6.6.7 Other Facilities

6.6.7.1 Conventional Berths

(1) Berth No.3

Berth No.3 is to be used mainly by grain ships, however berth occupancy ratio of grain ships is not so high as shown in the 6.4. Hence remaining capacity is available for the use of non-commercial ships. In CES report, extension of conveyer to Berth No.2 is proposed, however that plan is not proposed in this report because of following reasons;

(i) Multipurpose berth is fully used by container ships and larger size conventional ships, RO/RO ships and live stock ships. As already stated, there is no enough capacity to accommodate grain ships.

(ii) According to the demand forecast, the amount of grains is only 250,000 tons even in 2000, and expected number of ships is only about 18.

(2) Berth No.6

Berth No.6 is to be used for conventional cargoes as discussed in 6.6.6. In this berth, cargo handling yard and open yard are reserved as shown in Fig. 6-6-13.

(3) Demolition of Covered Storages

For the future use of land area, Transit Sheds Nos.1A, 1, 2, 3 and 4 are to be demolished.

6.6.7.2 Cold Storage

According to the future demand forecast, the amount of chilled & frozen food stuffs will be 75,000 tons and 112,400 tons in 1995 and 2,000 respectively. In order to handle these commodities in the port, cold storage facilities will be required somewhere in the port. The area required for cold storage can be estimated by the formula explained in 6.5. To estimate the area the necessary variables can be set as follows:

(i) throughput	112,400(tons)
(ii) Dwelling Time	7(days)
(iii) Working Days	300(days)

(iv) Stacking Density 2.5(t/m2)

(v) Peak Factor 1.6

(vi) Allowance 1.4

Using these variables, the area required is 2,350m^2, hence a cold storage facility with two stories (40m x 40m) is adequate to accommodate the above mentioned chilled & frozen foodstuffs. This cold storage facility is to be built on the space next to Transit shed No.7. (see Fig. 6-6-13(c))

6.6.7.3 Administration Office Building

For the staff members of the PSC, an administration building should be constructed including a yard control tower. Mina Qaboos consists of a conventional cargo area and a container area, and the building should be constructed where container movement can best be seen as well as in such a location as not to disturb cargo and container movement in the port area. The building should be equipped with a computer system and serve as a concentrated control center for any operation in the terminal. Furthermore, amenity facilities for staff members working in the port should be provided in place of the demolished rest house. The best site for the building is considered to be behind Berth No.3 near the corner of Berth Nos.2 and 3, with a 20m width and 40m length with three floors.

6.6.7.4 Gate Facility

At the gate, documents necessary for handling containers and/or custody transfer are delivered, visual inspection of the containers and weight measurement are conducted, and at the same time, the drivers are instructed to which container stack they should go. In order to carry out this work smoothly, the gate must be separated for incoming and outgoing and the lanes needed should be prepared for the respective gates. Based on the data for 1988 the frequency of distribution of the containers passing the gate per day and their cumulative probability, the average volume to be handled and the peak factor are obtained. For 1995 and 2000 the maximum number of containers passing the gate daily estimated, using the result already obtained as well as the container traffic data from the demand forecast. The number of lanes needed at the gate is worked out using this data and the result is shown in Table 6-6-12 below.

Table 6-6-12 Gate Capacity

	1995	2000
Max. daily throughput	263 boxes	248 boxes
Working hours	8 hr.	8 hr.
Gate capacity	10 boxes	10 boxes
Number of lanes for containers	4 lanes	4 lanes
Number of lanes for conventional cargo	2 lanes	2 lanes
	6 lanes	6 lanes

For the gate, functionally subdivided into incoming and outgoing it is necessary to arrange six lanes: four lanes for container traffic and two lanes for conventional cargo traffic, each equipped with a truck scale. At the gate, a computer work station operated on line with the control center should be installed. The gate clerk requests and/or is informed of necessary data on line from the control center through this work station.

6.6.7.5 Electrical Power Station

There are three-sub stations on Berths Nos.2, 3 and 4 in the container zone. The electric power station should be moved to the foremer maintenance shop site for the following reasons (see Fig. 6-9-1):

1. An electrical power source is available from ministory of electricity.
2. To concentrate activities for easier control work.

6.6.7.6 Lighting

Lighting must be provided to keep a brightness of an average 20 lux in the container zone to ensure for safety and smooth operations.

Future development plan of Mina Qaboos is shown in Fig. 6-6-24.

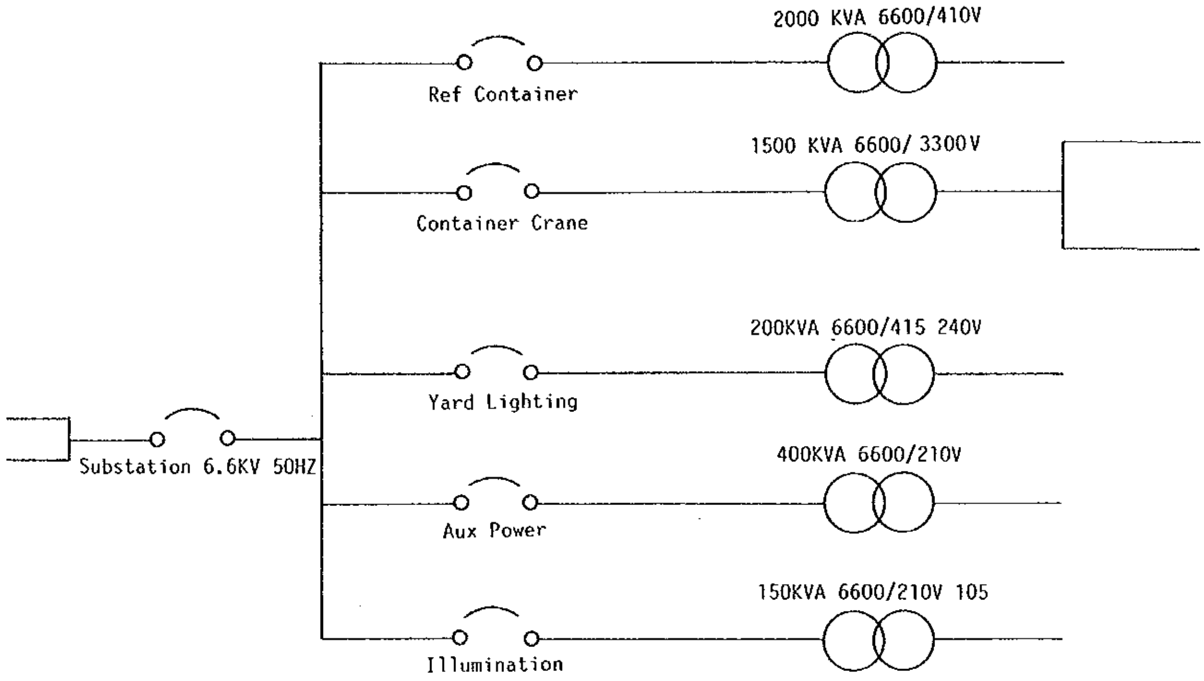


Fig. 6-6-23 Single Connection Diagram

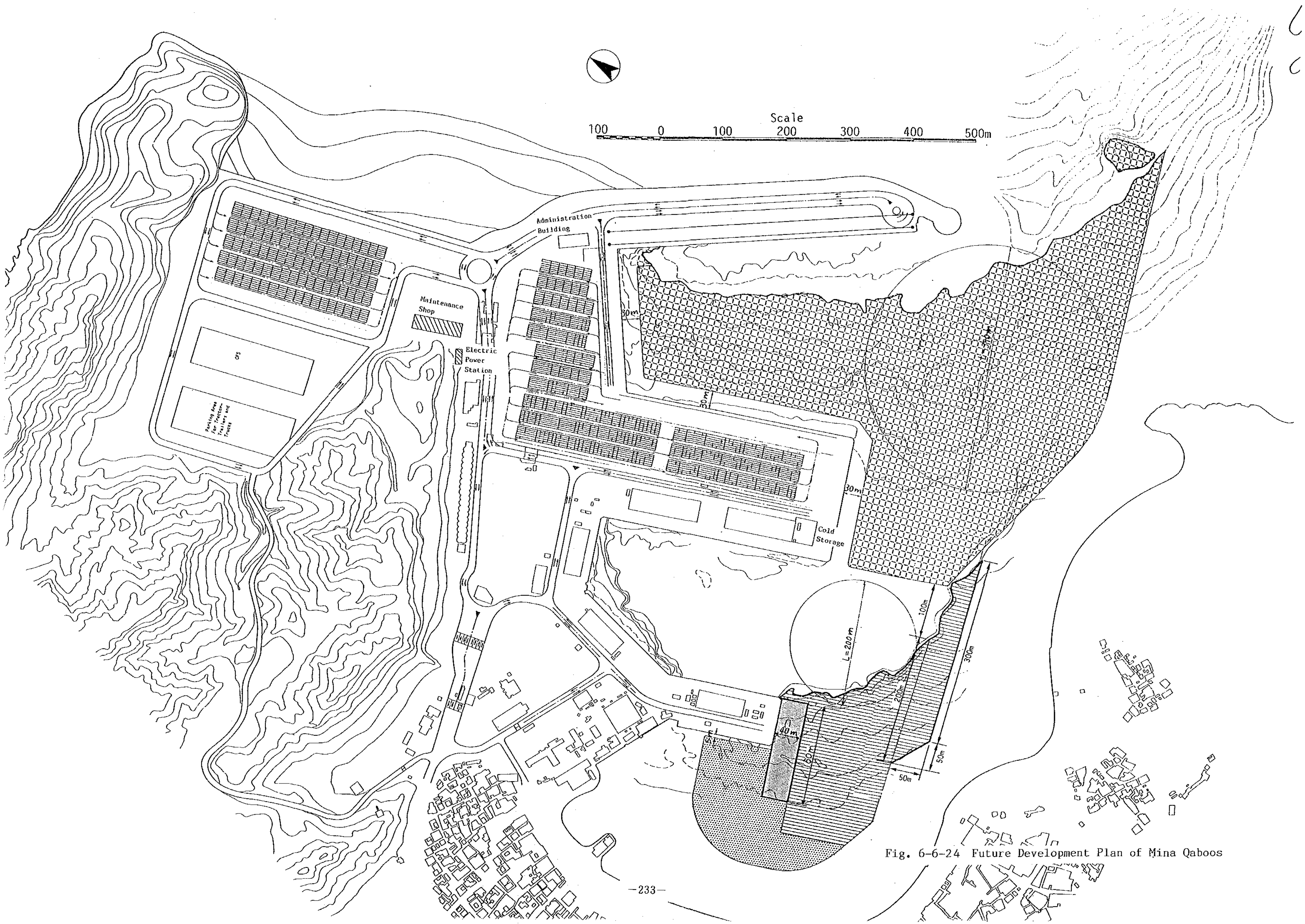


Fig. 6-6-24 Future Development Plan of Mina Qaboos

6.7 Operation System

6.7.1 Handling System

Chassis, straddle carrier and transfer crane systems are the handling systems now used in container yards but the chassis system is impracticable for Mina Qaboos Yard and we have studied the merits and demerits of other two systems with regard to the following factors:

(1) Maneuverability
(2) Efficiency of container crane
(3) Height of stack/land utilization
(4) Facility of handling containers
(5) Damage ratio of containers
(6) Maintenance of machinery
(7) Automation of operation
(8) Training of drivers
(9) Amount of investment (machinery)
(10) Amount of investment (container yard)
(11) Kind/type of terminal for which each system is best suited

(1) Maneuverability

In the case of a short distance operation, there is no difference in maneuverability between the two, but a transfer crane system using a tractor-trailer is considered better for long distance operations. In relation the width of passage, a tractor-trailer, transfer crane system, is advantageous in a straight line portion, but at a corner, a straddle carrier is advantageous.

(2) Efficiency of container crane

A container crane puts a container directly on the ground. It is later picked up by a straddle carrier, but when a tractor-trailer does not put a container down to the ground, the movement of the crane is restricted and in this sense, a straddle carrier system can more easily accommodate loading and discharging in peak periods and better in terms of the efficiency of the container crane.

(3) Height of stacking/land utilization

The stacking height of containers should be considered in relation to ease of delivery. When container are piled in higher tiers non-commercial handling of containers increases. A transfer crane can handle containers more easily even if these are stacked in higher tiers. Consequently the transfer crane system can stack containers at a high density and ensure better land utilization.

(4) Facility of handling containers

In the case of a transfer crane system, a tractor-trailer has to use other deliver gear at both ends but a straddle carrier has a function whereby it can both lift up and down as well as a carrying function which facilitates containers handling.

(5) Damage ratio of containers

In general, the damage ratio of the containers carried by a straddle carrier is higher than that in the case of a tractor-trailer, transfer crane system.

(6) Maintenance of machinery

In principle, the maintenance of a straddle carrier is similar to that of a car and can be done easily by a mechanics of average expertise, while transfer crane maintenance requires a higher level of expertise. There is no difference in the rate of occurrence of serious trouble between the two systems provided that they are properly maintained, but a straddle carrier often needs a change of parts because of its mobility, which raises maintenance costs.

(7) Automation of operation

A transfer crane system has greater possibility of being automated.

(8) Training of drivers

Compared with a transfer crame system, a straddle carrier system uses many carriers and requires more skilled drivers, who must be trained periodically. Besides, the duration of their service is considered to be shorter due to the unnatural driving position they must adopt.

(9) Amount of investment(machinery)

The minimum number of pieces of machinery required for one gantry crane unit is three/four straddle carrier units or one/two transfer crane units together with five tractor-trailer units. A straddle carrier system thus proves more expensive.

(10) Amount of investment(yard)

A transfer crane system proves more expensive in terms of for construction.

(11) Kind/type of terminal for which each system is best suited

A transfer crane system suits terminals where there are many LCL and empty containers. A straddle carrier system suits the terminals where container traffic is well balanced between FCL and LCL containers. The optimum annual throughput of containers is around 100,000 TEU for a straddle carrier system and more than 100,000 TEU for a transfer crane system.

On the basis of the above analysis as well as the actual circumstances at Mina Qaboos, we consider a transfer crane system to be appropriate. A summary of this comparison is provided in Table 6-7-1.

Table 6-7-1 Comparison of Handling Systems

	Transfer Crane Sytem	Straddle carrier System
(1) Maneuverability	normal	good
(2) Efficiency of container crane	normal	good
(3) Height of stack/land utilization	good	normal
(4) Facility of handling containers	normal	good
(5) Damage ratio of containers	good	normal
(6) Maintenance of machinery	good	normal
(7) Automation of operation	good	normal
(8) Training of drivers	good	normal
(9) Amount of investment (machinery)	good	normal
(10) Amount of investment(yard)	normal	good
(11) Kind/type terminal for which systm is best suited	more than 100,000 TEU mainly for LCL/empty containers	around 100,000 TEU LCL/FCL well balanced

6.7.2 Computer System

6.7.2.1 Outline of Computerization

As mentioned in 3.5.7, planning of the container handling operations is still processed manually. Among these processes, LCL handling in the CFS is difficult area for computerization due to its mixture of containers and general cargo. On the other hand, Yard Location Planning and Stowage Planning are both popular in many container terminals in different ports of the world. The target of stage III, Empty Container Movement, is therefore, to automate the selection of suitable locations for empty containers while stage IV, Shipping Operations, aims at computerizing planning for loading operations. However, possibility of expanding the present computer based container handling system to the greatest extent should be taken into consideration in order to maximize the utilization of existing system and streamline the present procedures such as sequencing of discharging and calculation of stevedoring charges before further development of system.

Despite of the abovementioned factors, the need for computerization of the container terminal will become more acute as container traffic increases. The container traffic in the port is increasing phenomenally. Thus deployment of a new container handling system is being seriously studied as a way of counteracting the extremely small amount of storage space, so that the port can accommodate the increased traffic volume. From the historical view, the degree and extent of computerization has generally been as shown in table 6-7-2 below.

Table 6-7-2 Degree and Extent of Computerization

	Approximate annual throughput	Terminal office operation	Yard operation
Level 1	~60000 TEU	manual	manual
Level 2	60000~150000TEU	computerized	manual
Level 3	150000TEU~	computerized	partly computerized
Level 4	~	computerized	computerized

Almost all the container terminals in the world fall under Level 2. Some in Europe, the U.S.A, and Japan have been proceeding toward Level 3.

Mina Qaboos is now at Level 2. The basic concept of this level is that computerization of the terminal office operation should be developed inclusive of:

1) Yard control, container status control, gate control
2) Various planning/sequencing operations concerning container movement
3) Documentation

While the berth or yard operation is still manually carried out. Below we describe a typical framework for computerization of a terminal to Level 2.

6.7.2.2 Terminal Control System

This system includes the following two major programs:

a) Marshalling yard control program
   Function: Determination of export container locations
   Determination of import container locations
   Determination of change of locations, instruction and revision of them
   Storage container list *inclusive of container* locations and status

b) Gate control program
   Function: In bound container control
   Out-bound container control

For maintenance and the computer file, yard planners input the data into the computer system based on booking lists, stowage plans and other documents that are sent by the shipping company and/or obtained at the time of delivery or receipt of containers at the gate. According to this data, yard planners using this system can allocate spaces in the marshalling yard for containers according to their specifications; numbers, kinds, dimensions, ports of destination weight, etc. Once these files, on container location and status are established in the system, it is easy for yard planners to output required information and instruct all personnel concerned by means of an on line computer system and/or a yard communication system.

6.7.2.3 Terminal Planning System

This system includes the following three major programs:

a) Loading schedule program

Function: Inputting and filing the number of loading containers and their status for a specific vessel. Preparing preliminary plans, a bay plan, a stowage plan, a schematic plan, a sequence checklist, etc. Finalization/revision of preliminary plans. Calculation of weight, height of center of gravity of the ships and cargo combinations and monitoring and others.
Monitoring of operation

b) Discharging schedule program

Function: Inputting and filing the number of containers discharged and their status from a specific vessel. Preparing preliminary plans, a schematic plan, a sequence checklist and rehandling list. Finalization/revision of preliminary plans.
Monitoring of operation

c) Program for optimal handling equipment procedure.

The loading schedule plan is prepared on the basis of the information in relation to the export container location in the marshalling yard which can be generated by the concerned program as well as by the stowage plan sent by the shipping company. Discharging container information is also important because of the spaces occupied by such containers are usually scheduled to be loaded. A stowage plan is prepared with program a) on the basis of specifications for containers such as their dimensions, kinds, ports of destination, weight etc., and a check of the ship's stability is simultaneously carried out, using a related program. Optimal procedures of yard handling equipment will be decided on the basis of stowage plan and export container location. Bay plans, sequence of handling equipment and other necessary plans are prepared using related programs. The sequence checklist is printed out and distributed to key personnel. A terminal operator monitors the operation with the necessary plans displayed on a

CRT. The drivers of each piece of equipment report on the completion of each sequence using the yard communication system. The discharging schedule is prepared in the same way as the loading schedule.

6.7.2.4 Documentation System

The system finalizes all the information processed and/or developed in the systems described previously. Preparing documentation to submit to the parties concerned and filing the necessary information for port statistics can be carried out with this system.

The outline of the total computer system in each area and the whole area can be referred in Figs. 6-7-1(a)-(d), 6-7-2.

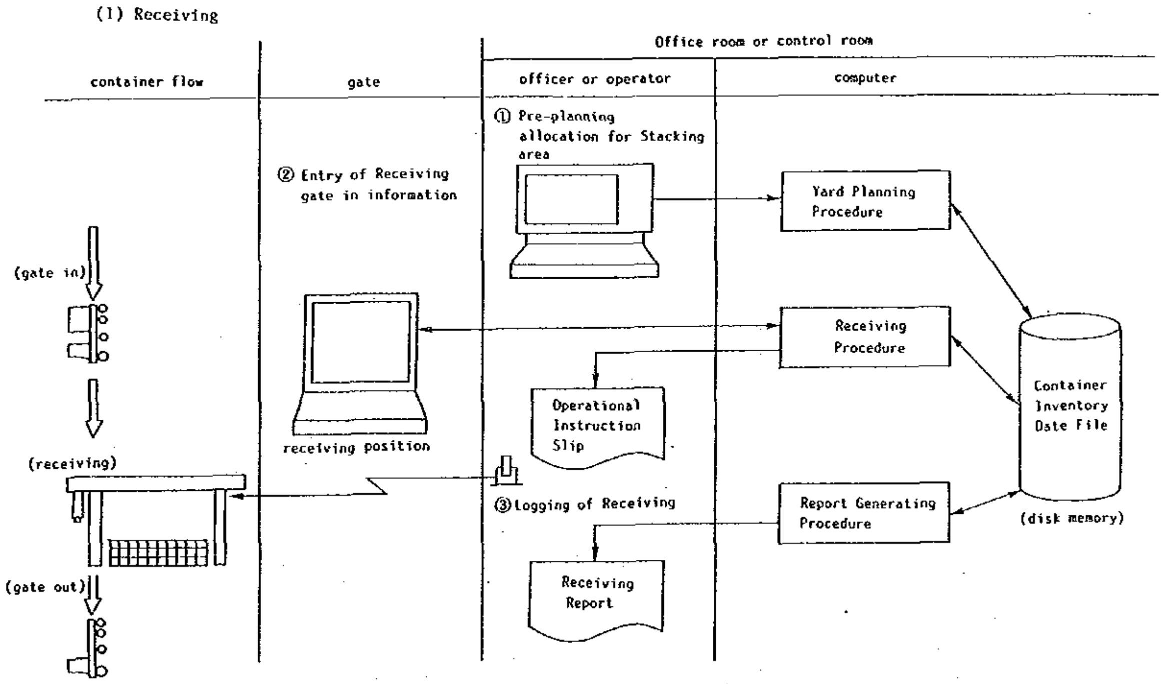


Fig. 6-7-1(a) Gate Control Program

(2) Delivery

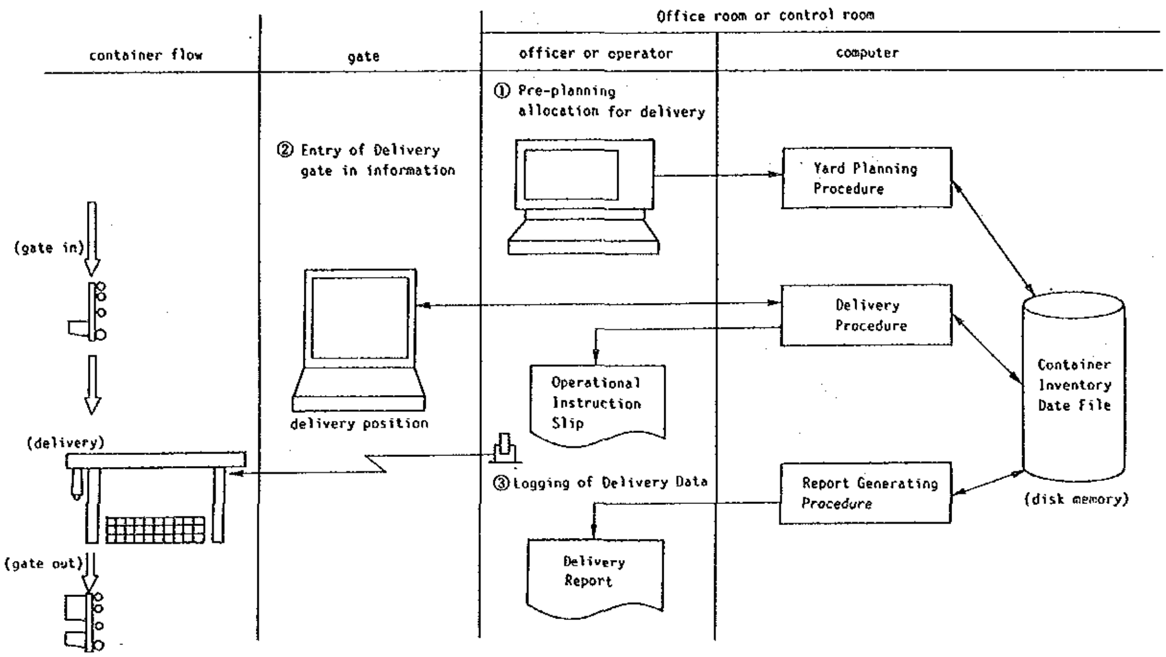


Fig. 6-7-1(b) Gate Control Program

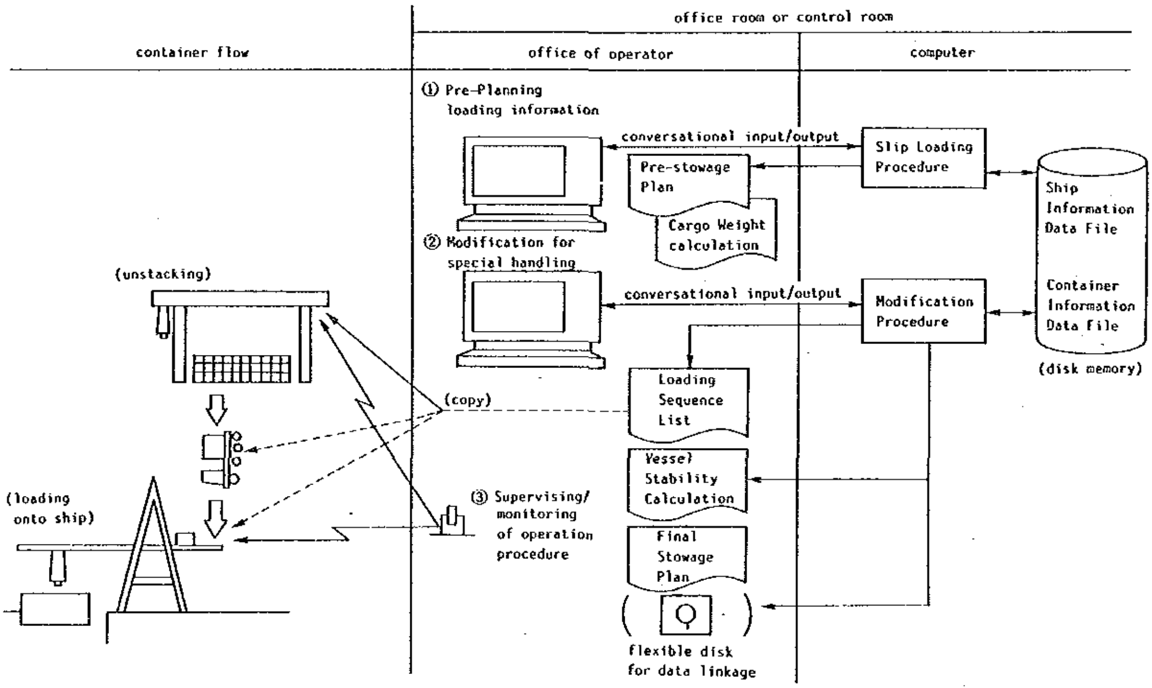


Fig. 6-7-1(c) Loading Schedule Program

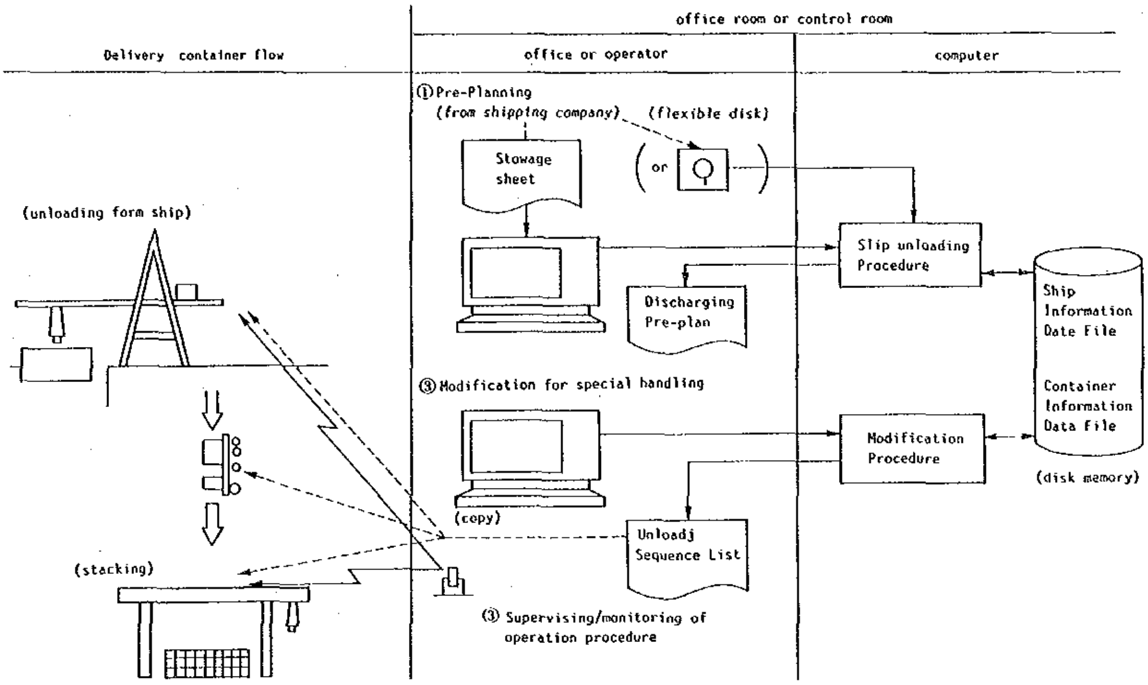


Fig. 6-7-1(d) Discharging Schedule Program

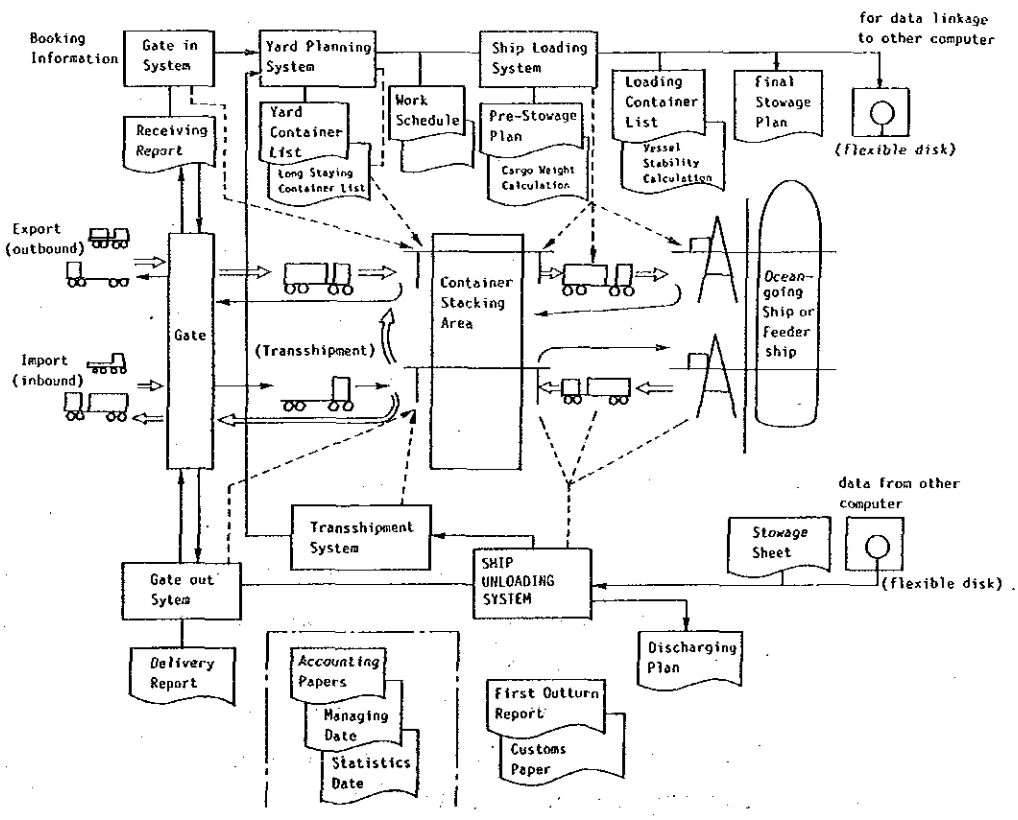


Fig. 6-7-2 Out Line of Total Computer System of a Terminal

6.7.3 Man Power

6.7.3.1 Conventional Cargo Operation

(1) Productivity

At present, on the shift-day, 7 gangs are available, and on the shift-night,5. The make-up of each gang was mentioned in 3.5.3. One gang's handling capability per hour is reported in 3.5.2. On the other hand, with a view to limiting the waiting time of incoming vessels to within an acceptable time, improvement of handling capability is absolutely necessary. The following are the targets in respect of three kinds of cargo:

	Productivity expected in 1995		
	Present rate	Expected rate	Improvement ratio
Steel and pipes	23.3 T/H	30 T/H	29%
Timber and plywoods	23.9 T/H	30 T/H	29%
General Cargo	18.9 T/H	25 T/H	32%

As regards general cargo, now handled as conventional cargo in Mina Qaboos, there will not be great change in handling methods in the next few years. Large-scale improvement on the productivity like that mentioned above is unfeasible. In as much as improvement of the Gangs' capabilities cannot be expected, an increase in the number of gangs is imperative. The need for an increase in the number of gangs also stems from the need to change port's working hours, since it is necessary to provide round-the-clock service instead of the present 2-shift-service over 16 hours.

(2) Number of gangs required corresponding to the berth capacity

To achieve the expected berth capacity, the following gangs for handling conventional cargo will be necessary in 1995 when the cargo volume will be greater than in 2000, for the operation, by berth and by commodity. Gangs for RO/RO, discharging of livestock and bulk grain are specially formed by the PSC or the consignees and are not directly concerned with the gangs for conventional cargoes when we calculate the number of gangs needed. Table 6-7-3 below shows the application of gangs, the operation ratio and the number of calling ships.

Table 6-7-3 Application of Gangs

Berth	2			6			7			8		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
Steel	9	8.5	26	9	7.2	22	9	8.0	24	9	8.0	24
Timber	9	7.5	26	9	2.1	7	9	2.2	8	9	2.2	8
General cargo	9	5.3	31	9	10.7	62	9	10.9	63	9	10.9	63
	9	21.3	83	9	20	91	9	21.1	95	9	21.1	95

Where (a): reserved gangs (b): operating ratio(%)
(c): number of calling ship

The maximum number required, if the PSC simply accommodates conventional cargo operation, will be 36 gangs. The minimum number of gangs requires, the sum of the products of the number of gangs at each berth multiplied by the operation ratio, will be 8 gangs. Neither of these figures are realistic. The optimum number of gangs should be determined with regard to the entire cargo work in the port, since this should and can be carried out comrehensively, supplementing each other. An appropriate operation ratio is considered to the 50% for the expected cargo because the reserve capacity for land side operations and operations for sorting of the stacking area or handling for delivery, should be kept around 30%. An 80% net operation ratio is considered to be the marginal ratio for an organization that keeps its gangs in good working condition. On the basis of the above reasons, the number of gangs required will be 17 in 1995.

(3) Annual volume of handling and the number of gang

Annual throughput recorded 1988 and forcasted in 1995 and 2000 is noted in the following table.

	1988	1995	2000	* 2000
Steel and Pipe	149,000 ton	230,200 ton	220,200 ton	*361,400 ton
Timber and Plywood	70,900 ton	100,500 ton	70,000 ton	*124,000 ton
General Cargo	170,300 ton	208,700 ton	171,700 ton	*313,100 ton
Total	390,200 ton	539,400 ton	461,900 ton	*798,500 ton

Note: * is the aggregate of the volumes handled in Mina Qaboos and the New Port in 2000.

General cargo handled in Mina Qaboos increases as above but from 1995 to 2000, the new port will start servicing with the result that the volume handled at Mina Qaboos in 2000 will be less than the volume in 1995.

Supposing that the volume at the peak is the average of that in 1995 and that in 2000 (presuming that the new port will not contribute to handling general cargo), the annual volume in 1997 - 1998 will be 670,000 tons. The number of gang in proportion to the volume estimated to be handled will be as follows:

	1988	1995	1997-1998	2000	2000*
Cargo throughput (tons)	390,200	539,400	670,000	461,900	798,500
Number of gang	12(G)	17(G)	21(G)	14(G)	25(G)

According to the tables above, we note that:

(1) 17 gangs will be necessary for Mina Qaboos for five years around 1995.

(2) The volume at the around 1997 will be 24% higher than the volume in 1995, which cannot be covered by an improvement of efficiency (only 10% may be expected at best), and thus some other steps should be taken.

(3) A maximum of 25 gangs will be necessary in case there is no allocation of cargo handling to the new port up to 2000, but 14

gangs will be sufficient if allocation is feasible as expected.

From the above analysis, it is considered necessary to increase the number of gangs to 17 until 1995, thereafter adjusting the number depending upon the extent of allocation of cargo handling to the new port.

Unless functional allocation between Mina Qaboos and the new port is feasible as expected, an increase in the number of gangs is indispensable for the PSC. However, this should be done strategically taking into consideration the gangs being transferred to the management body of the New Port or other countermeasures to compensate for the sudden change of cargo volume handled at Mina Qaboos. Moreover, efforts to improve the hourly handling capacity should be made continuously by the PSC; mechanization of handling, upgrading of skills and recruitment of younger labourers should be considered and carried out.

6.7.3.2 Container Cargo Operations

Shipside operations at the container terminal must be carried out for on a 24-hour, 365-day a year basis. In addition to berths Nos.4 and 5, container vessels must also be berthed at Berths Nos.1 and 2 thus more gangs will be necessary. At present, two gantry cranes operate at Berths Nos.4 and 5 and one gang is assigned to each shift for the operation. When both cranes are operating, half a gang is posted to each crane. in the light of the handling conditions in this port, handling can be operated by this system. Therefore, as for the container gangs, the number of gangs available for the container operation at Berths Nos.1 and 2 should be increased. An average 23.6% berth occupancy ratio is expected for the container operation, at berths Nos. 1 & 2 with each gang assigned exclusively to one shift. The gang should be organized as in the case of Berths Nos.4 and 5, with ship supervisors and planners posted likewise. The number of planners, however, should be reduced in the light of the progress in computerization, especially of the central control system of planning.

Container handling gangs

Common ship supervisors	:	1 man
Head planners	:	1 man
Planners	:	2 men

Inspection clerks	:	2 men(1 man/crane)
Foremen or gang leaders	:	2 men(1 man/crane)
Winchmans	:	2 men(1 man/crane)
Laborers	:	12 men(6men/crane)
Total	:	22 men/shift/gang/2 cranes

This formation of container gangs is appropriate even in future. 3 gangs, totaling 66 men, will be arranged before service starts at Berths Nos.1 and 2.

6.7.3.3 Gangs for the CFS Operation

Small lot cargoes stripped from the container for delivery and brought into the CFS to be stuffed are dealt with by the gangs engaged in the CFS operation. The cargo volume handled daily is expected to be 520 tons and 501 tons in1995 and 2000, respectively. On the assumption that the productivity of the gang for general cargo handled in the CFS is the same as the figure of the gangs for the conventional cargo, that is, 18.9 tons/hr./gang, the number of cargo-handling gangs needed will be more than 3. However, this can be reduced due to mechanization of the handling using many forklift trucks. Normally one forklift truck is provided for every two or three laborers with one tally clerk, hence productivity can be improved to from twenty five to thirty tonnes. Accordingly, the number of gangs required for the CFS operation will be more than two; approximately 3 gangs. The number of small fork lift truck needed will be nine. The gangs for the CFS operation now consists of the following personnel. This type of gang composition is does not need to be changed:

Foremen	:	1 man
Tally clerks	:	2 men
Marker boys	:	1 man
Laborers	:	8 men
Forklift truck drivers	:	3 men

6.7.3.4 Summary

Based on the above investigation, the recommended increase in the number of gangs by 1995 and onward is shown in table 6-24. The number of gangs needed to handle conventional cargo, however, should increase more than the figures indicated in the table, if cargo is not allocated between Mina Qaboos and the New Port. In such a case, the other gangs would still sufficient in number because the berth capacity will reach its limit first.

Table 6-7-4 Summary of Required Gangs

	Present	1995	2000
Conventional	12	17	14
Container	3	6	6
CFS	1+α	3	3

Note: The make-up of each gang is unchanged.

6.8 Handling Equipment

6.8.1 Handling Equipment for Container Operation

The quantity of handling equipment required is calculated for three parts of the part's operations: shipside operations, landside operations, and grounded area operations. Operations related to the CFS operation are included under landside operations. Flow for determing on number of handling equipment can be referred to Fig. 6-8-1.

6.8.1.1 Shipside Operations

The capacity of shipside operations is analyzed and the handling equipment required is worked out based on the following points:

(1) Function of each berth group, Berths Nos.1-2 and Nos.4-5

i) The estimated annual container throughput handled at each berth group is calculated taking into account their specific functions and the evaluation of container cranes' capacity based on their working ratio.

ii) The number of tractor trailers and transfer cranes corresponding to the handling rate of the container crane for the annual throughput is estimated as above.

iii) Establishment of the maximum number of container boxes, the target capacity handled by one container crane per hour in 1995 and 2000, respectively, and the corresponding number of handling equipment units.

6.8.1.2 Amount of Handling Equipment Required at Berth Nos.1-2

(1) The estimated annual container throughput at berths Nos.1-2 will be 63,484 boxes in 1995 and 70,580 boxes in 2000.

(2) The working ratio of the container cranes at present ranges between 35%-45% from month to month and is estimated to be 40% on average. This is the gross working ratio counted from the start to the finish of a gantry crane's work, including the time required for movement of the crane and opening and closing of the hatch cover. To analyze the container cranes' capacity corresponding to the volume in 1995 and 2000 on the basis of this working ratio, it becomes clear that they have sufficient capacity.

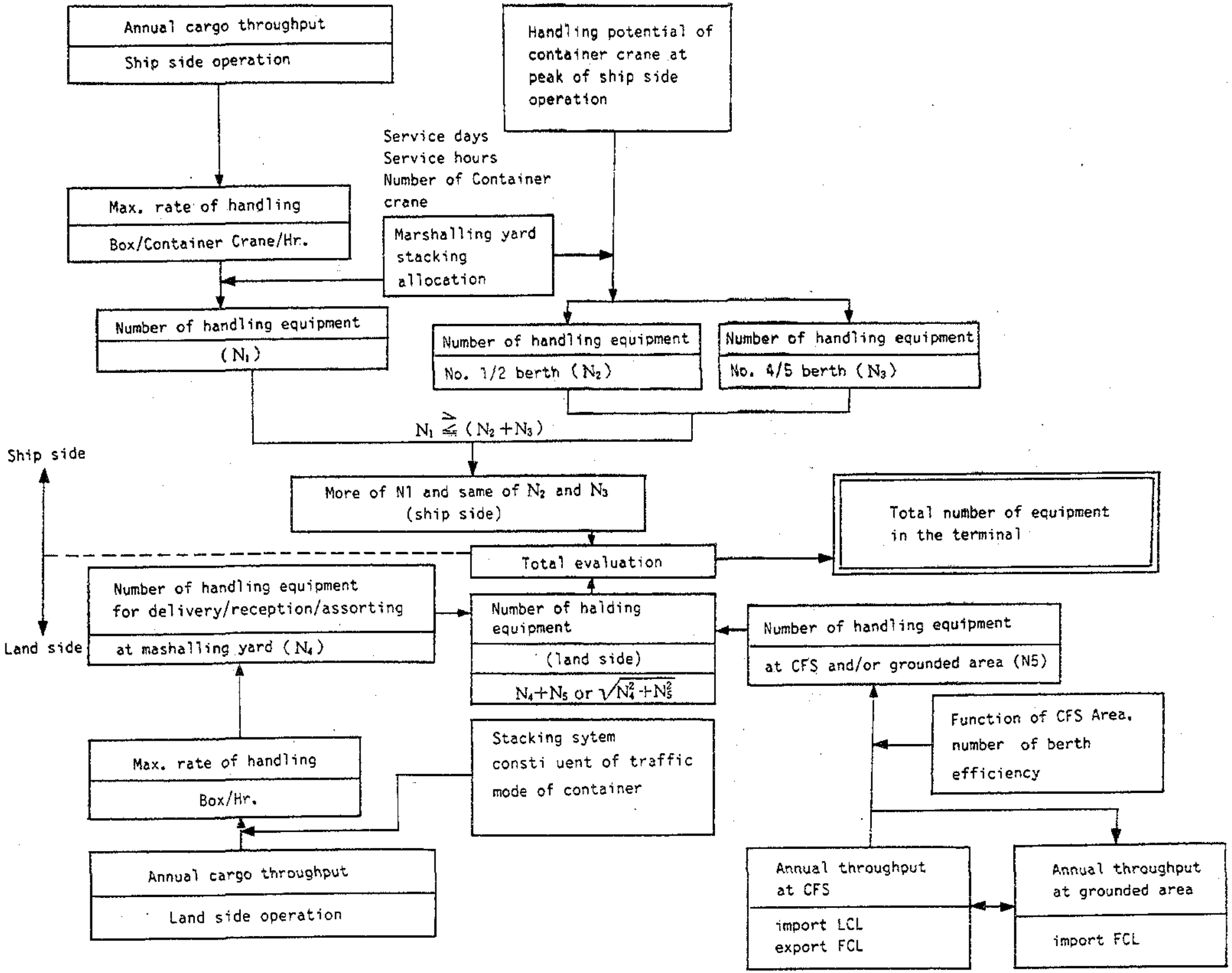


Fig. 6-8-1 Handling Equipment for Container Operation

Year	Handling rate (Boxes/hr./crane)
1995	63,484/2/365/24/0.4 = 9.1
2000	70,580/2/365/24/0.4 = 10.0

Two tractor-trailer units are necessary for each container crane.

(3) On the other hand, if the number of containers handled by the crane at the peak of operation is 25 boxes and will be increased to 30 boxes in the future, the number of tractor-trailers will be six and seven respectively. Therefore, when berths Nos.1-2 start operating, 12 tractor-trailers are necessary for two cranes and will increase to 14 in the future. Assuming that the transfer crane handles 20 boxes per hour, three units will be necessary for shipside operation.

6.8.1.3 Amount of Handling Equipment Required, at Berths Nos.4-5

(1) The estimated annual container throughput at berths Nos.4-5 will be 114,000 boxes in 1995 and 113,968 boxes in 2000.

(2) The working ratios of the container cranes at present are estimated to be 40% on average, the same as described in the previous item. Analyzing the container crane's capacity corresponding to the volume in 1995 and 2000 on the basis of this working ratio, it becomes clear that they have sufficient capacity.

Year	Handling ratio (Boxes/hr./crane)
1995	114,000/2/365/24/0.4=16.3
2000	113,968/2/365/24/0.4=16.3

Three tractor-trailer units are necessary for one container crane.

(3) On the other hand, if the number handled by the crane at the peak of operation is 25 boxes which will be improved to be 30 boxes in the future, the number of tractor-trailers will be four and five, respectively. As for transfer cranes' three units will be required, based on the same assumption as in the previous item.

6.8.2 Landside Operation

Containers unloaded from the vessels and stored in the marshalling yard are delivered to consignees and also transferred to the CFS or grounded area for unstuffing. Those brought by shippers to be loaded and unstuffed at the CFS or grounded area are stored in the marshalling yard. This is generally termed the "landside operation". Machinery required for this operation is calculated based on the following procedure:

a) Handling and delivery of the import containers from the yard
b) The movement of export containers in the yard
c) Estimate of the maximum container handling rate per day
d) Determining the machinery required.

(1) Hadling and delivery of the import containers from the yard

Containers needed by the consignees have to be delivered to their trailer from the relevant stacks, which are mostly in two/three tiers. When a container stowed in the second or third tier must be taken out, the one in the upper tier must be lifted up and is supposed to be stored in a temporary spot until delivered. In order to reduce the amount of non-commercial handling, putting containers back into their original position in the stacks should be discontinued. In the case of FCL containers, which are unstuffed in the yard as well as LCL containers, it should be taken into account that the work load is twice as much as the number of the units handled. Besides, these containers are stored in the stack for export after stripping hence three time the amount of handling work load should be taken into account, including the above work.

(2) Movement of export containers in the yard

The estimation of the workload should be adjusted in accordance with the actual movement of containers in the yard. FCL containers stuffed by the shippers or empty containers unstuffed by the consignees are dealt with as export containers. They are sorted according to vessel, destination size, weight, etc., and stored in the stack for export.

One fourth of the export containers are stuffed in the yard and twice the workload should be taken into account in handling them.

(3) Estimation of maximum container handling rate per day

The maximum container handling rate is estimated on the basis of annual container throughput based on demand forecast and workloads described above and is obtained as follows:

	1995	2000
Lifting frequency	577 Boxes	541 Boxes
Number of containers dealt with the CFS	50	48

Note: The number of containers dealt with at the CFS includes LCL containers and grounded containers in order to estimate the maximum quantity of equipment

(4) The numbers of handling equipment

The number of handling equipment units required for landside operations estimated on the following basis are:

(a) Transfer crane

Handling capacity: 20 boxes/hr.
Working hours : 8 hours
Units required : 4 units

(b) Tractor-trailer

Berth capacity of CFS : 2.5 boxes/day
Capacity of tractor : 7-8 boxes/hr.
Number of trailers required: 20 units
Number of tractors required: 3 units

As for the capacity of the tractors, it is possible maximum frequency to transfer the containers between the yard and the CFS. The to and fro operation of these container should be carried out in a short time,around an hour and on a concentrated basis. An average possible frequency is not meaningless because the CFS gangs' idle time will increase greatly if there is only average frequency. The number of tractor-trailers also means the necessary number to deal with peak periods of the CFS operation.

6.8.3 The Quantity of Machinery Necessary for Cargo Handling

Regarding the quantity of cargo handling machinery analyzed previously in respect of shipside, landside and grounded area operations, some can be reduced in respect of the entire terminal, since they should and can be operated comprehensively, supplementing each other. With this idea in mind, the quantities of machinery necessary for the terminal's operations in 1995 and 2000, respectively, is estimated as follows:

	Shipside operations		Landside operations	Number required
	Berths Nos.1-2	Berths Nos.4-5		
(1995)				
Container crane	2	2		4
Transfer crane	2	2	4	8
Tractor	12	8	3	23
Trailer	12	8	20	40
(2000)				
Container crane	2	2		4
Transfer crane	2	2	4	8
Tractor	14	10	3	27
Trailer	14	10	22	46

Note: A top lifter required at the grounded area is omitted from this table Regarding tractor-trailers, a lay-off time of 25% is usually assumed. However, it can be ignored for the above-mentioned reason. Parking area for these equipment, as well as others, are described in the last part of this section. The main dimensions of required handling equipment are shown as follows;

6.8.4 Container Crane

(1) Hoisting capacity under spreader	41 tonnes
(2) Outreach from centre line of water side rail	36 m
(3) Back reach from centre line of landside rail	11 m
(4) Span between centre lines of water side and landside rail	20 m
(5) Lifting height under spreader to top of crane rail	24 m
Lowering depth from top of rail	14 m
Total hoisting lift	28 m

(6) Approximate working speeds*

i) Hoisting speed with 41tonne load	50m/min.
ii) Hoisting speed with no load	120m/min.
iii) Trolley traversing speed	150m/min.
iv) Travel speed	45m/min.

Note: The actual operating cycle of a container crane is 25 cycles per hour in actual loading/unloading work. The potentioal cycle is 35 times an hour, 102 103 seconds per cycle. Thus operating efficiency is 65% of potential efficiency.

6.8.5 Tire Mounted Transfer Crane

(1) Hoisting capacity under spreader	30.5 (40) tonnes
(2) Span	23m 470mm
(3) Lift(9'6" containers 4 high)	14m 940mm

(4) Approximate working speeds

i)Hoisting speed with 30.5tonnes load	17m/min.
ii)Trolly traversing speed	35m/min.
iii)Travelling speed	90m/min.

Note: If the cost for 40 tonnes RTG is not so high compared with 30.5 tonnes RTG, 40 tonnes RTG could purchased.

6.8.6 Tractor-trailer

For 40 feet container

6.8.7 A List of Equipments

Equipment	Dimension	Units	Remark
Container crane	Cap, 35t Span 30m	2	(Exist) Berths Nos.4 and 5
Container crane	Cap, 41t Span 20m	2	(New) Berths Nos.1 and 1A
Transfer crane	Cap, 30.5t(40t) One over 4high	8	(New) Berths for Nos.3 and 4: 5 units for Shutaify Bay Yard: 3 units
Tractor trailer	for 40 feet container	27	(New) for Berths Nos.3,4 and 5: 10units for Berths Nos.1 and 1A : 14units for CFS : 3units
Trailer	for 40 feet container	19	(New) for CFS
Folk lift (Heavy type)	Cap, over 25t	5	(Exist) for Shutaify Bay Yard for general cargo
Folk lift (Light type)	Cap, over 1t	70	(Exist)

6.9 Maintenance System

Mina Qaboos need many pieces of cargo handling equipment fore its expansion toward 1995. The present efficiency of total cargo handling at the port is determined by the operating conditions of a given piece of equipments, not counting down time caused by sudden accidents. Many machines and other pieces of equipment must be maintained in good condition through daily servicing, weekly checks, monthly inspections or yearly tests. Parts should be replaced according to their specific maintenance schedules. The members of the engineering staff at Mina Qaboos have fine technical abilities and are able to keep the port's equipment in good working condition. They have been recording maintenance logs. Various kinds of spare parts are stored in a warehouse to cope with repairs or other servicing as needed. But the number of staff members in the engineering department has to be increased at the same rate as the part's equipment is added.

1) Staff increase

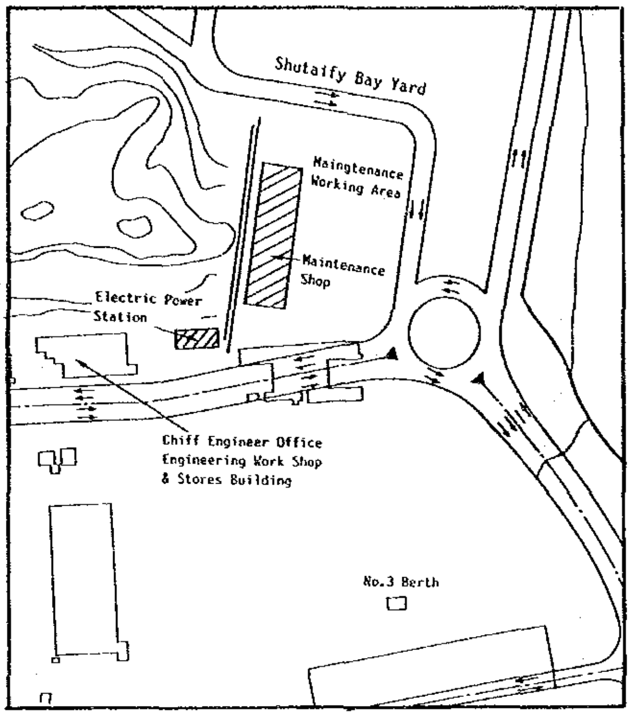
	Engineers	Workers
Electrical	2	6
Mechanical	2	10
Other		10
(ioncluding automobile drivers)		
Total	30	

2) Working area

A new maintenance shop should be built in the entrance zone at Shutaify bay to handle repairs and ensure the safety and case of port operations. (see Figs.6-9-1, 6-9-2)

	New	Former
Working area	$10,800m^2$	$5,000m^2$
Shop Building	$1,300m^2$	$700m^2$

In order to ensure profitability, it will become more important to carry out preventive maintenance as more modern handling equipment is used at the port. This preventive maintenance requires a lot of manpower, many spare parts and a large budget. Moreover, adequate preventive maintenance



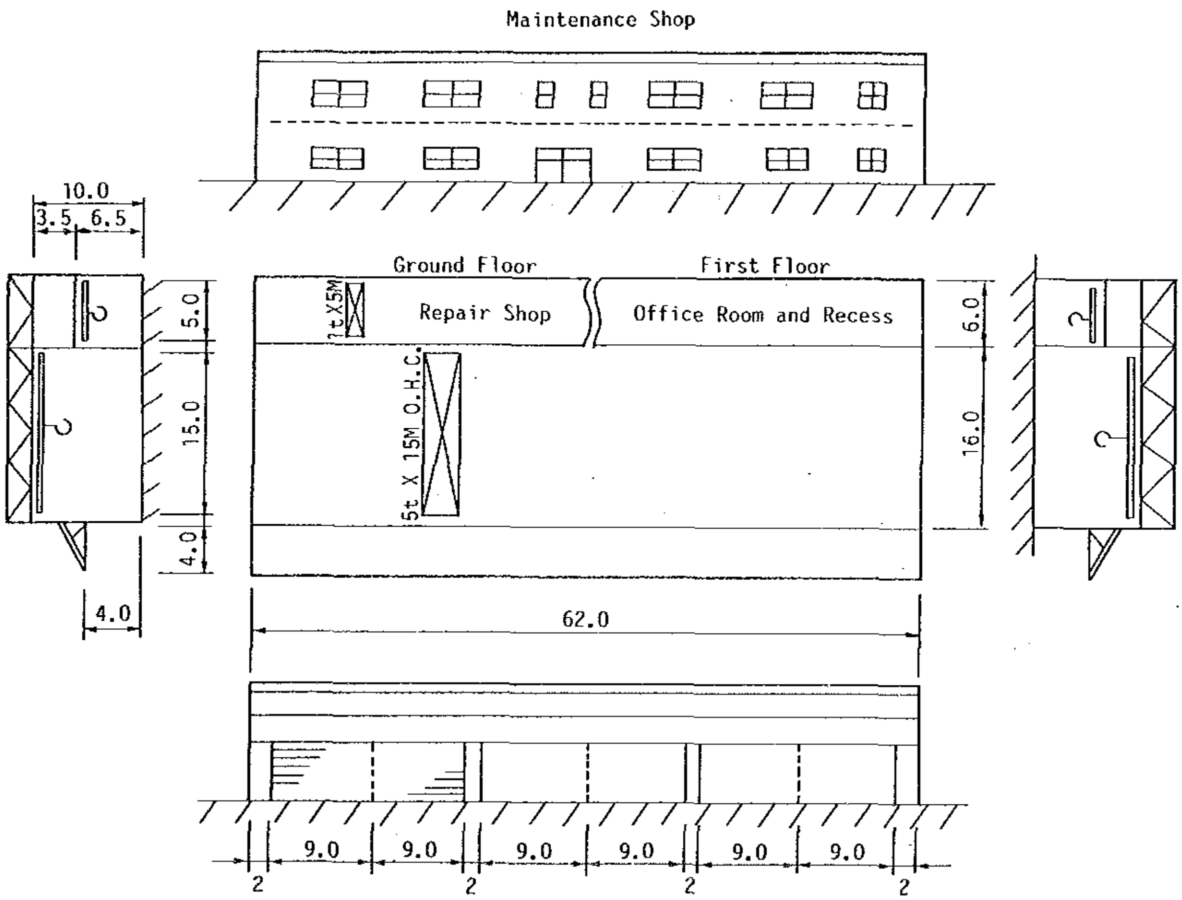
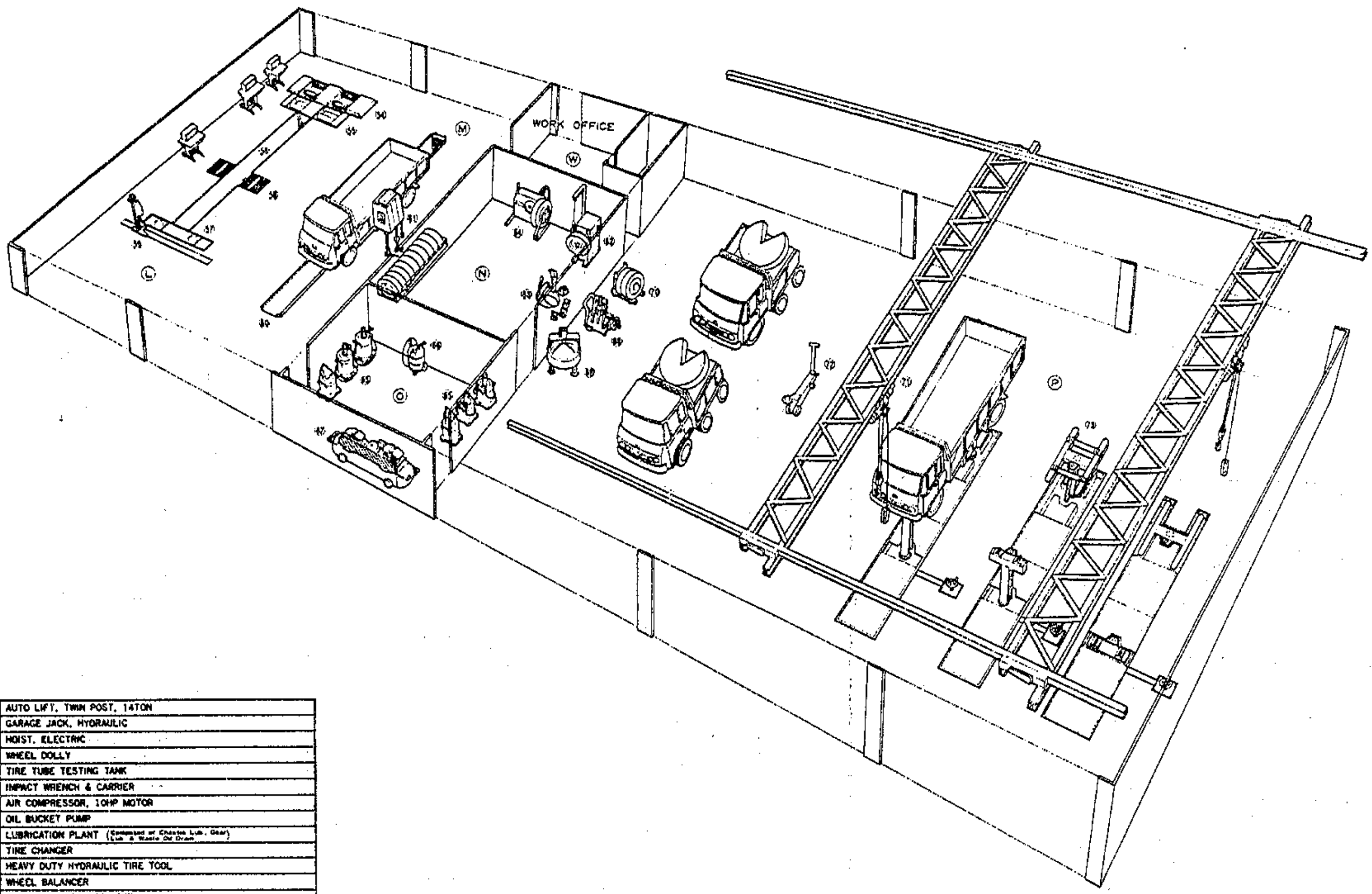


Fig. 6-9-1 Maintenance Working Area and Maintenance Shop



P	73	AUTO LIFT, TWIN POST, 14TON
	72	GARAGE JACK, HYDRAULIC
	71	HOIST, ELECTRIC
	70	WHEEL DOLLY
	69	TIRE TUBE TESTING TANK
	68	IMPACT WRENCH & CARRIER
O	67	AIR COMPRESSOR, 10HP MOTOR
	66	OIL BUCKET PUMP
	65	LUBRICATION PLANT (Composed of Chassis Lub., Gear Lub. & Waste Oil Drain)
N	64	TIRE CHANGER
	63	HEAVY DUTY HYDRAULIC TIRE TOOL
	62	WHEEL BALANCER
M	61	OVERHEAD HOSE REEL SET
	60	LUBRICATION PIT
L	59	HEAD LIGHT TESTER
	58	SIDE SLIP TESTER
	57	TURNING RADIUS GAUGE
	56	INSPECTION PIT
	55	SPEEDOMETER TESTER
	54	BRAKE TESTER

Fig. 6-9-2 Layout of Maintenance Shop (For Reference)

work requires the following items:

1) A preventive maintenance budget
2) A manual or checklist for preventive maintenance should be delivered to the staff after being translated from English or other languages, into Arabic
3) Training and education to upgrade technical ability.

6.10 Training of Maintenance and Operational Staff Members

In proportion to the increase in cargo volume and the number of containers, the PSC will employ a large staff. Details of training new staff members are explained in detail in Chapter 9, "Operational Procedure", Section 9.6, "Training," in the CES report. This CES report has been reviewed by the JICA study team and has been found to be a reasonable proposal.

CHAPTER 7 DESIGN OF FACILITIES

Chapter 7. DESIGN OF FACILITIES

The port facilities needed to meet the future traffic demand were discussed in the previous chapter. In this chapter their structural designs are discussed.

7.1 Berths

Berth No.12(A) is designed with a water depth of -8m, deep enough to accommodate 7,000t class ships. The water depth of berth No.12(B)is -4.0m, which can accommodate small craft such as tugboats and pilot boats.

7.1.1 Design Conditions

The design conditions are based on the results of the site surveys and requirements for future port planning, as detailed below.

(1) Soil Conditions

The soil conditions in the port area are detailed in Chapter II. The sub-soil at the seabed is broadly classified as sandy for around the -5m depth, and beneath the sandy layer the sand-gravel layer continues. The soil characteristics at the berth planned area are outlined below (Boring No. BH-3). (Fig. 7-1-1)

-- Depth from -5.0m to -10.0m
The sub-soil is silty sandy consisting of an upper layer of N-value 22 and a lower layer of N-value 50, or more than 50 about 20m below.

-- Depth from -10.0m to -15.0m
The sub-soil is sand-gravel layer of an N-value more than 50.

-- Depth under -15.0m
The sub-soil compositions change slightly, but the geotechnical characteristics are almost the same of those of the upper layer. The boring depth does not reach the base rock, but this layer seems to have enough hearing capacity as a soil foundation.

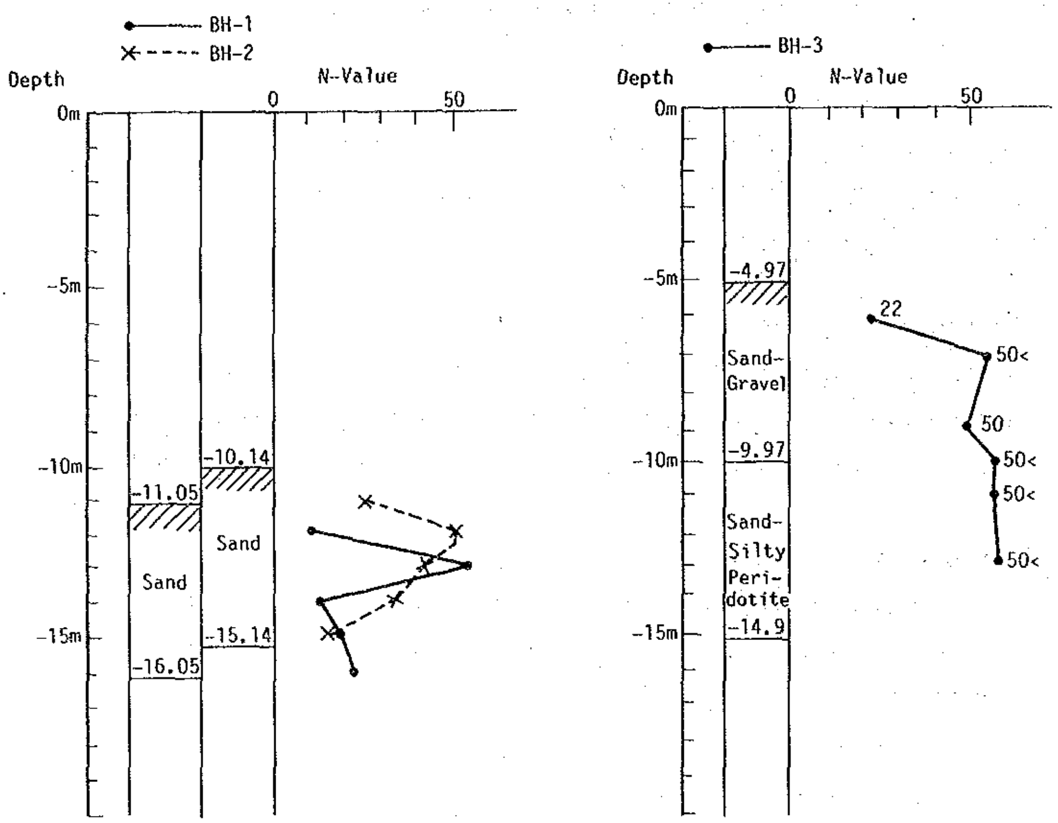


Fig. 7-1-1 Soil Characteristics at the Berth Planned Area

(2) Design Conditions

The berths are designed under the conditions shown in Table 7-1-1.

Table 7-1-1 Design Conditions of Berths

1) Design Ship Size	7,000 DWT	500 DWT
2) Water Depth	- 8.0 m	- 4.0 m
3) Quay Cope Level	+ 4.2 m	+ 4.2 m
4) Tidal Plane		
H.W.L	+ 2.70 m	+ 2.70 m
M.S.L	+ 1.85 m	+ 1.85 m
L.W.L	+ 0.80 m	+ 0.80 m
DL	+ 0.00 m	+ 0.00 m
5) Surcharge		
Ordinary	2.0 t/m^2	2.0 t/m^2
Extra Ordinary	1.0 t/m^2	1.0 t/m^2
6) Seismic Force	not considered	not considered
7) Berthing Velocity	0.10 m/sec	0.10 m/sec
8) Tractive Force	35 t	10 t
9) Wave Force	not considered	not considered
10) Service Life	50 years	50 years

7.1.2 Structural Design

(1) Comparison of the Structural Type of Berths

The following three structural types can be considered as possible structural types applicable for the berths planned in this project. (Fig. 7-1-2)

-- Gravity type bulk head berth (caisson)

-- Steel sheet pile type bulkhead berth

-- Steel pipe pile open type berth

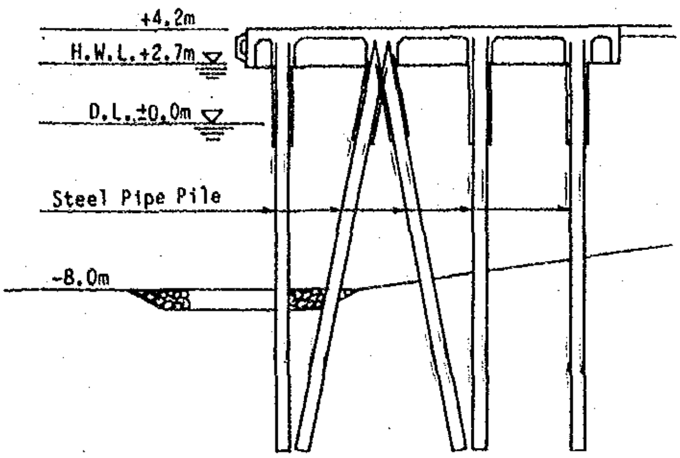
The advantages and disadvantages of the above three types are compared, as shown in Table 7-1-2 and summarized as follows.

The gravity type bulkhead berth is one of the desirable types for the site, since the sub-soil is hard with sufficient bearing capacity.

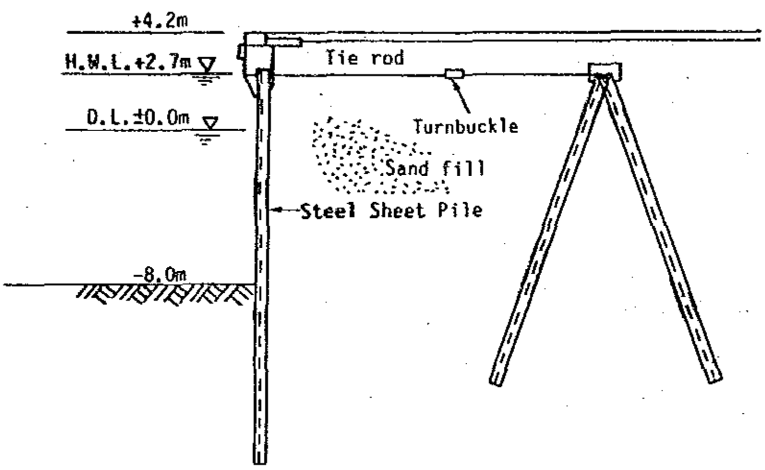
But, a floating dock has to be prepared for the construction of caissons, because there is no wide construction area for the caisson yard.

The new births extend into the sea, consequently the area behind the berths will be reclaimed.

Steel Pile Open Type



Steel Sheet Pile Type



Caisson Type

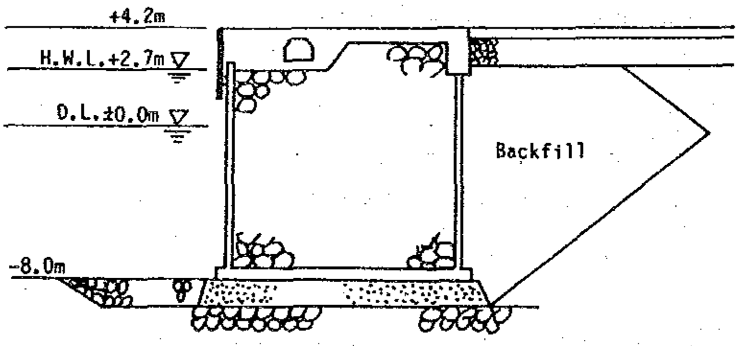


Fig. 7-1-2 Structural Types of Berth

Table 7-1-2 Comparison of Structural Types

Item \ Type	Steel Pile Open Type	Steel Shect Pile Type	Caisson Type
Required Work	Pile driving	Pile driving	Reinforced Concrete Caisson
Reclamation	Not necessary	Necessary	Necessary
Vessel	Barge	Barge Reclaimer	Floating Dock Reclaimer
Workability	Ordinary	Difficult	Ordinary
Construction Speed	High	Low	Low
Suitability to Sub-soil Condition	Fair	Poor	Good
Effect on Current	Lowest	High	High
Construction Cost	1.0	1.1	1.2

Selected materials for reclamation are needed. The surface sub-soil of the seabed is removed and replaced by cobble gravel to prevent scouring. The construction cost of this type is higher than the cost of the steel pile open type mainly because of the reclamation work required.

The steel sheet pile type bulkhead beach is an economical one and could be a good option at sites where the sub-soil characteristics are suitable. But, in this case, the N-values of the sub-soil are 50 or more than 50 about 2m below the seabed, and thus steel sheet pile-driving is difficult. Reclamation is also needed to construct the planned berths.

The steel pile open type does not disturb the waves and not interrupt sea water circulation. Hence, possible effects like scouring or silting up of the seabed are minimized. Thus this type is preferable from the environmental view point.

The steel pile open type is selected based upon the above advantages, its lower construction cost and its over-all suitability for construction. But it is recommended that more sub-soil surveys be carried out at the implementation stage, because there are many differences between the sub-soil strengths at each bore hole. (Ref. Chapter 2.2 Geology)

(2) Structure of Berths

The standard cross-section of the berths is shown in Fig. 7-1-3. As shown in the Figure, the berths are supported by steel pipe piles decked with a concrete superstructure. The horizontal force acting on the berth is resisted by the batter piles and the vertical load by both vertical and batter piles.

Both the berths will be provided with adequate fender systems and the steel pipe piles will be protected from corrosion by concrete coating and increasing steel thickness.

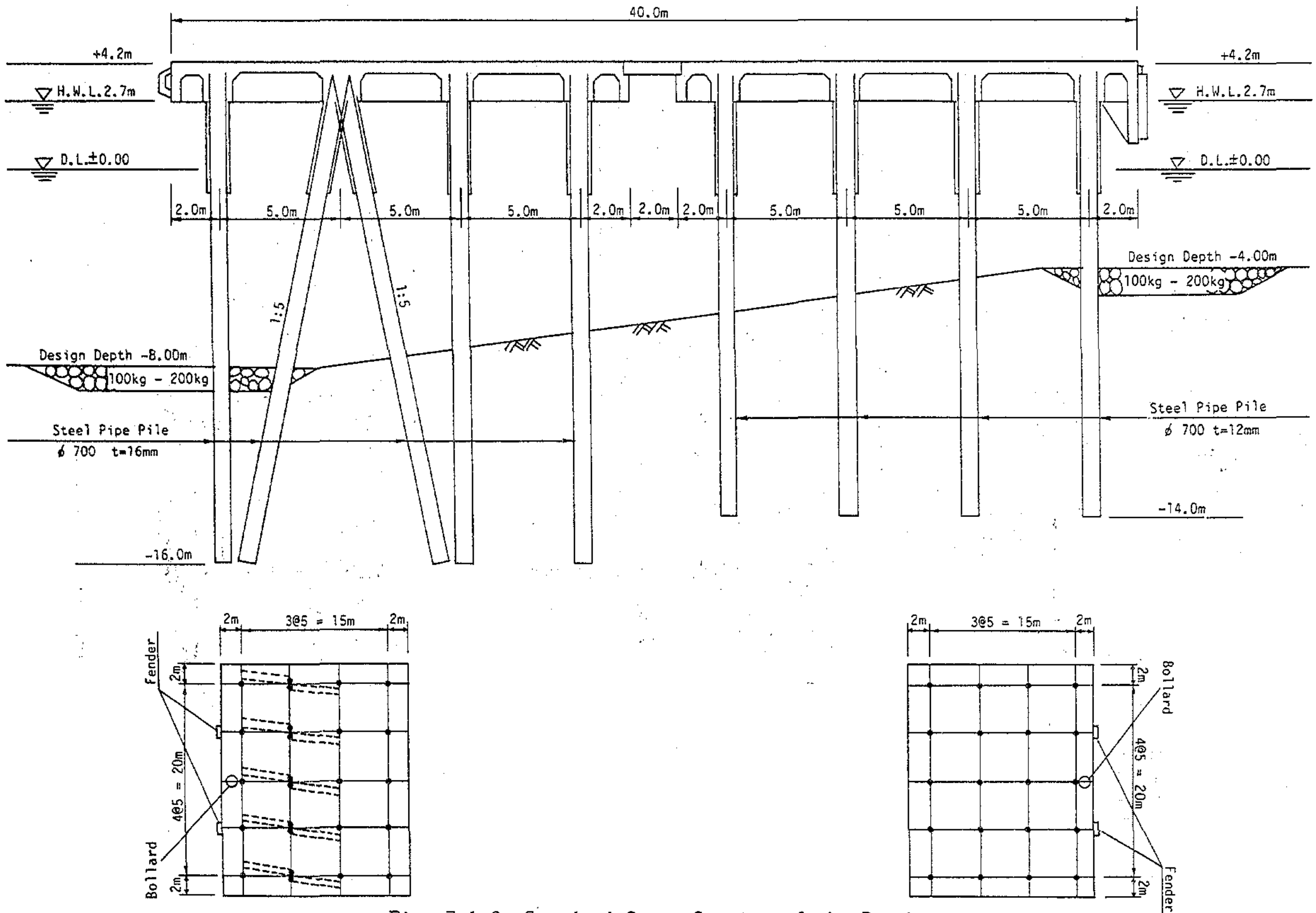


Fig. 7-1-3 Standard Cross Section of the Berths

7.2 Seawall

The Seawall for reclaimed land in Shutaify Bay is designed with an average water depth of -10m and a total length of 420m.

7.2.1 Design Conditions

(1) Tidal Plane

H.W.L	+ 2.70 m
M.S.L	+ 1.85 m
L.W.L	+ 0.80 m
DL	+ 0.00 m

(2) Design Waves

Design wave height at the depth of the planned seawall is determined as follows.

Table 7-2-1 Design Wave

	Deep Water Wave			Design Wave			
Direction	Ho (m)	T (sec)	Lo (m)	Ho' (m)	H1/3 (m)	H max (m)	β (degree)
ENE	6.4	12.0	224.6	5.6	5.8	9.5	0

Ho : Deep water wave height
T : Wave period
Co : Wave length
Ho' : Equivalent deep water wave height
H1/3 : Significant wave height
Hmax : Maximum wave height
β : Incident wave angle

7.2.2 Structural Design

The standard cross-section of the seawall is shown in Fig. 7-2-1.

(1) Weight of Armor Blocks

The weight of concrete blocks covering the slope surface of a structure receiving the action of wave force is calculated using the following formula:

$$W = \frac{rH^3}{Kp(Sr-1)^3\cot} \quad *$$

W : Minimum weight of concrete blocks (t)
r: Unit weight of block in air (t/m^3)
Sr: Specific gravity of block to sea water
: Angle of the slope to horizontal plane (degrees)
H : Significant wave height at the water depth at which the structure is constructed (m)
Kp: Constant determined by the armoring material and damage rate

$$W = \frac{2.3 \times 5.8^3}{8.3(2.3/1.03 - 1)^3 \times 2} = 14.4 \text{ (t)}$$

* Hudson, R.Y, "Laboratory investigation of rubble-mound breakwater", Proc. ASCE, Vol.85.

(2) Quantity of Wave Overtopping

The wave overtopping quantity can be estimated by the data obtained from the hydraulic model experiments carried out thus far.

H.W.L	+ 2.7 m
Ho'	5.6 m
Design depth (10 + 2.7)	12.7 m
Crown level of seawall	+ 9.8 m

q: Overtopping quantity ($m^3/m/sec$) *
q = 0.02

Above overtopping quantity is allowed for the container yard according to the following standard.

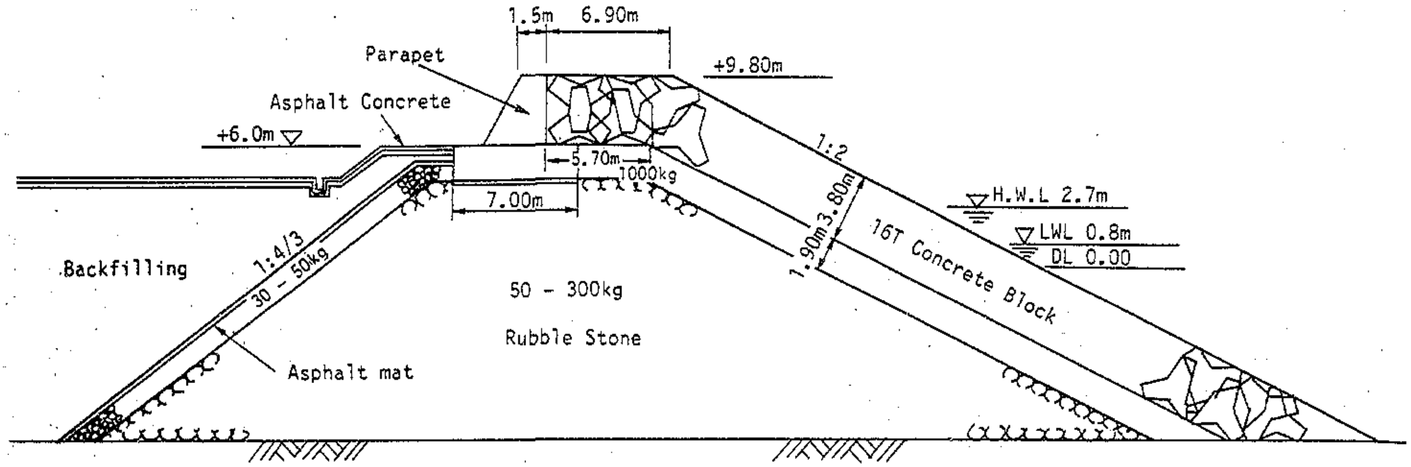


Fig. 7-2-1 Standard Cross Section of the Seawall

Table 7-2-2 Overtopping Quantity Standards

Area	Overtopping Quantity ($m^3/m/sec$)
Densely inhabited district	0.01
Important Area	0.02
Others	0.02 - 0.06

* Yoshimi GODA, Yasuharu KISHIRA and Yutaka KAMIYAMA: "Laboratory Investigation on the Overtopping Rate of Seawalls by Irregular Waves", Reft of PHRI, Vol 14.

7.3 Stability of the Existing Berths

7.3.1 Concrete Beam

Gantry cranes for container cargoes are planned at berths Nos 1A, 1 and 2. The structure and dimensions of the gantry cranes will be almost same as those of the existing ones at berths Nos.4 and 5.

At berths Nos.4 and 5, the reinforced concrete beam placed on a rubble-stone foundation is designed to ensure safely in terms of bending moment, shearing force and displacement, and its settlement is less than the maximum allowable settlement.

The same kind of foundation is applicable to berths Nos 1A, 1 and 2 for the railway foundation of the land-side wheels of the cranes. (cf. Fig. 7-3-1)

In this case, the position of the concrete beam should be determined such that the active failure plane from the sea bottom and the passive failure plane from the lower end of the concrete beam will not intersect below the ground surface, as shown in Fig. 7-3-2.

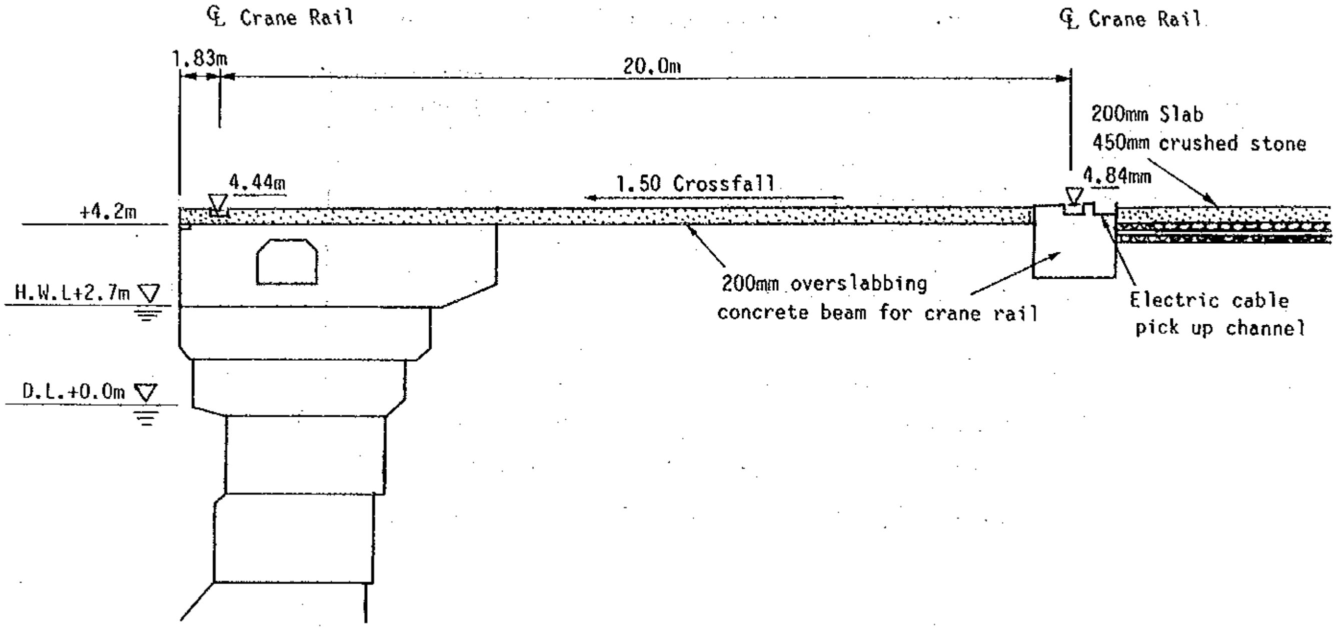


Fig. 7-3-1 Railway Foundation of the Crane

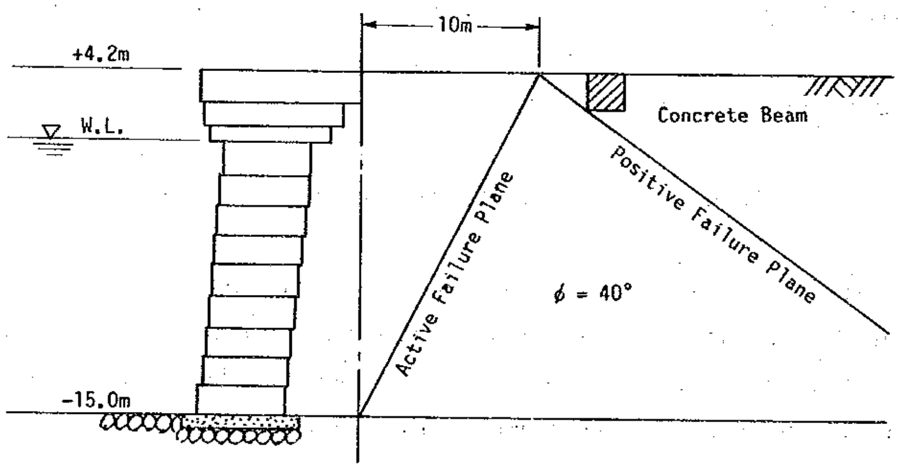


Fig. 7-3-2 Position of Concrete Beam

7.3.2 Examination of Effects of Gantry Cranes on Berths

The effects of the loads of the gantry crane on the structure of the berth are examined as follows.

(1) Berth Conditions for Examination

1) Surcharge

Ordinary 2.0 t/m^2

Extra ordinary 1.0 t/m^2

2) Gantry Crane

Total Weight 700 t

Wheel Load:

Items / Wheel	No of Wheels	Wheel Load (ton)	
		Wind Speed 20 m/s	Wind Speed 60 m/s
Sea-side Wheel	16	35	60
Land-side Wheel	16	28	48

3) Wind Force 160 t

4) Dead Weight of Wall 179 t

5) Soil Condition

Backfilling Material:

Angle of internal friction $\phi = 40°$

Unit weight in air $r = 1.8\ t/m3$

Unit weight in water $r' = 1.0\ t/m3$

Sub-soil under Foundation:

Angle of internal friction $\phi = 40°$

Unit weight in air $r = 1.8\ t/m3$

Unit weight in water $r' = 1.0\ t/m3$

6) Seismic conditions .... not considered

7) Residual Water Pressure ..... not considered

8) Coefficient of Friction

Concrete against concrete 0.5

Concrete against Bedrock 0.5

9) Tractive Forces of Ships ... not considered

These forces are resisted by other anchorage work.

(2) Effects of Gantry Cranes on Existing Berths

The effects of the gantry cranes on berths are determined as shown in Fig. 7-3-3.

The results of examination on the stability of the existing berths based upon the berth conditions above-mentioned are shown in Table 7-3-1. These figures indicate the sufficient berth stability when gantry cranes installed.

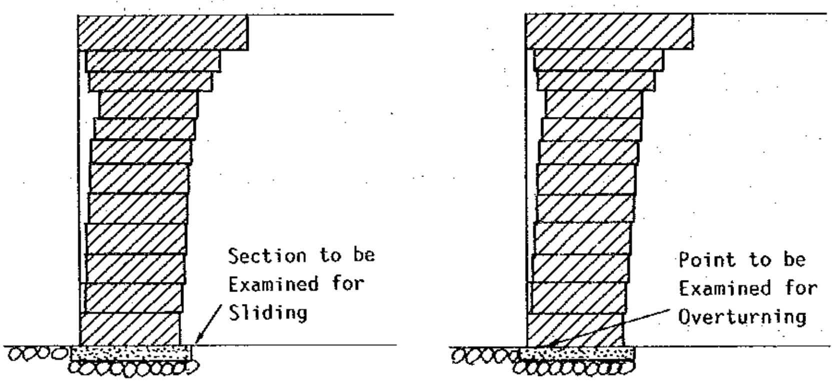


Fig. 7-3-3 Determination of Stability of the Berths

Table 7-3-1 The results of the Stability Examination

Items	Safety Facter	
	Ordinary	Extra ordinary
Overturning	1.6	1.5
Sliding	1.6	1.8
Beaing Capacity	2.5	2.7

7.4 Other Facilities

7.4.1 Pavements and Transfer Crane Tracks

Considering the construction and maintenance costs, all the pavement work will be bituminous except for the transfer crane tracks, and the standard cross-section will be as per the required strength owing to the cargo handling vehicles and equipment.

-- Transfer crane Track
  Container yard for the transfer crane
-- Pavement
  Container yards, open storage yards, in-port roads, parking areas, others

The cross-sections of the pavements and transfer crane tracks are shown in Fig. 7-4-1, 7-4-2.

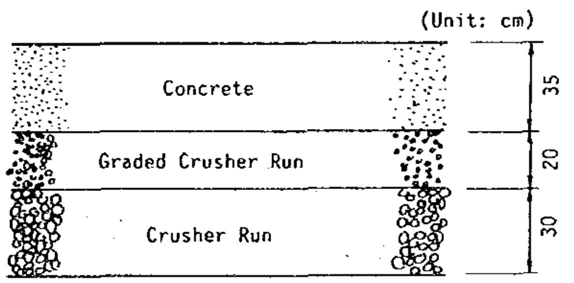


Fig. 7-4-1 Standard Cross Section of Transfer Crane Track

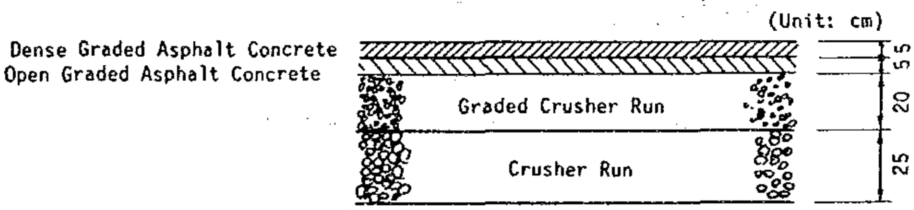


Fig. 7-4-2 Standard Cross Section of Pavement

CHAPTER 8 IMPLEMENTATION SCHEDULE

Chapter 8. IMPLEMENTATION SCHEDULE OF PORT CONSTRUCTION

8.1 General

It is quite important to formulate a well designed construction program that will not obstruct the on going operations of Mina Qaboos because it is a very busy port, with about one thousand ship calls a year. Given such conditions, how to dredge in front of the operational tub-basin is one of the key study points in terms of avoiding the most likely navigational obstructions to incoming and outgoing vessels.

Since construction equipment, particularly construction craft, are difficult to obtain in the Sultanate of Oman, they shall be procured outside the country. An economical construction plan shall be developed, making full use of local equipment.

The construction of the port facilities is to start in late 1990 and be completed by 1992. The project implementation schedule is briefly described below:

1) Blasting work at the quarry site at Jebel, and seawall construction will be executed, and reclamation and pavement work for the container yard will follow at Shutaify Bay.

2) In conjunction with the above work, the following work will be carried out on land; demolition of the sheds at Berths No.1 and 2; foundation-reinforcement work; and erection of container cranes, which will be installed at the container berths in due course.

3) Dredging work will be initiated at the -8m/-4m area, and the dredged materials will be used for reclamation at Shutaify Bay.

4) On completion of the dredging in the -8m/-4m area, dredging in the -13m area will start. The dredged materials therefrom will also be used for reclamation at Shutaify Bay.

5) Construction of Berth No.12 (A) (B) will start after completion of the dredging work.

6) The full package of the project is to be completed by the first half of 1992.

8.2 Amount of Construction Quantities

The construction quantities for each work component are shown in Table 8-2-1, and the main construction materials needed for are listed in Table 8-2-2.

Table 8-2-1 Construction Quantities

Facility	Unit	Quantity
Land/Container Yard at Shutaify Bay	m^2	153,000
Land/Container yard at Mina Qaboos	Tracks for Container Crane, Container yard and road	
Dredging/Dumping (-13m, -8m, -4m)	m^3	1,186,800
Berths No.1 and 2	Concrete beam and rails for Container Crane	
Berth No.12 (A)(B)	m^2	6,400 (160m x 40m)
Buildings	m^2	15,600
Cargo Handling Equipment	No	56

Table 8-2-2 Main Construction Materials

Material	Unit	Seawall	Quay	Total
Steel Pipe	Ton	-	1,660	1,660
Concrete	m^3	9,870	8,500	18,370
Concrete Block	No	5,880	-	5,880
Armoured Stone (1,000kg)	m^3	30,240	-	30,240
Steel Bar	Ton	500	400	900
Asphalt Mat	m^2	11,340	-	11,340

8.3 Preliminary Study on Construction Procedure

8.3.1 Preliminary Study on Construction Procedure

(1) Blasting and Land Reclamation

The blasting operation is to be carried out at Jebel. The project area at Jebel forms a steep cliff, with no flat area, so the materials quarried from Jebel will initially be utilized to reclaim the adjacent sea area so that the reclaimed land can serve as a construction yard.

After building the construction yard, the materials quarried from Jebel will be utilized as rubble stone and armoured stone for the seawall. The quarried materials will be carried by dump trucks and bulldozers to the seawall foundations. On completion of the seawall, the reclamation work will move into full gear. The placing of the fill materials will be executed by dump trucks and bulldozers from the construction yard.

The areas to be reclaimed with the materials from Jebel are shown in Fig. 8-3-1.

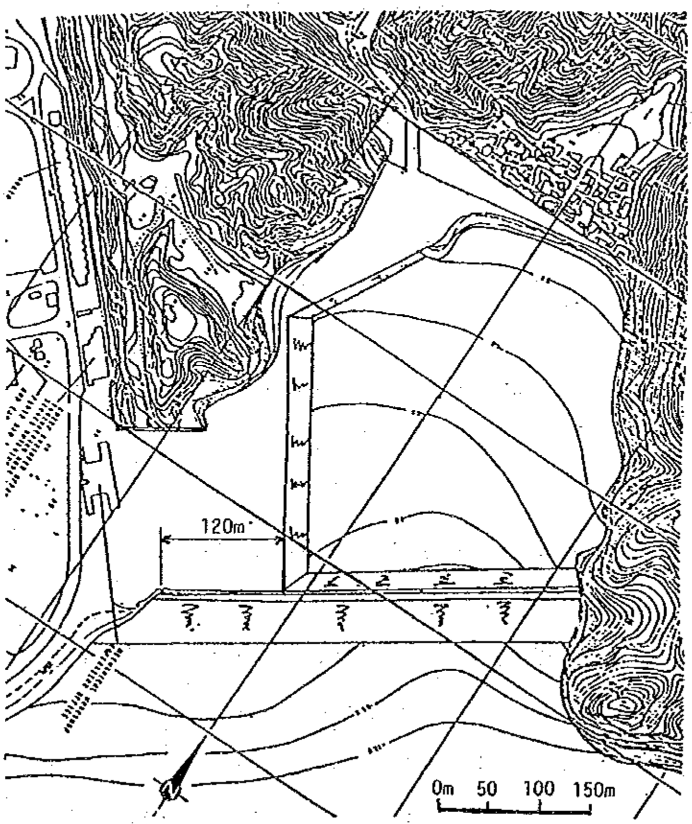


Fig. 8-3-1 The Area at Jebel Reclaimed with Material Obtained by Blasting

(2) Construction of Concrete Beam of Berths No.1 and 2

The container crane will be erected on Berths No.1 and 2, so it is necessary to reinforce the land-side portion of the berths to make them strong enough for the cranes to run on. In the process of reinforcing the existing structure, the existing pavement of the berth at the position of the concrete beam will be removed by concrete breakers or concrete cutters. Then, the necessary steel bars will be fabricated, followed by the placement of in-situ concrete.

(3) *Dredging work*

The required dredging volume is in the order of 383,300 m^3 in the -8m/-4m area, and 803,500m^3 in the -13m area. The dredged materials will be used for the reclamation at Shutaify Bay, and the reclaimed area of dredging in the -8m/-4m area is shown in Fig. 8-3-2(A) and in the -13m area is shown in Fig. 8-3-2(B). The height of the land including the pavement will be approximately 5.0m above D.L.

According to the boring data, the type of soils at the proposed dredging area are judged to be as follows:

In the -8m/-4m area	(between sea bed and -6.5m)...	N = 20
	(below that).................	N = 50
In the -13m area	(between sea bed and -12m)....	N = 20
	(below that).................	N = 50

*N means N-value (Standard Penetration Test)

In the case of dredging hard-type ground, a grab dredger or pump dredger is considered suitable dredging equipment.

In grab dredging, a dredger is generally accompanied by two barges and two tugboats which are used to carry dredged materials to the dumping area. The grab dredger does not need as much space as a pump dredger. The

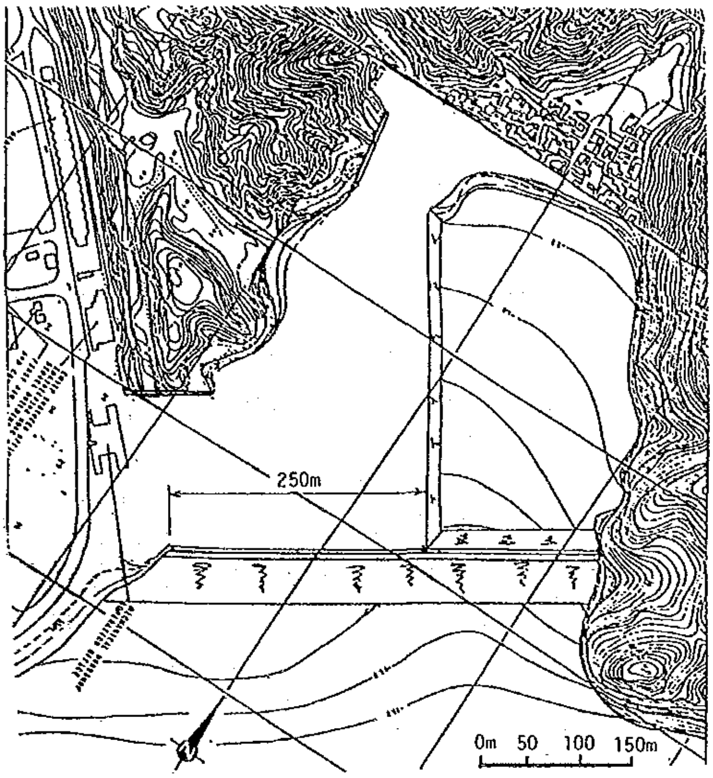


Fig. 8-3-2(A) Land Reclaimed with Materials Dredged in the -8m/-4m Area

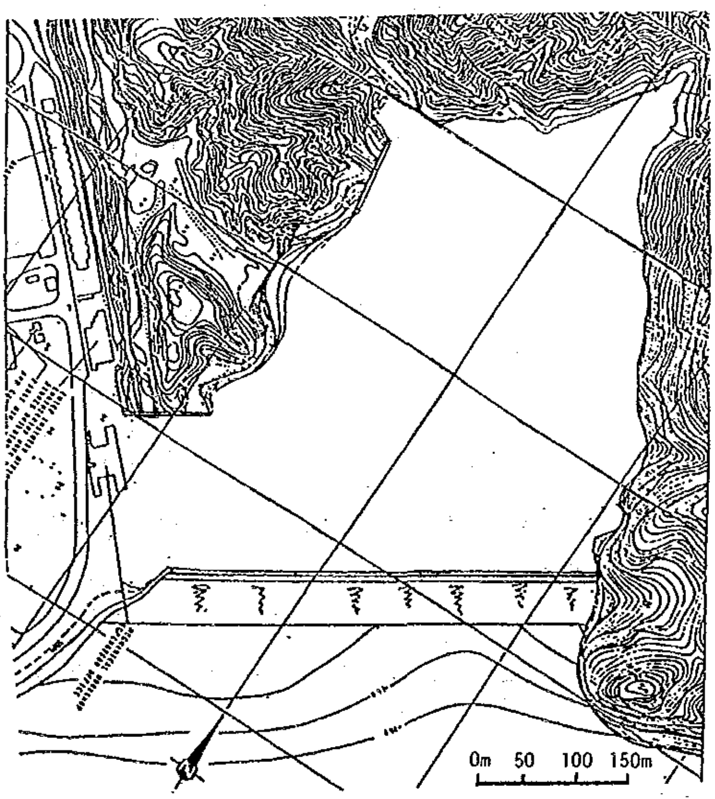


Fig. 8-3-2(B) Land Reclaimed with the Materials Dredged in the -13m Area quantity of dredging per hour by grab dredger, however, is much smaller than that of a pump dredger, resulting in longer working times and higher construction costs. Traffic congestion is usually caused by the barges and tugboats' frequent passage when carrying dredged material, hampering other vessels' navigation.

Addition to this, dumping of materials can be done up to an average depth 2m bellow the sea-level to allow for the draft of the barges. The remaining material should be carried and dumped at sites up to 3-4km away at sea.

In the case of pump dredging, on the other hand, other construction craft are not necessary, because the dredged material is carried through disposal pipelines. The dredging quantity per hour is three times as much as that of a grab dredger, which means construction will be completed in less time and more cheaply. However, the space occupied by a pump dredger is bigger than that by a grab dredger, and the disposal pipes which are placed on the surface of the water may hinder the passage of other vessels.

Moreover, the sea surface around the reclaimed land will become muddy, because of continuous disposal of muddy water.

Giving due consideration to these two methods, pump dredging is considered to be preferable, because the above-mentioned problems with the pump dredging method could be solved by applying appropriate countermeasures, while the problems with grab dredging cannot be solved technically at Mina Qaboos. The proposed countermeasures to solve the problems with pump dredging at Mina Qaboos are briefly described.

a) To divide the dredging area into various sections and to shorten the time spent by the dredger on each section, thus minimizing operational trouble to vessels passing nearby.
The various sections areas are shown in Fig.8-3-3, and the countermeasures during dredging periods are shown in Table 8-3-1.

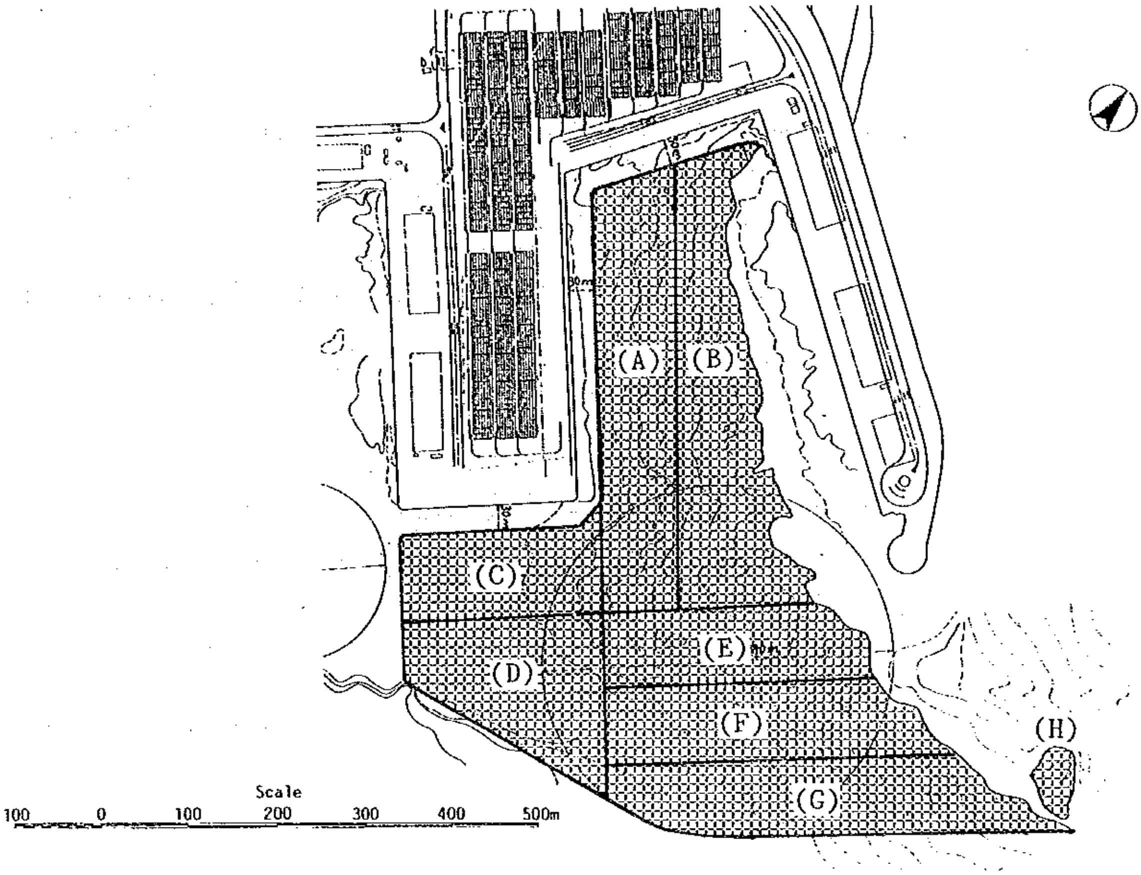


Fig. 8-3-3 Various dredging areas

Table 8-3-1 Dredging Areas and Countermeasures

Area	Occupying period by Dredger(day)	Navigational Problems	Countermeasures
(A)	16	Berths Nos.4 and 5 blocked by dredger	Use tentatively Berths Nos.1 and 2
(B)	16	Berths Nos.1 and 2 blocked by dredger	Use tentatively Berths Nos.4 and 5
(C)	8	Berth No.6 blocked by dredger	Use tentatively any berth other than Berth No.6
(D)	21	none	none
(E)	8	Turning basin fully blocked by dredger	Turn the ships outside the turning basin
(F)	9		
(G)/(H)	20		

Occupying period is actual working days excluding the period of shifting the dredger

b) To place the disposal pipeline on the seabed in order not to hinder the passage of other vessels, especially in the area where the disposal pipelines may be a great obstacle. The dredging should be carried out as follows:

The work should be started in areas (G)/(H). (Refer to Fig. 8-3-3) and proceed to areas (F), (E) and so on. Thus, the pipe lines can be kept in place on the seabed without disrupting shipping.

c) To discharge the muddy water around the reclaimed land after letting the fine materials sink in the settling tank installed inside the seawall of the reclaimed land.

These countermeasures will help minimize the likely problems at Mina Qaboos.

(4) Construction of Berth No.12(A)(B)

On completion of dredging work at a water depth of -8m/-4m, the construction of Berth No.12(A)(B) is to start. The berth is of a steel pipe pile open type, including 12-degree batter piles. The stratum for pile-foundation at the new berth area is silty sand with N value of 50, so a diesel hammer of 7 ton ram weight is to be used. After the completion of pile-driving, the pile heads are to be rigidly fastened to the quay beams, and gravel is to be placed for the consolidation of pier foundations. At the last stage, the slab concrete is to be placed and paved on top.

As for the concrete material, ready-mixed concrete will be used.

8.3.2 Construction Equipment and Construction Crafts

The main construction equipment and craft are shown in Table 8-3-2.

Table 8-3-2 Main Construction Equipment and Craft

Description	Capacity	Unit	Quantity
Pump Dredger	D-8,000 P.S.	No.	1
Self Anchor Barge	30 TON	No.	1
Self Submerge Boat	30 P.S.	No.	1
Flat Barge	300 TON	No.	1
Pile-driving barge	100ton, D30 P.S.	No.	1
Concrete Pumping Car	45 m^3/HR	No.	1

8.3.3 Construction Schedule

When considering the construction schedule, working days and working capacity for the above-mentioned method have been set as follows:

1) Assessment of Working Days

The annual working days for the onshore and offshore work at Mina Qaboos have been estimated based on the following considerations.

As there is no meteorological station in or near Mina Qaboos, all the data relevant to construction planning has been collected from nearby stations; wind records have been gathered from the meteorological observatory at Muscat and wave records from Marine Buoy Monthly Climatological Summary, M.O.C.

An average wind speed of 10m/sec and significant wave height of 1.0m have been assessed as critical for the carrying out of offshore work.

As for holidays, 52 non-working Fridays and 10 public holidays, a total of 62 non-operational days have been considered, but in the case of offshore work the number of non-working days has been reduced to 6 days annually. The working days used for construction planning are shown below:

Table 8-3-3 Estimated Annual Working Days

Description	Onshore Work (days)	Offshore Work (days)
Windy Days (non-working)	-	15
Rough Sea Days (non-working)	-	(2)
Holidays (non-working)	62	6
Total of Non-Working Days	62	21
Annual Working Days	303	344
Monthly Average Working Days	25.3	28.7

* Rough Sea Days are included in Windy Days.

2) Working Capacity

The working capacities of the majore works which will be used most frequently in the Project have been compiled as follows:

Table 8-3-4 Working Capacity of Pump Dredging

Dredging (pump dredger 8,000 P.S.)	N=20	11,000m^3/day
	N=50	7,500m^3/day
Pile-driving		4 piles/day
Disposal of rubble stone		2,770m^3/day
Pavement		2,500m^2/day

3) Construction Schedule

The construction schedule at Mina Qaboos is shown in Table 8-3-5.

Table 8-3-5 Construction Schedule

Item	Sub-Item	1990					1991												1992											
		8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Site Preparation		■																												
Land/Container Yard at Shutaify bay	Blasting Jebel		■	■	■	■	■	■																						
	SeaWall			■	■	■	■	■	■	■	■	■																		
	Reclamation/Surface Dressing		■	■	■	■	■	■	■	■	■	■	■	■																
	Road/Yard Trucks of Crane												■	■	■	■	■	■												
	Demolition											■																		
Land/Container Yard at Mina Qaboos	Demolition/Road Track of Crane		■	■	■	■																								
Dredging/Dumping	-8m/-4m Area								■	■																				
	-13m Area										■	■	■	■	■															
Quay	No.1, No.2 Berth						■	■	■	■																				
	No.12(A)(B) Berth										■	■	■	■	■	■	■	■	■	■	■	■	■							
Building	Office/C.F.S. etc.			■	■	■			■	■	■							■	■	■										
Cargo Handling Equipment	Transfer Crane/ Container Crane etc.				■		■				■																			
Miscellanies	Access Road behind Shutaify Bay																■	■												
	Mobilization			■				■		■																				

CHAPTER 9 COST ESTIMATION

Chapter 9. COST ESTIMATION

9.1 General

The cost of the development plan for Mina Qaboos has been estimated based upon the foregoing preliminary design, construction method and schedule.

The basic concept of cost estimation is briefly described below:

(1) Unit Rate for Labourers and Materials

These rates have been estimated using the average values obtained from various sources in Oman. If the rates were unavailable, they were estimated by comparison with other rates in Oman.

(2) Operating Cost of Equipment or Craft

(a) The cost of equipment or craft which are to be delivered from abroad has been calculated based on the standard used in Japan for calculating rental cost-that is the depreciation cost/maintenance cost per working days and operating hours.

(b) The cost of domestic equipment has been calculated from interviews with various sources. Wherever possible, these rates have been cross-checked.

(3) Unit Price

Unit price for each type of work, such as dredging, construction of quay and reclamation etc., are calculated as the sum of labour, fuel, material, rental and other unit costs, and were checked by comparison with the corresponding unit prices in Oman and Japan.

9.2 Conditions for Cost Estimation

The main conditions for the cost estimation are as follows:

(a) Construction costs have been estimated using the prices and rates obtaining in December 1989 in principle.

(b) The inflation factor has been excluded from the estimation.

(c) The exchange rates of the U.S.$ against the Oman Rial (R.O.) and Japanese Yen (J¥) are as follows:

1U.S.$ = 0.385 R.O.
1U.S.$ = 144 J¥

(d) Rents or compensation for land and fishing activities have been excluded from the estimation.

(e) In general, the costs of the foreign portion of the operation include the following:

i) Materials, equipment, machinery and craft not produced in Oman.

ii) Materials available in Oman but which have been imported.

iii) Cost of foreign labourers.

Based on the above criteria, the foreign portion comprises:

- Skilled crew
- Rental cost of pump dredger and its attachments, pile-driving barge, barge, and other craft
- Mobilization/demobilization charge of the above craft and the cargo handling equipment
- Steel pipe piles and steel bars
- Rubber fender, bits, crane rails and their attachments
- Container cranes, transfer cranes, tractor trailers and trailers
- Consultation and technical cooperation fee
- Customs duties

(f) The construction cost of water and electric supply, drainage and communication facilities is excluded.

(g) Customs duties on the imported materials are fixed at 5% of their cost.

For construction equipment and craft mobilized outside of Oman, customs duties are excluded in the cost estimation.

(h) Indirect costs except the above mobilization costs and administration costs are fixed at 23% of the direct cost.

(i) Physical contingencies are as follows:

- 0% Cargo-handling equipment
- 5% Dredging costs, costs of roads and land
- 10% Construction costs of quay, seawall, and buildings

(j) The consultation and technical cooperation fee is 5%.

Items of (g)(h)(i) and (j) are not included in direct cost.

9.3 Estimation Procedure

The estimation procedure has been carried out on the above conditions and the resulting of the unit prices and rates are as follows:

i) The unit prices for main materials

. Ready-mixed concrete	15 R.O./m^3
. Steel pipe pile	214 R.O./t
. Steel bar	152 R.O./t
. Armoured Stone (1,000kg)	2.6 R.O./m^3

ii) The day work for main labourer per day

. Skilled workers	10 R.O.
. Unskilled workers	8 R.O.
. Crew	10 R.O.

iii) The prices per unit quantity of main items

. Building	70 R.O./m^2
. Pavement	2.0 - 4.5 R.O./m^2
. Demolition	1.6 - 5.0 R.O./m^2
. Dredging	2.13 R.O./m^3
. Quay (Berth No.12(A)(B))	303.4 R.O./m^2
. Seawall	6,042.8 R.O./m

9.4 Result of Estimation

A summary of the estimation results is presented in Table 9-4-1, the result for each item is presented in Table 9-4-2 and the cost of cargo handling equipment in Table 9-4-3.

On the basis of the construction schedule drawn up in Table 8-3-5, the yearly disbursement schedule has been estimated as shown in Table 9-4-4.

Table 9-4-1 Construction Costs

Unit:1,000 R.O.

Item	Construction Cost		
	Foreign Portion	Local Portion	Total
1. Land/Container Yard at Shutaify Bay	170	3,934	4,104
2. Land/Container Yard at Mina Qaboos	-	117	117
3. Dredging/Dumping (-13m, -8m, -4m)	2,159	367	2,526
4. Quay	739	1,368	2,107
5. Buildings	76	1,016	1,092
6. Cargo Handling Equipment	8,380	-	8,380
7. Miscellanies	600	9	609
8. Total	12,124	6,811	18,935
9. Indirect Cost	6,018	567	6,585
10. Grand Total	18,142	7,378	25,520

Table 9-4-2 Construction Cost for Each Item

Unit:1,000 R.O.

Facilities		Unit	Quantity	Unit Cost (R.O.)			Foreign Portion	Local Portion	Total
Item	Sub Item			Foreign Currency	Local Currency	Total			
1. Land/Container Yard at Shutaify Bay	(1) Blasting Jebel	m3	319,000	-	1.50	1.50	-	479	479
	(2) Seawall	m	420	405.05	5,637.30	6,042.80	170	2,368	2,538
	(3) Reclamation/Surface Dressing	m2	153,000	-	0.94	0.94	-	143	143
	(4) Road/Yard	m2	150,000	-	4.50	4.50	-	675	675
	(5) Tracks of Transfer Crane	m	2,900	-	7.00	7.00	-	203	203
	(6) Demolition	m2	13,200	-	5.00	5.00	-	66	66
	Sub-Total						170	3,934	4,104
2. Land/Container Yard at Mina Qaboos	(1) Demolition of Sheds	m2	22,100	-	1.60	1.60	-	35	35
	(2) Road	m	1,100	-	44.00	44.00	-	48	48
	(3) Tracks of Transfer Crane	m	4,820	-	7.00	7.00	-	34	34
	Sub-Total						-	117	117
3. Dredging/Dumping	(1) -8m/-4m Area	m3	383,300	1.82	0.31	2.13	697	118	815
	(2) -13m Area	m3	803,500	1.82	0.31	2.13	1,462	249	1,711
	Sub-Total		1,181,800				2,159	367	2,526
4. Quay	(1) Berhts No.1 and 2	m	970	14.76	155.79	170.55	14	151	165
	(2) Berth No.12(A)(B)	m2	6,400	113.2	190.20	303.40	725	1,217	1,942
	Sub-Total						739	1,368	2,107
5. Buildings	(1) Office/C.F.S. etc.	m2	15,600	4.84	65.16	70.00	76	1,016	1,092
	Sub-Total						76	1,016	1,092
6. Cargo Handling Equipment	(1) Transfer Crane/Container Crane etc.	No	56	-	-	-	8,380	-	8,380
	Sub-Total						8,380	-	8,380
7. Miscellanies	(1) Access Road behind Shutaify Bay	m	940	-	10.00	10.00	-	9	9
	(2) Mobilization	L.S.	3	-	-	-	600	-	600
	Sub-Total						600	9	609
8. Total							12,124	6,811	18,935
9. Indirect Cost	(1) Indirect Cost /Administration	L.S.	1				4,316	-	4,316
	(2) Consultation /Technical Cooperation	L.S.	1				1,154	-	1,154
	(3) Contingencies	L.S.	1				209	567	776
	(4) Customs Duties	L.S.	1				339	-	339
	Sub-Total						6,018	567	6,585
10. Grand Total							18,142	7,378	25,520

Table 9-4-3 Cargo Handling Equipment

Unit:R.O.

Description	Unit	Q'ty	Unit Cost	Amount
Container Crane	No	2	2,680,000	5,360,000
Transfer Crane	No	8	268,000	2,144,000
Tractor Trailer	No	27	26,800	723,600
Trailer	No	19	8,000	152,000
Total	No	56		8,379,600

Table 9-4-4 Yearly Disbursement Schedule

Unit:1,000 R.O.

No.	Item	Total		1990		1991		1992	
		Foreign Portion	Local Portion	Foreign Portion	Local Portion	Foreign Portion	Local Portion	Foreign Portion	Local Portion
1.	Land/Container Yard at Shutaify Bay	170	3,934	57	1,158	113	2,776	-	-
2.	Land/Container Yard at Mina Qaboos	-	117	-	117	-	-	-	-
3.	Dredging/Dumping	2,159	367	-	-	2,159	367	-	-
4.	Quay	739	1,368	-	-	460	900	279	468
5.	Buildings	76	1,016	25	339	34	452	17	225
6.	Cargo Handling Equipment	8,380	-	3,020	-	5,360	-	-	-
7.	Miscellanies	600	9	400	-	200	9	-	-
8.	Total	12,124	6,811	3,482	1,614	8,346	4,504	296	693
9.	Indirect Cost	6,018	567	1,820	129	3,662	309	536	129
10.	Grand Total	18,142	7,378	5,302	1,743	12,008	4,813	832	822

APPENDICES

Appendix 1-1-1 Main Liner Services in the Gulf Region

Table A-1-1-1 Main Liner Services in the Gulf Region

Ship NO.	North Europe	Mediterranian	Europe	America	Far East	Singapore	Colombo	India	Karachi	Australia	Jeddah	Mina Qaboos	Dubai	Abu Dhabi	Bahrain	Kuwait	Dammam	Doha	Fujairah	Sharjah	Khor Fakkan	Jubail	Aqaba
1	O	O	O	X	X	X	X	X	X	X	O	O	O	O	O	O	O	F	F	F	X	O	X
2	X	X	X	X	O	O	X	X	X	X	X	O	O	X	O	O	O	X	X	X	X	X	X
3	X	X	X	X	O	O	X	X	X	X	X	O	O	O	O	O	O	F	X	X	X	X	X
4	X	X	X	X	O	O	X	X	X	X	X	O	O	O	O	O	O	F	X	X	X	X	X
5	O	O	O	X	X	X	X	X	X	X	O	O	O	O	O	O	O	F	F	F	X	X	X
6	X	X	X	X	O	O	X	X	X	X	X	O	O	O	O	O	O	F	X	X	X	X	X
7	X	X	X	X	O	O	X	X	X	X	X	O	O	O	O	O	O	F	X	X	X	X	X
8	O	O	O	X	X	X	X	X	X	X	O	O	O	O	O	O	O	F	F	F	X	X	X
9	X	X	X	X	O	O	X	X	X	X	X	O	O	O	O	O	O	F	X	X	X	X	X
10	O	O	O	X	X	X	X	X	X	X	O	O	O	O	O	O	O	F	F	F	X	O	X
11	O	O	O	X	X	X	X	X	X	X	O	O	O	O	O	O	O	F	F	F	X	X	X
12	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
13	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
14	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
15	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
16	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
17	X	X	X	X	O	O	X	X	X	X	X	O	O	X	O	O	O	X	X	X	X	X	X
18	O	O	O	X	X	X	X	X	X	X	O	O	O	O	O	O	O	F	F	F	X	X	X
19	O	O	O	X	O	O	O	F	F	X	O	O	X	F	F	F	F	X	X	X	X	X	X
20	O	O	O	X	O	O	O	F	F	X	O	O	X	F	F	F	F	X	X	X	X	X	X
21	O	O	O	X	O	O	O	F	F	X	O	O	X	F	F	F	F	X	X	X	X	X	X
22	X	X	X	X	O	O	X	X	X	X	X	O	O	X	O	O	O	X	X	X	X	X	X
23	O	O	O	X	O	O	O	F	F	X	O	O	X	F	F	F	F	X	X	X	X	X	X
24	O	O	O	X	O	O	O	F	F	X	O	O	X	F	F	F	F	X	X	X	X	X	X
25	X	X	X	X	X	O	O	O	F	O	X	O	O	F	O	O	O	F	X	X	X	X	X
26	X	X	X	X	X	O	O	O	F	O	X	O	O	F	O	O	O	F	X	X	X	X	X
27	X	O	O	X	X	X	X	O	X	X	X	O	X	X	X	O	X	X	X	X	X	X	X
28	X	O	O	X	X	X	X	O	X	X	X	O	X	X	X	O	X	X	X	X	X	X	X
29	X	O	O	X	X	X	X	O	X	X	X	O	X	X	X	O	X	X	X	X	X	X	X
30	X	O	O	X	X	X	X	O	X	X	X	O	X	X	X	O	X	X	X	X	X	X	X
31	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
32	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
33	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
34	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
35	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
36	X	O	O	X	X	X	X	O	X	X	X	O	X	X	X	O	X	X	X	X	X	X	X
37	X	X	X	X	X	X	X	O	O	X	X	O	O	X	X	X	X	O	X	O	X	X	X
38	X	X	X	X	X	X	X	O	O	X	X	O	O	X	X	X	X	O	X	O	X	X	X
39	X	X	X	X	X	X	X	O	O	X	X	O	O	X	X	X	X	O	X	O	X	X	X
40	X	O	O	X	X	X	X	X	O	X	X	O	O	O	X	O	O	X	X	X	X	X	X
41	X	O	O	X	X	X	X	X	O	X	X	O	O	O	X	O	O	X	X	X	X	X	X
42	X	O	O	X	X	X	X	O	X	X	X	O	X	X	X	O	X	X	X	X	X	X	X
43	X	O	O	X	X	X	X	O	X	X	X	O	X	X	X	O	X	X	X	X	X	X	X
44	X	O	O	X	X	X	O	O	O	X	O	O	X	F	F	F	F	X	X	X	X	X	X
45	X	O	O	X	X	X	X	O	X	X	X	O	X	X	X	O	X	X	X	X	X	X	X
46	X	O	O	X	X	X	X	O	X	X	X	O	X	X	X	O	X	X	X	X	X	X	X
47	X	X	X	X	X	X	O	X	O	X	X	O	X	X	X	X	X	X	O	X	X	X	X
48	X	O	O	X	X	X	O	O	O	X	O	O	X	F	F	F	F	X	X	X	X	X	X
49	X	O	O	X	X	X	O	O	O	X	O	O	X	F	F	F	F	X	X	X	X	X	X
50	X	X	X	X	X	O	X	O	F	O	X	O	O	F	O	O	O	F	X	X	X	X	X
51	O	O	O	X	O	O	O	F	F	X	O	O	X	F	F	F	F	X	X	X	X	X	X
52	X	X	X	X	X	O	X	O	F	O	X	O	O	F	O	O	O	F	X	X	X	X	X
53	O	O	O	X	O	O	O	F	F	X	O	O	X	F	F	F	F	X	X	X	X	X	X
54	X	X	X	X	X	O	O	O	F	O	X	O	O	F	O	O	O	F	X	X	X	X	X
55	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
56	O	O	O	X	O	O	X	X	O	X	X	O	O	O	O	O	O	X	X	O	X	X	X
57	O	O	O	X	O	O	O	F	F	X	O	O	X	F	F	F	F	X	X	X	X	X	X
58	X	O	O	X	X	X	O	O	O	X	O	O	X	F	F	F	F	X	X	X	X	X	X
59	X	X	X	X	O	O	X	X	X	X	X	X	O	X	O	O	O	X	X	X	X	X	X
60	X	O	O	X	X	X	X	X	O	X	O	X	O	X	X	O	O	X	X	X	X	X	X
61	X	O	O	X	X	X	X	X	O	X	O	X	O	X	X	O	O	X	X	X	X	X	X
62	X	O	O	X	X	X	X	X	O	X	O	X	O	X	X	O	O	X	X	X	X	X	X
63	X	O	O	O	X	X	X	X	X	X	O	X	O	X	O	X	O	X	X	X	X	X	X
64	X	O	O	O	X	X	X	X	X	X	O	X	O	X	O	X	O	X	X	X	X	X	X
65	X	X	X	O	O	O	X	X	X	X	O	X	O	X	X	X	O	X	X	X	X	X	X
66	X	X	X	O	O	O	X	X	X	X	O	X	O	X	X	X	O	X	X	X	X	X	X
67	X	X	X	O	O	O	X	X	X	X	O	X	O	X	X	X	O	X	X	X	X	X	X
68	X	X	X	X	O	O	X	X	X	X	X	X	O	X	O	O	O	X	X	X	X	X	X
69	X	X	X	X	O	O	X	X	X	X	X	X	O	X	O	O	O	X	X	X	X	X	X
70	X	O	O	O	X	X	X	X	X	X	O	X	O	X	O	X	O	X	X	X	X	X	X
71	X	X	X	O	O	O	X	X	X	X	O	X	O	X	X	X	O	X	X	X	X	X	X
72	X	X	X	X	O	O	X	X	X	X	X	X	O	X	O	X	X	X	X	X	X	X	X
73	X	X	X	X	O	O	X	X	X	X	X	X	O	X	O	X	X	X	X	X	X	X	X
74	O	X	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X
75	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X
76	O	X	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X
77	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X
78	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X
79	X	X	X	O	O	O	X	X	X	X	O	X	O	X	X	X	O	X	X	X	X	X	X
80	X	X	X	O	O	O	X	X	X	X	O	X	O	X	X	X	O	X	X	X	X	X	O
81	X	X	X	O	X	X	X	X	X	X	O	F	X	F	O	O	O	F	F	F	X	X	O
82	X	X	X	O	X	X	X	X	X	X	O	F	X	F	O	O	O	F	F	F	X	X	O
83	X	X	X	O	X	X	X	X	X	X	O	F	X	F	O	O	O	F	F	F	X	X	O
84	X	X	X	O	X	X	X	X	X	X	O	F	X	F	O	O	O	F	F	F	X	X	O
85	X	O	O	O	X	X	X	X	X	X	O	X	O	X	X	O	O	X	X	X	X	X	X
86	X	O	O	O	X	X	X	X	X	X	O	X	O	X	O	X	O	X	X	X	X	X	X
87	X	O	O	O	X	X	X	X	X	X	O	X	O	X	O	X	O	X	X	X	X	X	X
88	X	O	O	O	X	X	X	X	X	X	O	X	O	X	X	O	O	X	X	X	X	X	X
89	X	X	X	X	X	O	X	O	O	O	X	X	O	X	O	O	O	X	X	X	X	X	X
90	X	X	X	X	O	O	X	X	X	X	X	X	O	X	O	O	O	X	X	X	X	X	X
91	X	X	X	X	O	O	X	X	X	X	X	X	O	X	O	O	O	X	X	X	X	X	X
92	X	X	X	X	O	O	X	X	X	X	X	X	O	X	O	O	O	X	X	X	X	X	X
93	X	O	O	O	X	X	X	X	X	X	O	X	O	X	X	O	O	X	X	X	X	X	X
94	X	O	O	O	X	X	X	X	X	X	O	X	O	X	X	O	O	X	X	X	X	X	X
95	X	O	O	X	X	X	X	X	X	X	O	F	X	O	F	F	F	X	X	X	X	X	X
96	X	O	O	X	X	X	X	X	X	X	O	F	X	O	F	F	F	X	X	X	X	X	X
97	X	X	X	X	X	O	X	O	O	O	X	X	O	X	O	O	O	X	X	X	X	X	X
98	X	X	X	X	X	O	X	O	O	O	X	X	O	X	O	O	O	X	X	X	X	X	X
99	X	X	X	X	O	O	X	X	O	X	X	X	O	X	X	O	O	X	X	X	X	X	X
100	X	X	X	X	O	O	X	X	O	X	X	X	O	X	X	O	O	X	X	X	X	X	X
101	X	X	X	X	O	O	X	X	O	X	X	X	O	X	X	O	O	X	X	X	X	X	X

Appendix 1-2-1 Container Ships in the Gulf Region

Table A-1-2-1 Dimensions of Container Ships in the Gulf Region

Ship NO.	Draft	Length	Width	TEU	DWT
1	12.0	264.5	32.2	2,068	35,331
2	12.0	207.0	32.3	1,997	38,466
3	11.9	190.5	28.5	1,107	31,262
4	11.9	190.5	28.5	1,107	31,262
5	11.9	190.5	28.5	1,107	31,262
6	11.7	237.9	30.6	2,092	31,560
7	11.6	212.5	32.3	2,214	35,975
8	11.5	221.7	32.3	1,948	30,804
9	11.5	239.3	30.6	N.A	29,914
10	11.3	211.5	32.3	1,846	35,615
11	11.3	211.5	32.3	1,846	35,615
12	11.3	211.5	32.3	1,846	35,615
13	11.3	211.5	32.3	1,846	35,615
14	11.3	211.5	32.3	1,846	35,615
15	11.3	211.5	32.3	1,846	35,615
16	11.3	211.5	32.3	1,848	35,615
17	11.3	211.5	32.2	1,846	35,615
18	11.2	172.9	28.4	1,546	27,830
19	11.2	173.4	28.4	1,546	27,830
20	11.1	248.7	32.3	2,025	42,600
21	11.1	248.7	32.3	2,025	42,600
22	11.1	248.7	32.3	2,025	42,600
23	11.1	187.4	28.4	1,879	30,950
24	11.1	187.4	28.4	1,740	33,893
25	11.1	187.4	28.4	1,879	30,950
26	11.0	218.1	32.3	1,944	34,589
27	11.0	216.1	32.3	1,944	34,477
28	11.0	N.A	N.A	1,950	33,952
29	11.0	183.0	23.7	1,182	30,254
30	11.0	183.0	23.7	1,182	30,254
31	10.8	180.0	27.6	1,270	25,070
32	10.8	248.7	32.3	2,025	42,600
33	10.6	163.3	27.5	1,597	23,434
34	10.6	163.3	27.5	1,597	23,465
35	10.6	227.6	27.7	1,930	33,621
36	10.6	163.3	27.5	1,597	23,465
37	10.6	163.3	27.5	1,597	23,465
38	10.5	197.1	29.8	1,218	24,617
39	10.5	197.1	29.8	1,218	24,617
40	10.1	177.0	27.1	909	18,674
41	10.1	158.1	23.1	896	17,088
42	10.1	177.0	27.1	909	18,964
43	10.1	164.5	23.1	950	18,155
44	10.1	164.5	23.1	946	18,155
45	10.1	188.9	25.9	871	19,114
46	10.1	188.9	25.9	871	19,114
47	10.0	197.5	32.2	1,315	22,853
48	10.0	197.5	32.2	1,315	22,735
49	10.0	183.2	27.5	1,612	24,272
50	10.0	183.2	27.5	1,612	20,353
51	10.0	183.2	27.5	1,612	20,282
52	10.0	183.2	27.5	1,612	20,282
53	9.8	173.9	25.9	938	16,030
54	9.8	173.9	25.9	938	16,030
55	9.8	173.9	25.9	938	16,030
56	9.8	173.9	25.9	938	16,030
57	9.7	187.4	28.4	1,742	31,205
58	9.7	187.4	28.5	1,940	31,205
59	9.7	187.4	28.4	1,742	31,205
60	9.7	187.4	28.5	1,940	31,205
61	9.7	187.4	28.5	1,940	31,205
62	9.6	181.4	28.3	634	17,665
63	9.4	164.3	26.1	926	19,455
64	9.4	178.4	26.0	1,266	21,207
65	9.4	178.4	26.0	1,266	21,207
66	9.4	170.8	22.9	924	21,876
67	9.4	168.9	25.2	721	16,114
68	9.3	162.6	22.9	818	16,802
69	9.3	162.6	22.9	818	16,822
70	9.3	162.6	22.9	818	16,858
71	8.6	133.3	20.2	605	7,897
72	8.6	153.9	21.6	574	11,031
73	8.6	153.9	21.6	574	11,031
74	8.6	128.5	22.6	368	11,007
75	8.5	N.A	N.A	550	5,661
76	8.5	192.6	26.6	1,306	21,439
77	8.5	192.6	26.6	1,306	21,439
78	8.4	145.1	22.1	602	12,800
79	8.4	145.1	22.1	602	12,800
80	8.0	147.5	22.2	724	12,739
81	8.0	147.5	22.2	724	12,749
82	8.0	147.5	22.2	724	12,739
83	6.9	147.0	21.8	416	7,478
84	6.9	144.4	21.8	416	7,478
85	6.6	139.7	19.2	242	4,605
86	6.6	139.7	19.2	242	4,605
87	6.6	127.7	20.1	582	8,020
88	5.8	119.0	19.4	235	4,508
89	5.8	119.0	19.4	235	4,463
90	5.3	114.9	19.8	378	4,634
91	N.A	N.A	N.A	1,800	N.A
92	N.A	N.A	N.A	1,800	N.A
93	N.A	N.A	N.A	N.A	15,120
94	N.A	N.A	N.A	N.A	N.A
95	N.A	N.A	N.A	1,681	41,800
96	N.A	N.A	N.A	N.A	N.A
97	N.A	N.A	N.A	N.A	N.A
98	N.A	N.A	N.A	1,740	35,229
99	N.A	N.A	N.A	1,800	N.A
100	N.A	N.A	N.A	N.A	11,235
101	N.A	N.A	N.A	N.A	N.A

Appendix 3-2-1 LIST OF PORT EQUIPMENT AVAILABLE WITH PORT SERVICES CORPORATION

Table A-3-2-1 Existing Port Equipment

Make	Model	PSC Sl.No.	Qty.	Lifting Capacity	Year of Purchasing	Usage
CONTAINER CRANES						
Mitsubishi		1 & 2	2	35 T	1981	Container Berth
				under Spreader Containers	1981	"
CONTAINER SPREADER						
	40 Ft. long	1 & 4	2	30 T		Container Crane
	20 Ft. long	2 & 3	2	20 T		"
	20 Ft. long	6	1	35 T		"
FORKLIFT TRUCKS						
Hyster	H 80C	25 to 44	20	3628 kg	1976	G.C.
Hyster	H 165E	45 to 49 & 51-53	9	7484 kg	1975	G.C.
Hyster with long fork	H 165E	50	1	7484 kg	1975	Empty container
Hyster (electric)	E 60BS	54,55	2	2500 kg	1978	C.F.S.
Hyster	H 800A	57 to 60	4	35000kg	1981	Loaded container
Hyster	H 275H	61,62	2	6590 kg	1982	Empty container
Hyster	H 800A	63	1	35000kg	1983	Loaded container
Kalmar	LMV 25	64	1	25000kg	1984	Ro-Ro

Make	Model	PSC Sl.No.	Qty.	Lifting Capacity	Year of Purchasing	Usage
Hyster	H 130F	65 to 68	4	5500 kg	1984	G.C.
Komatsu	FD70-3	69,70	2	5600 kg	1984	G.C.
Kalmar	KLMV42-1200	71	1	35000kg	1984	Loaded container
Hyster	H 360C	72	1	7500 kg	1984	Empty container
Lancer Boss	B75ECH/MK IV-1	73	1	7000 kg		Empty container
Hyster	H 920B	74	1	35800kg	1984	Loaded container
Hyster	H 580 C	75	1	25000kg	–	Ro-Ro
Mitsubishi	FD-30	76	1	2900 kg	–	C.F.S.
Mitsubishi (Electric)	FD-70	77	1	5500 kg	–	G.C.
Komatsu	FD-70-3	78	1	5600 kg	–	G.C.
Komatsu	FD-30T-8	79,80	2	–	–	C.F.S.
		81	1	5500 kg	–	G.C.
		82	1	5500 kg	–	G.C.
		83	1	5500 kg	–	G.C.
RO-RO TRACTORS (Haul Majors)				Maximum Trailer Weight		
Reliance Mercury	MK-2	1 to 3	3	60 T		Container Terminal & General Cargo
-do-	MK-2C	4,5	2	70 T		
-do-	SERIES-4	6,7	2	70 T		
TRACTORS						
M.F.	MF	1,2,5	3	–	–	–

Make	Model	PSC Sl.No.	Qty.	Lifting Capacity	Year of Purchasing	Usage
RO-RO TRAILERS WITH GOOSE NECK AND PARK STAND						
W.H.Davies	40 Ft.	1 to 4,6	5	40 T	–	Tractors
W.H.Davies	20 Ft.	5,6 to 16	10	20 T	–	"
PLAN	40 Ft.	50 to 59	10	60 T	–	"
RTS	40 Ft.	60 to 69	10	60 T	–	"
MOBILE CRANES						
Nellen	N 115L		1	9 T	–	G.C.
-do-	-do-	2	1	2.5 T	–	"
-do-	-do-	3	1	10 T	–	"
-do-	-do-	4	1	2.5 T	–	"
American Hoist	8450	5	1	150 T	–	"
Coles	Aeneas	6	1	13.625 T		
						G.C.
Clarklime	7010 TC	7	1	75 T		"
Coles	Vigorous	8	1	17 T		"
-do-	Aeneas	9	1	17 T		"
-do-	-do-	10	1	6.5 T		"
-do-	Adonis	12	1	7.5 T		"
-do-	-do-	13	1	7.5 T		"

Appendix 3-3-1 Change in Amount of Cargo in November and December 1988

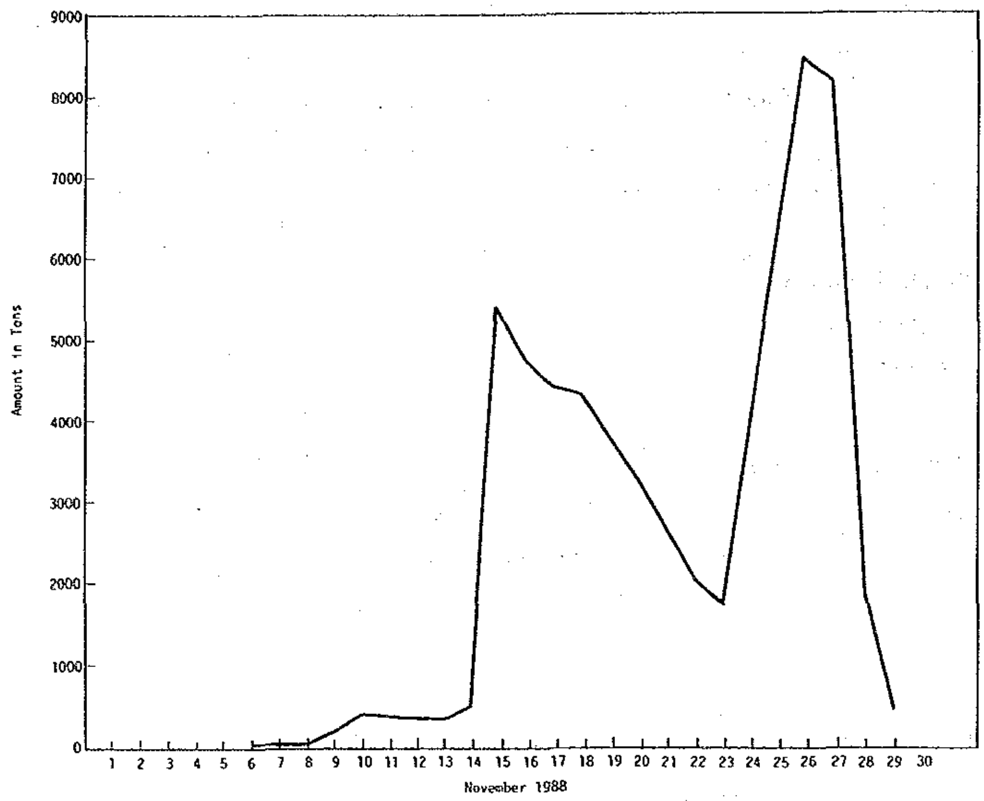


Fig. A-3-3-1(a) Change in Amount of Cargo (Steel/Pipes)

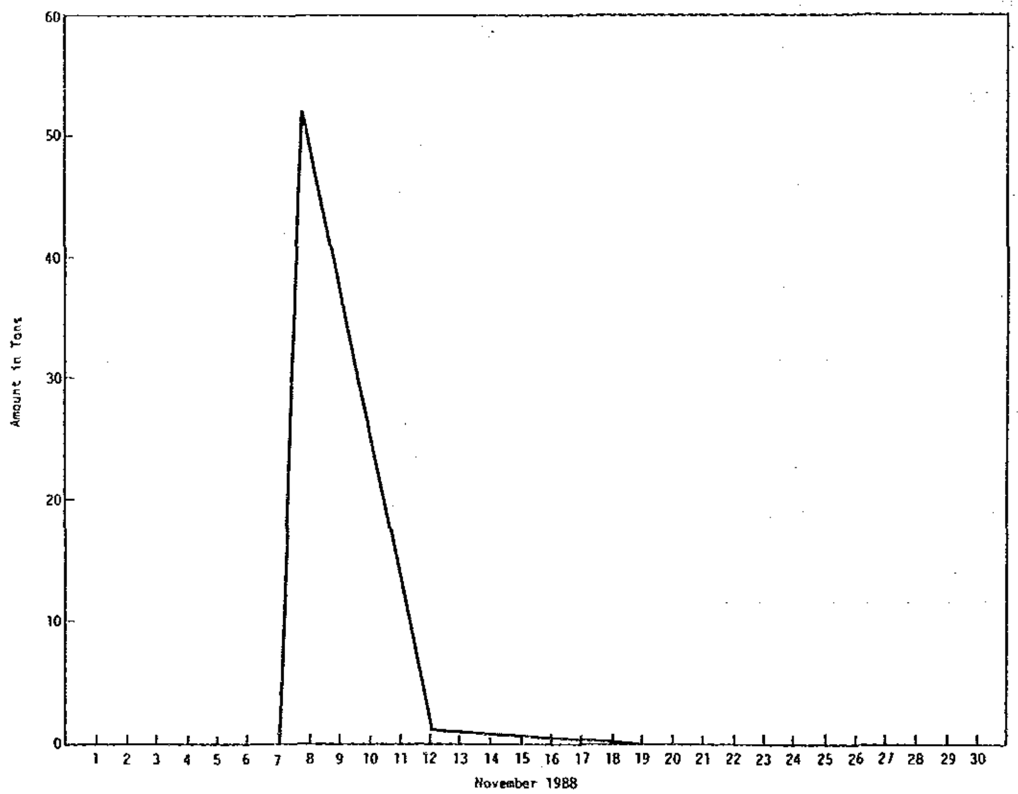


Fig. A-3-3-1(b) Change in Amount of Cargo (Rice)

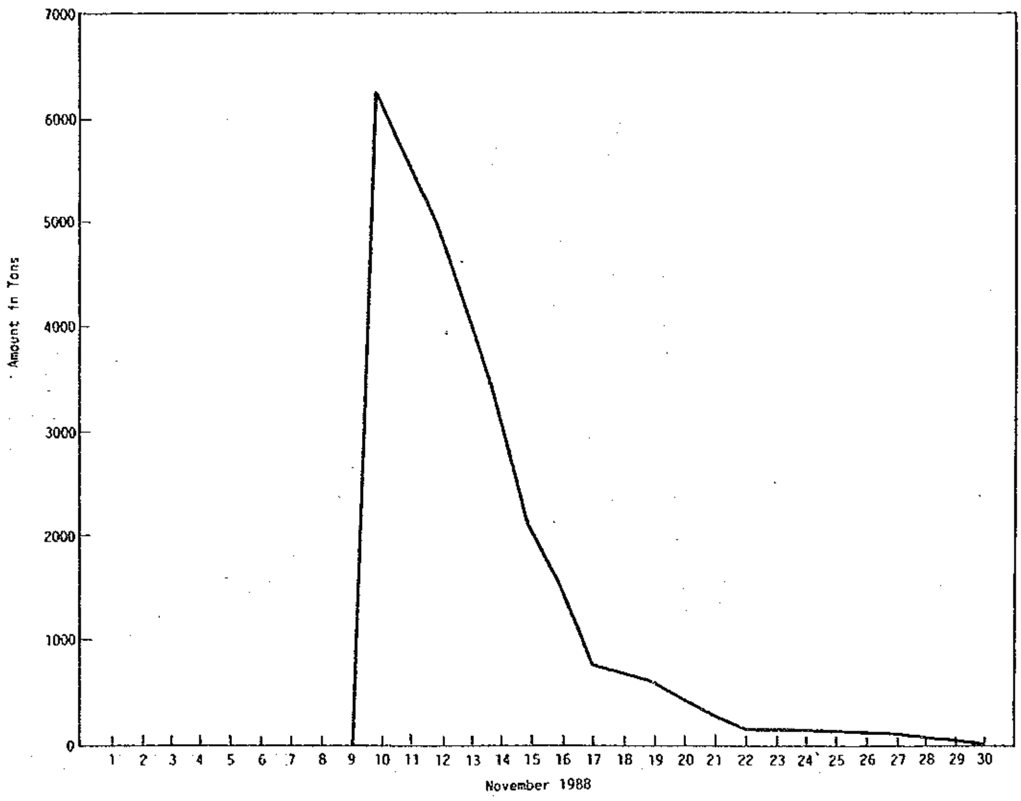


Fig. A-3-3-1(c) Change in Amount of Cargo (Timber/Plywood)

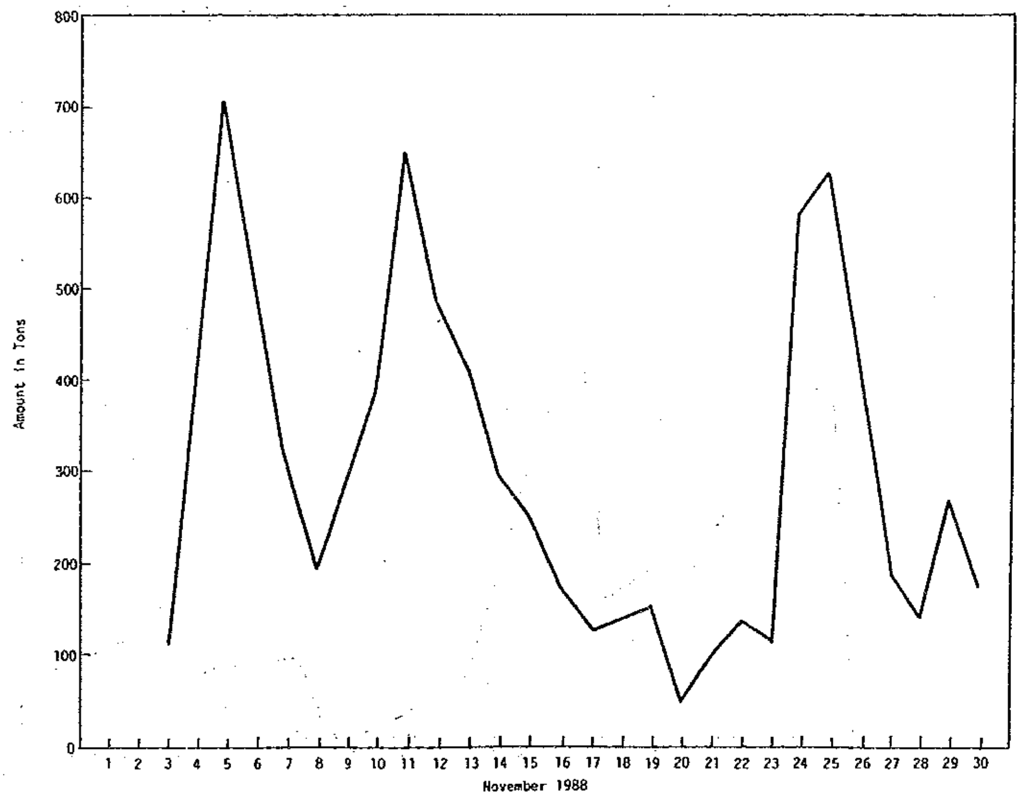


Fig. A-3-3-1(d) Change in Amount of Cargo (Vehicles)

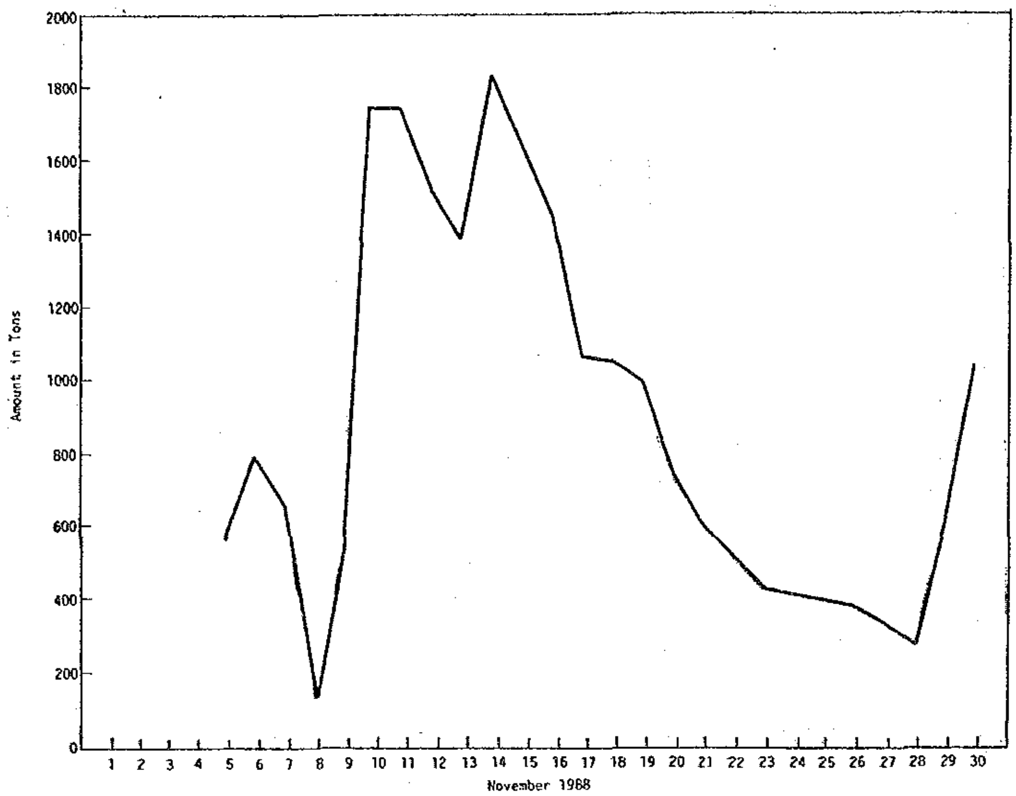


Fig. A-3-3-1(e) Change in Amount of Cargo (General Cargo)

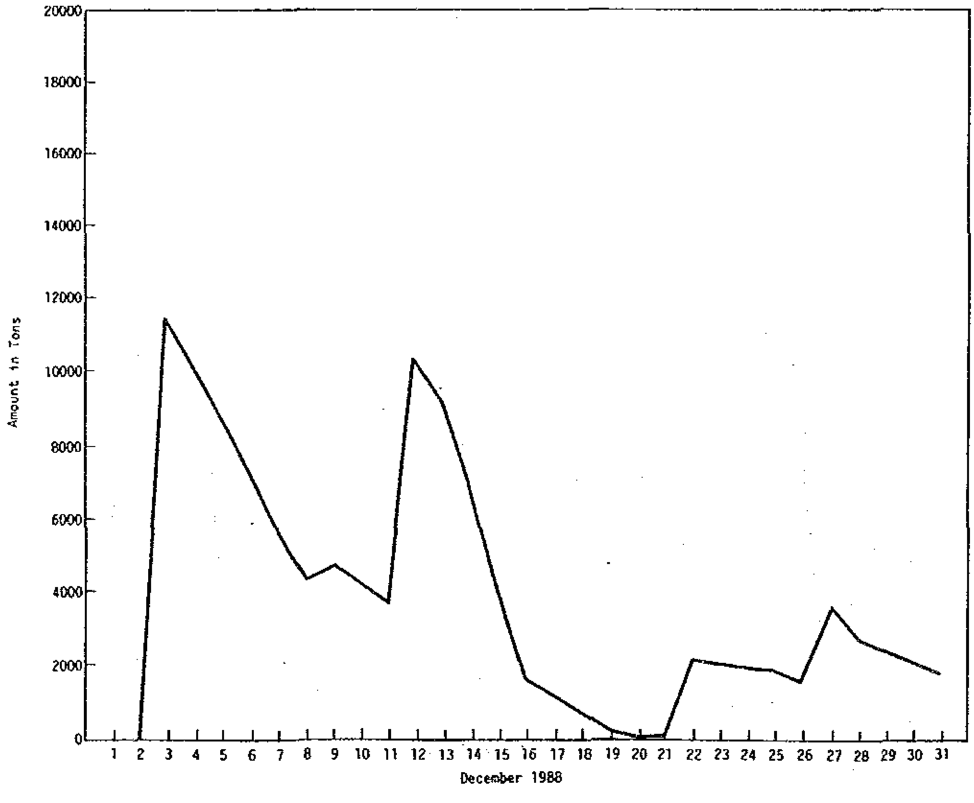


Fig. A-3-3-1(f) Change in Amount of Cargo (Steel/Pipes)

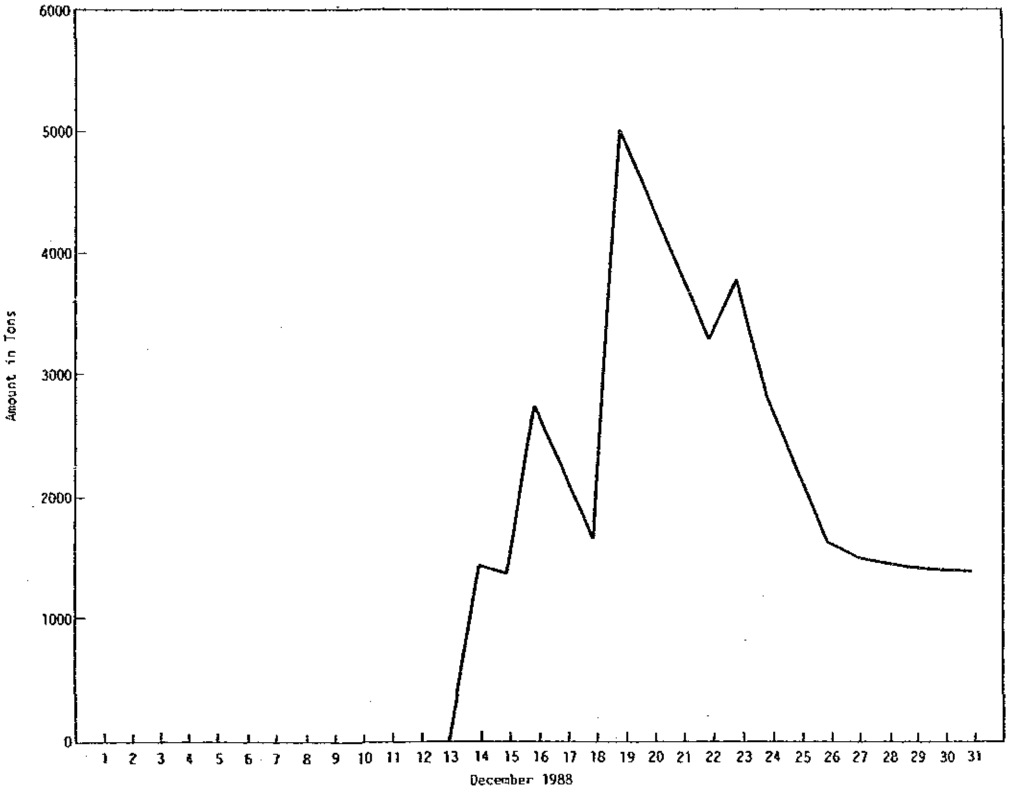


Fig. A-3-3-1(g) Change in Amount of Cargo (Timber/Plywood)

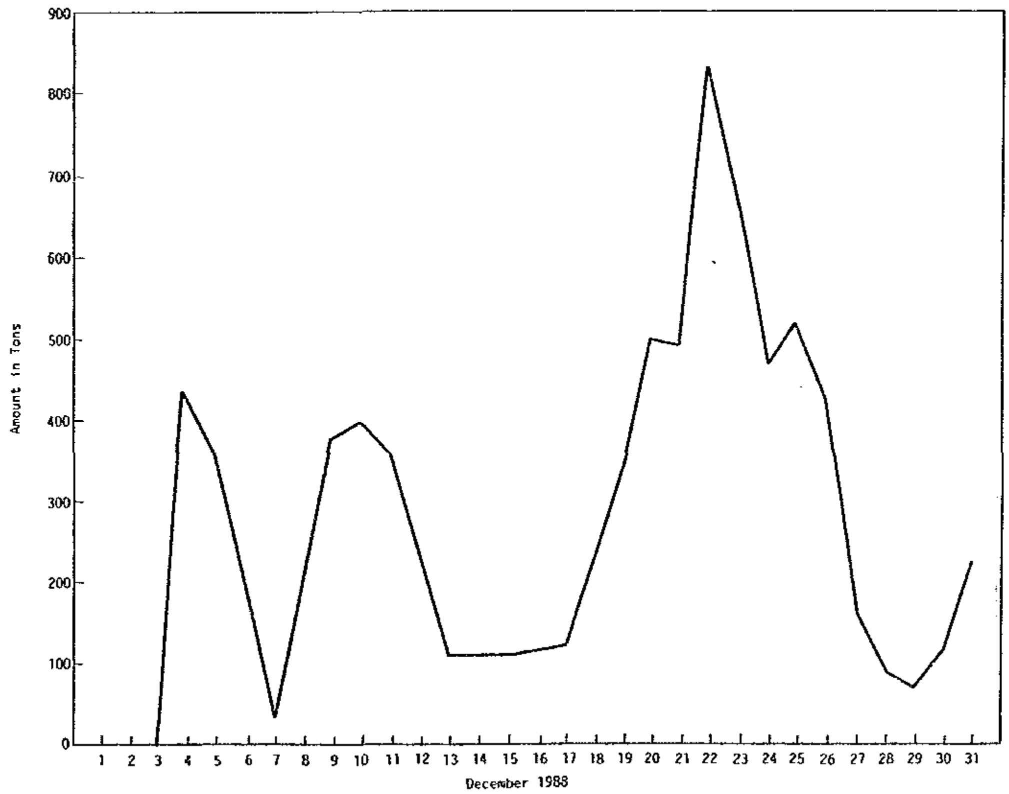


Fig. A-3-3-1(h) Change in Amount of Cargo (Vehicles)

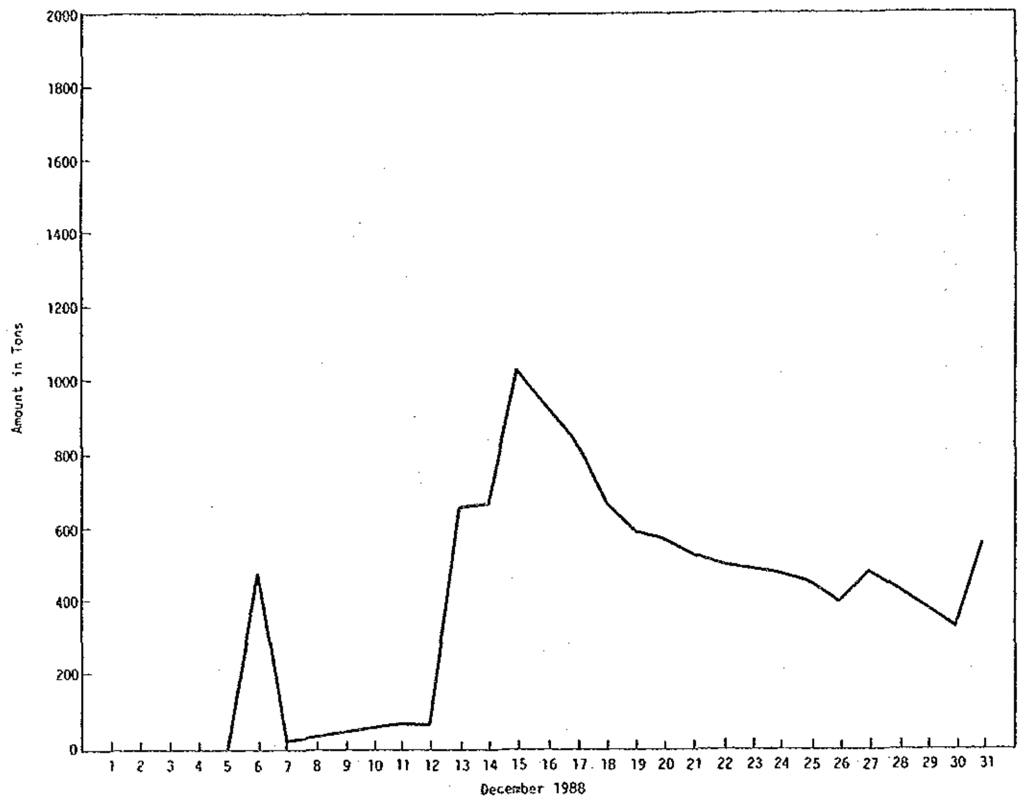


Fig. A-3-3-1(i) Change in Amount of Cargo (General Cargo)

Appendix 3-4-1 Distribution of Ship Arrivals by Gross Tonnage

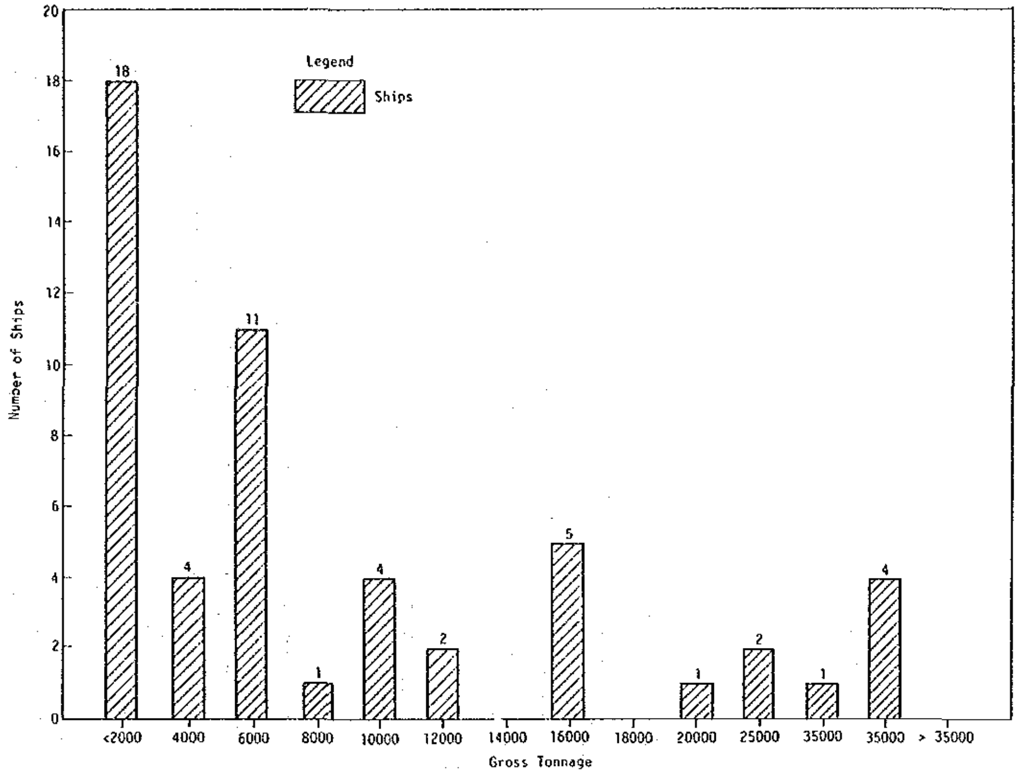


Fig. A-3-4-1(a) Distribution of Ship Arrivals by Gross Tonnage
(Semi-Container Ships
Year 1988)

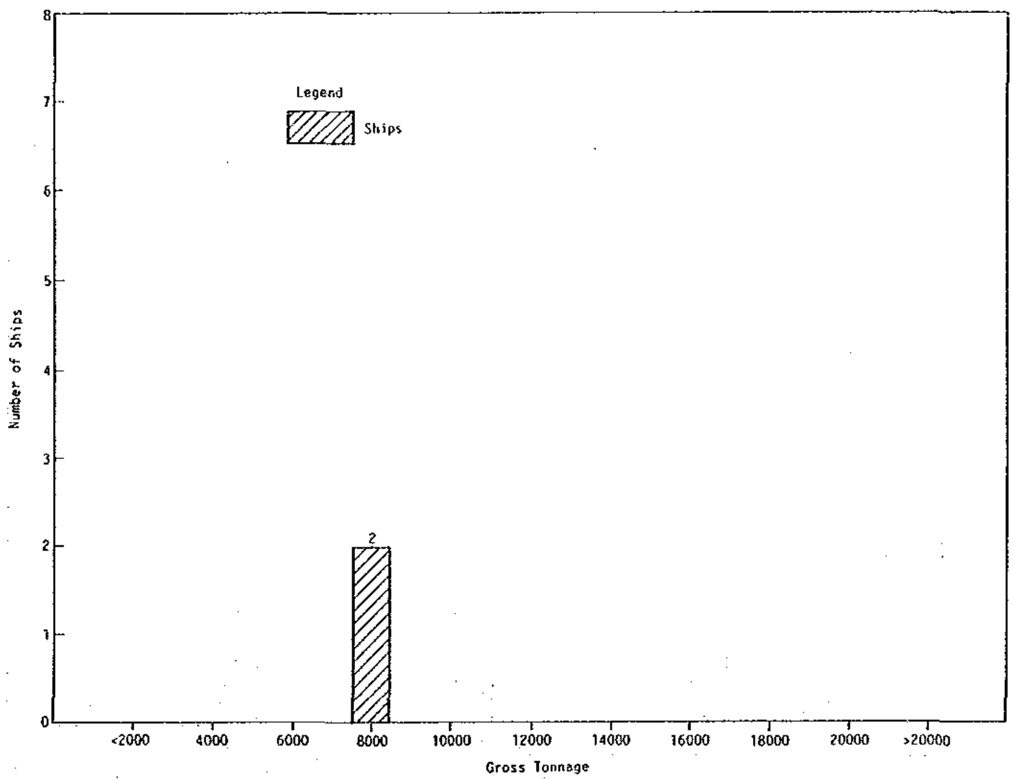


Fig. A-3-4-1(b) Distribution of Ship Arrivals by Gross Tonnage
(Dry Bulk Carrier Ships
Year 1988)

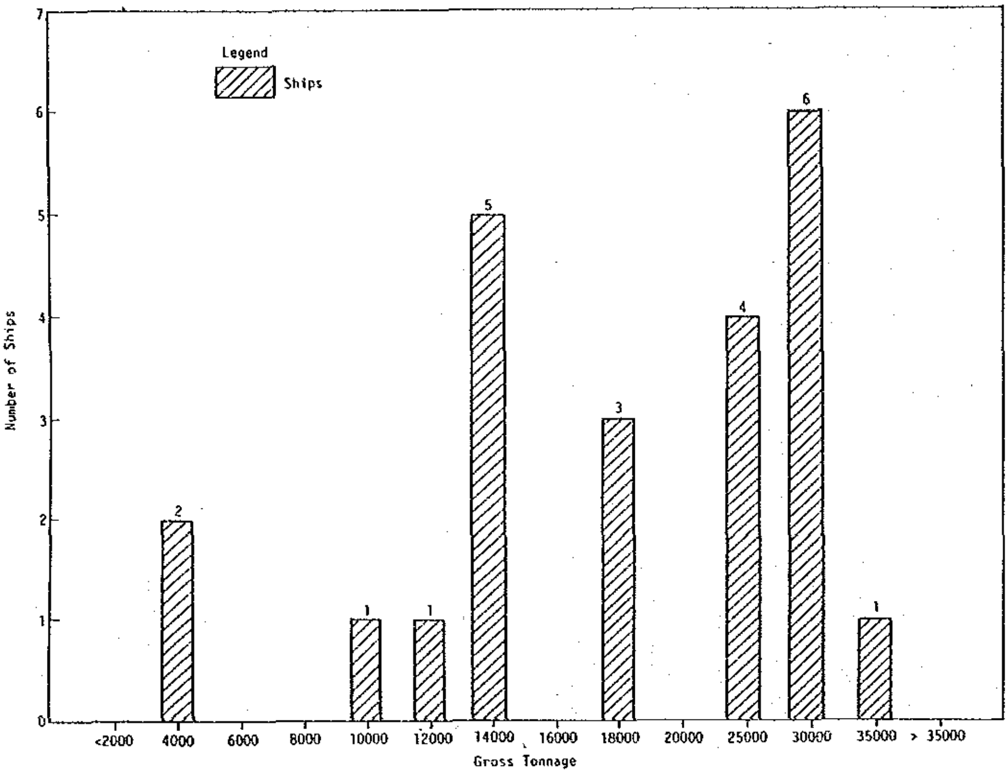


Fig. A-3-4-1(c) Distribution of Ship Arrivals by Gross Tonnage
(Livestock Carrier Ships
Year 1988)

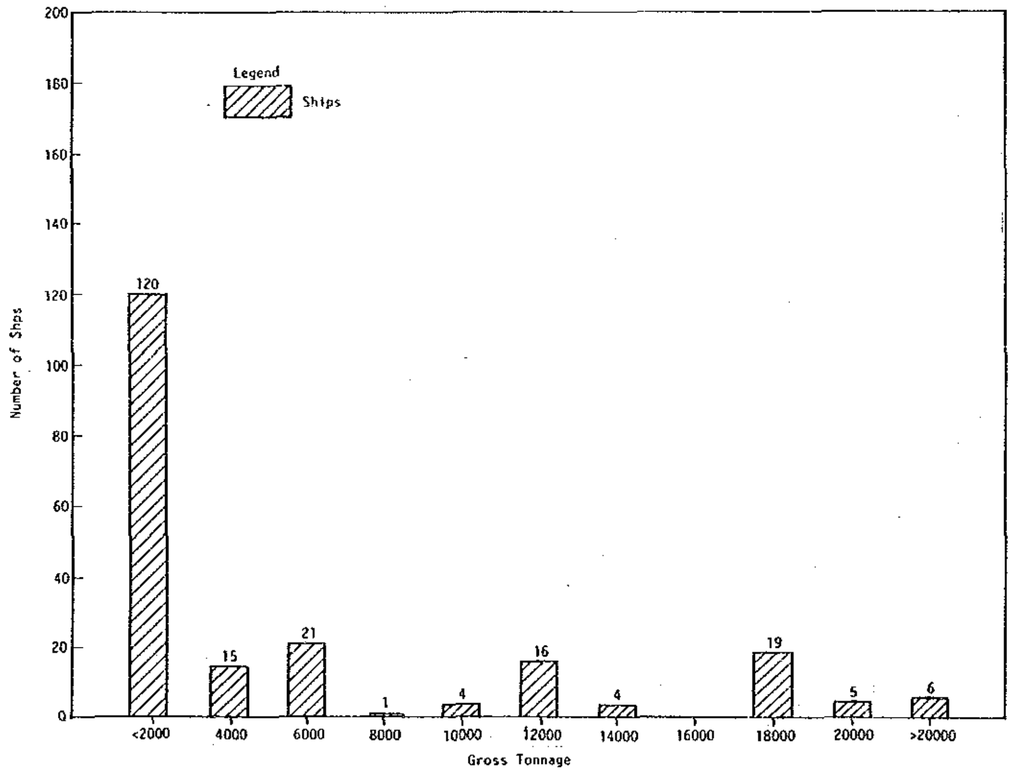


Fig. A-3-4-1(d) Distribution of Ship Arrivals by Gross Tonnage
(Visiting/Other Ships
Year 1988)

Appendix to Chapter 6

Appendix 6-2-1 Revised Cost Estimates for Further Expansion of Mina Qaboos which Had Planned by CES

The CES recommended the scheme II for further expansion of Mina Qaboos as shown in Fig. A-6-2-1. They phased the scheme II to the phase I and the phase II. The berth length of the phase I is 1,120m which is just the same as our plan in 2000. In order to compair their plan with our plan, we revised their cost estimate as follows.:

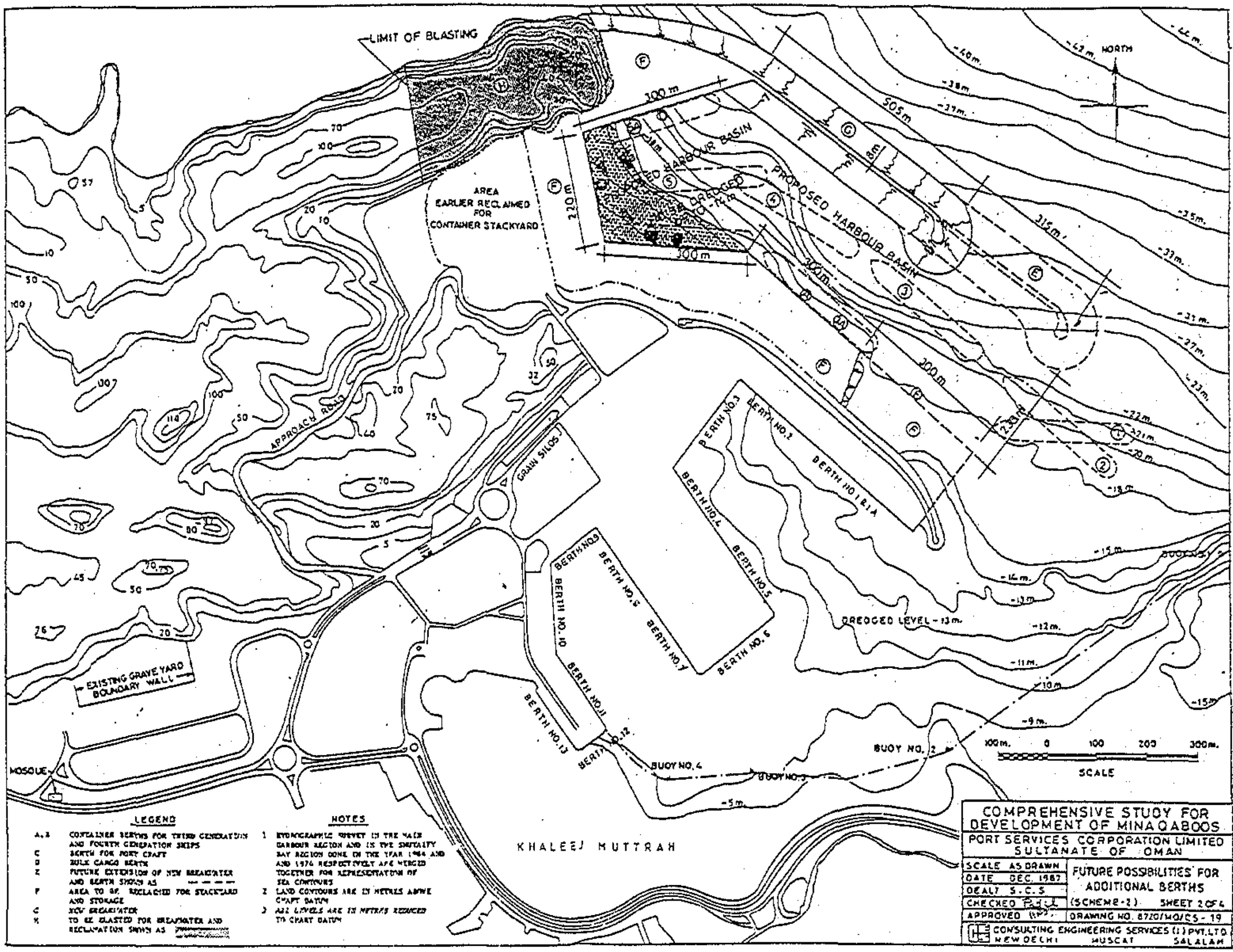


Fig. A-6-2-1 Scheme II of Further Expansion of Mina Qaboos

Table A-6-2-1 Breakup of Quantity and Cost of Items for Various Alternatives by CES

Phase	Item	Scheme I Qty.	Scheme I Unit	Scheme I Rate (RO)	Scheme I Amount M(RO)	Scheme II Qty.	Scheme II Unit	Scheme II Rate (RO)	Scheme II Amount M(RO)	Scheme III Qty.	Scheme III Unit	Scheme III Rate (RO)	Scheme III Amount M(RO)	Scheme IV Qty.	Scheme IV Unit	Scheme IV Rate (RO)	Scheme IV Amount M(RO)
I	Reclamation with																
	i) Dredged soil	Nil	-	-	-	75,000	m3	4	Negligible	85,000	m3	4	Negligible	400,000	m3	4	2
	ii) Blasted Jebel	30,00,000	m3	4	12	27,00,000	m3	4	11	29,50,000	m3	4	12	800,000	m3	4	3
	Total	30,00,000	m3		12	27,75,000	m3		11	30,35,000	m3		12	12,00,000	m3		5
	Breakwater																
	i) Stone	10,00,000	m3	6	6	8,33,000	m3	6	5	10,00,000	m3	6	6	8,33,000	m3	6	5
	ii) Stabits	2,67,000	m3	30	8	2,33,000	m3	30	7	2,67,000	m3	30	8	2,00,000	m3	30	6
	Total	12,67,000	m3		14	10,66,000	m3		12	12,67,000	m3		14	10,33,000	m3		11
	Blasting	40,00,000	m3	1.5	6	33,40,000	m3	1.5	5	40,00,000	m3	1.5	6	20,00,000	m3	1.5	3
	Dredging	Nil	-	-	-	75,000	m3	11	1	85,000	m3	11	1	4,00,000	m3	11	4
	Berth	810	m	10,000	8	1,120	m	10,000	11	1,200	m	10,000	12	1,120	m	10,000	11
	Approach Road	1,000	m	1,000	1	1,000	m	1,000	1	1,000	m	1,000	1	1,000	m	1,000	1
	Grand Total				41				41				46				35
II	Reclamation with																
	i) Dredged soil	Nil	-	-	-	Nil		-	-	Nil	-	-	-	Nil	-	-	-
	ii) Blasted Jebel	7,50,000	m3	4	3	7,50,000	m3	4	3	7,50,000	m3	4	3	1,00,000	m3	4	4
	Total	7,50,000	m3		3	7,50,000	m3		3	7,50,000	m3		3	1,00,000	m3		4
	Breakwater																
	i) Stone	5,00,000	m3	6	3	5,00,000	m3	6	3	3,30,000	m3	6	2	6,66,000	m3	6	4
	ii) Stabits	1,67,000	m3	30	5	1,33,000	m3	30	4	1,00,000	m3	30	3	1,66,000	m3	30	5
	Total	6,67,000	m3		8	6,33,000	m3		7	4,30,000	m3		5	8,32,000	m3		9
	Blasting	13,50,000	m3	1.5	2	13,30,000	m3	1.5	2	13,30,000	m3	1.5	2	13,30,000	m3	1.5	2
	Dredging	Nil	-	-	-	Nil			-	Nil		-	-	Nil		-	-
	Berth	300	m	10,000	3	300	m	10,000	3	300	m	10,000	3	550	m	10,000	6
	Grand Total				16				15				13				21

Table A-6-2-2 Comparison of Further Expansion of Mina Qaboos with New Port Development

Cost Estimate by CES for Phase I of Scheme II Mina Qaboos					Revised Cost Estimate by JICA Team for Phase I of Scheme II Mina Qaboos					Cost Estimate by JICA Team for Majis Port Development in 2000				
ITEMS	UNIT	Q'TY	UNIT RATE	AMOUNT	ITEMS	UNIT	Q'TY	UNIT RATE	AMOUNT	ITEMS	UNIT	Q'TY	UNIT RATE	AMOUNT
			(R.O.)	(x1.000 R.O.)				(R.O.)	(x1.000 R.O.)				(R.O.)	(x1.000 R.O.)
Reclamation					Reclamation									
1) dredged Soil	M^3	75,000	4	300	Surface Dressing	M^2	144,000	0.94	136	-	-	-	-	-
2) Blasted Jebel	M^3	2,700,000	4	10,800	Pavement	M^2	144,000	4.50	648	Yard Pavement	M^2	248,000	(8)	1.986
Breakwater	M	(505)	(23,700)	(11,988)	Breakwater	M	505	30,214	15,260	Breakwater	M	2,695	(3,714)	10,008
1) Stone	M^3	333,000	6	4,998										
					Revetment	M	350	24,171	8,460	-	-	-	-	-
2) stabits	M^3	233,000	30	6,990										
Blasting	M^3	3,340,000	1.5	5,010	Blasting	M^3	3,340,000	1.50	5,010	-	-	-	-	-
Dredging	M^3	75,000	11	825	Dredging	M^3	75,000	2.13	160	Dredging	M^3	12,458	(1.12)	13,999
Berth					Berth					Berth				
-14M					-14M	M	590	8,483	5,005	-14M	M	580	8,483	4,920
-18M					-18M	M	530	11.028	5,844	-13M	M	540	9,148	4,400
Total	M	1,120	10,000	11,200										
Approach road	M	1,000	1	1	Approach Road	M	1.000	1	1	Road	M	3,500	86	301
					Direct Cost				40,524	Direct Cost				35,614
GRAND TOTAL				40,124	Grand TOTAL			(1.23)	49,849	GRAND TOTAL			(1.23)	43,805

IV. Appendix to Chapter 9

Appendix 9-2-1 Indirect Cost

In general, the ratio of indirect cost/administration cost against direct cost is as follows:

Indirect Cost (in site)	
Delivery	0.2 - 1.0%
Preliminaries	0.3 - 0.5%
Security	0.1%
Technical control	0.3 - 0.4%
Temporary facilities	0.7 - 1.1%
Management of construction	10.7 - 11.7%
Administration (including profit)	9.4%
Total:	21.7 - 24.2%

In this project, the total ratio is fixed at 23% of direct cost

JICA