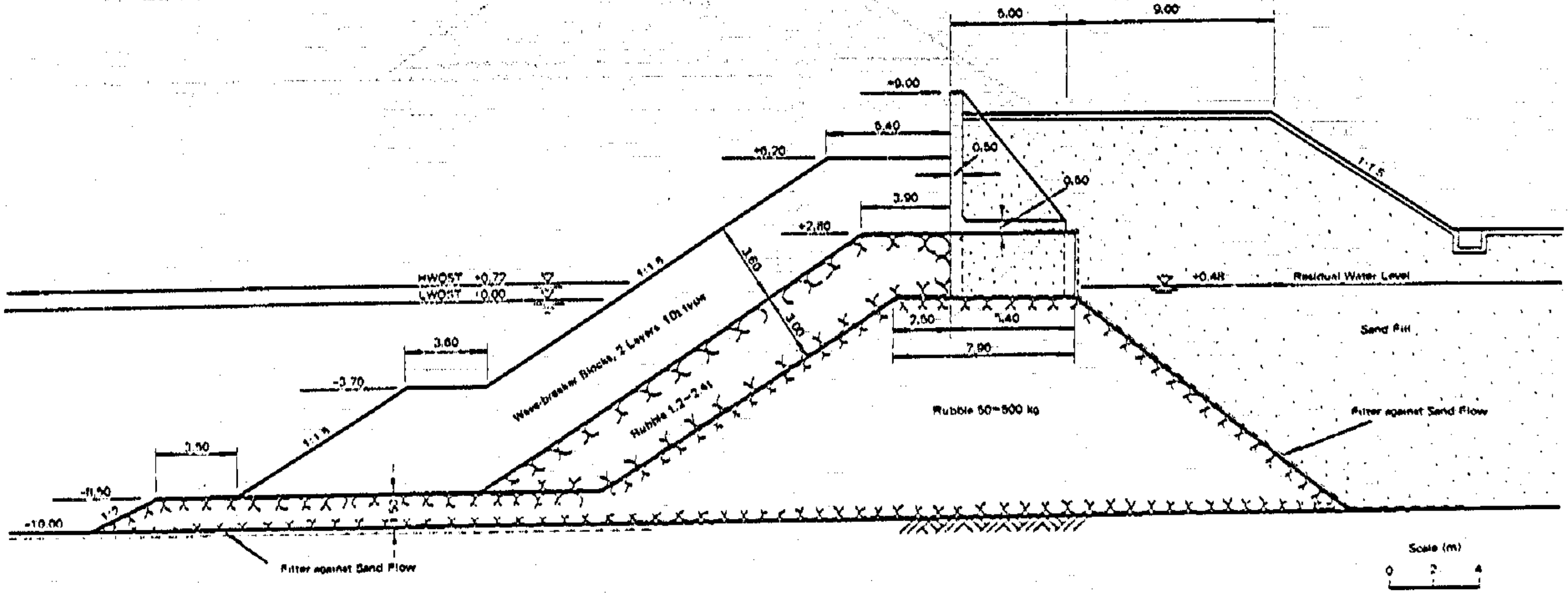


Fig. – IV.4.3(a) Cross-Section of Gravity-Type Caisson Quaywall (Design C)

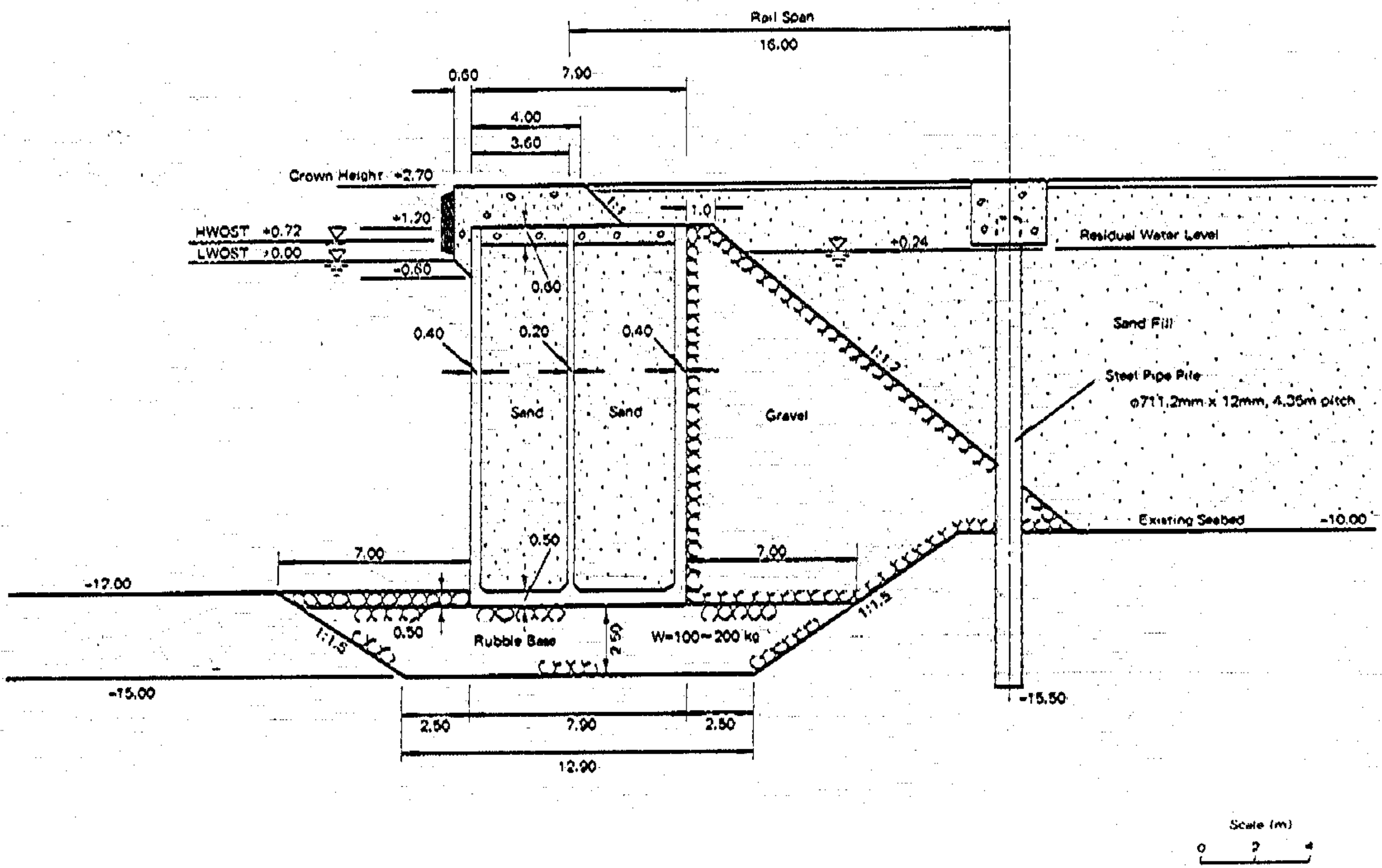


Fig. – IV.4.3(b) Plane of Gravity-Type Caisson Quaywall (Design C)

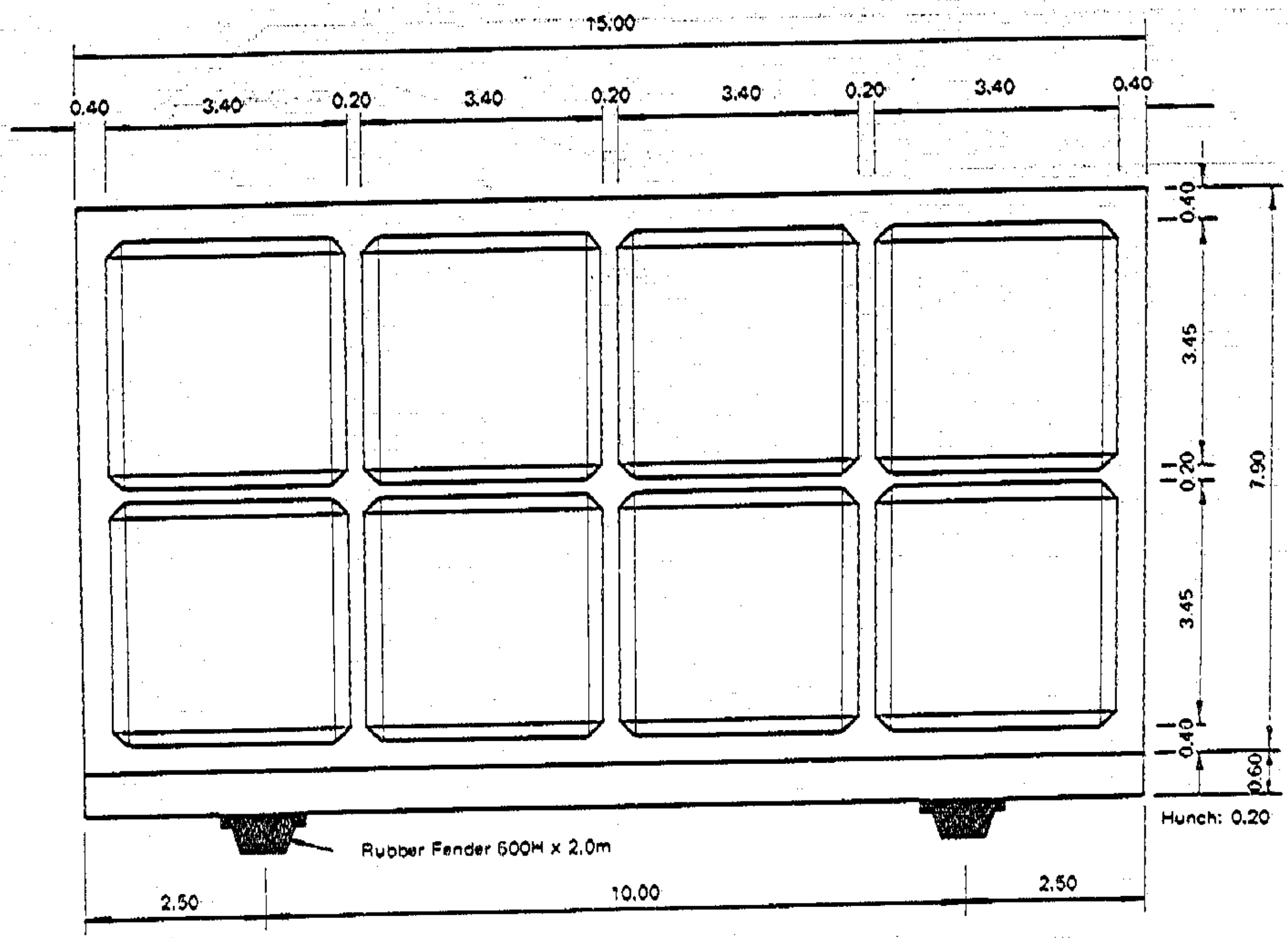


Fig. –IV. 4.4 (a) Cross-Section of Steel Sheet Pile Cellular Cofferdam Quaywall (Design D)

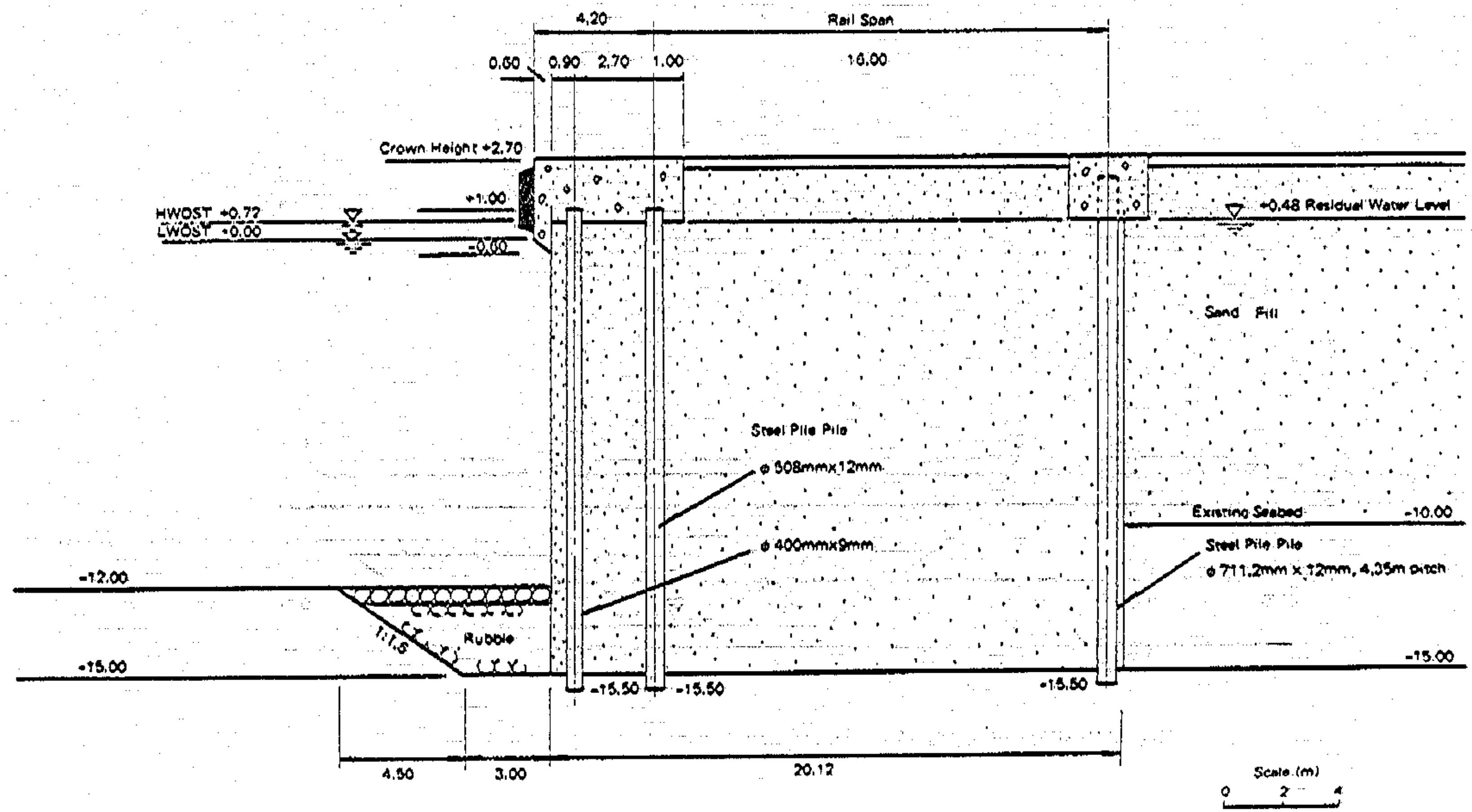


Fig. – IV.4.4 (b) Plane of Steel Sheet Pile Cellular Cofferdam Quaywall (Design D)

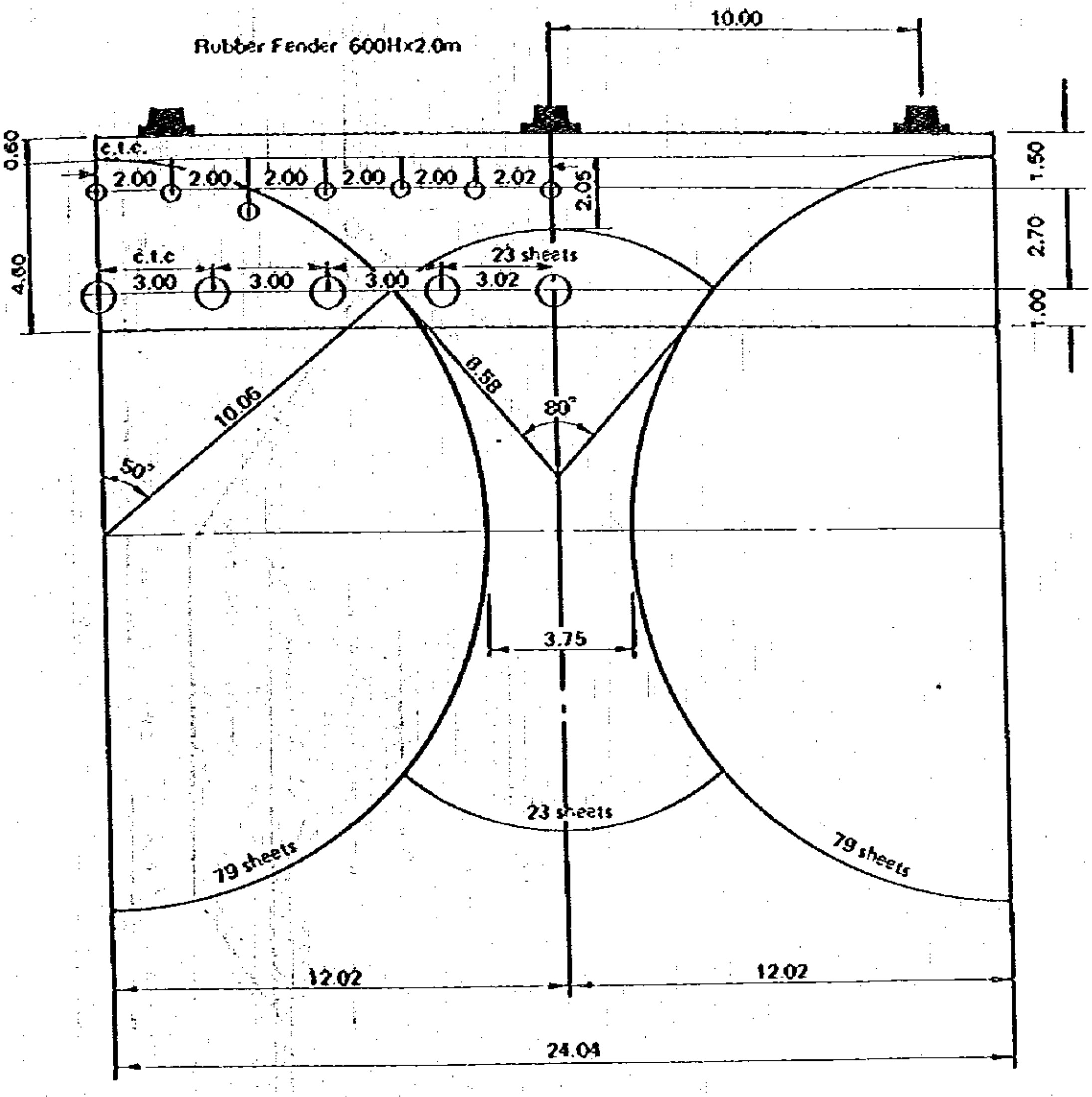


Fig. –IV. 4.5 (a) Cross-Section of Gravity-Type Cellular Concrete Block Quaywall (Design E)

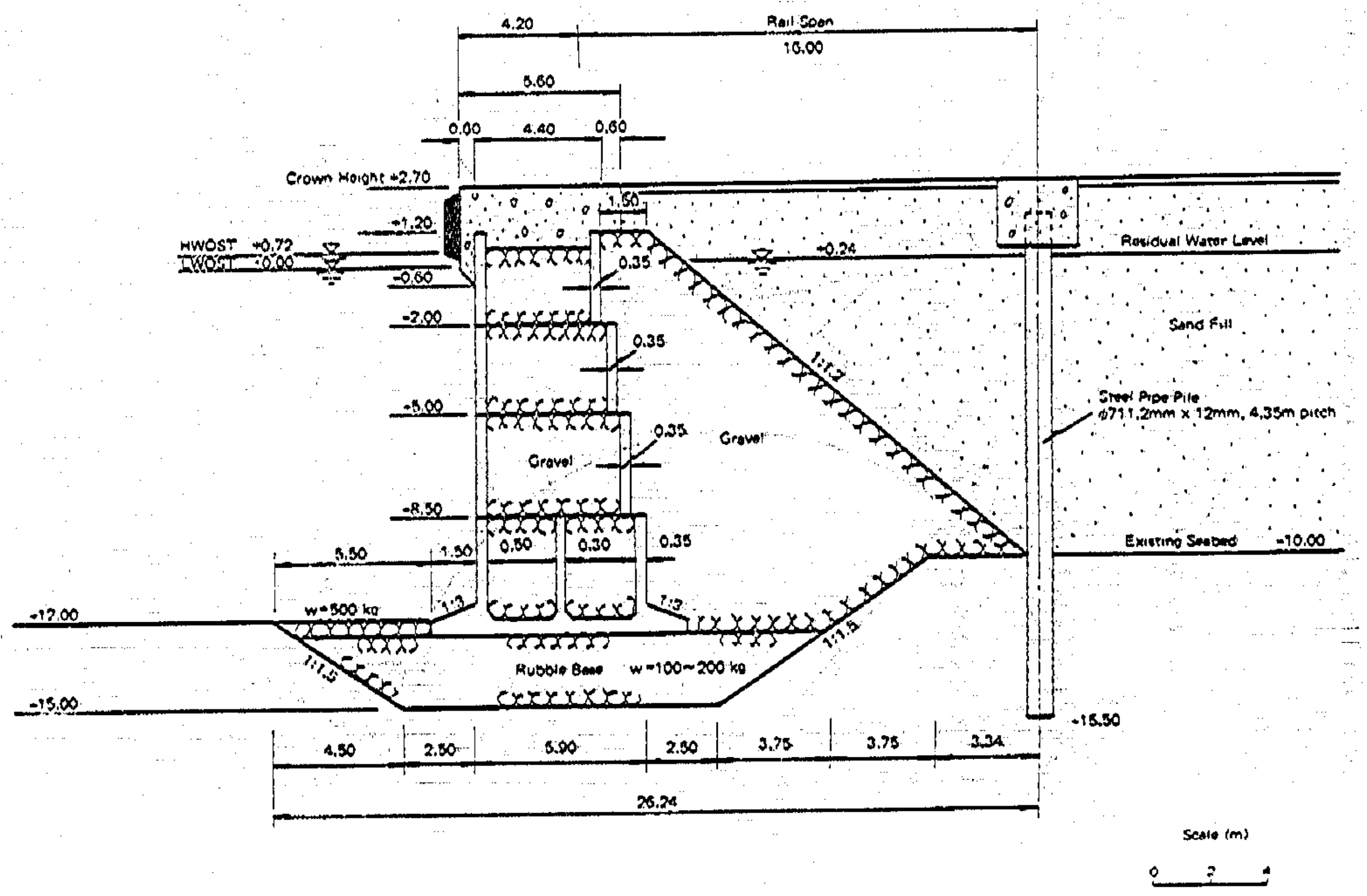


Fig. – IV.4.5 (b) Plane of Gravity-Type Concrete Block Quaywall (Design E)

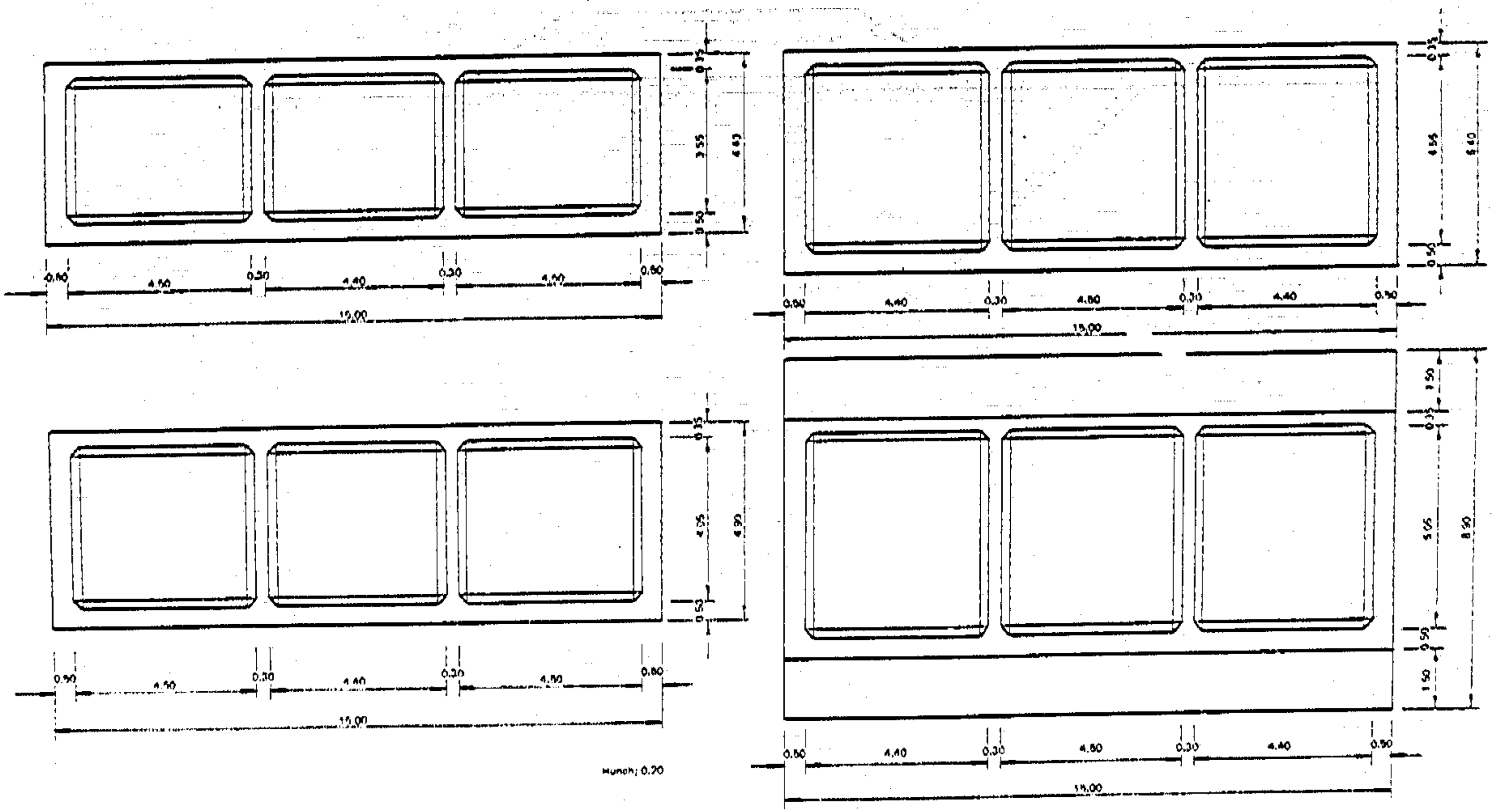


Fig. – IV. 4.6 Cross-Section of Gravity-Type Caisson Quaywall (–10m)

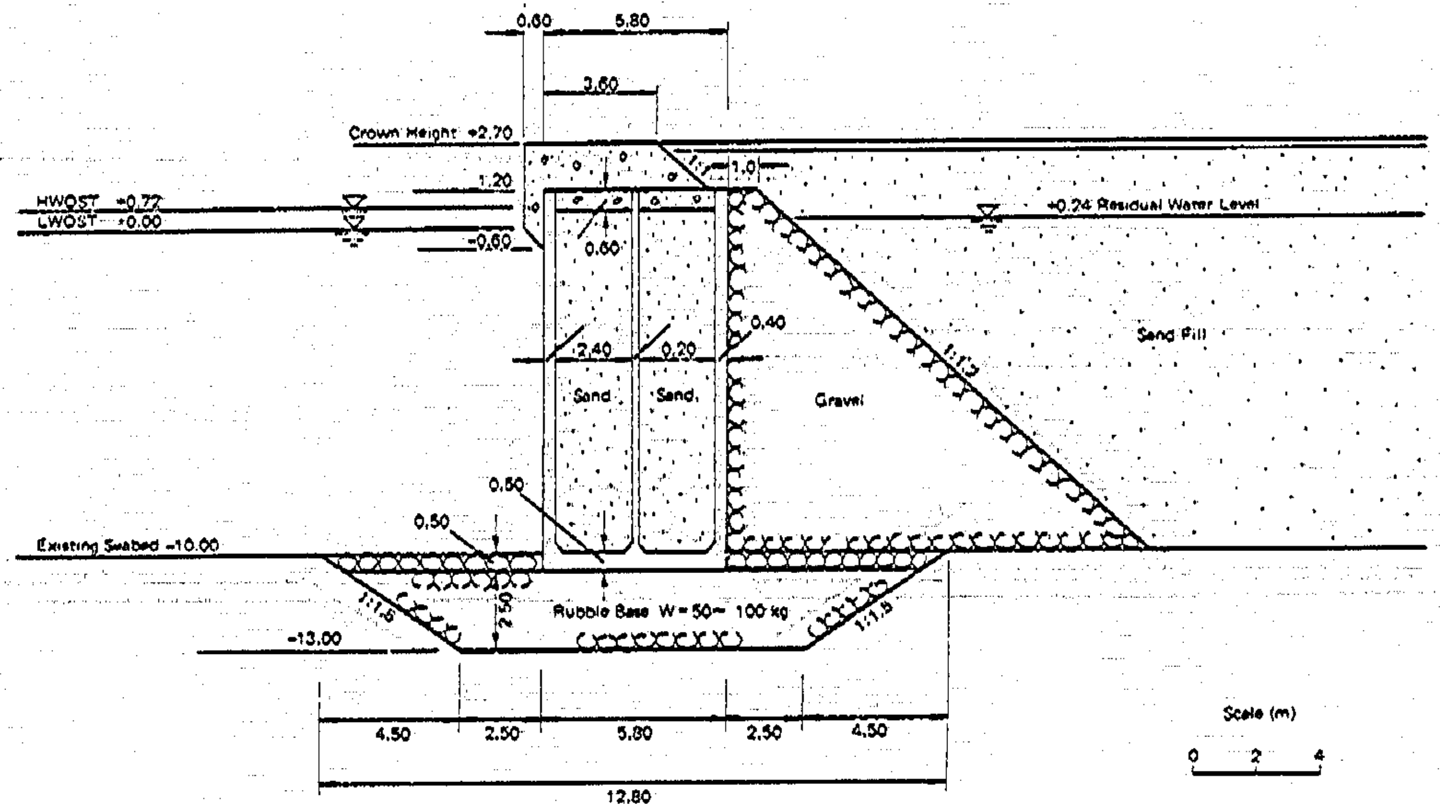


Fig. — IV.4.7 Cross-Section of Rubble Mound-Type Revetment (-7m)

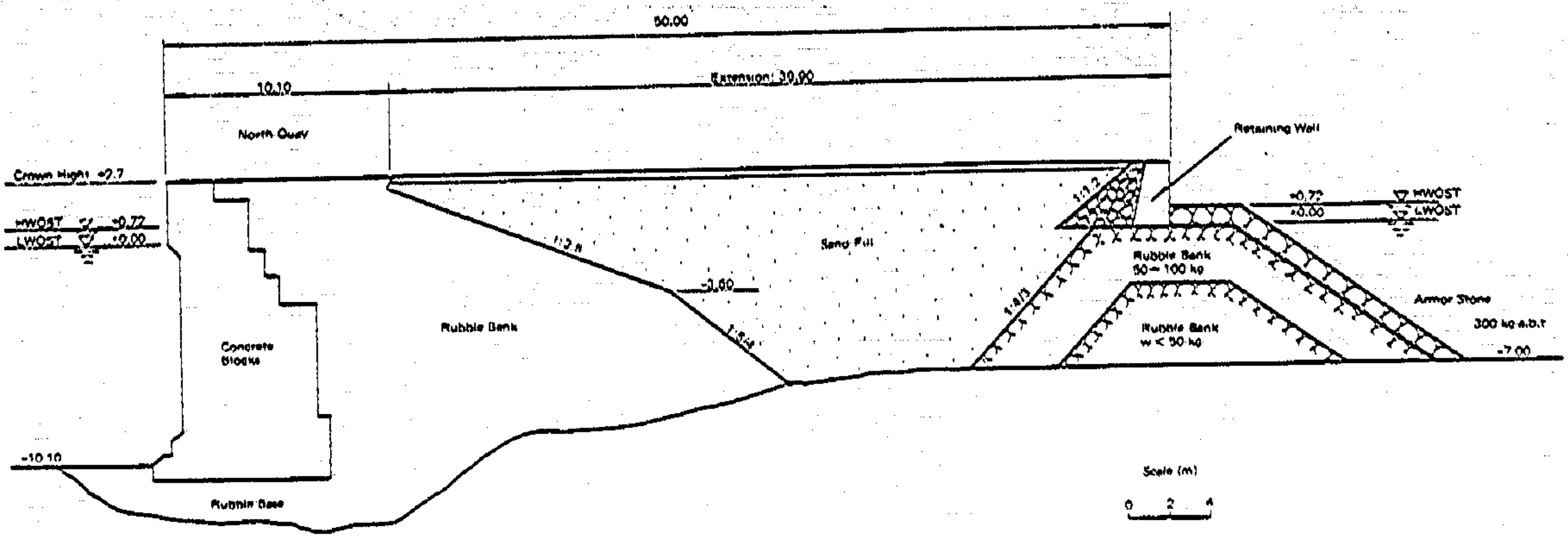
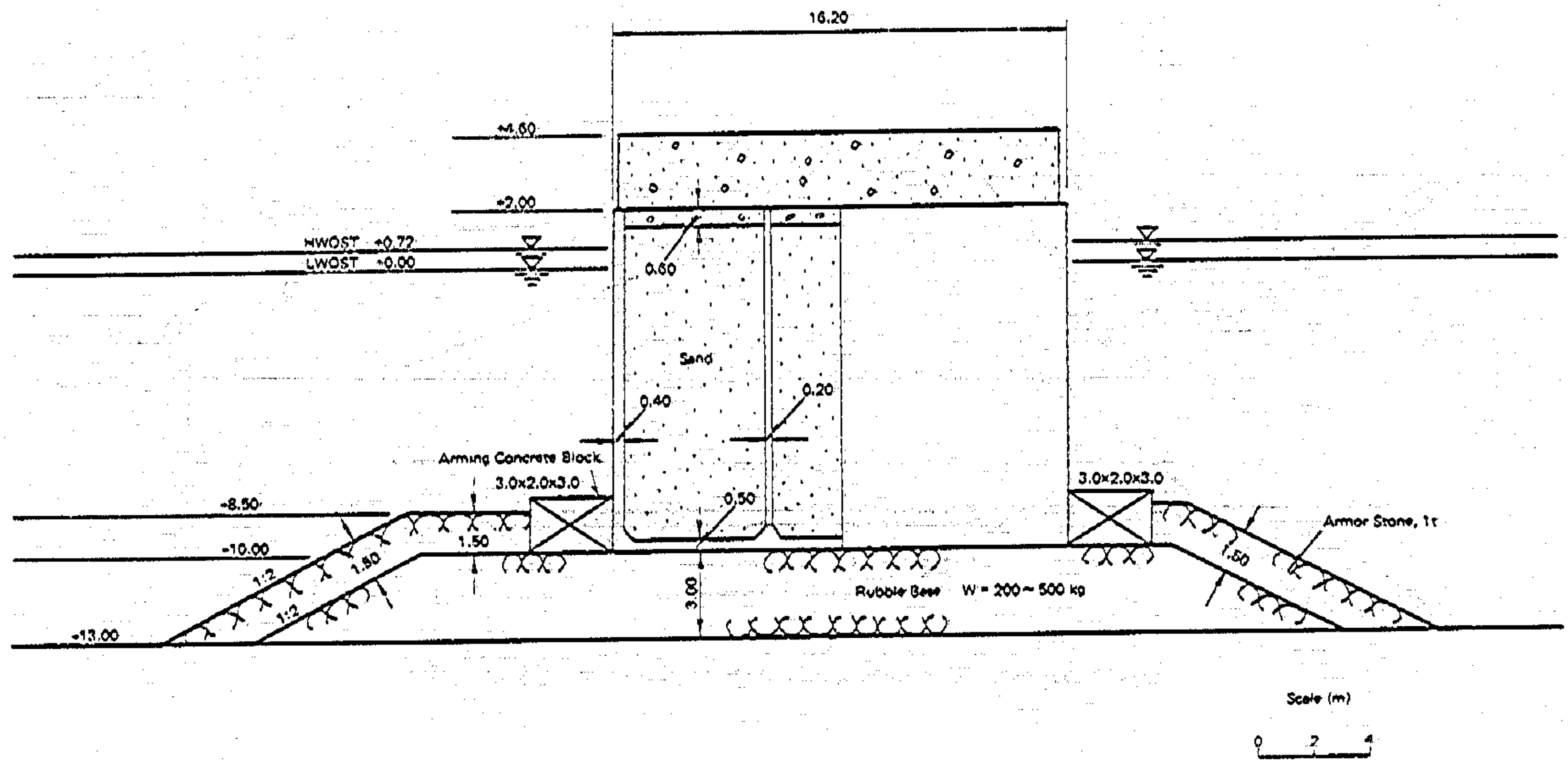


Fig. – IV.4.8 Typical Cross-section of Breakwater (–13m)



# CHAPTER 5 CONSTRUCTION WORK

## 5-1 Conditions for Construction Work

As the Port of Colombo has the Indian Ocean to the west, marine conditions can be generally divided into a clam season and a relatively rough season, depending on the direction of monsoon winds. Assuming days with wave heights greater than 1.0 meter as "rough days", such days account for more than 20% of 30% of the months of June to October, which period therefore can be called the rough season. In other months, less than 1 0% of the days experience wave heights greater than 1.0 meter. However, sufficient calmness is maintained for the Port, as it is sheltered by the South-West Breakwater and North-West Breakwater.

The seabed in the vicinity of the Port of Colombo consists generally of sandy soil so that it can be utilized as fill for reclamation and caissons. However, precautions should be taken as it is anticipated that in certain areas, clayey soil will be sandwiched in depths and bedrock will appear at a shallow depth.

At present, a −12.0 m − quaywall with concrete cylinder structure is being constructed at the Queen Elizabeth Quay No. 5. The work is being performed under the direct supervision of the Colombo Port Commission, and materials such as stone, and fine and coarse aggregates are presently supplied from facilities owned by the Colombo Port Commission in the vicinity of the Port. Though these materials can be obtained from the facilities for the proposed project, it will be necessary to procure equipment from abroad in order to obtain these materials quickly and in quantities. Quarries for producing rubblestone must be newly developed and suitable sites are located near Colombo. Though cement is domestically manufactured, imported cement is also used to meet the large demand in this country where large projects such as "Mahaweli" is underconstruction.

## 5-2 Method of Construction

Major works proposed for the Project are shown in Table-IV.5.1.

Location of each work is shown in Fig. -IV.5.1. In respect of the structure of the major works, one of gravity-type caisson quaywall was selected because of the possibility of bedrock appearing in shallow depths and the requirements for speedy and economical execution.

For producing caissons, a caisson yard must be provided. Presently, the shoreline of the Port is fully used for cargo handling, docks, ship repairing and other purposes so that there is no space for constructing the yard in the Port. Also, there is no suitable site for the construction of the yard in the vicinity of the Port of Colombo. In addition, it is required to provide such facilities where by about 6 caissons can be produced at a time to satisfy the requirement for construction speed, and the construction of such a large yard will require a considerable amount of investment and time. Therefore, the caissons will be produced on a floating dock in the Port of Colombo. As the slip Ⓐ shown in Fig.-IV.5.1 has the capacity of 1,200 tons, it can be utilized as an auxiliary means of caisson production. Also, the building Ⓑ in Fig.-IV.5.1 can be utilized without modification as shop for fabricating concrete forms and reinforcing bars.

Construction procedures for caisson type quaywall and revetment are stated in V-4-1 "Construction of Korteboam Quay".

Reclamation fill will be obtained by a large pump dredger from the seabed outside of the Port and directly transferred to the reclamation area through discharge pipes.

Target year for completion of each proposed facility is shown in Table -IV.5.2.

The Construction schedule for the Master Plan is shown in Table -IV.5.2.

## 5-3 Sunken Crafts

There are a total of 12 sunken crafts in the Port of Colombo. Locations and types of such crafts are shown in Fig. -IV.5.2, and Table -IV.5.3, respectively of these crafts, those marked with ⑤, ⑥, ⑩ and ⑫ must be removed at the stage of execution of the Master Plan. The costs of their removal are not included in chapter 6 "Rough Estimate of Construction Costs".

## Table – IV.5.1. Facilities to be Constructed

| No. | Facilities | Major works to be performed | Quantity | Target year for completion |
|---|---|---|---|---|
| 1 | Containerization QEQ#5 | Crane foundation (pile foundation) | 200 m | 1981 |
| 2 | KQ contriner terminal (3 berths) | -12m quaywall (caisson type)<br>-7.5m to -10m revetment (caisson type)<br>Reclamation (11m x 235,000 $m^2$)<br>Heavy pavement (900m x 200m + 550m x 100m)<br>CFS | 900 m<br>1,010 m<br>2,600,000 $m^3$<br>235,000 $m^2$<br>16,000 $m^2$ | 1983 for 550m of quaywall<br>1987 for 350m of quaywall |
| 3 | Oil Berth | Main dolphin (caisson type)<br>Bunkering dolphin (caisson type)<br>Pipeline<br>Wave dissipating concrete block/Seawall | 1 set<br>1 set<br>1,600 m<br>700 m | 1983 |
| 4 | North Pier | -4m to -10m revetment (rubblestone type)<br>-10m revetment (caisson type)<br>Reclamation (11m x 50m x 360m)<br>Pavement (80m x 360m) | 360 m<br>50 m<br>198,000 $m^3$<br>18,000 $m^2$ | 1985 |
| 5 | Road in port (4 lane) | Improvement of existing road (5.0 km), Construction of new road (0.7 km), and 2 tunnels. | | 1982, 2 Lanes<br>1986, 4 Lanes |
| 6 | Dredging of waterway | -15.5 m | 1,240,000 $m^3$ | 1983 |
| 7 | Dredging of turningbasin | -14.0 m | 3,500,000 $m^3$ | 1983, 1987 |
| 8 | SW Breakwater | Work for 150 m of extension | 150 m | 1982 |
| 9 | NW Breakwater | Demolishing 75 m of existing portion | 75 m | 1983 |

## Table – IV.5.2 Construction Schedule for Master Plan

| Item | | | Quantity | | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | Target year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Civil Engineering Works | QEQ #5 | Containerization | 200 | m | | | | | | | | | 1981 |
| | KQ | Quaywall & Revetment | 1,910 | m | | | | | | | | | Quaywall 550m 1983 350m 1987 |
| | | Reclamation | 2,600,000 | $m^3$ | | | | | | | | | |
| | | CFS and Others | 1 | Set | | | | | | | | | |
| | NP | Revetment | 410 | m | | | | | | | | | 1985 |
| | | Reclamation | 198,000 | $m^3$ | | | | | | | | | |
| | Road | | 5,700 | m | | | | | | | | | 1982 2-Lanes 1986 4-Lanes |
| | Dredigng | | 1,500,000 | $m^3$ | | | | | | | | | |
| Equipment | Conventional | | 1 | Set | | | | | | | | | 1980 |
| | QEQ #5 | | 1 | Set | | | | | | | | | 1981 |
| | KQ | | 1 | Set | | | | | | | | | 1 Berth 1983 2 Berths 1987 |
| Oil Berth | Feasibility Study | | 1 | Set | | | | | | | | | |
| | Berth | Dolphines | 1 | Set | | | | | | | | | |
| | | Pipelines | 1 | Set | | | | | | | | | |
| | Dredging (Turning Basin) | | 2,000,000 | $m^3$ | | | | | | | | | |
| | Dredging (Waterway) | | 1,240,000 | $m^3$ | | | | | | | | | |
| | Improvement of Port Entrance | SW Breakwater Extension | 150 | m | | | | | | | | | |
| | | NW Breakwater Removal | 75 | m | | | | | | | | | |
| | | NW Breakwater Seawall/ Wave Dissipating Work | 700 | m | | | | | | | | | |

Table – IV.5.3 Sunken Crafts in The Port of Colombo

| No. | Sunken Craft |
|---|---|
| (1) | Wooden Lighter at "Drun buoy" mooring, almost touching the pendant chain. |
| (2) | "Behest" tug. |
| (3) | Two old timber lighters on the jetty. |
| (4) | Very old wreck of a sloop. Depth 3 ft. |
| (5) | "Bracongleon". Steam Trawler. |
| (6) | "Sir William Mathew" Dredger. |
| (7) | Wooden Lighter No. CO 985 of P (C) C. |
| (8) | Coal Lighter of P (C) C. No. 1113. |
| (9) | Wreck of an old lighter – to be confirmed. |
| (10) | Wreck of an old lighter. |
| (11) | Old boiler. |
| (12) | "Titan Barge" – QEQ 5 |

Note: (12) is under removal

Source: CPC

Fig. – IV.5.1 Locations of Civil Engineering Works – Master Plan

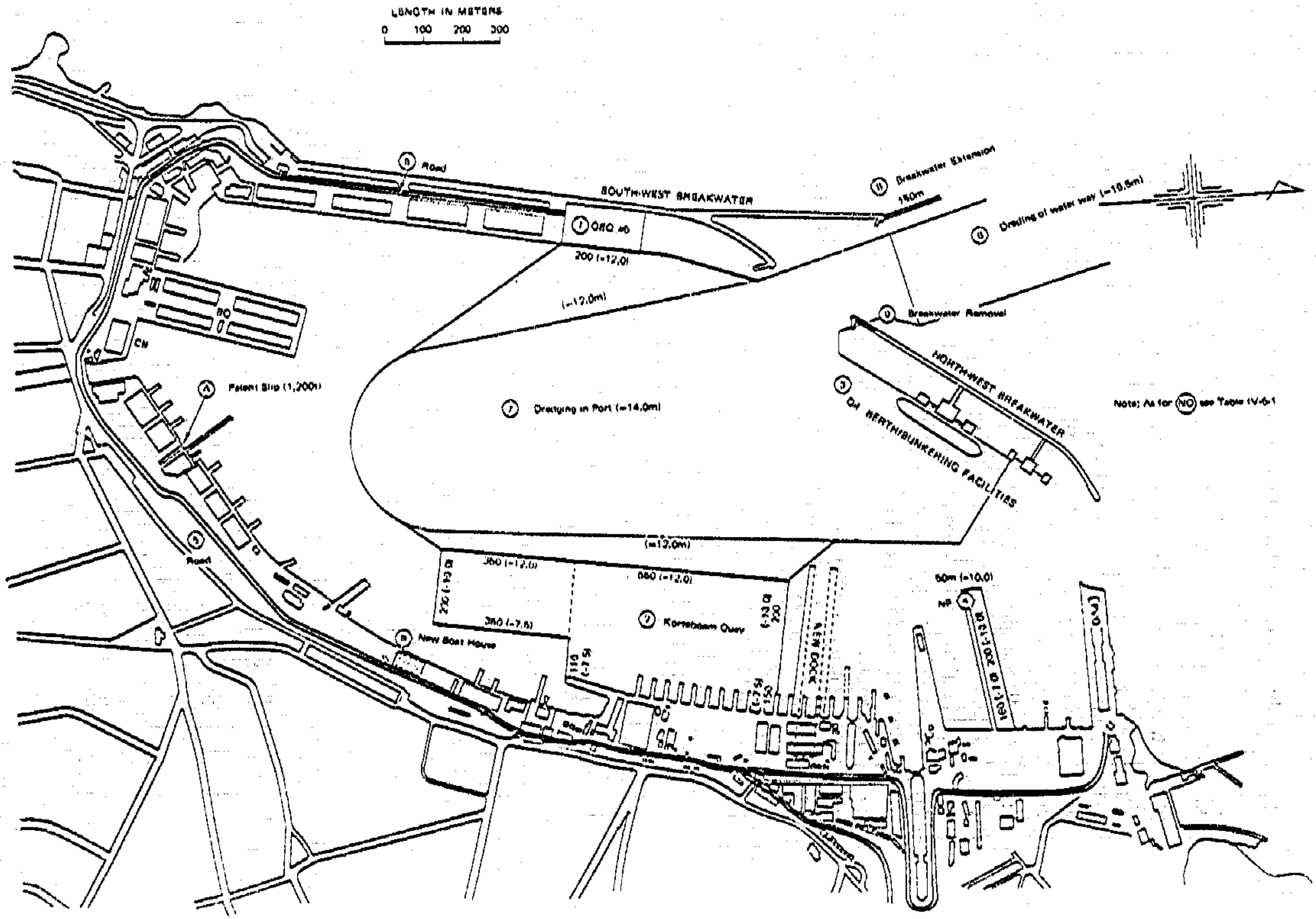
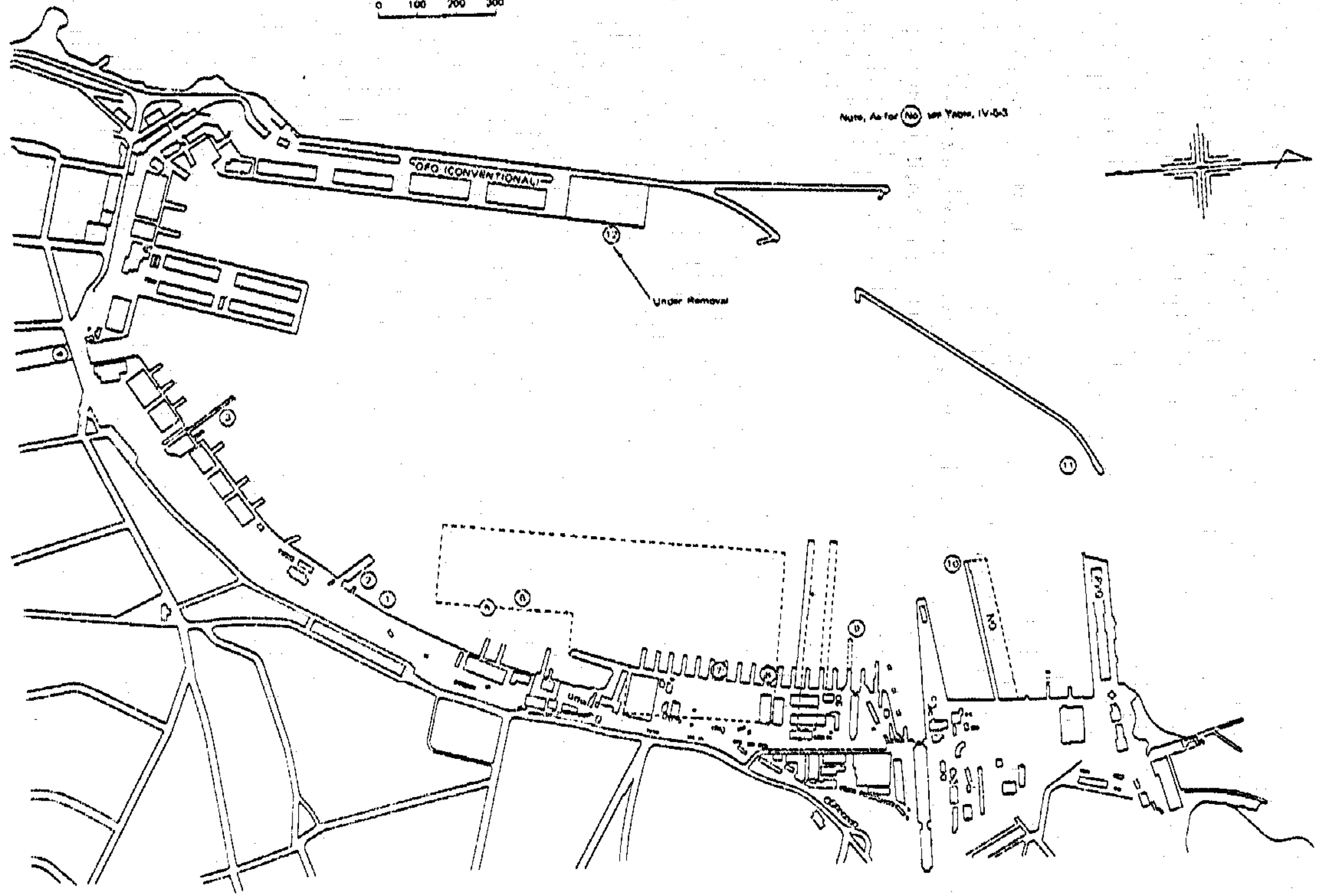


Fig. – IV.5.2 Locations of Sunken Crafts



# CHAPTER 6 ROUGH ESTIMATE OF CONSTRUCTION COSTS

A rough estimate of construction costs for facilities shown in Table-IV.5.1 is given in Table -IV.6.1. Unit prices used for each facility are based on Chapter 5 "Estimate of Construction Cost" of Port V "Urgent Plan". The construction costs are estimated using prices as of June, 1979. The exchange rate is determined as follows using IMF data:

US$1 = Rs. 15.625 = ¥218.89
Rs. 1 = ¥14

The total project costs by major facilities are shown in Table -IV.6.2 which includes the costs of cargo handling equipment as well as facilities.

According to Table -IV.6.2, the total cost of civil works amounts to US$91.7 million and that of cargo handling equipment US$38.6 million bringing the grand total cost of the Project to approximately US$130.3 million.

## Table – IV.6.1 Rough Estimate of Construction Costs

(Unit: US$)

| | No. | Facility | Main item | Quantity | | Unit Price | Rough Cost Estimate |
|---|---|---|---|---|---|---|---|
| | | | | | | (US$) | (Thousand US$) |
| Container & Conventional Berths | 1 | QEQ #5 | Crane foundation | 200 | m | 6,540 | 1,308 |
| | | | Heavy Pavement | 40,000 | m² | 8 | 320 |
| | | | (Sub Total) | | | | (1,628) |
| | 2 | KQ Container terminal | –12.0m Quaywall | 900 | m | 20,750 | 18,675 |
| | | | –7.5m Revetment | 610 | m | 9,960 | 6,076 |
| | | | –10.0m Revetment | 400 | m | 14,200 | 5,680 |
| | | | Reclamation | 2,600,000 | m³ | 2.5 | 6,500 |
| | | | Heavy Pavement | 235,000 | m² | 31 | 7,285 |
| | | | C.F.S | 16,000 | m² | 220 | 3,520 |
| | | | (Sub Total) | | | | (47,736) |
| | 3 | North Pier | –4.0 ~ –10.0m Revetment | 360 | m | 5,680 | 2,045 |
| | | | –10.0m Revetment | 50 | m | 14,200 | 710 |
| | | | Reclamation | 198,000 | m³ | 2.5 | 495 |
| | | | Pavement | 18,000 | m² | 16 | 288 |
| | | | (Sub Total) | | | | (3,538) |
| | 4 | Road | | 5,700 | m | | 1,981 |
| | 5 | Dredging | –12.0m Dreding | 1,500,000 | m³ | 1.92 | 2,880 |
| | Total | | | | | | 57,763 |
| Oil Berth | 6 | Oil Berth | Main dolphins | 1 | Set | | 937 |
| | | | Bunkering dolphins | 1 | Set | | 686 |
| | | | Piplines | 1 | Set | | 11,515 |
| | | | (Sub Total) | | | | (13,138) |
| | 7 | Dredging (Turning Basin) | –14m Dredging | 2,000,000 | m³ | 1.9 | 3,800 |
| | 8 | Dredging (Waterway) | –15.5m Dredging | 1,240,000 | m³ | 2.5 | 3,100 |
| | 9 | SW Breakwater | 150m Extension | 150 | m | 41,142 | 6,171 |
| | 10 | NW Breakwater | 75m Removal | 75 | m | 6,857 | 514 |
| | | | Seawall/Wave Dissipating Work | 1 | Set | | 5,326 |
| | 11 | Tug boat | | 1 | No. | | 1,919 |
| | Total | | | | | | 33,968 |
| Grand Total | | | | | | | 91,731 |

## Table – IV.6.2 Project Cost of Master Plan

(Unit: Thousand US$)

| Item | | | Unit | Quantity | Cost (%) | Remark |
|---|---|---|---|---|---|---|
| Conventional Berth | ⓐ | North Pier | Berth | 2 | 3,538 ( 2.7) | ③ |
| | ⓑ | Cargo Handling Equipment | Set | 1 | 7,537 ( 5.8) | |
| | Sub total | | | | 11,075 ( 8.5) | |
| Container Berth | ⓒ | QEQ #5 | Berth | 1 | 1,628 ( 1.2) | ① |
| | ⓓ | KQ #1/#2/#3 | Berth | 3 | 47,736 (36.6) | ② |
| | ⓔ | Dredging | $M.m^3$ | 1.5 | 2,880 ( 2.2) | ⑤ |
| | ⓕ | Container Equipment | Set | 1 | 31,092 (23.9) | |
| | Sub-total | | | | 83,336 (63.9) | |
| Oil Berth | ⓖ | Dolphine | Berth | 1 | 937 ( 0.7) | ⑥ |
| | ⓗ | Pipline, Others | Set | 1 | 11,515 ( 8.8) | ⑥ |
| | ⓘ | Bunkering Facilities | Berth | 1 | 686 ( 0.5) | ⑥ |
| | ⓙ | Improvement of Port Entrance | Set | 1 | 12,011 ( 9.2) | ⑨,⑩, |
| | ⓚ | Dredging | $M.m^3$ | 3.2 | 6,900 ( 5.4) | ⑦,⑧ |
| | ⓛ | Tugboat | No. | 1 | 1,919 ( 1.5) | ⑪ |
| | Sub total | | | | 33,968 (26.1) | |
| Road | ⓜ | | Km | 5.7 | 1,981 ( 1.5) | ④ |
| Ground Total | | | | | 130,360 ( 100) | |

Note 1) As for NO in Remark see Table – IV.6.1

# CHAPTER 7 FURTHER DEVELOPMENT POTENTIAL OF THE PORT

The further development of the Port of Colombo, after the completion of the Master Plan, could be directed to the north of the existing port, along the coast up to the Kelani Ganga, using a breakwater or breakwaters. This would be necessary only if the scale of the development exceeded the capacity of the existing port area.

Some spaces within the Port has not been used in the Master Plan, and would be available. These are described below.

## 7-1 *Space for Alongside Berths*

The area between the canal and the Block Jetty is left untouched in the Master Plan, and is reserved for future development of the Port. Two to four alongside berths can be planned in this area, with relatively small backup yard.

Assuming that four berths are planned and conventional cargo of 150 thousand freight tons is handled annually per berth, the overall capacity of the Port, including the conventional/ container cargo in the Master Plan, within the existing area, could increased to about 5,800 thousand freight tons of overall dry cargo, with 2,800 thousand freight tons of conventional cargo, and 3,000 thousand freight tons of container cargo.

## 7-2 Open Yard/Storage

The Port lacks area for open yard/storage, excluding the Coaling Jetties area where bulk coal had been unloaded, because most of the cargo handled in the Port requires covered storage. At present, however, the temporary parking of imported cars, during the clearance of port and custom formalities, is causing severe congestion in the port area. The situation is likely to be aggravated from the expected economic development of the country. Thus, reserving spaces for future open yard/storage appears to be indispensable. Not including inland location, reclamation of the rear of the Queen Elizabeth Quay is the most favourable location in the Port for this purpose.

# PART V
# URGENT PLAN

# PART V URGENT PLAN

## CHAPTER I COVERAGE OF URGENT PLAN

Amont the items included in the Master Plan, those required to be completed by 1983 are formulated in the Urgent Plan which includes every details indispensable for verifying both the physical and the economic feasibility of itself.

The following three items are urgently required:

① Improvement/introduction/construction of facilities/equipment to meet the expected increase both in cargo traffic and in containerization.

② Transfer of the oil berth and the bunker facilities to the new site accompanied by the widening of the approach channel.

③ Modification of a cargo handling berth in the North Guide Pier to a ship repair berth.

Among the above three, the item ② is not included in the Urgent Plan, since a feasibility study including an in situ survey of the bedrock in the approach channel has to be carried out.

### 1-1 Conventional Berth

The tonnage of dry cargo, excluding containers, forecast for 1983 is 2,414 thousand freight tons.

Assuming that 150 thousand freight tons are handled at each alongside berth, 16 berths are required to cover the above forecast cargo tonnage.

On the other hand, however, the number of alongside berths available in 1983 is counted as 14.5 under the following conditions;

① The No. 5 berth of the Queen Elizabeth Quay is used exclusively for container handling.

② A cargo handling berth in the North Guide Pier is modified to a ship repair berth.

③ A conventional cargo handling berth is secured in the Korteboam Quay to substitute the above modified berth.

④ Three small berths in the Bandaranaike Quay and the Coaster Berths are counted as 0.5 berths each.

Thus, there is two berths short in 1983. This shortage, however, is of temporary, since, after 1983, convensional cargo is considered to decrease with the increase in container cargo. Hence, moderate congestion is better to be accepted in the meantime.

Further, the queuing analysis gives the results that the rate of berth occupancy is 78% and the average awaiting days are 0.20 to 0.32 days assuming 8,500 tons per vessel and 1,700 tons per vessel for brought/loaded food and general cargo respectively and 3.6 days per vessel for the average working days. The result is reasonable enough to be accepted.

Thus, 14.5 berths are adopted as the number of conventional berths in the Urgent Plan.

### 1-2 Container Berth

The tonnage of container cargo to be handled in 1983 is 1,144 thousand freight tons, including tranship containers. Hence, one berth could be sufficient because the cargo handling capacity of a full scale container berth is estimated as one million tons. However, since a full scale berth is not available until the Korteboam Quay is completed, the No. 5 berth in the Queen Elizabeth Quay is planned to be temporarily used as a container berth to respond to the urgent demand for containerization. As the capacity of container cargo handling of the berth, 500 thousand freight tons is employed by considering that a container crane can be accommodated only for the length of 200 meters due to a structural problem and that the marshalling yard behind it is narrow. Thus, two berths, one in the Queen Elizabeth Quay and the other in the Korteboam Quay, are planned here.

By the queuing theory, the rate of berth occupancy is given as 61% and the average awaiting period as 0.32 to 0.60 days assuming the tonnage brought/loaded per vessel to be 2,550 tons.

### 1-3 Cargo Handling Equipment

#### 1-3-1 Conventional Cargo Handling Equipment

Concerning the equipment for handling conventional cargo, all the equipment included in the Master Plan is within the coverage of the Urgent Plan.

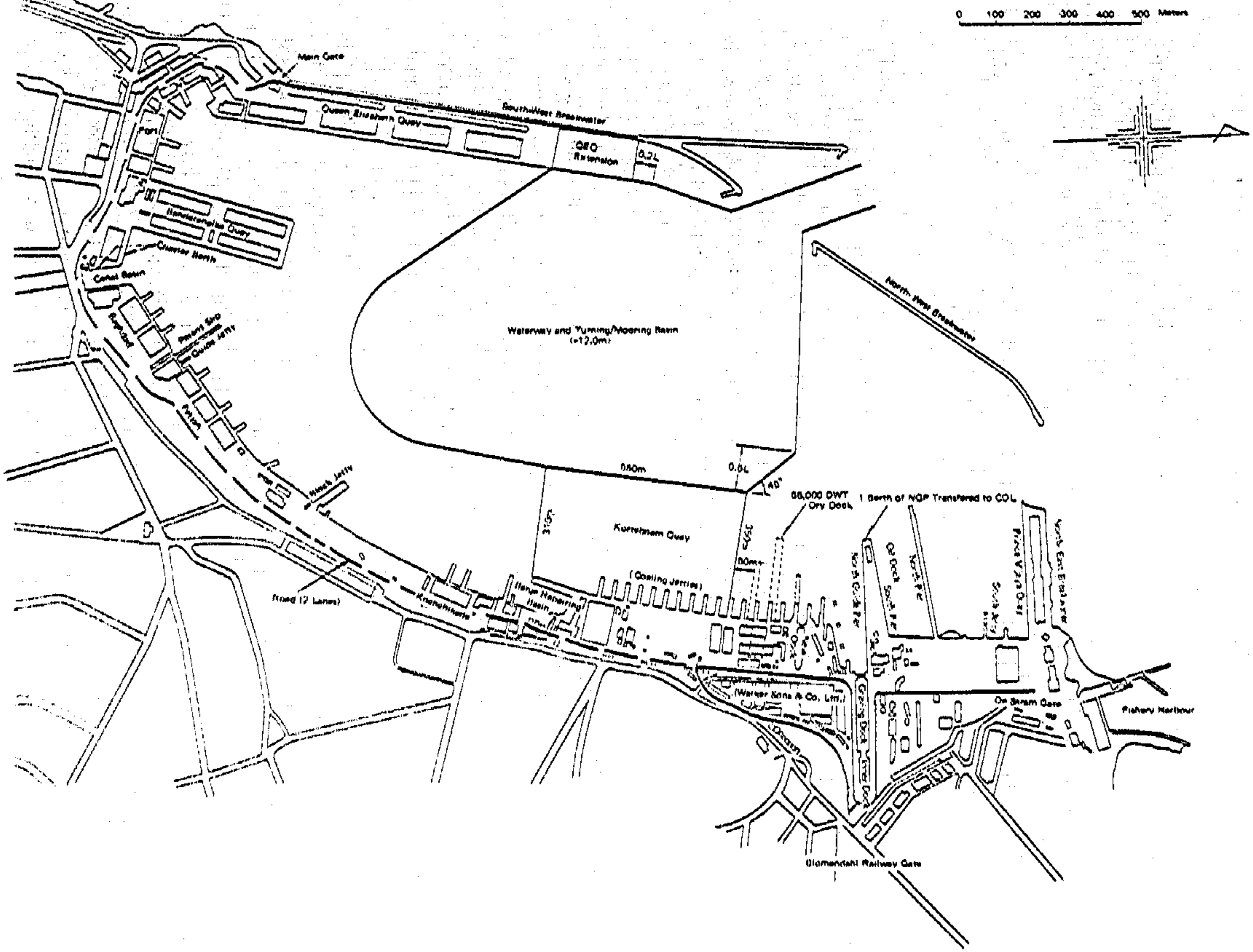
#### 1-3-2 Container Handling Equipment

Two different sets of container handling equipment, one for the Queen Elizabeth Quay and the other for the Korteboam Quay, is planned to be purchased.

### 1-4 Port Layout

The port layout described above is shown in Fig.-V.1.1.

Fig. – V.1.1 Port Layout – Urgent Plan
(L: 250m)



# CHAPTER 2 FACILITY AND EQUIPMENT PLAN

## 2-1 Container Terminal and Container Equipment

As stated in the foregoing chapter, the improvement of the Queen Elizabeth Quay No. 5 and the Korteboam No. 1 Container Berth is required to cope with the container demand forecast of 1,144,000 tons (about 80,000 TEU) for 1983. Container terminal facilities and equipment required for effective handling of a large number of containers and of full container ships are described here.

The layout of both terminal facilities are shown in Figs-V.2.1 and V.2.2 The required container equipment and costs are shown in Table-V.2.1.

### 2-1-1 Terminal Facilities

#### (1) Control Office

Control offices for the supervision of all terminal work, including loading/unloading ships is required to perform the work effectively and on schedule. These offices will be provided in a transit shed at the Queen Elizabeth Quay No. 4 by its partial remodeling and additional offices will be near the terminal entrance for the Korteboam Quay No. 1. The size of office will be 735 $m^2$ for the Queen Elizabeth Quay No. 5 and 2,250 $m^2$ (30 x 25 m, 3 stories) for the Korteboam Quay No. 1.

#### (2) Container Freight Station (CFS)

A CFS, where small lots of cargo (LCL cargo) are received from and delivered to shippers/consignees, and loaded into and unloaded from containers, is planned for the Queen Elizabeth Quay No. 4 warehouse (floor area: 6,713 $m^2$, after partially remodeling to control office), while the Queen Elizabeth Quay No. 4 warehouse is also to be used for conventional cargo loaded/unloaded at the Queen Elizabeth Quay No. 4 berth. For the Korteboam Quay No. 1, a new warehouse with a floor area of 6,000 $m^2$ is proposed to be built as shown in Fig.-V.2.2.

The necessary size of the CFS warehouse depends on the quantity of LCL cargo to be handled. From experience, the quantity of LCL cargo (LCL containers) is about 15 to 20% of the total containers handled. Since the Korteboam No. 1 Container Terminal has slots for 1,912 containers, and the number of containers handled per year is assumed to be about 90,000 TEU, (112,000 TEU/year maximum), if 15% is employed, the quantity of LCL containers should be 13,500 TEU/year or about 230 thousand cargo tons/year (17 tons/TEU). Since the cargo storing capacity of CFS warehouse is about 1.5 ton/$m^2$, the yearly tonnage of cargo which can be handled is about 39 tons/$m^2$ if the rate of cargo turnaround is 26 times/year (period of stay: 14 days). Therefore, the floor area of CFS warehouse required for the Korteboam No. 1 Container Terminal is calculated at 5,900 $m^2$, by dividing the LCL cargo of 230 thousand tons/year by CFS cargo handling ability of 39 tons/$m^2$.

(3) Maintenance Shop

Maintenance shop for inspecting, cleaning, and repairing containers and for maintaining and repairing the equipment used in the terminal is provided at both the Queen Elizabeth Quay No. 5 and the Korteboam Quay No. 1. These shops are to be equipped with compressors, welders, and general tools and equipment required for repairing machines and containers.

A reduction in the number of operating equipment due to mechanical troubles will directly reduce the terminal capacity, resulting in lower efficiency of overall terminal work. Thus, the maintenance and repair work for equipment must be sufficiently performed. In particular, inspection and maintenance work for preventing troubles in advance should be conducted. Thus, a system that allows immediate repair after the occurrence of equipment troubles must be organized.

(4) Gate

A container terminal gate is installed at the Korteboam Quay No. 1, where inspection of the container's condition received and/or delivered, weighing the containers and the exchanges of necessary documents are carried out. The gate of the Korteboam Quay No. 1 has 5 container lanes, 2 of which are equipped with scales. No scales or gates are installed at the Queen Elizabeth Quay No. 5 since there is a possibility of converting this terminal to a conventional berth by transferring its container facilities and equipment to the Korteboam Container Terminal in the future. Necessary inspection of the conditions of containers can be performed by using a platform whenever necessary, and the container weight can be determined by finding the weight of the cargo in the container from the container loading plan.

(5) Power Source for Reefer Containers

A total of 140 stand-type power plug sockets are installed in the Korteboam No. 1 Container Terminal for the reefers. For the same reason given in Paragraph (4) above, no plug sockets are provided in the Queen Elizabeth Quay No. 5, but portable generators can be used if necessary.

(6) Other Facilities

1) Power Supply Facilities

The Ceylon Electricity Boad supplies the Port of Colombo high voltage Power of 11,000 V, which is transformed at substations within the Port. Since a container terminal requires a large amount of electric power to supply the container crane, illumination and reefer containers, etc., adequate power supply facilities are needed. Approximate power required in each terminal is shown below.

| Equipment | Voltage | Power | |
|---|---|---|---|
| | | QEQ No. 5 | Korteboam No. 1 |
| Container crane: | 3,300 V | 750 KVA | 1,500 KVA |
| Illumination for terminal: | 440 V | 150 KVA | 300 KVA |
| Maintenance shop: | 220 V | 50 KVA | 100 KVA |
| Control office: | 220 V | 50 KVA | 100 KVA |
| Reefer container: | 220 V | – | 1,000 KVA |
| CFS: | 220 V | – | 100 KVA |
| Total: | | 1,000 KVA | 3,100 KVA |

The substation at the Queen Elizabeth Quay No. 3 warehouse is used for the power supply of the Queen Elizabeth Quay No. 5, since it has sufficient allowance to provide power to the Queen Elizabeth Quay No. 5 (according to the Sri Lanka Port Authority information). A substation is installed within the Koateboam No. 1 terminal.

2) Water Supply Facilities

Water supply facilities for ships are to be rigged up on the wharf apron for the Konteboam Quay No. 1. Necessary water must be supplied to the maintenance shop for washing containers.

3) Oil Supply Facilities

Oil supply facilities for straddle carriers and tractors are to be provided in the Korteboam No. 1 container terminal.

2-1-2 Container Equipment

Various kinds of container handling equipment of the terminal must be functionally combined in order to effectively carry out the terminal work of loading/unloading, storing and receiving/delivering a large number of containers. Kinds and numbers of equipment must be selected and determined in reasonable consideration of the specifications, working efficiency and capacity of each equipment. The number of required equipment, its main specifications and cost for the Queen Elizabeth Quay No. 5 and the Korteboam No. 1 container terminals are shown in Table-V.2.1.

(1) Container Crane (Fig.-V.2.3)

Two container cranes are provided for the Korteboam Quay No. 1 and one for the Queen Elizabeth Quay No. 5 because the range of crane movement is only 200 meters within the total berth length of 300 meters. If two cranes with a width of 20 to 25 m are installed, the capacity of each crane could not be fully utilized due to mutual interference between cranes during operation. A narrow crane rail width (span) of 16 m is adopted due to the narrow width of the Queen Elizabeth Quay No. 5 (118 m) and the required structure of the foundation for a container crane, as stated IV-3-2-1 "Container Terminal". The same rail width is adopted for the Korteboam Quay No. 1 since the Queen Elizabeth Quay No. 5 crane might be shifted to this terminal in the future. The principle specifications of the container crane are shown below:

| | |
|---|---|
| Lifting load : | 35 tons under hook |
| | 30.5 tons under spreader |
| Outreach : | 36 m |
| Backreach : | 11 m |
| Span : | 16 m |
| Lift : | 25 m above |
| | 13 m below |
| Winding speed : | 50/120 m/minute (full load/no-load) |
| Traversing speed : | 150 m/minute |
| Travelling speed : | 45 m/minute |

(2) Straddle Carrier (Fig.-V.2.4)

The Queen Elizabeth Quay No. 5 is equipped with 3 straddle carriers capable of stacking 20/40 feet containers in 3 layers while 8 straddle carriers are slated for the Korteboam Quay No. 1. The number of straddle carriers required is estimated in the following manner:

1) Queen Elizabeth Quay No. 5

Container crane handling capacity:

25 containers/hour x 1 crane = 25 containers/hour

Number of containers received & delivered:

Given 40,000 containers handled, 300 working days annually and working 10 hours a day;

40,000 ÷ 300 ÷ 10 = 13.3 containers/hour

(Total number of containers to be handled: 38.3 containers/hour)

While the actual working cycle of the straddle carrier is about 4 to 5 minutes, a working cycle of 4 minutes is employed since the terminal area of the Queen Elizabeth Quay No. 5 is narrow. Therefore, handling ability becomes 15 containers/hour. Thus, the required number of straddle carriers is: 38.3 ÷ 15 = 2.6 ( units).

2) Korteboam Quay No. 1

Container crane handling capacity:

25 containers/hour x 2 cranes = 50 containers/hour

Number of containers received / delivered:

90,000 ÷ 300 ÷ 10 = 30 containers/hour

(Total number of containers to be handled: 80.0 containers/hour)

Given a straddle carrier handling capacity of 12 containers/hour (5-minute work cycle) the required number of straddle carriers is: 80.0 ÷ 12 = 6.7 (7 units) + 1 unit for spare

NOTE: To accurately calculate the required number of straddle carriers, the calling pattern of container ships, the number of containers shipped and landed by one ship, the pattern of container receiving and delivery (period of time of containers' stay in the terminal), and so forth should be assumed first, then analysis on the required work should be made, on which basis the calculations should be made in consideration of the equipment capacity. However, the simplified method stated above is adopted since there are no reliable data for calling pattern, number of containers landed and period of time of containers' stay. The numbers of straddle carriers calculated above concide with the number actually required according to experience and actual records in many container terminals of Japan.

(3) Tractor/Trailer

These are used for transporting LCL containers between the container yard and CFS, and for transporting empty containers to the storing yard, or for landing special containers that cannot be carried by straddle carriers.

(4) Forklift Trucks

Two 15-ton forklifts (capable of stacking empty containers in 3 layers) are necessary for handling empty containers behind the Queen Elizabeth Quay warehouses. Six 1.5-ton forklifts for the Queen Elizabeth Quay No. 5 and eighteen 1.5-ton forklifts for the Korteboam Quay No. 1 are required respectively for CFS operation. Since the 1.5-ton forklift for CFS is used for within the container, electrically driven forklifts with proper weight in view of the strength of the container floor (bearing load of 5.460 kg per axle based on tire's contact of 142 $cm^2$ per wheel) must be used. The heights of the mast and head guard of the forklift should naturally be smaller than the container ceiling of 2.15 meters.

2-1-3 Operation

(1) Outline of Operation

The operation of the container terminal is outlined hereinafter with respect to the export containers, and reverse operation is applicable to the import containers.

① Export containers brought to the terminal gate by truck are inspected for appearance, damage, and the seal on container door, and their weights are computed. Details of the information of the container (name of shipping company, name of ship, destination, container number, type of cargoes, particularly the presence of dangerous cargo, etc.) as well as weight are given to the control office. This inspection at the gate will constitute the formal hand-over of the containers from the shipper to the terminal and the responsibility of the container terminal for the container begins at this point, so that necessary check shall be fully performed and results shall be recorded.

② The control office decides the location where the container is to be stored in the container yard based upon the information it has received for the gate. The storing location of the container is given to the truck and straddle carrier drivers. The determination of storing location of containers in the yard is based upon the arrival schedule of export-import containers and plan for loading the ships. If container yard planning is not made well, efficiency of terminal work will drop due to shortage in yard space and increase in rehandling of containers in the yard.

③ The driver of the straddle carrier will receive the container at the transfer point from the truck, carry it to the instructed location, and store it as directed by the control office. Guidelines are drawn on the yard surface for identifying the storing location. These guidelines are helpful for effective use of yard space, useful for safe operation by designating the passage of the straddle carriers, and indispensable for stock control of containers within the yard.

④ At the time of loading onto the ship, a container stored in the yard is carried to the spot directly below the container crane by straddle carrier in accordance with container ship plan, where it is then loaded to the ship by container crane.

⑤ Small lots of export cargo (LCL cargo), which is insufficient to fill one container, is carried by truck into the container freight station (CFS). There, it is loaded into a container (LCL container) together with other LCL cargo having the same destination in accordance with the container loading plan, based upon the destination and type/quantity of cargo. The LCL container is then carried into the yard and stored for loading.

(2) Management

The number and functions of workers required to effectively perform the operation stated in the foregoing paragraph depend on various factors, such as regulations related to labor, employment agreements between labor and employer, work schedule as well as the ability of each worker in the Port of Colombo. It is difficult to predict the number of workers required, and therefore the type of workers and their roles in container terminals of Japan are described for reference.

① Operation management department

Ship planner: Preparation and execution of ship loading/unloading plan.

Yard planner: Preparation and execution of container yard plan.

Radio operator: Communicating and giving instructions for work to be performed to drivers of container handling equipment in accordance with the container yard plan and ship plan.

Gate clerk: Receiving and delivering of containers at gate and necessary documentation work.

Documentation/accounting clerk:
Preparation and issuing of necessary documents, and receiving of payment for work done.

Maintenance engineer:
Inspection, maintenance and repair of containers and handling equipment.

② Operation department

Operators of container crane, straddle carrier, yard tractor, etc.

Gate checker: Inspection of containers upon receiving or delivery at the gate.

Worker on ship: Lashing and unlashing of containers on ship.

③ Container freight station (CFS) department

Clerk: Preparing and issuing of documents for cargo receiving and delivery, and preparation of plans for loading cargo to containers.

Worker and forklift operator:

Stuffing/unstuffing cargo to/from containers, or cargo receiving from or delivery to trucks.

Tallying man: Tallying and checking during cargo stuffing and unstuffing and during cargo receiving or delivery.

(3) Preparation of Regulations and Tariff Schedule for Container

All container cargo is presently loaded into or unloaded from containers within the port area, and so-called house delivery, by which cargo are delivered/received while it is in the containers, is not allowed by the customs authority. However, in order to receive and deliver a number of containers quickly and effectively and to have more effective transportation of goods by containers, house delivery and/or land transport of bonded containers are indispensable in the future, as the containerization system progresses.

The present port tariff for container works seems to be a tariff revised from that for general cargo. That is, the conventional tariff for general cargo handling work is adopted for the container with different rate schedules. A more simplified tariff for containers, in conformity with the actual work performed at the container terminal, must be prepared.

Improvment and establishing of regulations to simplify the tariffs and various procedures for custom clearance and etc. related to containers is recommended. The merit of container transport as an efficient means of cargo transport can be fully utilized only by use of efficient regulations.

## 2-2 Inside-port Road

As described in Part IV, the inside-port road of 2 lanes is expected to be sufficient in capacity until 1983, therefore, only 2 lanes and side-walks are planned to be improved at the stage of the Urgent Plan.

## 2-3 Conventional Cargo Handling Equipment

The present cargo handling situation is explained in Chapter 5, Part II. The conclusion is that the annual tonnage of cargo handled per berth is high with 180,000 tons/berth or 1,024 tons/m, but the tonnage of cargo handled per ship is low with approximately 420 tons/day (600 tons/day for food ship and 380 tons/day for general cargo ships). This occurs because ships wait an average of 1.6 days for berthing (7.5 days for food ships and 1.1 days for general cargo ships) and berths are extremely congested with a rate of berth occupancy of nearly 100%.

The low level port services being offered increase cargo shipping costs, resulting in rises in freight charges for import-export cargo. An example of such a freight increase is the congestion surcharge imposed to the Port where ships are constantly involved in waiting for berthing. Delay in receiving cargo for several days due to congestion means an increased burden of interest against cargo value to the consignees. In addition, it reduces the operating efficiency of existing port facilities and creates the necessity for new facilities and investment, which negatively effects the national economy both directly and indirectly. Improvement of various services offered by the Port of Colombo will give great benefits to the economy fo Sri Lanka since the Port handles about 94% of all import-export dry cargoes and is eventually to be the sole international port in Sri Lanka. If it is intended for the Port to develop as an intermediate port to other neighboring countries and to take advantage of its geographical location in the future, the service level of the Port must be improved through which the port charges for various services can be kept competitive.

In this chapter, necessary measures for eliminating current port congestion, shortening ship's lay time in the Port and improving efficiency of cargo handling will be considered, and necessary cargo handling equipment will be reviewed to increase port efficiency and also to respond to future increase of demand.

### 2-3-1 Mechanization for Cargo Handling

It is already stated that cargo handling to transfer cargo from ships to consignees or from shippers to ships is mainly performed by hand in this Port. This inefficient method of transporting cargo from wharf apron to transit sheds and storing them is the bottleneck to improving the overall efficiency. It is recommended to mechanize the cargo handling work through the use of forklifts and pallets, and to handle the export cargo through the transit sheds in the same manner as import goods.

Presently, each package of cargo is carried by hand and stacked onto rope sling or net sling on board ship and then landed to the wharf apron. Efficiency can be greatly improved if cargoes are combined to larger units by use of slings, and are carried as they are by forklift to the transit shed and stacked there for storage. However, since the rope sling or net sling is not suited to forklifts (and also since tallying and sorting for each cargo are needed), cargoes combined by a sling are disassembled at the wharf apron and moved to the transit shed for storage by hand, using handcarts capable of carrying more than 1 to 2 packages at a time. Cargo handling by this method takes lots of time, causing lower overall efficiency in cargo handling and also idle time for the men working in the ship. Thus pallets, which make the forklift operation possible, must be used. Cargo handling operation utilizing pallets is described hereinafter.

Cargo is loaded by hand to pallets within ship's holds, and landed to wharf apron by using a pallet sling. Then, without removing cargo from the pallet it is carried to the transit shed by using a forklift and stored there still on the pallet. When delivered, the cargo – which has remained on the pallet all the time – is carried by forklift to the consignee's truck, removed from the pallet, and handed over. (A reverse procedure for shipping cargo). For the purpose of quick tallying and sorting, cargo of the same lot (same cargo mark) should be placed on the same pallet on ship, avoiding mix stowage of different cargo marks. When cargoes of different marks are stowed, landed pallets should be immediately transferred and temporarily stored in the transit shed without tallying and sorting. Later, the tallying and sorting should be performed, at a more convenient time such as when there is no ship at berth, to assure the smooth movement of cargo between the apron and transit shed and to improve cargo handling efficiency.

When placing cargo on the pallets in the ship, efficiency can be improved if number of workers of a ship's gang are assigned on the basis of the commodity, packing style, and weight of the cargo.

The "direct alongside" method presently being adopted to export cargo (loading) eliminates cargo handling work in the area between transit shed and apron. Nevertheless, its cargo handling efficiency is 9.0 tons/gang/hour which is not significantly different from the 8.3 tons/gang/hour for the imported general cargo. This seems to occur, as stated before, because waiting time is increased since the required cargo is not brought to the ship's side apron when required and because preparing in advance the work schedule required for achieving efficient loading work is difficult. In other words, the "direct alongside' method ("direct delivery" method) does not provide efficient cargo handling since the buffer function of transit sheds is not effectively utilized. The buffer function is capable of adjusting to two types of cargo transport, between ship and shed and between shed and shipper (consignee), by means of temporary storing of cargo. Therefore, higher efficiency can be expected for export cargo by adopting "terminal receiving sytem" (or pre-warehousing) in which cargo is brought into transit sheds in advance and then loaded on to the ship after the ship's arrival.

Though handling of foods is performed by the "direct delivery" methods, this should be continued for the time being instead of immediately adopting cargo handling through the transit sheds, because ① transit shed space is insufficient (see NOTE), ② there are some berths having no transit sheds, and ③ food cargo is mostly large lots for limited consignees so that arranging of receiving trucks in order is not difficult compared to general cargo. (This can be substantiated by the fact that cargo handling efficiency of food ships is 20.1 tons/gang/hour, better compared to that of general cargo ships)

Similiraly to the above, cargo handling by lighter at lighter berths should be performed using forklift and pallets through the transit sheds. It is recommended to load the cargo on pallets to the lighter if there is any allowance in lighter capacity. The storage efficiency of the lighters may be decreased, but cargo handling efficiency not only between land and lighter but also between lighter and ship can be much improved.

NOTE: Annual cargo handling capacity of transit shed can be estimated by:

Floor area x Storage factor x Occupancy x Turnround

Transit shed floor area: 52,620 $m^2$ (transit sheds behind berths at the Queen Elizabeth Quay No. 1 to No. 4, Bandranaike Quay No. 1 to No. 4, and Prince Vijaya Quay No. 1 and No. 2)

Storage factor: 2 tons/$m^2$ (standard value when forklift and pallets are used)

Average Rate of Occupancy: 0.6 (60%)

Number of turnrounds: 26 times/year (365/14 = 26 times/year since maximum period of stay of cargo is 2 weeks according to the Sri Lanka Ports Authority.)

Therefore, the total tonnage of cargo handled annually in the transit sheds behind the alongside berths is:

$$52{,}620 \times 2 \times 0.6 \times 26 = 1{,}642 \text{ thousand tons}$$

On the other hand, the transit shed demand when 80% of all general cargo (excluding foods) uses transit shed is as follows:

| | 1978 | 1983 | (Unit: 1,000 tons) |
|---|---|---|---|
| General Cargo (excluding foods): | 2,099 | 1,837 | (excluding containers) |
| General cargo utilizing transit shed (80%) : | 1,679 | 1,470 | |
| Foods: | 836 | 577 | |
| Cargo using transit shed (g. cargo + foods): | 2,515 | 2,047 | |

From the results shown above, present capacity of transit sheds will become insufficient if foods are handled through the transit sheds.

### 2-3-2 Cargo Handling Equipment Required

The numbers and costs of cargo handling equipment to be supplied are shown in Table-V.2.2, together with the existing and required numbers in the Port. These cargo handling machines should be provided and employed as quickly as possible to improve the cargo handling efficiency and to eliminate constant congestion of ships waiting for berthing. The necessary number of machines and other requirements are as follows:

(1) Forklift

In order to shorten the stay per ship and eliminate congestion, cargo handling efficiency per gang must be improved. In addition, the amount of cargo handled oer ship per day must be increased. Even though the cargo handling efficiency is improved to 15 tons/gang/hour by utilizing the forklifts, the amount of cargo handled per ship will become about 650 tons/day if 2.5 to 2.8 gangs work per ship with 2 shifts per day for 16.5 working hours (from 07:30 to 24:00), as in the case of the actual record in 1978. If the target is 800 to 1000 tons/day, that is the capacity generally expected by shipping companies for a port, then 100 tons/day ÷ 15 tons/hour ÷ 16.5 hours = 4.04, or about 4 gangs will be required to work. The required number of forklifts will be calculated below assuming 4 gangs working per ship:

① 35 5-ton forklifts and 35 3-ton forklifts for ship cargo handling (landing and delivery): Given 4 gangs, 2 forklifts (landing, transit sheds, and delivery) per gang, a 60% operation rate and 20% rate of non-operation for the forklift, for a total of 12 berths including the Queen Elizabeth Quay; 4, Bandaranike Quay; 5, Prince Vijaya Quay; 2 and Coaster Berth; 2 (to be calculated as one berth) berths where cargo handling can be made through transit sheds, then required number of forklifts is

$$12 \times 4 \times 0.6 \times 1.2 = 69.12 \text{ (70 units)}$$

② 14 5-ton forklifts and 14 3-ton forklifts for cargo handling for lighters at lighter berths: Two forklifts are required for each of 14 transit sheds at the lighter berths (a rate of non-operation is taken into consideration).

③ 30 2-3 ton forklifts for stevedoring on-board ship:

Two forklifts for each of 15 alongside berths (2 coaster berths are calculated as one berth) will be needed (rate of non-operation is considered). These forklifts should have mast height smaller than 2.5 meters to allow work on the second deck of ships.

In calculating the number of forklifts to be supplied, the life of forklifts is usually considered to be 8 to 10 years in consideration of the maintenance and repair costs. Forklifts over 10 years old will be disposed of and replaced.

REFERENCES: For utilizing forklifts in handling of general cargo, it will be required to use pallets and pallet slings. The number of these required can be calculated as shown below:

* Pallets: 14,000 pieces required

| | |
|---|---|
| General Cargo handled in 1978 (excluding foods): | 2,099,000 tons |
| Amount handled by the Queen Elizabeth Quay No. 5 containers (forecasted): | −500,000 tons |
| Amount of general cargo handled: | 1,599,000 tons |

General cargo using pallets (assumed): 70% of the above
Number of turnround (assumed): 52 times/year (365 days/7 days)
Amount of cargo handled per pallet (assumed): 1.5 ton/ea

1,599,000 x 0.7/(52 x 1.5) = 14,350 pallets

* Pallet slings: 80 pieces required (Fig. -V2.5)

4 slings per berth; total of 60 for 15 alongside berths.

One sling per 50m (length of lighter) for 1,000 meters of the lighter berth; total of 20 slings.

(2) Mobile Cranes

The mid-stream berths which handles 300,000 tons/year of dry cargo, or 10% of all dry cargo in 1978, will rapidly lose its function as a cargo handling facility for the Port after construction container berths and the progress of containerization. (In comparison with about 2.93 million tons of general cargo handled in 1978, about 2.41 million tons excluding container cargo are forecasted for 1983.) Therefore, providing and investing in mobile cranes for lighter cargo handling should not be made. However, all of the existing mobile cranes and berth cranes are more than 10 years old and extremely deteriorated, and some of them seem to have been used for more than 25 years. Thus, it is required to arrange and own mobile cranes for auxiliary cargo handling means as a part of port facilities for low performance ships (such as single-boom ships) or for handling cargo on shore. For each ship's berth unit, the Queen Elizabeth Quay, the Bandaranaike Quay, the NOrth Guide Pier and the Prince Vijaya Quay, two mobile creanes will be needed and, thus, a total of 8 are required. For the purpose of performing loading/unloading of the berthed ship, it is assumed that each mobile crane will have a 16-meter working radius and lifting capacity of 3 tons at full extension. (Maximum lifting capacity is 3ons for 3-meter working raius.)

(3) Floating Crane

It is very apparent that the use of cranes for handling large-size heavy cargo or equipment, such as handling heavy generators for the Mahwelli project, removal of sunken ships within the Port, removal or maintenance of the mid-stream berths, etc. will further increase in demand during the process of port development, and also in the progress of the social development of the Sri Lanka economy. The Sri Lanka Ports Authority reports that the existing floating crane (60-ton max. lifting capacity, steam type, 35 years old) has insufficient capacity and poor efficiency. In order to respond to future demand, a floating crane of 100-ton lifting capacity will be needed. Its main specifications are shown below and its approximate external view is shown in Fig.-V-2.6.

Maximum lifting capacity: 100 tons (at 12 m outreach)

Swing type boom; non propelling; no accomodation provided.

## 2-3-3 Effects of Mechanization

By mechanizing cargo handling as stated in the foregoing paragraphs, the following effects are expected:

① Improvement in cargo handling efficiency

② Effective use of transit shed spaces

As a result, the following effects are also expected:

③ Improvement in service level

1) Shortening of ship's lay time at the Port (because of elimination of congestion and reduced time for cargo handling)

2) Reduced damage to cargo during cargo handling

④ Efficient port management

1) Improvement in productivity
2) Inviting more transhipment cargo
3) Reduced investment for port facilities

(1) Improvement in Cargo-handling Efficiency

By using forklifts and pallets, cargo handling efficiency in the area between transit sheds and apron will be greatly improved, eliminating the bottleneck existing in cargo handling work. The cargo handling efficiency for general cargo with forklifts and pallets in Japan is 30 to 40 tons/gang/hour, but, in order to achieve such a high efficiency, not only the training and experience of the workers in handling of forklifts and pallets is required but also functions other than cargo handling must be improved to enable cargo to be effectively transported between ships and transit sheds. For example, they are ① improving the skill of winchmen, ② quickening tallying without blocking smooth flow of cargo (cargo with the same marks are to be placed on the pallet whenever possible), ③ good planning of the cargo-handling work schedule and of cargo stacking and storage schedule for transit sheds, and ④ execution of overall supervision over the work. In consideration of the present situation at the Port of Colombo, such as the nature of the workers, climate, etc., it is considered that an efficiency of 15 tons/gang/hour will be possible if cargo handling is made with forklifts and pallets, which is about 2 times the efficiency in 1978 for general cargo, excluding foods.

(2) Effective Use of Transit shed Spaces

The present stacking height is 1.0 to 1.5 m since cargo is stacked by hand in the sheds, thus, the storage factor is approximately 1 ton/m$^2$ with about 20% of floor area used as traffic space. By stacking cargo higher than before, by using forklifts and pallets, the storage factor is improved and the transit sheds can be used more effectively. This means that export cargo presently handled by the direct alongside method can be handled through transit shed, thus improving the cargo handling efficiency.

(3) Improvement in Service Level

1) Shortening the ship's lay time at the Port

By improving cargo handling efficiency and increasing the amount of cargo handled per day, the lay time of each ship will be shortened and operating efficiency of the ship can be improved. Shortening the ship's lay time as shown below, a total of 4,970 days annually or 4.0 days/ship will be saved, in comparison to 1978:

Figures Recorded in 1978.

| | Number of ships (A) | Number of waiting days (B) | Number of days work-ed (C) | Lay time (D=B+C) | Total lay time (AxD) |
|---|---|---|---|---|---|
| Food ships: | 101 | 7.5 | 13.9 | 21.4 | 2,161.4 |
| Import general cargo ships: | 591 | 1.4 | 5.0 | 6.4 | 3,782.4 |
| Export ships: | 548 | 0.8 | 4.8 | 5.6 | 3,068.8 |
| Total | 1,240 | | | | 9,012.6 |

9,012.6 days/1,240 ships ≒ 7.3 days/ship

* If the cargo handling efficiency for import general cargo and export ships is improved to 15 tons/gang/hour, and the amount of daily cargo handling increases to 800 tons (15 tons/gang/hour × 16.5 hours/day × 4 gangs × 0.8 operation rate), the the following figure is obtained:

| | | Total lay time |
|---|---|---|
| Food ships : | 101 (ships) x 13.9 days | 1,403.9 days |
| Ships for import general cargo and export: | 2,109,000 tons/800 tons | 2,636.3 days |
| Total | | 4,040.2 days (1,240 ships) |

4,040.2 days/1,240 ships = 3.3 days/ship

NOTE: When cargo handling efficiency improves as shown, the days of waiting for berthing due to congestion will become zero. That is, the rate of berth occupancy given is 4,040.2 ship-days (total days of lay time)/15 berths x 365 days = 0.74 (74%), so that congestion due to waiting for berthing can be eliminated except for temporary waits caused by a large concentration of ships arriving at the Port.

2) Decrease in Damage to Cargo during Handling

It is natural that chances of cargo being damaged will be increased as the number of loading, unloading or handling of cargo increases. When a pallet is used, the cargo will be handled only during delivery to the ship or consignee. During handling between ship and consignee (or shipper) cargo will be retained on the same pallet. This means that the chances of cargo being damaged can be much reduced in comparison with the present method where cargo is handled with rope sling and net sling.

(4) Improvement in Port Management Efficiency

1) Improvement in Productivity

As a result of improved cargo handling efficiency and mechanization (derease in number of workers per gang), the profit ratio will be increased since present cargo handling charges are based on the charge per ton of cargo. In respect to increasing productivity per worker, the present number of workers per gang is 17 to 21 for stevedore, 15 for landing, and 7 to 9 for delivery, amounting to 39 to 45 in total. However, after mechanization, 25 to 30 workers (see NOTE) will be sufficient saving about 35% in consequence. Thus, even through the present number of workers of the Sri Lanka Ports Authority (former the Port (Cargo) Corporation) is maintained, approximately 4 gangs per ship will be possible to work, a 35% increase over 1978.

NOTE: Number of workers per gang at present and after mechanization is as follows:

| | Function | Present | After Mechanization | Remarks |
|---|---|---|---|---|
| Stevedore: | Tindal | 1 | 1 | |
| | Winchmen | 4 | 2 | With skill improved |
| | Holdmen | 12 to 16 | 12 to 16 | After mechanization, stevedoring will govern the overall efficiency & this number may be needed. |
| | Subtotal | (17 to 21) | (15 to 19) | |
| Landing: | Kangany | 1 | 1 | |
| | Labours | 14 | 4 | By mechanization, about 4 persons are sufficient for attaching or removing slings. |
| | (Subtotal) | (15) | (5) | |
| Delivery: | Kangany | 1 | 1 | |
| | Labours | 6 to 8 | 4 to 5 | After mechanization, reduction in the number of workers is possible. |
| | (Subtotal) | (7 to 9) | (5 to 6) | |
| Total : | | 39 to 45 | 25 to 30 | |

2) Inviting Transhipment Cargo

Though the Port is presently very busy handling cargo originated to/from Sri Lanka, transhipment cargo may be invited and handled after the improvement in operating efficiency of the facilities. This will increase the revenues of the Port and contribute to the economy of Sri Lanka.

A port for the transhipment cargo is usually selected in consideration of not only geographical convenience but also the various port services offered with a reasonable level of charges. A shorter ship's lay time at the Port created by high cargo handling efficiency and maintenance of low level of charges for services (a result of increased productivity) are considered to be vitally important factors for inviting transhipment cargo.

3) Reduction of Investment for Port Facility

Higher efficiency will offer a maximum handling capacity while using limited port facilities and eliminates the necessity of constructing new port facilities, and which results in a minimum of investment required. This will greatly contribute not only to the port administration but also the national economy.

## 2-4 Summary of Facility/Equipment in the Urgent Plan.

The summary of facility and equipment in the Urgent Plan is shown in Table-V.2.3.

Table – V.2.1 List of Equipment required for QEQ No. 5 and Korteboam Container Terminals and Cost Estimates for Urgent Plan

(Unit: $1000 US$)

| Equipment | Specifications | QEQ #5 | | Korteboam | | Total Cost |
|---|---|---|---|---|---|---|
| | | Q'ty | Cost | Q'ty | Cost | |
| Container Crane | Rated load under hook 35 tons (under spreader 30.5 tons) Rail span 16 m | 1 | 3,017 | 2 | 6,034 | 9,051 |
| Straddle carrier | Rated load under spreader 30.5 tons Stacking 3 high for 20'/40' | 3 | 960 | 8 | 2,560 | 3,520 |
| Yard-use Tractor | Coupling load 12.5 tons, Hydraulic lifting coupler type | 2 | 52 | 5 | 130 | 182 |
| Yard-use Trailer | Rated load 30.5 tons for 40' | 2 | 18 | 15 | 135 | 153 |
| Chassis | Rated load 20.5 tons for 20' | 8 | 56 | 20 | 140 | 196 |
| Forklift Truck | Rated load 15 tons with spreader stacking 3 high | 2 | 274 | – | – | 274 |
| Forklift Truck | Rated load 1.5 tons, Battery driven | 6 | 84 | 18 | 252 | 336 |
| Weighing Scale | 50 tons load | – | – | 2 | 82 | 82 |
| (Total) | | | 4,461 | | 9,333 | 13,794 |

Table – V.2.2 Summary of Needed and Available Cargo Handling Equipment and Cost Estimates

(Unit: $1000 US$)

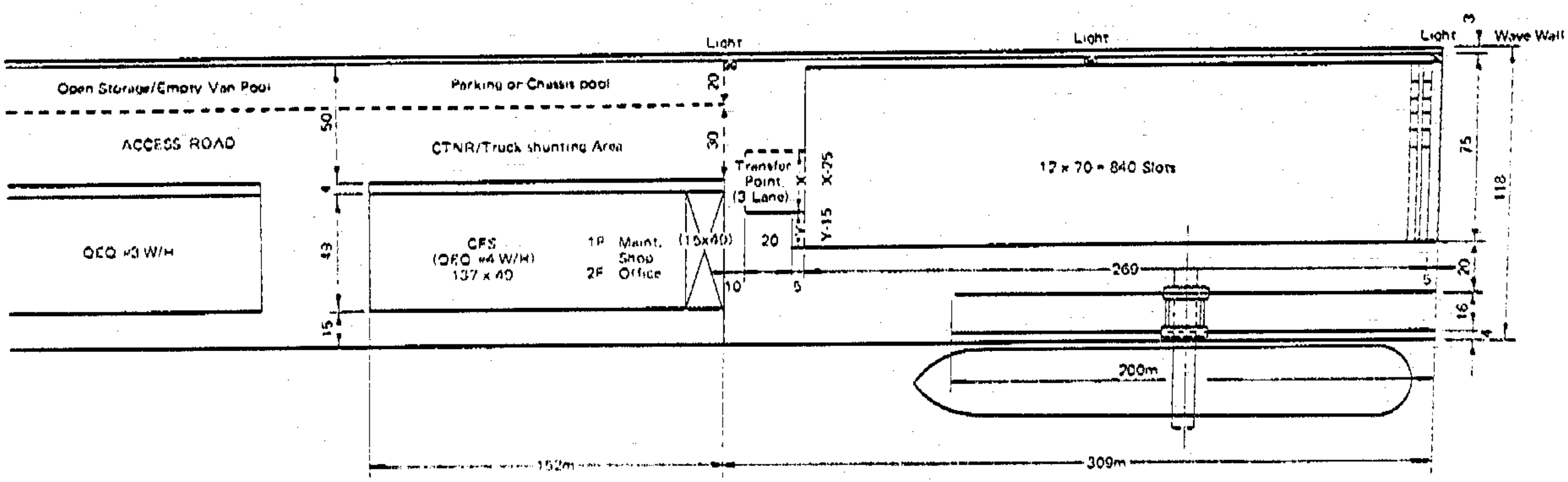
| Equipment | Capacity (Tons) | No. existing | No. to be condemned | No. Available | No. Needed | No. to be Purchased | Cost per unit | Total Cost |
|---|---|---|---|---|---|---|---|---|
| Forklift Trucks | 2–3 | 71 | 30 | 41 | 79 | 38 (3T) | 12.2 | 464 |
| | 5–6 | 2 | – | 2 | 49 | 47 (5T) | 22.1 | 1,039 |
| | 10 | 3 | – | 3 | 3 | – | – | – |
| | 25 | 2 | – | 2 | 2 | – | – | – |
| | | | | | | | (Sub. Total) | (1,503) |
| Mobil cranes | 2–4 | 20 | 20 | – | – | – | – | – |
| | 10 | 5 | – | 5 | 5 | – | – | – |
| | 30 | – | – | – | 8 | 8 | 182.8 | 1,462 |
| Portal wharf cranes | 3 | 1 | – | 1 | 1 | – | – | – |
| | 6 | 19 | – | 19 | 19 | – | – | – |
| Wharf cranes | 1.5–3 | 13 | – | 13 | 13 | – | – | – |
| | | | | | | | (Sub. Total) | (1,462) |
| Floating cranes | 60 | 2 | – | 2 | 2 | – | – | – |
| | 100 | – | – | – | 1 | 1 | 4,572.0 | 4,572 |
| | | | | | | | (Sub. Total) | (4,572) |
| | | | | | | | Total Cost | 7,537 |

(Note) Forklift trucks and mobile cranes of more than 10 and 15 years old respectively are regarded as to be condemned.

## Table – V.2.3 Summary – Urgent Plant

| Item | Unit | Q'ty | Cost | | Target Year | Note |
|---|---|---|---|---|---|---|
| | | | Value (1,000 US$) | Share (%) | | |
| Conventional Berths | | | | | | |
| KQ #2 (New Berth, Temporary) | Berth | 1 | – | | 1983 | Modified to CTNR Berth after 1988 |
| NGP #1 (Cargo Berth → Ship Repair Berth) | Berth | 1 | – | | 1983 | Transferred to CDL |
| Cargo Handling Equipment | Set | 1 | 7,537 | 10.7 | 1980 | |
| Forklift (3t) | (No.) | (38) | (464) | | | |
| Forklift (5t) | (No.) | (47) | (1,039) | | | |
| Mobile Crane (30t) | (No.) | ( 8) | (1,462) | | | |
| Floating Crane (100t) | (No.) | ( 1) | (4,572) | | | |
| Sub Total | | | 7,537 | 10.7 | | |
| Container Berth | | | | | | |
| QEQ #5 (Crane Foundation, etc.) | Set | 1 | 2,293 | 3.2 | 1981 | |
| KQ #1 (Bulkhead, etc.) | Set | 1 | 33,912 | 48.1 | 1983 | Includes Construction Cost for 250m of #2 |
| Dredging | | | 2,880 | 4.1 | 1983 | |
| Container Equipment | Set | 1 | 13,794 | 19.6 | 1981, 1983 | |
| (Container Crane) | (No.) | 3 | (9,051) | | | |
| (Straddle Carrier) | (No.) | 11 | (3,520) | | | |
| (Others) | (Set) | 1 | (1,223) | | | |
| Sub Total | | | 52,879 | 75.0 | | |
| Road (2 Lanes) | km | 5.7 | 1,524 | 2.2 | 1982 | 2 Lanes, Ditchs and Sidewalks |
| Engineering | Set | 1 | 2,111 | 3.0 | | |
| Physical Contingency | Set | 1 | 6,407 | 9.1 | | |
| Grand Total | | | 70,458 | 100.0 | | |

Fig. – V.2.1 Layout of QEQ No. 5 Container Terminal (Urgent Plan)



## Fig. -- V.2.2 Layout of Korleboam Container Terminal (Urgent Plan)

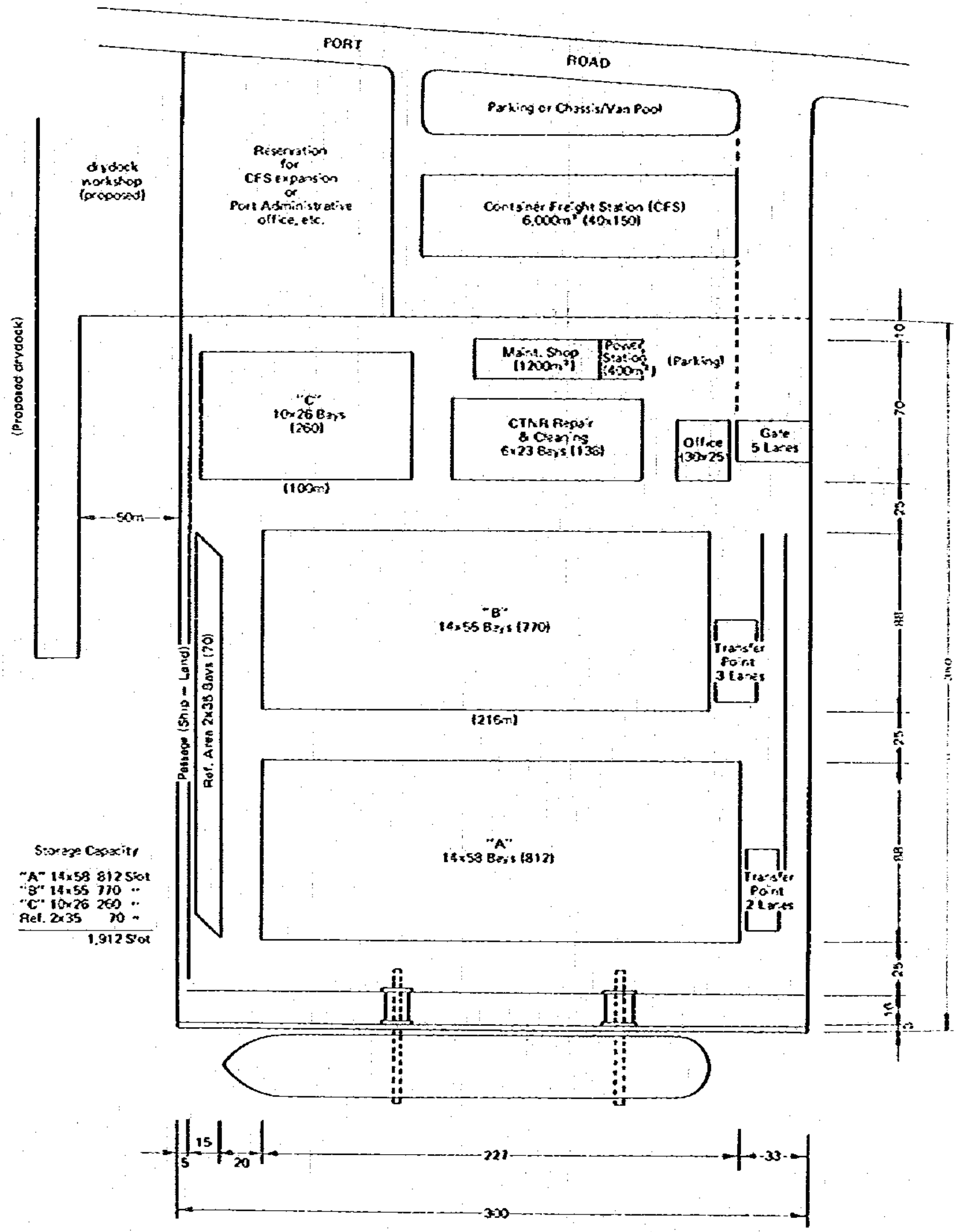


Fig. -- V.2.3 Container Crane

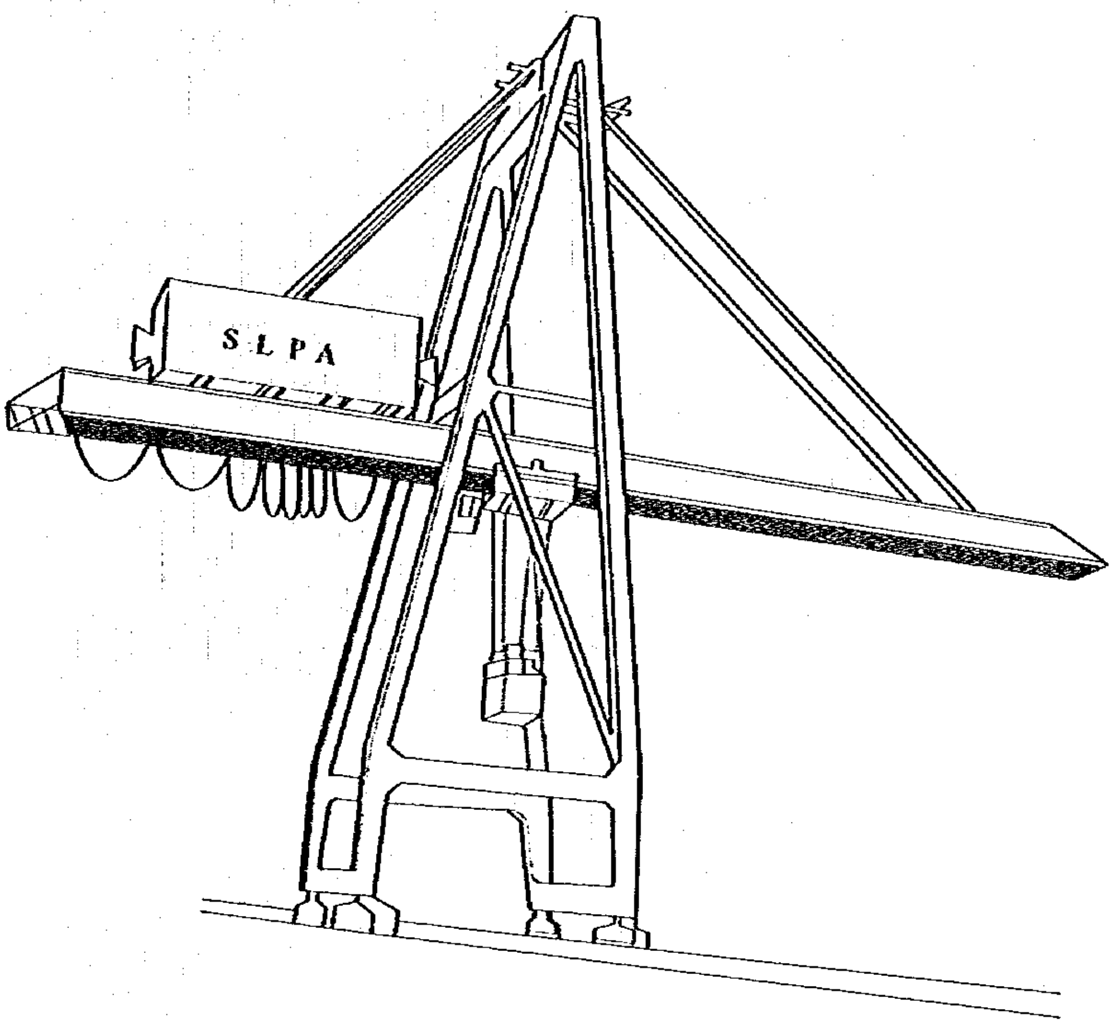


Fig. – V.2.4 Straddle Carrier

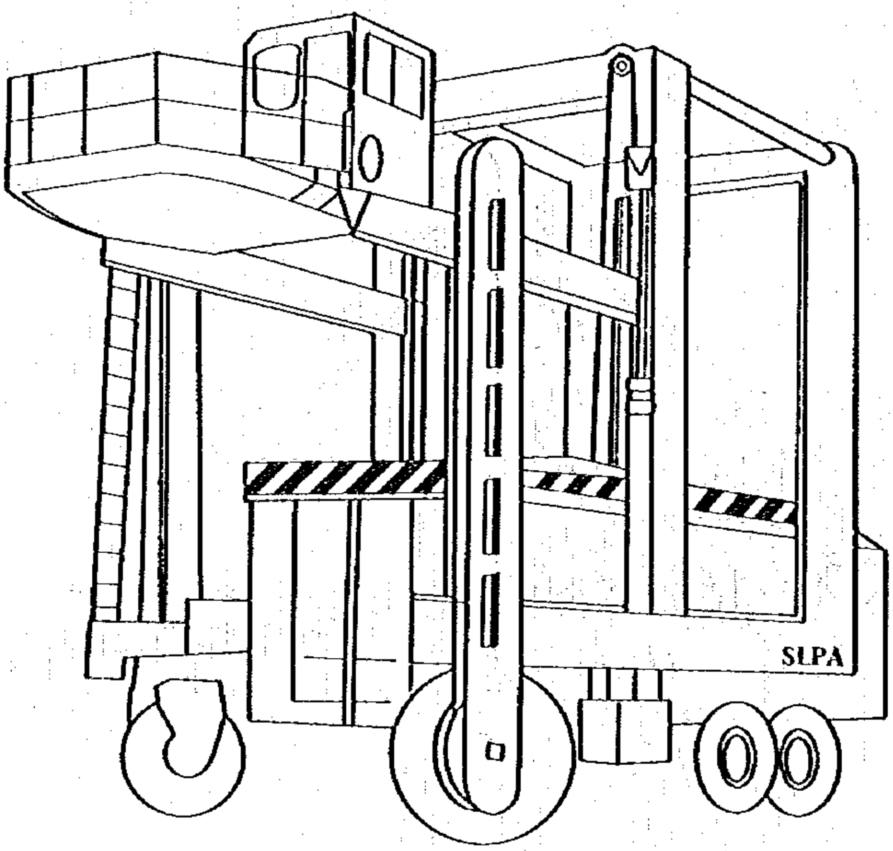



Fig. – V.2.5 Pallet Sling

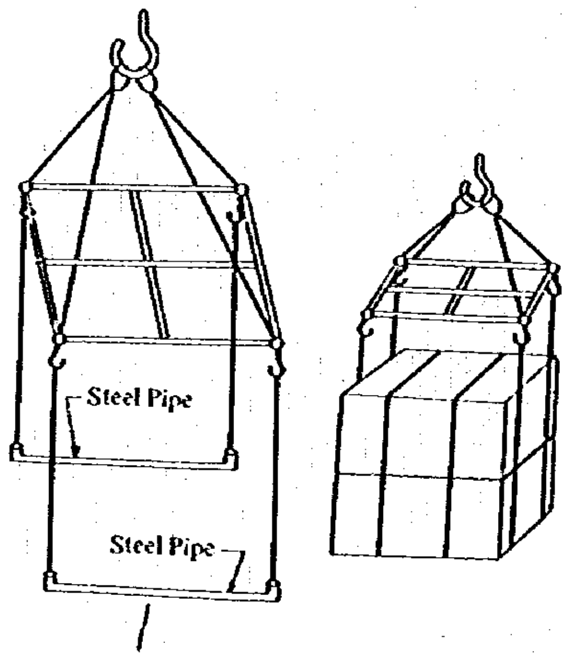


Fig. -- V.2.6 100 ton Floating Crane