12.2.5 Proposed Plan (Alternative-6) for Container Handling

(1) Dimensions of the Proposed Plan (Alternative-6)

Major components of the proposed plan are 1) three new off-shore jetty-type container berths, whose water depth is -13.5m, connected with Victoria Dock Container Yard by access bridge, 2) 2,930 G. slots of container marshaling yard on Victoria Dock Container Yard which is created by reclamation of Victoria Dock, 3) 2,836 G. slots of empty container yard on various locations (ID-1: 240 G. slots, Victoria Dock Container Yard: 802 G. slots, CDW: 972 G. slots and TPS: 1,140 G. slots), 4) dedicated road for container traffic between on-dock container yard and off-dock CFS and container yard, 5) deepening both the basin of the proposed container berths, whose berthing area is deepened to -13.5m, and the Approach Channel to -11.0m, and 6) six quay-side gantry cranes, 19 transfer cranes, 97 yard tractor-chassis units and 55 road tractor-chassis units (refer to Section 12.2.6).

Since it is still very difficult for MBPT to evict adequate space for the development, there would be a shortage of 187 G. slots of empty container yard in the port area. However, empty container yard is apt to be located adjacent to the factory for FCL container, as FCL/LCL container ratio increases. Therefore, the shortage of approximately two hundred G. slots of empty container yard in the port area would not be a crucial point for the proposed plan.

Dimensions of major container handling facilities and equipment are summarized in Table 12.2.9.

(2) Layout of the Proposed Plan (Alternative-6)

On-dock layout of the proposed plan is shown in Figure 12.2.7, including 1) three new off-shore jetty-type container berths connected to Victoria Dock Container Yard by access bridge, 2) 2,930 G. slots of container marshaling yard and 802 G. slots of empty container yard on Victoria Dock Container Yard, 3) dedicated road for container traffic between on-dock container yard and off-dock CFS and empty container yard and 4) Deepening both the basin of the proposed container berths, whose berthing area is deepened to -13.5m, and the Approach Channel to -11.0m.

Table 12.2.9 Dimensions of Proposed Major Container Handling Facilities

Features	Unit	Alternative-6	
1. Existing Container Berths		Infrastructure	Equipment
1. Number of Berths		1	---
2. Berth Depth	(m)	-9.8	---
3. Berth Length	(m)	244	---
4. Berth Location		BPS	---
5. Quay-side Gantry Crane	(unit)	---	2
6. Transfer Crane	(unit)	---	3
2. Proposed Container Berths			
1. Number of Berths		3	---
2. Berth Depth	(m)	-13.5	---
3. Berth Length	(m)	300	---
4. Berth Location		800m off ID-HW	---
5. Quay-side Gantry Crane	(unit)	---	6
6. Transfer Crane	(unit)	---	19
3. Container Marshaling Yard		3,446	
1. Existing Yard	(G. Slots)	516	
2. Proposed Yard	(G. Slots)	2,930	
1. Yard Tractor-Chassis Unit	(unit)	---	97
2. Road Tractor-Chassis Unit	(unit)	---	55
3. ID-1	(G. Slots)	0	---
4. ID-2 to 5	(G. Slots)	0	---
5. ID-HW	(G. Slots)	0	---
6. VD-CY	(G. Slots)	2,930	---
7. CDW	(G. Slots)	0	---
8. TPS	(G. Slots)	0	---
9. CRS	(G. Slots)	0	---
4. Empty Container Yard	(G. Slots)	3,341	
1. Existing Yard	(G. Slots)	-	
2. Proposed Yard	(G. Slots)	3,154	
1. ID-1	(G. Slots)	240	---
2. VD-CY	(G. Slots)	802	---
3. CDW	(G. Slots)	972	---
4. TPS	(G. Slots)	1,140	---
5. CRS	(G. Slots)	0	---
3. Shortage of Yard	(G. Slots)	187	
5. Container Freight Station (CFS)	(sq. m)	67,687	
1. Existing CFS	(sq. m)	48,487	---
2. Proposed CFS	(sq. m)	19,200	---
1. CDW	(sq. m)	19,200	---
6. Dedicated Road for Containers			
1. No. of Lanes	(lanes)	4	---
2. Ground Length	(m)	1,000	---
3. Elevated Length	(m)	700	---

Remarks) BPS: Ballard Pier Station, ID-1: Indira Dock No. 1, ID-2 to 5: Indira Docks Nos. 2 to 5, ID-HW: Indira Dock Harbour Wall, VD-CY: Victoria Dock Container Yard, CDW: Cotton Depot West, TPS: Timber Pond South, CRS: Central Railway Stores

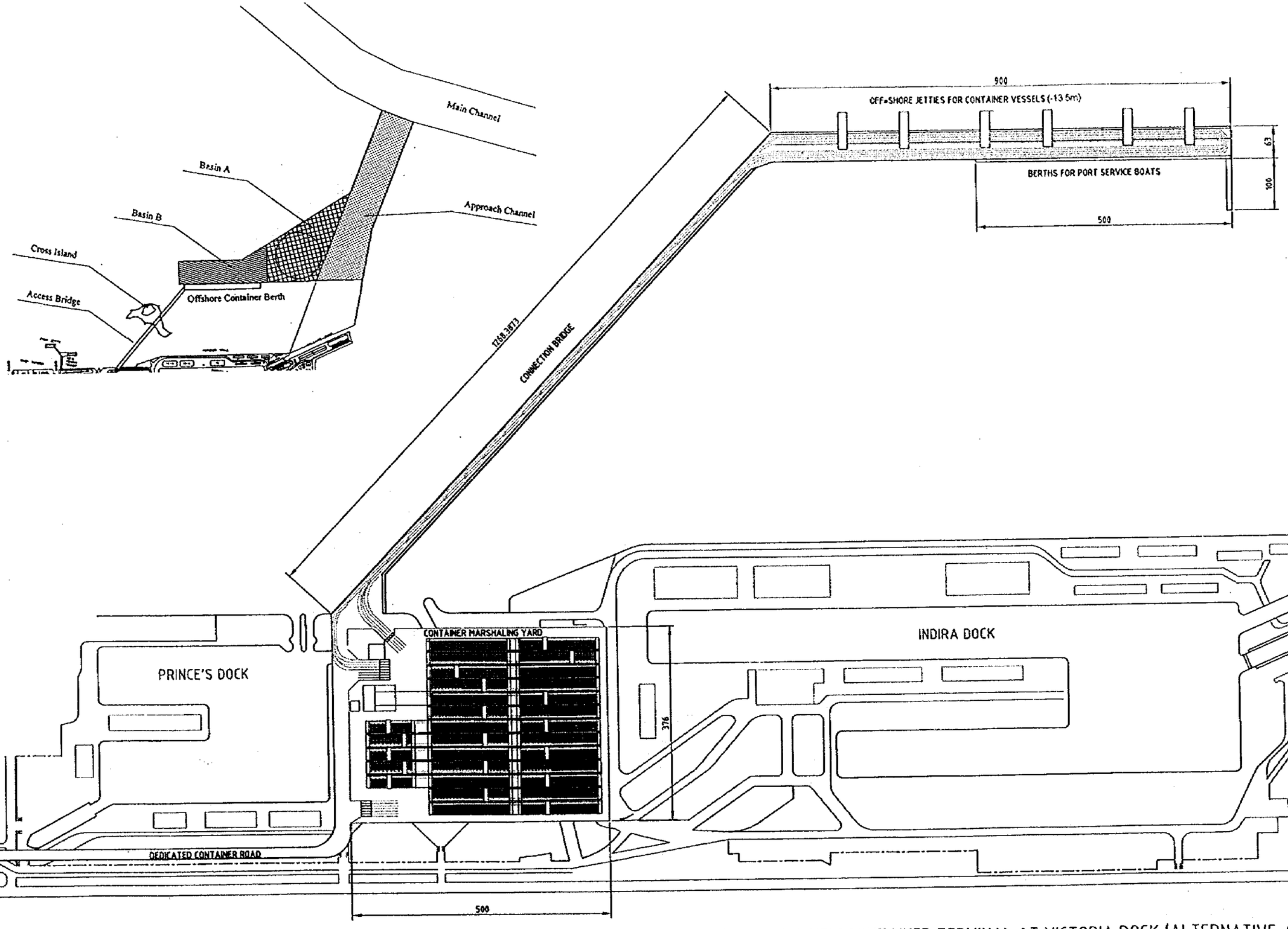

Figure 12.2.7 LAYOUT PLAN OF A NEW CONTAINER TERMINAL AT VICTORIA DOCK (ALTERNATIVE-6)

SCALE1:7,000

1) Three New Container Berths

Three new off-shore jetty-type container berths are located approximately 800 meters off the Indira Dock Harbour Wall connected with Victoria Dock which will be filled up as a container yard by access bridge using water-through structure such as pile-structure. Hard material lays under the seabed with a depth ranging from -4.0 to -10.0 meters within the area up to about 800 meters off the front of the Harbour Wall. Detailed information of hard materials distribution is given in Chapter 2. Berth alignment of Alternative-6 is proposed to be parallel to the Harbour Wall so as to ensure more tranquillity for mooring vessels and container-handling operations, considering the tidal flows.

In addition, the existing Ballard Pier Station (BPS) with container marshaling yard of 516 G. slots will be utilized as a container berth for the future.

The other side of the jetty facing Indira Dock Harbour Wall is planned to be used as a 500 m long berth for port service boats. This will enable ID-18, 20 and 21 berths to be fully utilized for conventional cargo handling.

2) Victoria Dock Container Yard

The container yard at Victoria Dock accommodates 2,930 G. slots of laden containers and 802 G. slots of empty containers. As to empty container yard, ID-1, Cotton Depot West (CDW) and TPS accommodate 240 G. slots, 972 G. slots and 1,140 G. slots respectively. Since the required dimension of empty container yard is 3,341 G. slots, however, the remaining required empty container yard of 187 G. slots will be in short supply and need to be prepared outside the port.

3) Dedicated Road for Container Traffic

Dedicated road for container traffic would be essential for the smooth flow of container traffic between on-dock container yard and off-dock CFS and empty container yard. The dedicated road starts from the gate of Victoria Dock Container Yard and extends to and connects with the Link Road. The fly-over structure is adopted for the dedicated road to cross over Malet Road so as to smoothly evacuate containers from the dock area. Heavy traffic congestion currently seen at the junction of Dock Expressway and Malet Road is expected to be reduced drastically by fly-over road.

General-purpose road along the container-dedicated road is prepared within the port area for port-related traffic including general cargo trucks. This could also reduce traffic congestion on P D'Mello Road where heavy congestion from both port-related traffic and city traffic is currently seen.

However, Mumbai Metropolitan Region Development Authority (MMRDA) is planning to build "East Island Freeway" along the Link Road and Dock Expressway within the MBPT's landed estate as an extension of Eastern Express Highway to the Gateway of India. "East Island Freeway" is planned basically for city traffic rather than port-related traffic. Since the above-mentioned container-dedicated road could reduce city traffic congestion and MBPT's landed estate has to be utilized basically for port-related activities, precious space for the container-dedicated road should be reserved for this Master Plan.

4) Deepening both the Basin and the Approach Channel to -11.0m

As mentioned in Section 12.2.4, Indira Dock and the Approach Channel were designed to be deepened at -9.8m and -7.6m respectively. Since the tidal range of MBP is 5.2m, the Approach Channel was designed at a depth of -7.6m by utilizing the tide for ship's entering/departing Indira Dock so as to minimize capital and maintenance dredging costs. Both the basin of the proposed container berths, whose berthing pocket area is deepened to -13.5m, and the Approach Channel are planned to be deepened up to -11.0m.

On the other hand, it is not necessary to deepen the Approach Channel (-11.0m) up to the gate of Indira Dock, which will be mainly used by relatively small conventional cargo vessels. Since depth of Indira Dock Entrance lock is maintained at -7.6m, Approach Channel is expected to be maintained at the same water depth of -7.6m as it is maintained.

Cotton Depot West (CDW): 972 G. slots

Timber Pond South (TPS): 1,140 G. slots

Indira Dock No.1 (ID-1): 240 G. slots

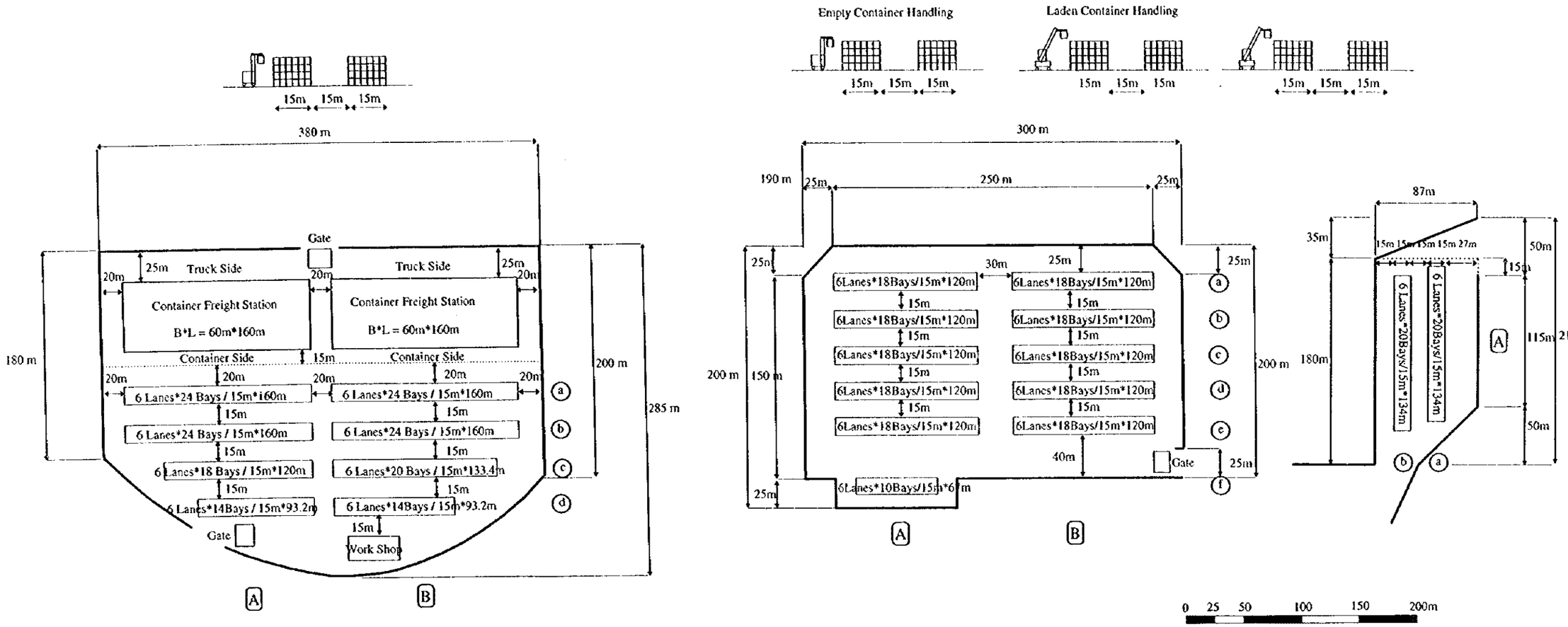

Figure 12.2.8 Layout Plan of Off-Dock Container Depot

(3) Operational Conditions for Cargo Handling along the Proposed Container Berths

During the monsoon season from the middle of June to the end of September, the significant waves generated by the SW monsoon winds enter the Mumbai Harbour. On the other hand, during the remaining non-monsoon season from October to June, the harbour is calm due to prevailing wind direction of NE, namely land wind. In this regard, it is necessary to assess whether the critical wave height of 0.5m for cargo handling along the proposed container berths would be maintained at the required level generally adopted in the range of 90 to 95% of the year.

During the former monsoon season, waves generated by the winds from WSW-SW-SSW in direction enter at the harbour mouth and reach the proposed berths. Due to refraction during the penetration into the harbour, the wave direction is almost parallel to the front line of the existing Indira Dock Harbour Wall, N-NNE, regardless of the difference of wave directions at the harbour mouth, which vary from WSW to SSW (Figure12.2.9). Hence, waves reaching vessels berthing at the proposed berths pass through from bow to stern or vice versa.

The non-excess probability of the critical wave height for cargo handling is estimated at approximately 90% in the SW monsoon and 97% throughout the year, which satisfy the above criteria[1] (Figure 12.2.10).

(4) Supplementary Jetty to Prevent Waves for Port Service Boats

As mentioned above, large container vessels are expected as operational in the range of 90 to 95% of the year. However, port service boats to be moored along the western side of the proposed jetty need more tranquillity than large container vessels do.

Assuming that the critical wave height is 0.3m for mooring the port service boats along the western side of the off-shore jetty, those small boats should be safely moored along the length of 250m of the port service boat jetty whose total length of 500m. Necessary length of supplementary jetty to prevent waves for port service boats is calculated as 100m, whose alignment is presented in Figure 12.2.7 (1).

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[1] Master Plan Study by Bertlin and Partners (India)

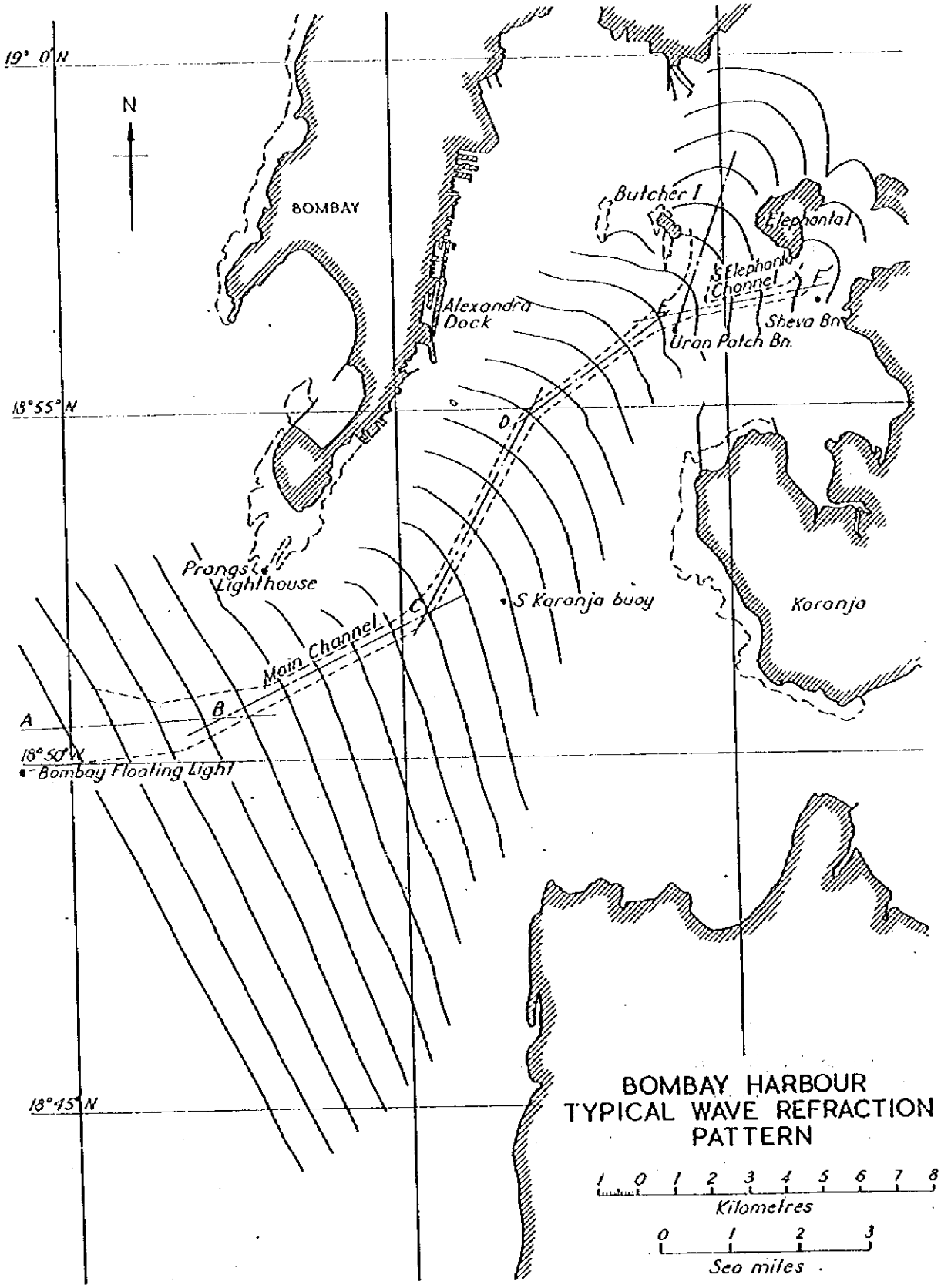


Figure 12.2.9 Mumbai Harbour Typical Wave Refraction Pattern[1)]

[1)] Master Plan Study by Bertlin and Partners (India)

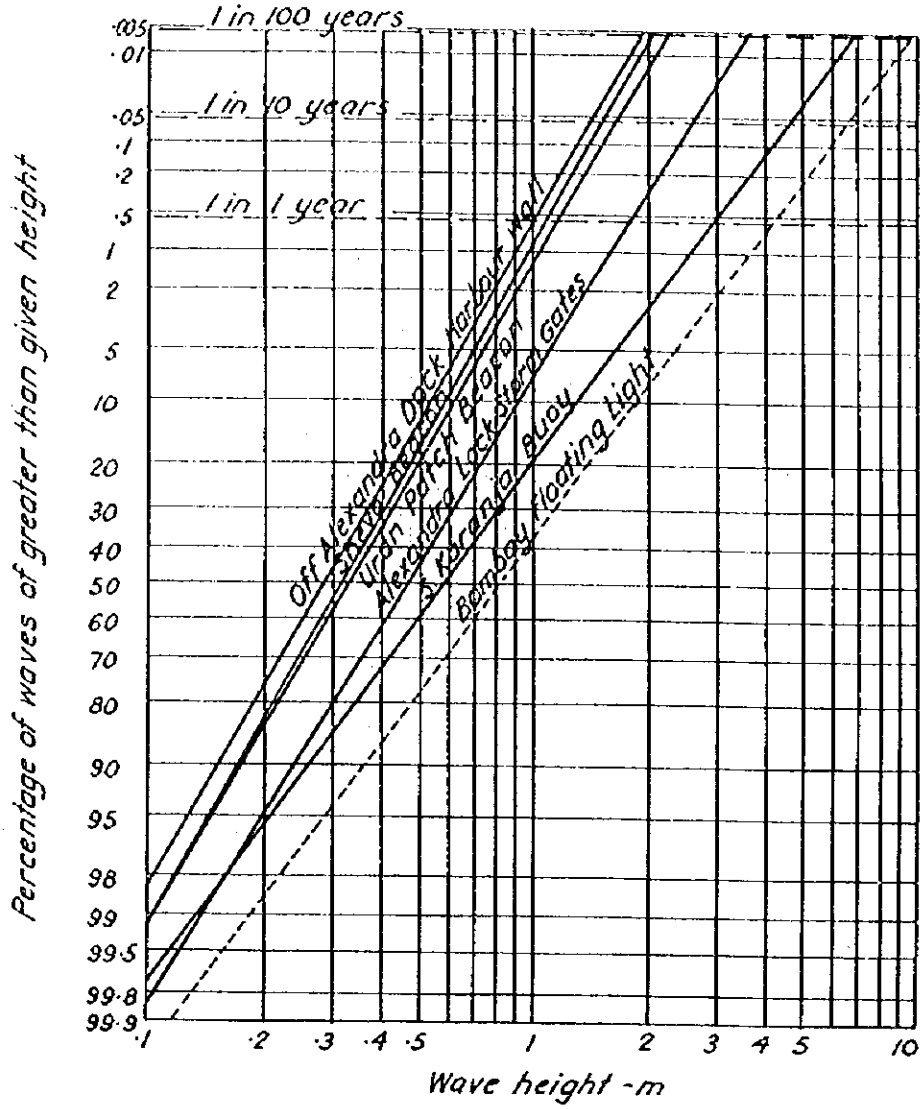


Figure 12.2.10 Wave Height Probabilities during Monsoon 3 Hours before HW

(5) Ship Maneuvering

Turning circle for the container vessels departing from the proposed container berths is designed for 2,500 TEU-size container vessels with a diameter of 520m which is equal to twice as long as LOA of 2,500 TEU-size container vessel. This turning circle is located a little apart from the corner of the Approach Channel and the basin (Figure 12.2.11. Designed depth of the Approach Channel and the basin is planned as -11.0m, taking into account the tidal range of 5.2m at MBP as mentioned above.

Since the designed depth of the proposed container berths is -13.5m, however, the container berth front area is planned to be deepened up to -13.5m within the berthing pocket area of 65m width which is twice as wide as Molded Breadth of 2,500 TEU-size container vessel.

(6) Potential Location of Additional Off-shore Container Jetties

As mentioned in Section 11.9, the total container handling capacity of MBP could be increased up to 2 million TEUs and more on the condition of constructing additional off-shore berths next to the berths proposed in the Master Plan, converting the existing facilities at Prince's Dock into another container marshaling yard. The second phase container terminal project at the Prince's Dock, so to speak, has a great advantage because the access channel, the connection bridge and the dedicated container road to be prepared in the first phase project would be usable as common infra-structures. The construction cost of the additional off-shore berths, container marshaling yard at Prince's Dock and related facilities is preliminarily estimated as 15.8 billion Rs. which is 80% of the proposed project cost as 20.0 billion Rs. (see Section 13.3).

The timing of the start of the second phase container terminal project needs be carefully determined after confirming satisfactory progress of the first phase project. In this meaning, the second phase container terminal project would be started beyond the target year of the Master Plan, 2017, and excluded in the Master Plan.

Figure 12.2.11 Layout Plan of Approach Channel and Basin for Alternative-6

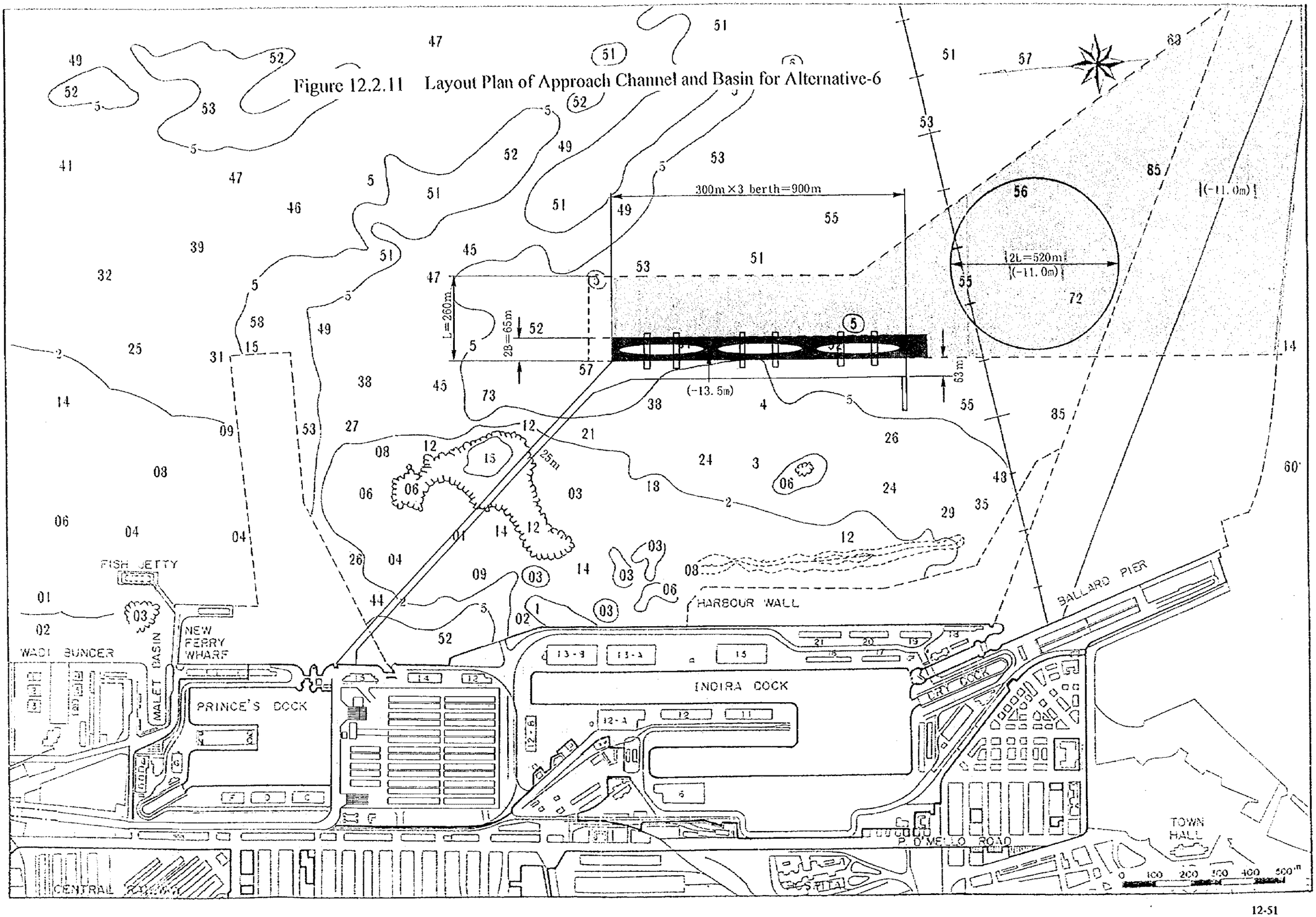
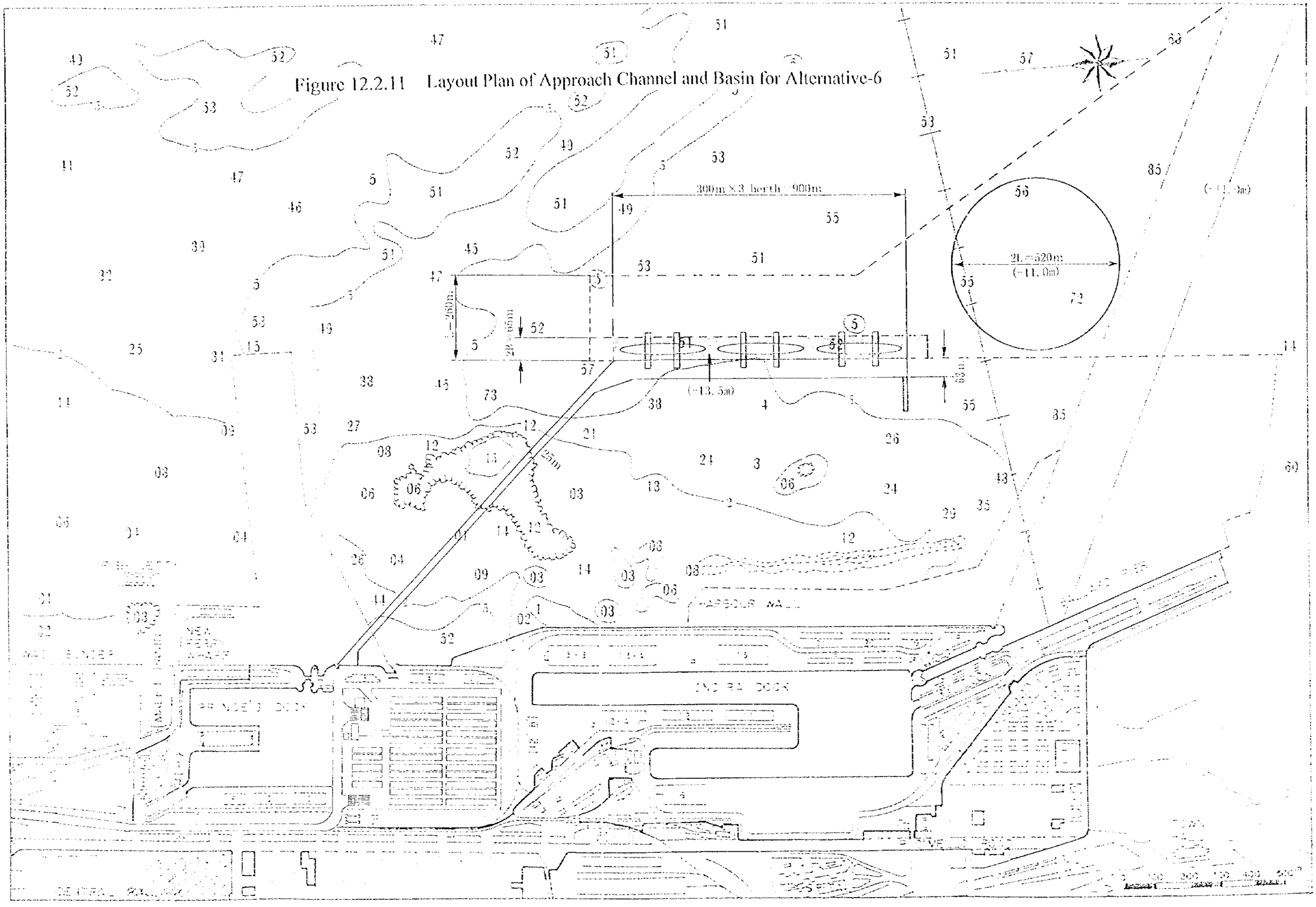


Figure 12.2.11 Layout Plan of Approach Channel and Basin for Alternative-6



12.2.6 Required Dimensions of Major Equipment for Container Handling

(1)Selection of Container Handling Equipment

Generally speaking, there are three types of container handling equipment as listed below and specific consideration should be given to the following items.

1) Type

a) Transfer Crane

b) Straddle Carrier

c) Top Lifter or Reach Stacker

2) Items to be considered

a) Scale and size of container marshaling yard.

b) Initial volume of the containers, forecast future increase, and possibility of marshaling yard expansion in future.

c) Initial investment for purchasing equipment.

d) Service life of equipment (depreciation period).

e) Running cost (maintenance cost) of equipment.

f) Workability (quick response) and safety of the container operation.

g) Degree of mechanical development of equipment.

h) Conditions of the marshaling yard foundation.

3) Advantages/disadvantages of transfer crane

Careful examination should be done prior to introduction of the transfer crane system.

Advantages:

a) Although this is dependent on the size and form of marshaling yard, this type has the maximum container storage capacity per unit area among the three types.

b) As the transfer crane's running lanes are fixed in the marshaling yard, total costs for pavement will be reduced since heavy pavement is required only for the running lanes.

c) As the running lanes in the marshaling yard are fixed, more safety can be secured in connection with other vehicles and the passage for personnel.

d) Running cost, including maintenance cost, of this type is approximately half of that of straddle carrier according to actual results in Japan.

e) As an engine is connected directly with the generator, it can rotate at the constant speed, thus longer life and more economical operation can be expected.

f) Heavy cargo other than containers may be handled by using wire sling.

g) Systematic operation can be conducted from the office gate, and each piece of equipment can easily be operated by means of computerization in future.

h) Layout of container is a block stacking of six rows, which is suitable for storage against strong winds and other hard natural phenomenon. (In case wind of 25m/sec or more acts upon stacked empty containers, they may overturn.)

Disadvantages:

a) Compared with other container handling equipment, this type is so on a larger scale that it seems to travel a little bit slower than a straddle carrier in the marshaling yard. Actually, its traveling speed is 5% to 7% slower than that of straddle carrier.

b) The main function of transfer crane is only to load/unload containers on/from the chassis, and the tractor-chassis is used for transverse movement of containers. Then, larger initial investment is required as compared with other systems.

c) Work other than work inside the marshaling yards and outside the running lanes cannot be executed.

d) As containers are piled up in the marshaling yard, re-handling of container has to be done in delivery, which will cause difficulty in real time operation of inventory.

e) Containers will be stacked in block of six rows with three or four tiers in marshaling yards, which makes it difficult to check the conditions of container in the yard.

(2)Estimation of the Required Number of Container Handling Equipment

1) Quay side gantry crane

The available number of quay side gantry crane for handling containers at the port is a governing factor in determining the turnaround time of container ships. Hence, it is necessary to provide an optimum number of container handling equipment to ensure the completion of loading and unloading operations within the shortest possible time.

The required number of quay side gantry crane for handling containers can roughly be estimated by the following formula on some assumptions.

$$Nqc = A / (T \times \eta_1 \times \rho \times Pqc \times \eta_2 \times E)$$

where, Nqc : Required number of quay side gantry crane (unit),

A : Annual throughput in TEU,

T : Maximum available working hours during the year (=8,760hr/year),

ρ : Berth occupancy (=0.6),

Pqc : Productivity of quay side gantry crane on the basis of net (=30 box/hr/crane),

η_1 : Percentage of availability,

η_2 : Cargo handling efficiency, and

E : Conversion rate (=1.44 TEU/box, assumed).

Assuming that η_1 is 0.8, based on an actual percentage of availability obtained at the existing Ballard Pier Station (B.P.S.), and η_2 is 0.8, and giving a forecast annual throughput of 830,000 TEUs for the projected new container berths and that of 170,000 TEUs for the existing B.P.S., respectively, the required number of quay side gantry crane will be calculated at six units for the projected new container berths and two units for the existing B.P.S., respectively. This result corresponds to the recent requirements for two container cranes for one berth.

2) Transfer crane in the marshaling yard

The transfer cranes used in the marshaling yard just behind the quay must operate in good combination with the quay side gantry cranes. Their job assignments are to handle containers carried by tractor-chassis between the quay side apron and the marshaling yard, i.e. quay side operation, as well as to re-handle and/or pre-marshal containers in the yard, i.e. in-yard operation. In addition, in Mumbai Port the transfer cranes have to handle most of the export and import containers which shall be carried daily between the on-dock marshaling yard and the off-dock container depots.

As for quay side operations, one or two units of transfer crane will be adequate to work in combination with one quay side gantry crane. In general the operating efficiency of transfer crane under delivery/pickup operations is reduced to approximately 15 containers per hour due to re-handling of containers stacked in three or four tiers, hoisting or lowering operations across stacks, block-to- block movement, etc.

The required number of transfer cranes used in the on-dock marshaling yard is estimated by the following formula on an assumption that all containers loaded and unloaded will be stacked once temporarily in the on-dock marshaling yard.

$$Ntc = Ntc_1 + Ntc_2 + Ntc_3$$

where, Ntc : Required number of transfer cranes (unit),

Ntc_1 : Transfer cranes mainly used for quay side operations (=1unit/crane×Nqc),

Ntc_2 : Transfer cranes mainly used for in-yard operations (unit),

$Ntc_2 = Amy / (T \times \eta_1 \times Ptc \times E)$

Amy : Annual throughput handled in the on-dock marshaling yard in TEU. A peak ratio of 1.7 will be taken into consideration when estimating.

T : Maximum available working hours during the year (=8,760hr/year),

η_1 : Percentage of availability,

Ptc : Productivity of transfer crane on the basis of gross (=15 box/hr/unit),

E : Conversion rate (=1.44 TEU/box), and

Ntc_3 : Standby transfer cranes to cope with pre-marshaling of containers, immobilization due to repairs or periodical maintenance or other unforeseen circumstances (=2 units, assumed).

Assuming that a projected new container park will handle containers of 830,000 TEUs per year and the Ballard Pier Container Park (B.P.C.P.) 170,000 TEUs per year, the required number of transfer cranes will be calculated as given in Table 12.2.10.

Table 12.2.10 Estimated Number of Required Transfer Cranes Used in the On-dock Marshaling Yard (Units)

Option	Number of Transfer Cranes Required	Number of Transfer Cranes to be Provided in the Project*
Alternative-1	17	17
Alternative-2	18	18
Alternative-3	18	18
Alternative-4	18	18
Alternative-5	18	18
Alternative-6	18	18
Ballard Pier C.P.	4	1

Note: The column marked with " * " describes the number of transfer cranes taken into consideration when estimating the Project Cost.

3) Yard tractor and chassis

The yard tractors with chassis run between the quay side apron and the marshaling yard, and transport containers for loading onto or unloading from container ships. They are also used to speed up in-yard container movements.

According to the distance between the quay side gantry crane and the marshaling yard, one job cycle time of tractor and chassis shall change. Therefore, an estimation of required number of tractors and chassis for each proposed option was carried out on the following conditions.

Travel speed of tractor and chassis	:	15 km/hr (Average)
Handling time under the gantry crane	:	1 minute
Handling time under the transfer crane	:	2 minutes
Handling productivity of gantry crane	:	24 box/hr (Gross)
Container berth	:	Length 900 m × Width 63 m (for Alternative-3 to -6)
Length of connecting bridge	:	It will change from 800 m to 1,200 m according to each proposed option.

The number of tractors and chassis required for each proposed option will be estimated as given in Table 12.2.11.

Table 12.2.11 Estimated Number of Required Tractors/Chassis Used in the Projected Container Terminal (Units)

Option	Projected New Container Terminal	Ballard Pier Container Station	Total Number Required
Alternative-1	30 / 33	8 / 9	38 / 42
Alternative-2	36 / 40	8 / 9	44 / 49
Alternative-3	75 / 83	8 / 9	83 / 92
Alternative-4	80 / 88	8 / 9	88 / 97
Alternative-5	80 / 88	8 / 9	88 / 97
Alternative-6	80 / 88	8 / 9	88 / 97

Note : Numbers in each cell give number of tractor / number of chassis.

As for the yard chassis, the minimum requirement should be equal to the number of yard tractors and allowance must be made for additional chassis to serve for the purpose of temporary storage, since it is often necessary to keep container-loaded chassis in the yard in order to meet operational needs or to speed up container handling. The estimated number of chassis for each proposed option given in Table 12.2.11 includes this allowance, which was assumed to be 10%. Not only systematic operation but also management of these tractor-chassis is of great importance in the Port.

4) Road tractor and chassis

In addition to the yard tractors and chassis for on-dock services, the Port of Mumbai needs additional tractors and chassis in order to transport most of the import and export containers between the on-dock marshaling yard and the off-dock container depots. In this study, the following areas were considered as the off-dock container depots, i.e. the existing five depots including Frere Basin(FB), Manganese Ore Depot(MOD), Cotton Depot(COD), Timber Pond(TP), and Wadala Area(WA), and another two candidacy areas, i.e. Cotton Depot West (CDW) and Timber Pond South(TPS), both of which are expected to be returned to MBPT in near future,.

The required number of road tractor and chassis was examined on an assumption that each tractor-chassis runs between the on-dock marshaling area and the off-dock container depots ten round trips a day with the travel speed of 35 km/hr and transports 20 boxes of container in three shifts. In this estimation of one cycle time of each tractor-chassis, times lost due to loading/unloading of container onto/from the chassis, gate in/out procedure, travel both in the marshaling yard and the off-dock depots, and so forth were considered.

Although an estimation revealed that the total required number of tractor-chassis would be 183 units, this study proposed that 55 units of them shall be provided including standby units to cope with peak traffic, immobilization due to repairs or periodic maintenance, etc. This number of unit will correspond to 30% of the total units of road tractor-chassis, which is an assumed rate derived from the ratio of yard area of proposed new container depots against total required container depot area in the off-dock. As to the transportation of containers to/from the existing five container depots, it was assumed that the present logistic system would be preserved.

5) Container handling equipment at the off-dock depots

Another container handling equipment such as reach stacker shall be required for handling containers at the proposed new depots. This type of equipment will load/unload a container onto/from a chassis, re-handle and pre-marshal containers in the depots in order to increase container handling services, and be operated in good combination with the road tractors and chassis. This study proposed that each proposed new container depot shall be provided with two units of reach stacker, then four units altogether.

6) Container handling equipment at the existing CFSs

CFS containers are currently required to be placed on the ground before stuffing/de-stuffing work in front of the existing CFSs. Thus, laden containers are lifted off chassises before de-stuffing and empty containers are lifted onto chassises after de-stuffing by toplifter/forklift, and vice versa. Maximum daily number of CFS containers to be handled at the existing CFSs is estimated as 1280 TEUs/day for the year 2017. Thus, required number of toplifters/forklifts is estimated to be five (5) as follows;

$$\frac{\{1280(TEUs/day)/1.44(TEUs/box)\}}{20(boxes/hr/lift)\times 20(hrs/day)\times 0.5(operational\ factor)} = 4.4 \quad < \quad 5\ (forklifts)$$

There are five existing CFSs such as Frere Basin, Manganese Ore Depot, Cotton Depot, Timber Pond and Wadala Area. Each existing CFS will need one (1) toplifter/forklift for the year 2017. Although those toplifters/forklifts will need to be prepared by the private operators such as the transportors, the existing toplifters/forklifts owned by the transportors can be diverted. Thus, they are not included in the proposed project.

7) Electric facility

The proposed new container terminal in the dock area needs an installation of substation through which electric power will be supplied to quay-side container cranes, reefer containers, yard lighting installations, administration building, gate house, maintenance shop, etc. It is also recommended to provide Diesel-Generator units of appropriate capacity to cope with unexpected power failure.

12.2.7 A New Container Handling System

It is necessary to introduce a new container terminal system and an efficient management system to accompany the increasing number of containers and incoming vessels in the future.

The important point in establishing an efficient management system is the accurate and quick transfer of information to all the functions (personnel) of the container terminal. Loading and unloading information is essential for the personnel of each machine and yard controller in the container yard. Accurate and quick transfer of information is especially vital.

For instance, when a container is loaded or unloaded between container vessel and container terminal, personnel in container yard are busily engaged in handling equipment. By quickly transferring necessary information, idling time for handling equipment can be decreased and this contributes to the efficiency of the whole container terminal.

To increase operational efficiency, the arrangement of the containers to be stored in the yard should be classified at least according to the following factors.

1) Whether the containers are laden or empty
2) Whether the containers are for import or for export
3) The container size and type

The export containers should be arranged by freight company and by size so as to enhance operational efficiency.

It is important that handling equipment be always maintained in best condition. To do so, the personnel who operate each machine should at the beginning be required to inspect each machine, to report the conditions in writing and to do his best to find any troubles as early as possible. Furthermore, there should be periodic checks (monthly, biannually and annually) of each function and item to decrease the rate of trouble during operation.

To strengthen the function of transship containers, the transship container freight and other export oriented freight should raise its storage fees. In addition, other preferred discount measures compared to the domestic and import containers, and discounted loading fees for those containers may result in more quick operations.

It is also necessary to establish more favorable conditions compared to neighboring container terminals to attract the container ships.

(1) Container Terminal Operation System (see Table 12.2.12)

Container terminal operation starts from receipt of loading or unloading containers. It is important that these operations be handled by one container terminal operator. The following items should be implemented to increase the operational efficiency of the terminals.

1) Efficient Gate Operation

The most important work in the container terminal is an efficient gate operation. The gate function includes checking the exterior of the containers, the transfer No. and the documentation. Controlling the work inside the container terminal is also included in the gate function. It is necessary to introduce a system which enables a gate handling time of 3-4 minutes per container.

2) Preparation of Sequence Check List

For loading and unloading operation, a sequence check list on which necessary information of the work sequence is listed should be drafted in advance. Copies of this list should be released to the operating personnel. The following items should be included in the sequence check list:

① Sequence No.,
② Container No.,
③ Yard location / ships stowage location,
④ Loading port / unloading port, and
⑤ Container weight.

3) Improved Accuracy of Inventory

Inventory is extremely important for efficient management of a container terminal. For instance, if the stowage location within the yard can be found right away as noted in the import documentation, the information will go to the personnel working with equipment in the yard and the amount of time that the equipment is left waiting can be remarkably decreased. The following are items are necessary for efficient management of inventory.

Table 12.2.12 Structure of Container Terminal Operation System

Name of System	Sub System
1. Container inventory system	1. Container inquiry system by container 2. Container inquiry system by yard stacking spot 3. Container storage system by shipping agent and by type
2. Gate operation system	1. Container receiving system by empty and laden container 2. Container releasing system by empty and laden container 3. Container stacking spots deciding system
3. Export container handling system	1. Booking information system by local, RCD and transshipment container 2. Export container documentation system
4. Import container handling system	1. Manifest information system by local, RCD and transshipment container 2. Import container documentation system
5. Empty container handling system	1. Empty container reception and delivery system by container size and type 2. Empty container documentation system by shipping lines
6. Yard planning and operation system	1. Export container stacking spot deciding system by container size, weight and port of destination 2. Import container stacking spot deciding system by local, RCD and B/L No. 3. Yard operation data transmitting system 4. Yard equipment management system
7. Ship stowage data planning and operation	1. Export container loading planning system 2. Import container unloading planning system 3. Container re-handling system 4. Loading container documentation sytem
8. Empty container handling system	1. Damaged container repairing system 2. Repairing cost management system
9. Handling equipment management system	1. Quay-side Gantry Crane maintenance system 2. Yard equipment maintenance system 3. Equipment space-parts control system
10. Data statistics system	1. FCL container statistics system 2. LCL cargo statistics system 3. Export and import container statistics system by port of loading and unloading and by container size and weight
11. Terminal management system	1. Terminal billing and payroll control system 2. Terminal expense control system 3. Personnel management system

① Container No.,

② Yard Location,

③ Receiving Data (from sea or land),

④ Loaded or Empty,

⑤ Container size,

⑥ Kind of Container, and

⑦ Shipping Company (Shipping Agent)

(2) Container Flows through a New Container Terminal

1) Export Containers

Terminal operator begins to receive export containers from a week before the arrival of the vessel. Shippers arrange tractor trailers and bring loaded containers to the Container terminal. At the gate of terminal, gate clerks check the exterior and seal of the containers. (In case of refrigerated containers, they also check the temperature of containers.) Then they measure weight of the container. They input necessary data (container number, name of shipping company, name of vessel, port of discharge, size of container, weight, cargo description, whether customs clearance is done or not) into a terminal computer at the gate house. Gate clerks instruct the stacking location of containers. At the same time, this information is transmitted to operators of RTGs via Yard Operator from Gate clerks. The driver of tractor trailer goes to the designated place of CY and waits for a RTG. An RTG moves to the place where the tractor stays. Then the RTG picks up the container from the trailer and stacks it in the designated slot. After arrival of a vessel, RTGs pick up containers and load them onto yard trailers according to the working schedule prepared by the ship loading planner. Yard trailers carry the containers to the place below the designated quay side gantry crane. According to the working schedule, quay side gantry cranes pick up the containers from yard trailers and load the containers into the designated slot in the hold or on deck of a vessel.

2) Import Containers

The ship unloading planner receives documents related to the import containers (bay plan of vessel, cargo manifest, hazardous cargo list, information on refrigerated containers and special cargoes) at least three days before arrival of the vessel from the shipping line/agent. The ship planner considers above mentioned information very carefully and prepare the unloading schedule to make operation time shortest. After berthing of the vessel, operators of quay side gantry cranes unload containers from the vessel to yard trailers according to the unloading schedule. Yard trailers move containers from quay side to the designated place in CY. RTGs pick up the containers from yard trailers and put them on the designated locations. When unloading operations are completed, a shipping line/agent informs each consignee of the arrival of the vessel. At the shipping line/agent office, consignees get D/O in exchange of B/L. Then the consignee informs the documentation section of the container terminal of the schedule to pick up the container. Documentation Section of the terminal check D/O and Permission of Customs Clearance or Bonded Transportation. Demurrage or other charges are recovered at the release of the containers, if necessary. Then Documentation Section sends the delivery application to Yard Control Section. Yard Control Section checks the yard plan with the delivery application and makes the list of containers for delivery. Drivers of container trailers arranged by consignees presents D/O to the gate clerks at the gate house. The gate clerks check D/O against the list of containers for delivery. If the container is on the list, the clerk lets the driver go to the designated location for receiving the container. Yard operator instructs a operator of RTG to pick up the container for delivery. The operator of RTG checks the number of the container and RTG picks up the container from the stack of containers and loads it onto the trailer. The driver of trailer stops at the out lane of the gate where the gate clerk checks the exterior and seal of the container.

(3) Container Terminal Management Information System

Introduction of computers is necessary for an efficient container inventory management, but in the beginning, efforts should be made to improve the accuracy of container inventory management. Once the terminal personnel have improved their working capability up to a certain level, the next stage of computerization will be considered.

In the second stage, computerization of the container yard operation and loading/unloading operation should be implemented. The final objective of computerization is to build up a total system for container terminal operation.

A container terminal has to keep cargo distribution on schedule for the shipping companies, and to ensure minimum machine trouble.

It is necessary to maintain a certain level of capability of each operating personnel, and to do so it is more important to introduce and practice necessary techniques.

(4) Tractor/Trailer Traffic Access to Container Terminal and Container Yard

As containers are stacked in 3 or 4 tiers in the container yard, it is important to ensure that vehicles operating in the yard do not face any obstacles to preserve safety and efficiency. The movement of tractors/trailers in particular, requires at least two access lanes as vehicle come from outside for pick-up and delivery of container, or for loading/unloading of a berthed vessel. Therefore, a traffic system must be planned for each yard to avoid crossing of vehicles.

In the plan proposed by the study term, vehicle movement will be kept as simple as possible by introducing a one-way traffic system in which the crossing of vehicles is minimized.

1) Alternative-2,3 and 4

The container berth and yard are linked by bridge using a simple anti-clockwise system in which traffic flows on the left hand side.

2) Alternative-1 and 5

The distance between the container berth and back-area of Indira dock No-2 to No-6 berths, which is used as a container yard, is 4.5 kilometers. There are jetty container berths, also between the Indira dock and the Victoria dock side there are an edible oil tanks and a break-bulk cargo warehouses, which could hinder the traffic flow. Even if this problem were overcome by introducing a fly-over traffic system, the sharp incline of the access bridge would make it difficult for even high-powered trucks to smoothly move traffic between

container jetty and yard. Finally the construction cost of these alternatives would be high, making them uneconomical.

3) Alternative-6

In the case of reclaiming Victoria Dock the traffic system between the container yard and the container berth would be a simple one-way system. Moreover, the distance from the existing Link Road to the fly-over road is shorter, making this alternative economical as the construction cost would be low.

12.2.8 Container Handling Machines

The followings are the general description of principal particulars of container handling equipment provided in the Project. Each dimension shall be reviewed at the time of detailed design.

1) Quay side gantry crane

Prior to design of principal particulars of quay side gantry crane, the following dimensions were assumed as an objective container ship that will berth at the proposed open-sea berths.

Maximum size	:	3,550 TEU (Panamax)
Breadth (Mold)	:	32.3 meters
Depth (Mold)	:	21.5 meters
On-deck containers	:	Overall width 31.8 m × Height 14.5 meters
		(13 rows and 5 tiers of 9'6" container)
Draft	:	11.5 meters (Full) / 6.0 meters (Light)

The quay side gantry crane will have the following principal particulars.

Type of crane	:	Rope trolley, hinged boom type gantry crane
Rated load under the spreader	:	40 MT
		(35.5 MT for Alternative-1)
Rate load under the lifting beam	:	50 MT
Span of the crane track	:	20 meters
		(16 meters for Alternatives-1 and 2)
Out reach	:	Approx. 41 meters
		(36 meters for Alternative-1)
Back reach	:	Approx. 12 meters
Lift Above the seaside rail	:	Approx. 32 meters above the top of seaside rail
		(26 meters above the rail for Alternative-1)
Below the seaside rail	:	Approx. 17 meters below the top of seaside rail
		(14 meters below the rail for Alternative-1)
Speed Hoist with rated load	:	Approx. 60 m/min
Trolley traverse	:	Approx. 180 m/min

	Gantry travel	:	Approx. 45 m/min
	Boom hoist	:	Approx. 8 min/cycle
Spreader		:	20'- 40'- 45' Telescopic hydraulically operated
Power		:	6.6kV, 50Hz, 3 ϕ
Distance between face line of the wharf and seaside crane rail		:	4.0 meters
Grown height		:	+7.00 meters

A general arrangement of quay side gantry crane with the crane truck span of 20 meters is illustrated in Figure 12.2.11. The quay side gantry cranes that will be introduced into the new open-sea container berths are recommended to be provided with such advanced technologies as digital control system, crane monitoring system, anti-sway device, higher operational speed, etc., which will contribute to increase a cargo handling efficiency and be helpful for maintenance management.

2) Transfer crane

Type of crane		:	Rubber tired gantry crane
Function		:	6 rows of containers with a lane for chassis 1 over 4 high stacking of 9'6" high containers
Rated load under the spreader		:	40 MT
Span		:	23.47 meters
Lift		:	Approx. 15.8 m
Speed	Hoist with rated load	:	Approx. 20 m/min
	Trolley traverse	:	Approx. 70 m/min
	Gantry travel	:	Approx. 90 m/min
Spreader		:	20'- 40'- 45' Telescopic hydraulically operated
Power source		:	Diesel engine and generator

A general arrangement of transfer crane is illustrated in Figure 12.2.12. In order to enhance container handling services in the marshaling yard, the proposed transfer cranes will be provided with the advanced technologies such as digital control system, automatic steering system, etc.

3) Tractor and chassis

Yard tractor and trailer	:	Each 20', 40' and two-20' type
Road tractor and chassis	:	Each 20', 40' and two-20' type

4) Reach stacker

Type	:	4-high stacking, (Available for 9'6" high container)
Maximum lifting capacity	:	42 MT
Spreader	:	Telescopic hydraulically operated

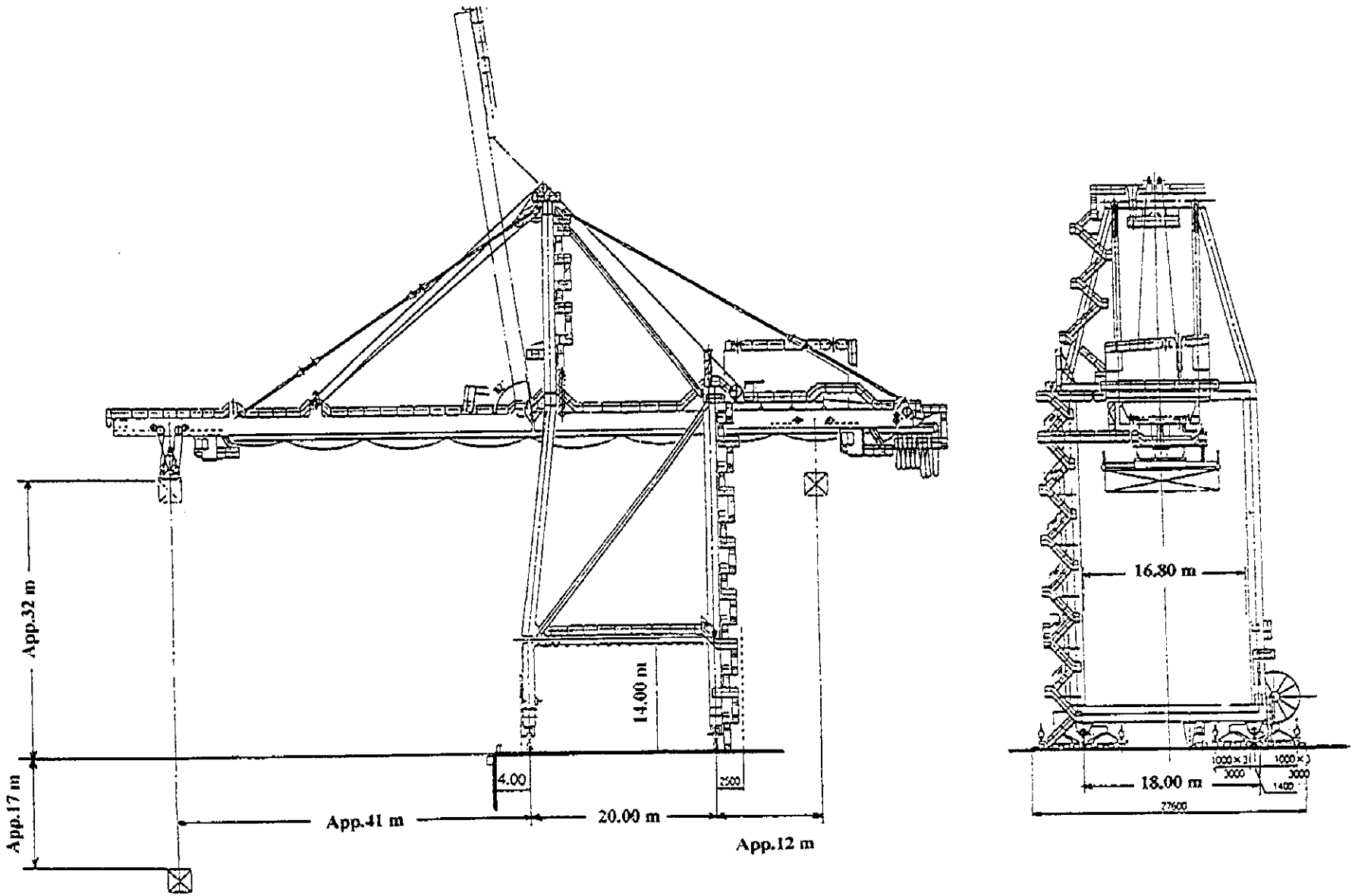


Figure 12.2.12 General Arrangement of Quayside Gantry Crane

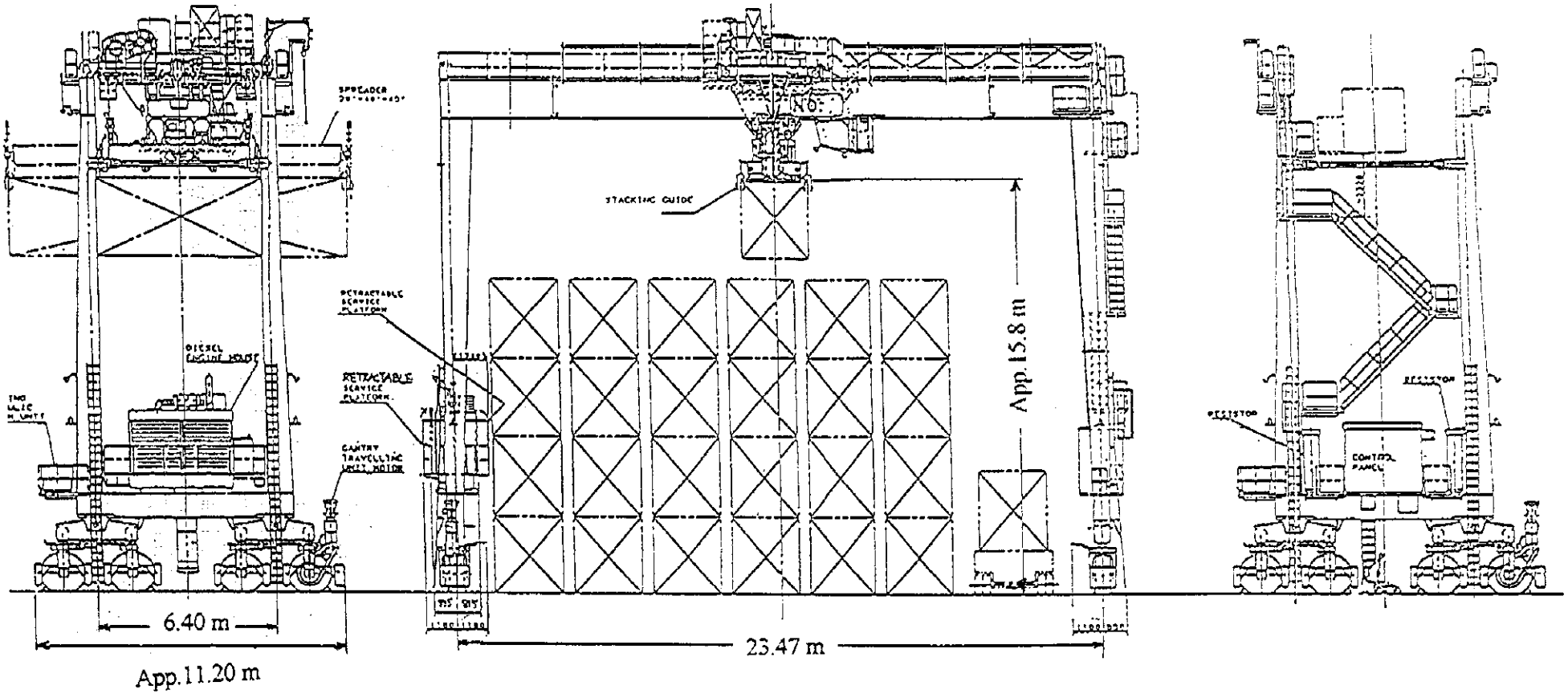


Figure 12.2.13 General Arrangement of Transfer Crane

12.3 The Master Plan for Modernizing Existing Conventional Cargo Handling Facilities

12.3.1 Modernizing Existing Conventional Cargo Handling Facilities

(1) Target Volume of Handling Break and Dry Bulk Cargo

Forecast demand of break and dry bulk cargo to be handled at MBP in 2017 is summarized in Table 12.3.1.

Table 12.3.1 Target Volumes of Break and Dry Bulk Cargo to be Handled at MBP in 2017

(unit: thousand tons)

Type of Cargo	1995/96	2007	2017
1.Break Bulk Cargo	---	5,044	6,061
1) Bagged Cargo	---	1,295	1,853
a) Pulses	---	460	751
b) Rice	---	449	570
c) Sugar	---	67	95
d) Oil Cakes	---	319	437
2) Iron and Steel	---	1,956	2,536
3) Miscellaneous	---	1,775	1,672
2. Dry Bulk Cargo	---	1,236	1,855
1) Phosphate Rock	---	551	856
2) Sulfur	---	566	880
3) Scrap	---	119	119
Grand Total	5,293	6,262	7,916

(2) Scenario for Modernizing the Existing Conventional Cargo Handling

Since off-shore jetty-type container berths are planned as the Master Plan for container handling, as mentioned in Section 12.2.2, which are connected with Victoria Dock Container Yard by access bridge, Victoria Dock will no longer be able to be used as conventional cargo berths. Prince's Dock should be mainly used for ship repair activities, idling etc., because berths in Prince's Dock are so shallow (berth depth: -6.4m) that Prince's Dock is inconvenient for larger conventional cargo vessels. However, the number of the berths in Indira Dock is not sufficient to handle the target volume of break and dry bulk cargo in 2017. Prince's Dock need to be partly

used for conventional cargo handling.

Most of break bulk and dry bulk cargo vessels are assigned to the berths inside/outside Indira Dock. "Iron and Steel" is assigned to ID-1 to ID-5 and ID-14, which retain adequate open yard for handling heavy cargo. "Bagged Cargo" is assigned to ID-6, ID-13A, ID-13B, ID-15, ID-16, ID-17, ID-18, ID-20 and ID-21, which retain sheds behind them. Since "Phosphate Rock" and "Sulfur" are unloaded directly to trucks along the berths, no shed is required to be located behind them.

Table 12.3.2 Conventional Cargo Vessel Assignment Plan

Berth Name	Berth Length (m)	Berth Depth (m)	Shed (sq. m)	Assigned Cargo Type	BOR (%)
ID-1	180	-9.81	---	Iron and Steel	46
ID-2	158	-9.81	---	Iron and Steel	46
ID-3	158	-9.81	---	Iron and Steel	46
ID-4	158	-9.81	---	Iron and Steel	46
ID-5	158	-9.81	---	Iron and Steel	46
ID-6	158	-9.81	9,144	Bagged Cargo	61
ID-7	152	-9.81	---	Phosphate/Sulfur	44
ID-8	152	-9.81	---	Phosphate/Sulfur	44
ID-9	152	-9.81	---	Phosphate/Sulfur	44
ID-J/E	130	-9.81	---	Phosphate/Sulfur	44
ID-10	152	-9.81	---	Phosphate/Sulfur	44
ID-11	152	-9.81	4,876	Phosphate/Sulfur	44
ID-12	152	-9.81	4,876	Phosphate/Sulfur	44
ID-12A	180	-9.81	7,665	Phosphate/Sulfur	44
ID-12B	180	-9.81	3,109	Scrap	19
ID-13	158	-9.81	8,361	Edible Oil	42
ID-13A	180	-9.81	9,290	Bagged Cargo	61
ID-13B	180	-9.81	8,361	Bagged Cargo	61
ID-14	158	-9.81	---	Iron and Steel	46
ID-15	158	-9.81	8,990	Bagged Cargo	61
ID-16	158	-9.81	6,196	Bagged Cargo	61
ID-17	158	-9.81	5,400	Bagged Cargo	61
ID-18	183	-7.77	2,542	Bagged Cargo / Miscellaneous	65
ID-20	168	-7.77	5,946	Bagged Cargo / Miscellaneous	65
ID-21	168	-6.56	5,946	Bagged Cargo / Miscellaneous	65
BPS	244	-9.86	---	Container	58
BPX	232	-10.46	6,117	Cruise Passenger	---
Container-1	300	-13.0	---	Container	58
Container-2	300	-13.0	---	Container	58
Container-3	300	-13.0	---	Container	58
PD-A	138	-6.39	---	Miscellaneous	33
PD-B	138	-6.39	---	Miscellaneous	33
PD-C	140	-6.39	7,804	Miscellaneous	33
PD-D	140	-6.39	7,804	Miscellaneous	33
PD-N/O	212	-6.39	6,410	Miscellaneous	33
PD-P/Q	212	-6.39	6,410	Miscellaneous	33

Remarks) BOR means Berth Occupancy Ratio

"Phosphate Rock" and "Sulfur" are assigned to ID-7 to ID-10, which do not have sheds behind them, and ID-11, ID-12 and ID-12A, which retain relatively small sheds behind them. "Scrap" is assigned to ID-12B which retains relatively a large open yard.

Small portion of conventional cargo is assigned to some berths in Prince's Dock. "Miscellaneous Cargo" is assigned to ID 18, ID-20 and ID-21 as a mixed use of those berths with "Bagged Cargo". "Miscellaneous Cargo" is also assigned to PD-A, PD-B, PD-C, PD-D, PD-N/O and PD-P/Q whose water depth is only -6.39m and enables only small vessels to use them.

Container vessels are separately assigned to the proposed three container berths off the Harbour Wall and BPS and never enter any docks.

Berth occupancy ratios of berths of Indira Dock and Prince's Dock are estimated by computer simulation and presented in Table 12.3.2.

(3) Required Dimensions of the Sheds and Open Yards

The required dimensions of the sheds and open yards at peak condition are estimated by using computer simulation based on the future cargo handling conditions shown in Table 12.3.3.

Table 12.3.3 Summary of Conventional Cargo Handling Conditions in 2017

Package Style	Annual Cargo Volume	Unit Load per Vessel	Annual Vessel Calls	Net Productivity	No. of Gangs	Operational Factor	Dwelling Time in Storage Space
	(thousand tons/yr.)	(ton/vessel)	(vessels/yr.)	(ton/gang/hr)	(gangs)		(days)
1. Bagged Cargo	1,853	---	174	---	---	---	---
1) Pulses	751	11,324	66	34.7	3	0.8	3
2) Rice	570	10,357	55	31.9	3	0.8	3
3) Sugar	95	13,124	7	34.7	3	0.8	3
4) Oil Cakes	437	9,421	46	31.9	3	0.8	3
2. Iron and Steel	2,536	12,795	198	50.0	3	0.8	3
3. Miscellaneous	1,672	3,900	429	28.0	2	0.8	3
4. Dry Bulk Cargo	1,855	---	168	---	---	---	---
1) Phosphate	856	17,192	50	43.2	3	0.8	0
2) Sulfur	880	8,000	110	43.2	3	0.8	0
3) Scrap	119	14,868	8	50.0	3	0.8	3
Total	7,916	---	969	---	---	---	---

The required dimensions of the sheds and open yards are summarized in Table 12.3.4, assuming the future productivity of each cargo at internationally reasonable level.

Table 12.3.4 Summary of Required Dimensions of the Shed and Open Yard at MBP in 2017

Type of Storage Space	Type of Cargoes	Required Area of Shed / Open Yard
1. Open Yard	Iron and Steel, Miscellaneous Cargo and Scrap	95,000 (sq. m)
2. Shed	Bagged Cargo, Miscellaneous Cargo, Paper Products	125,000*(sq. m)

Remarks) * One fourth of the cargo volume is assumed to be handled by direct loading/unloading.

12.3.2 Usage Plan for the Existing Conventional Cargo Handling Facilities

(1) Conventional Cargo Handling Facilities

Each berths are planned to be used by specific type vessels taking account of berth characteristics such as with/without shed, warehouse and open yard behind them. The detailed conventional cargo vessel assignment plan is shown in Table 12.3.2 and Figure 12.3.1.

(2) Storage Facilities

The existing storage facilities such as sheds, warehouses and open yards on MBPT's premises of Indira, Victoria and Prince's Docks are summarized in Tables 5.1.3 (1) and 5.1.3 (2) in Chapter 5. However, all the sheds, warehouses and open yards in and adjacent to Victoria Dock are planned to be demolished so as to develop the container marshaling yard. Warehouses located along the Link Road: PD-3, PD-4, PD-5, PD-6 and PD-7 are also planned to be demolished so as to develop the dedicated road for container traffic.

The remaining existing storage facilities such as sheds and warehouse which can serve the future bagged cargo, miscellaneous cargo and so on is estimated as 161,212 sq. m. No additional sheds is needed for the Mater Plan compared with required dimension of shed and warehouse of 125,000 sq. m.

The existing open yard which can serve the future "Iron and Steel", "Miscellaneous Cargo" and "Scrap" is estimated 153,153 sq. m. Therefore, no additional open yard is also needed. for the

Indira Dock	Length (m)	Depth (m)	Shed (sq. m)	Assigned Cargo
1	180	-9.81	---	Iron and Steel
2	158	-9.81	---	Iron and Steel
3	158	-9.81	---	Iron and Steel
4	158	-9.81	---	Iron and Steel
5	158	-9.81	---	Iron and Steel
6	158	-9.81	9,144	Bagged Cargo
7	152	-9.81	---	Phosphate/Sulphur
8	152	-9.81	---	Phosphate/Sulphur
9	152	-9.81	---	Phosphate/Sulphur
J/E	130	-9.81	---	Phosphate/Sulphur
10	152	-9.81	---	Phosphate/Sulphur
11	152	-9.81	4,876	Phosphate/Sulphur
12	152	-9.81	4,876	Phosphate/Sulphur
12A	180	-9.81	7,665	Phosphate/Sulphur
12B	180	-9.81	3,109	Scrap
13	158	-9.81	8,361	Edible Oil
13A	180	-9.81	9,290	Bagged Cargo
13B	180	-9.81	8,361	Bagged Cargo
14	158	-9.81	---	Iron and Steel
15	158	-9.81	8,990	Bagged Cargo
16	158	-9.81	6,196	Bagged Cargo
17	158	-9.81	5,400	Bagged Cargo
18	183	-7.77	2,542	Bagged Cargo/Miscellaneous
20	168	-7.77	5,946	Bagged Cargo/Miscellaneous
21	168	-6.71	5,946	Bagged Cargo/Miscellaneous
BPS	244	-9.86	---	Container
BPX	232	-10.46	6,117	Passenger
Proposed Berth-1	300	-13.5	---	Container
Proposed Berth-2	300	-13.5	---	Container
Proposed Berth-3	300	-13.5	---	Container
Prince's Dock				
PD-A	138	-6.39	---	Miscellaneous
PD-B	138	-6.39	---	Miscellaneous
PD-C	140	-6.39	7,804	Miscellaneous
PD-D	140	-6.39	7,804	Miscellaneous
PD-N/O	212	-6.39	6,410	Miscellaneous
PD-P/Q	212	-6.39	6,410	Miscellaneous

Figure 12.3.1 Conventional Cargo Vessel Assignment Plan

Master Plan compared with required dimensions of 95,000 sq. m.

Table 12.3.5 Usage Plan of Storage Facilities of Indira and Prince's Docks

Berth No.	Covered Area		Open Area	Berth No.	Covered Area		Open Area
	Shed (sq. m)	Warehouse (sq. m)	Yard (sq. m)		Shed (sq. m)	Warehouse (sq. m)	Yard (sq. m)
Indira Dock				Prince's Dock			
ID-1	---	17,983	9,000	PD-A	---	---	1,881
ID-2	---	---	12,640	PD-B	8,919	4,459	1,881
ID-3	---	---	21,330	PD-C	7,804	---	323
ID-4	---	---	21,330	PD-D	7,804	3,902	298
ID-5	---	---	8,800	PD-E	2,397	---	---
ID-6	9,144	---	3,340	PD-G	2,434	---	91
ID-7	---	7,376	6,240	PD-N/O	6,410	---	908
ID-8	---	---	6,240	PD-P/Q	6,410	---	908
ID-9	---	---	5,600	PD-H	---	---	---
ID-J/E	---	---	2,240	PD-K/L/M	---	---	2,100
ID-10	---	---	---	Sub Total	42,178	8,361	8,390
ID-11	4,876	---	2,690				
ID-12	4,876	---	650				
ID-12A	7,665	---	590				
ID-12B	3,109	---	19,500				
ID-13	8,361	---	---				
ID-13A	9,290	---	15,200				
ID-13B	---	---	2,443				
ID-14	---	---	1,460				
ID-15	8,990	---	---				
ID-16	6,196	---	1,530				
ID-17	5,400	---	1,250				
ID-18	2,542	---	690				
ID-20	5,946	---	440				
ID-21	5,946	2,973	1,560				
Sub Total	82,341	28,332	144,763	Grand Total	124,519	36,693	153,153

(3) Waiting Space for Conventional Cargo Trucks

Since there is uncertainty of ship arrivals especially for break bulk cargo and dry bulk cargo at MBP, conventional cargo trucks need to wait some time for ship arrival which carries the cargo to be unloaded. Many conventional cargo trucks are currently seen parking along both sides of P D' Mello Road, which may accelerate traffic congestion on the road.

Gamadia Road Area of 45,000 sq. m will probably be evicted and be able to be used for port-related activities. Since there are some buildings which need to be demolished within Gamadia Road Area, however, shcedule of the eviction is still uncertain. Gamadia Road Area should be used as a parking and/or waiting space for conventional cargo trucks so as to utilize partly evicted area step by step. This will also relieve traffic congestion to a certain extent along P D'Mello Road due to unauthorized parking on both sides of the road.

12.3.3 Conventional Cargo Handling System

(1) Preparation Work Prior to Ship Arrival

The discharging cargo handling plan will be made by checking the ships stowage plan carefully according to cargo volume, kind of packing styles, the number of packages and storage hatches. On the other hand, the loading cargo handling plan will be made by checking the cargo forecast and the available berth for ships at a calling port. This information is supplied by the shipping company or it's agent.

The supervisor can then calculate the required cargo handling hours, the number of gangs, cargo handling tools and equipment after which the ship departure time can be estimated. MBP is not presently able to implement its own cargo handling stowage plan rapidly. It is carefully examined that the past relationship between shipping company or agents and the stevedores. The study team recommends the following points.

1) MBPT's undertaking to draw up a cargo handling stowage plan by themselves. It will be appropriate for MBPT to undertake this function by means of sufficient negotiations with organizations concerned and by the training of planners.
2) To obtain necessary cargo working document from shipping company or agents and consignees with enough time prior to a ship arrival. Required documents are the cargo stowage plan, cargo manifest, special cargo list, dimension list of heavy bulky cargo, hazardous cargo list and the export cargo booking summary list.
3) To secure proper assignment of stevedore gangs according to MBPT's cargo handling plan and to separate gang system based on the commodity and each working shift.
4) To establish a fixed base gang member system and give them cargo handling and working responsibility as a gang unit.

(2) Conventional Cargo Handling Tools

To handle conventional cargo efficiently and avoid a risk of cargo damages during loading and discharging, appropriate tool and sling are required to prepared for each cargo operation.

1) Light stuffed packages styled cargo operation

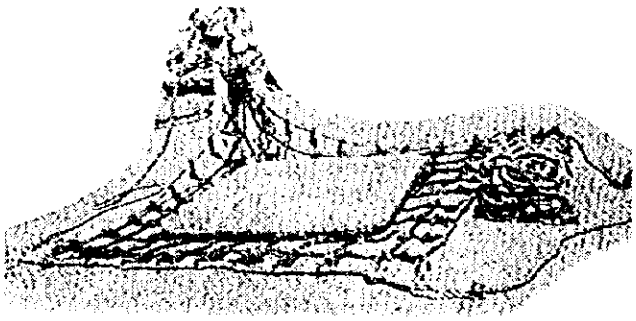
a) Paper carton box (general cargo)

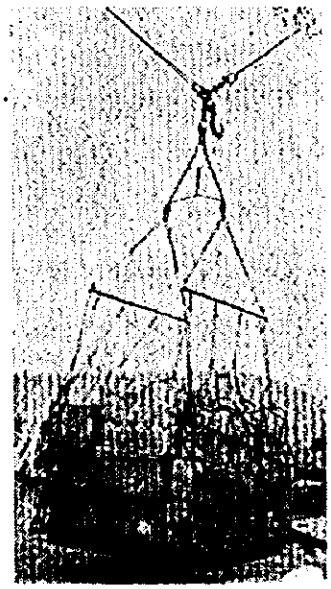
b) Light wooden box(plywood box)

c) Wooden crate cargo

d) Hard paper enveloped cargo

Above kinds of cargo should be handled by side-net pallet board.





Steel Bar for Pallet board with Protect Net

2) Hard package styled cargo handling

a) Hard wooden box cargo

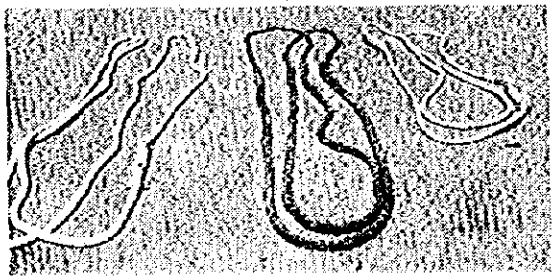
b) Steel sheet enveloped styled cargo and steel drums cargo

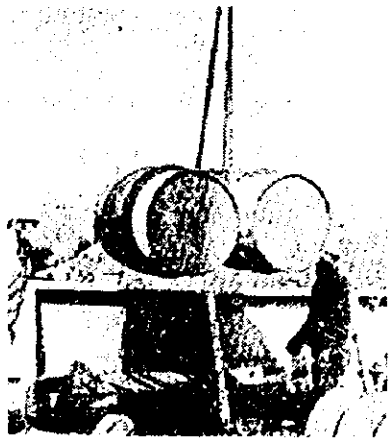
c) Roll paper (News paper print)

d) Fiber drums cargo

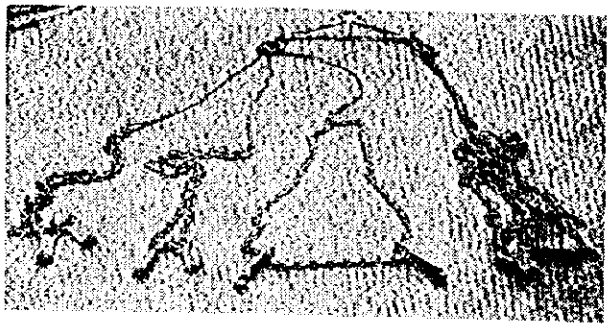
e) Metal ingot with bundled cargo

Above kind of cargo should be handled by special wire sling, chain sling with hook and special rope sling.

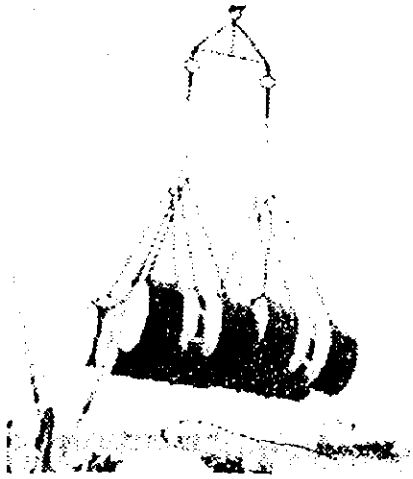


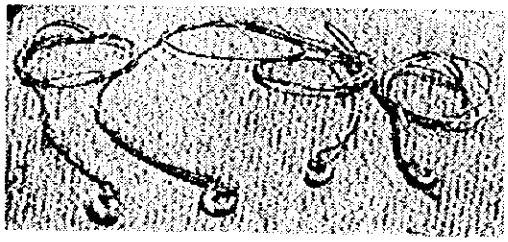


Special Rope Sling (Gunny Bag, Roll Paper, Fiber Drum)



Chain Sling for Steel Drum





Wire Sling with Small Hook

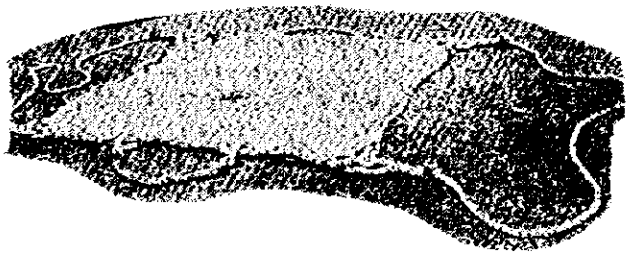
3) Bag styled cargo handling

a) Paper bagged cargo

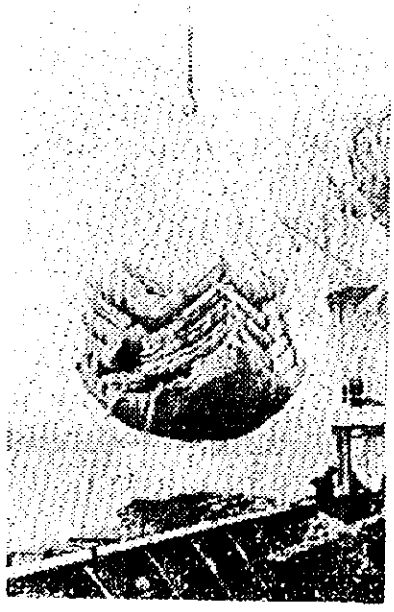
b) Gunny Bagged cargo

c) Polyvinyl bagged cargo

Above kind of cargo should be handled by canvas rope-nets sling.



Net Sling with Canvas



4) Steel products cargo handling

a) Steel sheets and plate

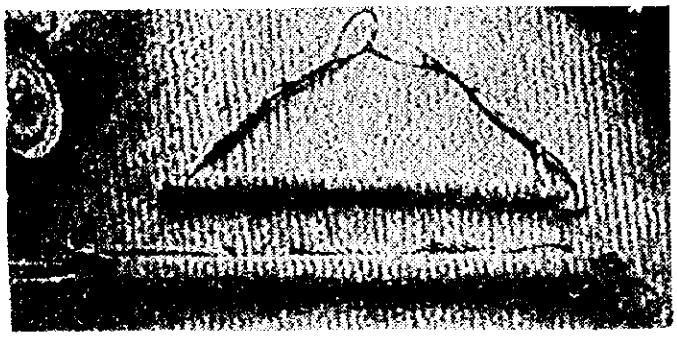
b) Steel round bar

c) Steel angle

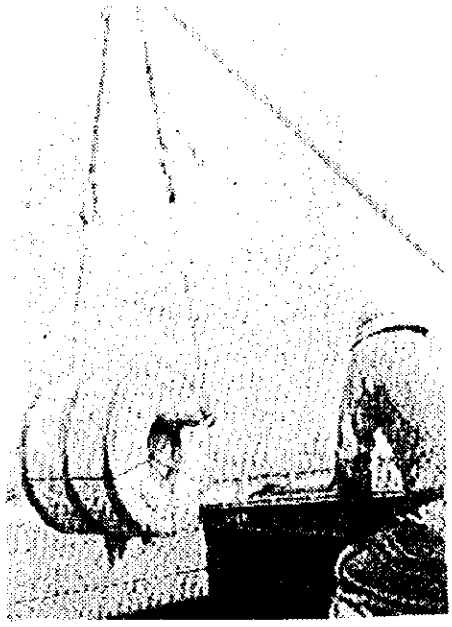
d) Steel coil

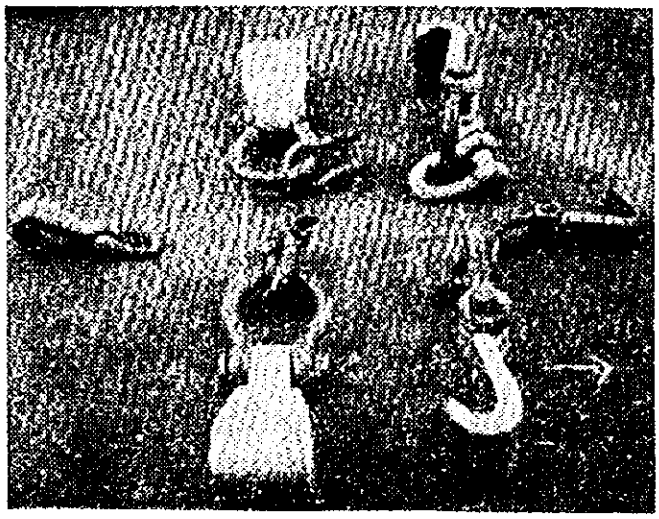
e) Steel Pipe

Above king of cargo should be handled by special hook wire and by eye plate wire sling.

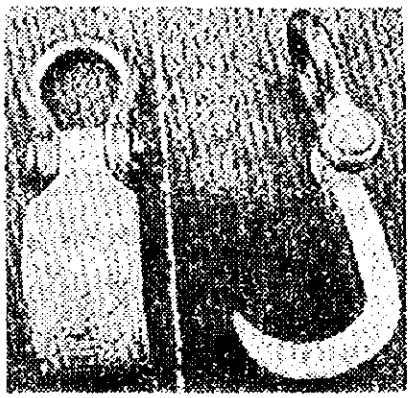


Steel Bar for Steel Coil

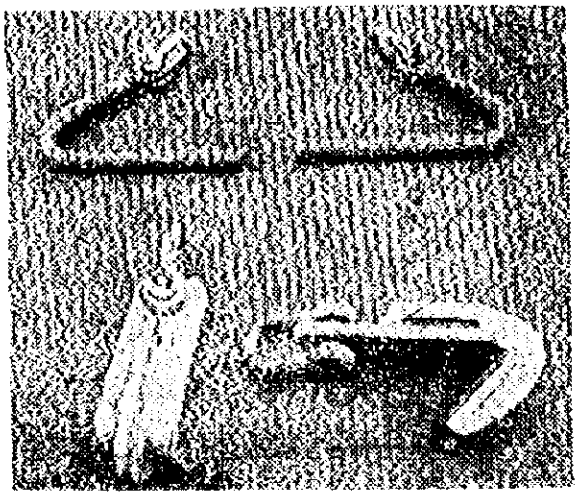


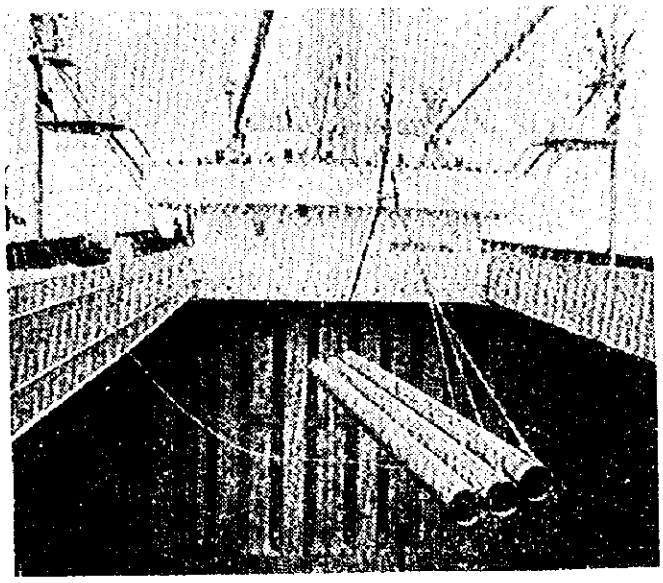


Steel Plate Hook



Plank Steel Plate Hook





Steel Pipe Hook

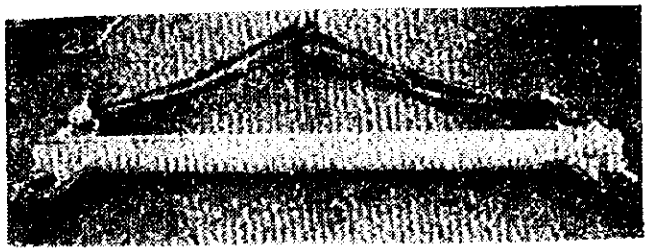
5) Bare styled cargo (Non packing cargo)

a) Timber with steel bundle

b) Bare stone

c) Machinery(Heavy bulky cargo)

Above king of cargo should be handled by special wire sling with steel spreader and corner pads.



Steel Bar for Heavy Cargo

12.3.4 Conventional Cargo Handling Equipment

(1)Cargo Handling Equipment for Dry Bulk Cargoes

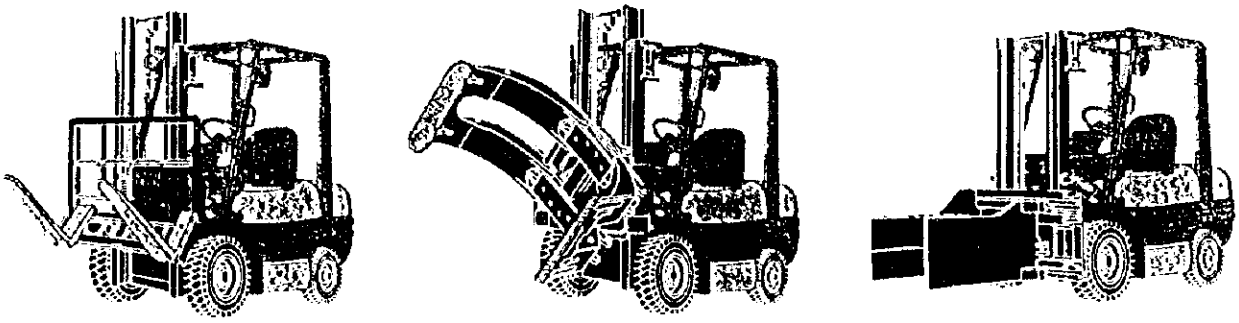
Dry bulk cargoes handled in the Port of Mumbai include Rock Phosphate, Sulphur and Fertilizer, more than 80% of which is handled in Indira Dock by using conventional ship's gears with the aid of grab bucket. The cargo handling productivity, defined as a ratio of the total cargo volume handled against the total berth time, is approximately 38 tons/hr for Rock Phosphate, 23 tons/hr for Sulphur and 22 tons/hr for Fertilizer, respectively.

As the annual volume of cargo handled in the port during 1995-95 was about 400,000 tons for Sulphur, 330,000 tons for Rock Phosphate and 78,000 tons for Fertilizer, respectively, it is possible to handle these volume of cargo by one unit of quay side unloader with 250-300 tons/hr unloading capacity at a berth occupancy of 0.7. Introduction of such a fully mechanized unloading system into the quay side operation accompanied with both belt conveyors and sheds exclusive use of dry bulk cargoes will increase the berth productivity. Judging, however, from the fact that the dry bulk cargoes are to be handled mainly in JNP, MBPT may be forced to increase the cargo handling productivity within the framework of the present handling system. It is recommended that the most effective and economical method for that purpose is to improve the shape and mechanism of receiving hopper, which is installed on the quay side apron and the bulk materials stacked in the hopper will be loaded on the trucks through the gate without scattering materials. The portable type receiving hopper of this kind is very popular.

(2)Cargo handling equipment for break bulk cargoes

In order to increase cargo handling productivity of break bulk cargoes, it is strongly recommended to provide an adequate number of forklift trucks with special attachments that are most suitable to the type and shape of cargoes to be handled. Such forklift attachments are helpful not only for improving the cargo handling productivity but for protecting the cargo from damages during handling. Figure 12.3.2 shows popular types of attachment and available type of cargoes.

It is also recommended to adopt a fully palletized system associated with the use of forklift trucks. Employment of the portable type conveyor system not only on the quay side but also in the shed operations is very helpful and efficient for handling bags and cartons.



Type A　　Type B　　Type C

Type A : Hinged fork for handling timber and steel pipes, also available for bulk cargo with an additional attachment of bucket.

Type B : Full turning roll clamp for handling rolled paper

Type C : Bale clamp for handling flexible or bulky cargo like bags, papers, etc.

Figure 12.3.2 Forklift Trucks with Special Attachments

12.3.5 Examination of Graving Dry Dock Location in terms of the Existing Dock Operation

There are two existing graving dry docks in MBP; Hughes Dry Dock in Indira Dock and Merewether Dry Dock in Prince's Dock. Since Victoria Dock is planned to be filled up and utilized as a container yard according to the Mater Plan for container handling, the remaining two docks, Indira and Prince's Docks will need to serve conventional cargo vessels excluding container vessels which will be served at the proposed off-shore jetty-type container berths. It is necessary to examine whether both of the remaining two docks can be operated by one-lock gate system to accommodate the calling vessel demand including repairing vessels in 2017.

(1) The Number of Cargo Vessels to Enter Indira and Prince's Docks

The number of cargo vessels to enter Indira and Prince's Docks to handle the future cargo demand in 2017 for the Master Plan for container handling (Alternative-6) is estimated and presented in Table 12.3.6.

Table 12.3.6 The Number of Cargo Vessels to Enter Indira and Prince's Docks in 2017

Vessel Type	Cargo Type	Indira Dock (vessels/year)	Prince's Dock (vessels/year)	Total (vessels/year)
Pulses	Bag	66	---	66
Rice	Bag	55	---	55
Sugar	Bag	7	---	7
Oil Cakes	Bag	46	---	46
Paper Products	Carton	81	---	81
Miscellaneous	---	150	198	348
Iron and Steel	Break	198	---	198
Phosphate Rock	Dry Bulk	50	---	50
Scrap	Dry Bulk	8	---	8
Sulfur	Dry Bulk	110	---	110
Edible Oil	Liquid Bulk	149	---	149
Grand Total		920	198	1,118

Demand for ship repair in the future will be determined by the ship repair business market in the world, in which private ship building and repairing companies will participate.

(2) Indira Dock

Total cargo vessel traffic entering Indira Dock in 1995-96 is 1,044 (=1,292-143-105) vessels (see Table 5.3.3). The total cargo vessel traffic to enter Indira Dock to handle the future cargo volume in 2017 is estimated 920 vessels showing a decrease from the present level owing to the construction of the open-sea jetties. Assuming that the productivity of lock is 2.0 hours/vessel, the total lock occupancy ratio is estimated as 42 % (=920 (vessels/year)*2 (in+out)*2.0 (hours/vessel) / 365days*24 hours).

Lock occupancy ratio of 42 % does not imply the excessive congestion at the lock to serve 920 cargo vessels per year in 2017 even if taking 38 repair ships' entrance in 1995-96 into consideration. Consequently, one-lock system of Indira Dock is expected to be sufficient to serve the future vessel traffic in 2017.

(3) Prince's Dock

Total cargo vessel traffic entering Prince's Dock in 1995-96 is 52 vessels (see Table 5.3.3). The total cargo vessel traffic to enter Prince's Dock to handle the future cargo volume in 2017 is estimated 198 vessels showing a considerable increase from the present level. Assuming that the productivity of lock is 2.0 hours/vessel, however, the total lock occupancy ratio is estimated as only 9% (=198 (vessels/year)*2 (in+out)*2.0 (hours/vessel) / 365days*24 hours).

Lock occupancy ratio of 9 % does not imply the excessive congestion at the lock to serve 198 cargo vessels per year in 2017 even if taking 34 repair ships' entrance in 1995-96 into consideration. Consequently, one-lock system of Prince's Dock is expected to be sufficient to serve the future vessel traffic in 2017.

(4) Potential Location of Dry Dock in case of filling up Prince's Dock

Alternative dock of Merewether Dry Dock would be required in case that Prince's Dock is to be filled up and utilized as container marshalling yard for handling up to two million TEUs with additional container berths beyond Master Plan. Floating-type dock is recommended and its potential location is considered as the vicinity of the Cross Island.

12.4 The Master Plan for Modernizing Marine Oil Terminal

12.4.1 Target Volume of Liquid Bulk Cargoes to be handled at MBP in 2017

Future demand of liquid bulk cargo is estimated in Chapter 9. Target volumes of each liquid bulk cargoes are summarized in Table 12.4.1. Remarkable increase in POL is revealed from 1995/96 to 2017, since POL consumption in the hinterland of MBP will increase whereas the existing refining capacity of crude oil is limited to 12 million tons per annum at Trombay.

Table 12.4.1 Target Volume of Liquid Bulk Cargo to be Handled at MBP in 2017

(Unit: thousand tons)

Kind of Cargoes		Import (2017)	Export (2017)	Grand Total (2017)	Total Volume (1995/96)
1. Crude Oil		8,891	10,000	18,891	14,548
2. POL		15,192	2,413	17,605	6,422
	1) White	10,893	2,200	13,093	4,972
	2) Black	4,299	213	4,512	1,450
3. Chemical		386	7	393	99
Total		24,469	12,420	36,889	21,069

Remarks) 1. Breakdown share of "White" and "Black" of POL in 2017 is assumed as same pattern as at present in 1995/96.

2. "White" consists of HSD (High Speed Diesel), SKO (Superior Kerosene Oil), Naphtha, MS (Motor Spirit), ATF (Aviation Turbine Fuel), Lube Oil (Lubricant Oil), and LPG (Liquefied Petroleum Gas).

3. "Black" consists of Bunker Oil, FO (Furnace Oil), LDO (Light Diesel Oil), and LSHS (Low Sulfur High Stock).

12.4.2 Present Liquid Bulk Cargo Handling System

Crude oil and POL products are handled at Marine Oil Terminal (MOT), Jawahar Dweep. The outline of the existing oil loading/unloading facilities of the terminal is described in Chapter V Clause 5.5 and a schematic diagram of the pipelines is given in Figure 5.5.1.

According to the "Individual Calling Vessels Records in 1995-96, MBPT," the number of ships called at the MOT berths totaled 439 tankers, which comprised 201 crude tankers and 238 product tankers. JD Berth No.1 accommodated 115 tankers, i.e. 53 crude tankers and 62 product tankers. Similarly, Berth No.2 accommodated 97 product tankers alone, Berth No.3 handled 20 crude tankers and 79 product tankers, and Berth No.4 handled 128 crude tankers only.

The tanker size was analyzed as follows.

Crude oil	JD Berth Nos. 1 to 3	JD Berth No. 4
Maximum tanker size	94,500 DWT	155,000 DWT
Average tanker size	60,000 DWT	86,000 DWT
POL Products		
Maximum tanker size	82,000 DWT	
Average tanker size	32,000 DWT	

The parcel size of tankers was also analyzed as follows.

Crude oil	JD Berth Nos. 1 to 3	JD Berth No. 4
Maximum parcel size	59,000 tons per ship	99,000 tons per ship
Average parcel size	46,000 tons per ship	59,000 tons per ships
POL Products		
Maximum parcel size	39,000 tons per ship	
Average parcel size	19,000 tons per ships	

It is known that the principal parameters that govern the oil terminal performance are parcel size of tankers, permissible turnaround time, rate of discharge and pumping capacity, and operational flexibility of the system.

The ships' turnaround time at a terminal is comprised of such components as pre-berthing detention, time for berthing/unberthing, actual pumping time, and time for peripheral activities. Usually, actual pumping time is considered to be within 24 hours for loading or unloading,

generally 10 to 20 hours for 50,000-100,000 DWT class tankers and time taken for peripheral activities upto 12 hours including berthing/unberthing.

The peripheral activities, which are the activities carried out prior to commencement of pumping and after completion of pumping/stripping, include the following components; berthing in, customs clearance and ship's survey, connection of hoses/loading arms, pipeline link to storage tanks and line clearance, flushing prior to loading/discharging in the case of some products or tankers with mixed products for the sake of avoiding contamination of oils, ballasting/fresh water/bunkering after completion of operations, disconnection of hoses/loading arms, time for waiting for high tide, and sailing out.

Operating time analysis was carried out with respect to the times spent by berthed tankers at the MOT berths. In this analysis, the time for peripheral activities was assumed to be a difference between the total berth time and the time worked, each of which was read from the operation record during 1995-96.

Table 12.4.2 shows the actual time worked together with the time for peripheral activities. As for crude tankers, the average time taken for peripheral activities is about 12 hours, though a maximum time sometimes exceeds 40 hours. In the case of product tankers, the average time taken for peripheral activities is about 21 hours and a maximum time exceeds 80 hours. For further convenience, the ratio of the time worked (Tw) to the total berth time (Tb), or Tw/Tb, was calculated as shown in Table 12.4.3.

Table 12.4.2 Operating Time Analysis of MOT Berths

Berth No.	Cargo Flow	Time worked (hour)				Time for peripheral activities (hour)			
		Crude Oil		POL Products		Crude Oil		POL Products	
		Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean
JD No.1	Import	38.0	22.8	151.0	50.1	27.0	12.3	65.0	19.5
	Export	37.0	15.0	84.0	53.3	41.0	14.2	34.0	20.8
JD No.2	Import	-	-	151.0	40.2	-	-	84.0	18.0
	Export	-	-	82.0	44.5	-	-	37.0	16.1
JD No.3	Import	-	-	143.0	56.3			74.0	23.0
	Export	21.0	14.8	97.0	53.8	22.0	11.6	78.0	27.6
JD No.4	Import	56.0	32.1	-	-	26.0	11.5	-	-
	Export	26.0	15.1	-	-	37.0	12.6	-	-

Note : Time for peripheral activities = Total berth time - Time worked

Table 12.4.3 Ratio of Tw/Tb

Berth No.	Crude oil		Products oil	
	Import	Export	Import	Export
JD No.1	0.65	0.51	0.72	0.72
JD No.2	--	--	0.69	0.73
JD No.3	--	0.56	0.71	0.66
JD No.4	0.74	0.55	--	--

The rate of discharge and pumping capacity depend on the maximum parcel size and the actual time available for pumping. Prior to, after, and during pumping operations, there are various kinds of activities, such as stopping cargo pumps for switch-over of tanks on-board and on-land, opening and closing cargo valves, flushing of lines, stripping, etc. Allowing for all these aspects, it is estimated that the effective time available for pumping could be on an average 85 % for crude tankers and 75 % for product tankers, respectively.

A review of a relationship between the crude tanker size (DWT) and the main cargo pump capacity (m^3/hr) per one unit was carried out and its result is given in Figure 12.4.1. The capacity of main cargo line increases in proportion to the tanker size, and usually 70,000 DWT class tankers have normally 3 cargo pumps each of 2,000 m^3/hr capacity and in the case of 100,000 DWT class tankers they are equipped with 3 or 4 cargo pumps each of 2,500 m^3/hr capacity. In the case of product tankers, a relationship between the size (DWT) and the capacity of main cargo pump (m^3/hr) per one unit is given in Figure 12.4.2. As they have usually 3 to 5 units of cargo pump, the total capacity of the cargo pump varies from a minimum of 2,000 m^3/hr to a maximum of 7,000 m^3/hr with the average at approximately 4,000 m^3/hr.

An analysis of the Individual Calling Vessels Records in 1995-96 revealed the present productivity of each MOT berth as indicated in Table 12.4.4.

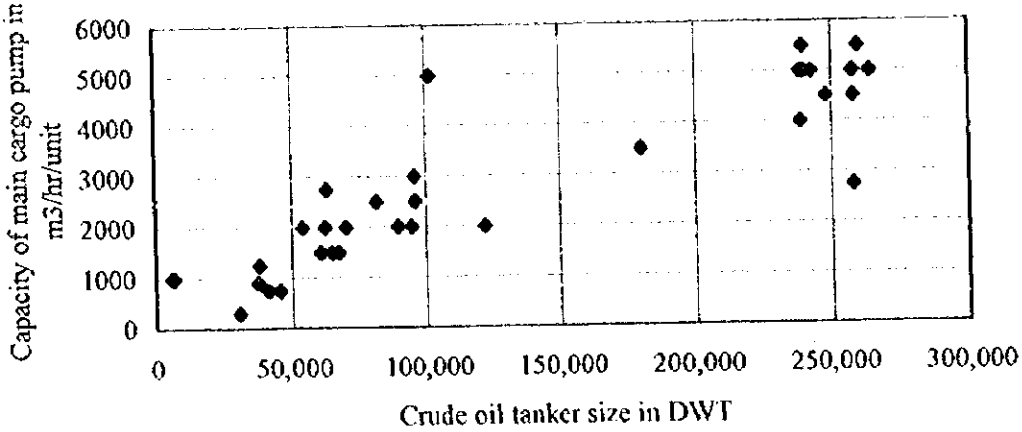


Figure 12.4.1 A Relationship Between Crude Tanker Size and Main Cargo Pump Capacity

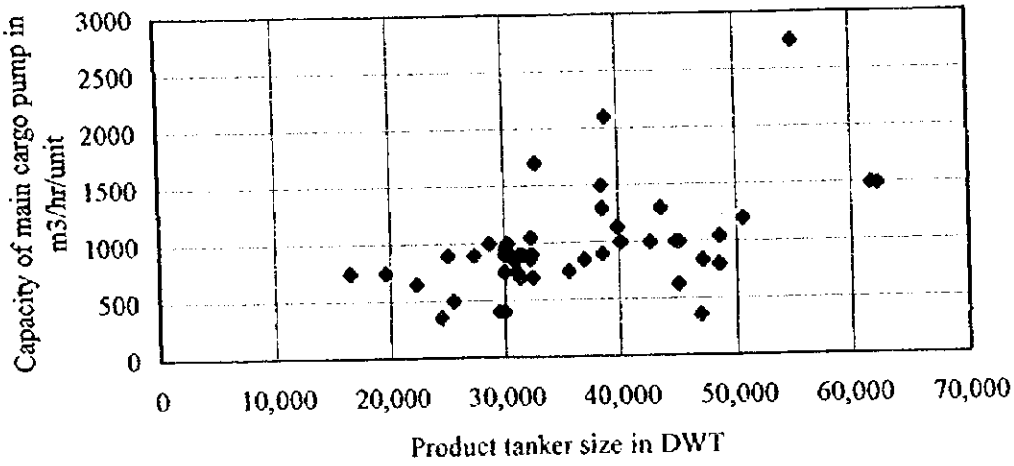


Figure 12.4.2 A Relationship Between Products Tanker Size and Main Cargo Pump Capacity

Table 12.4.4 Analysis of Present Productivity of MOT Berths

(Unit : ton/hr)

Berth No.	Cargo Flow	Berth Productivity (Gross)				Berth Productivity (Net)			
		Crude Oil		POL Products		Crude Oil		POL Products	
		Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean
JD No.1	Import	2,153	1,151	949	269	2,728	1,773	1,219	373
	Export	2,515	1,386	540	315	3,718	2,699	747	439
JD No.2	Import	-	-	849	245	-	-	2,028	355
	Export	-	-	528	319	-	-	785	434
JD No.3	Import	-	-	967	225	-	-	1,330	316
	Export	2,292	1,645	988	275	3,676	2,928	1,318	417
JD No.4	Import	1,992	1,294	-	-	4,483	1,760	-	-
	Export	3,364	1,832	-	-	4,643	3,360	-	-

Note : Berth Productivity (Gross) = Cargo volume handled / Total berth time
Berth Productivity (Net) = Cargo volume handled / Time worked

12.4.3 Plans for Replacement of Submarine Pipelines and Modernization of MOT Berths*

In order to increase the oil handling capacity of MOT, MBPT has studied the following plans.

(1)Replacement of Submarine Pipelines from MOT Jetties upto JD Manifold

MBPT intends to replace five submarine pipelines instead of the existing ones, as shown in Figure 12.4.3. The number of lines and line sizing to be replaced are as follows.

Crude : 1×42″
Black oils : 1×36″
White oils : 3×30″
Fresh water : 1×8″

Total length of lines between Pir Pau manifolds and Jawahar Dweep is approximately 5.1km, which consists of submarine pipelines section of 3.35km and on-land pipelines section of 1.75km. The site to be laid is chosen in the available interspace between the band of 7 existing lines and the 36″ ONGC crude line. They will be buried with a clear cover of 1.5m.

Re-designing of the system has been done with the governing parameters as indicated hereunder.

		Crude	Products
Maximum Parcel size	:	100,000 Te	40,000 Te
Permissible turn-around time	:	36 hrs	36 hrs
Time for pumping	:	24 hrs	24 hrs
Time for peripheral activities	:	12 hrs	12 hrs
Effective pumping time	:	20 hrs	18 hrs
Discharge rates	:	5,000 TPH	2,200 TPH
		Assumed duration of peak discharge as 85% of pumping time for crude and 75% for products.	

*Replacement of Submarine Pipelines and Modernization of MOT Berths, Detailed Project Report Part I , BPT, June 1993, and Part II , BPT, Oct.1994.

Minimum operating pressure : 7kg/cm^{2}G for tanker on-board pumps
5kg/cm^{2}G at the Pir Pau manifold

MBPT intends to implement this replacement project during the years from 1998 to 1999.

(2)Modernization of MOT Berths

Replacement of ship-shore transfer from flexible hoses to marine arms, upgrading the fire-fighting facilities, and construction of new trestle with new pipelines have been under consideration.

As for marine loading/unloading arms and fire-fighting facilities, their design concept will briefly be described in Clause 12.4.5 of this Chapter.

In addition to the following five pipelines, which are of same dimensions as the submarine pipelines to be replaced, MBPT has been reviewing the arrangement and dimensions of other pipelines to be installed on a new proposed trestle.

Crude oil : 1×42″
Black oil : 1×36″
White oil : 3×30″

Design basis for new trestle is reported as follows.

Wave force : 3.0m
Current velocity : 3 knots, corresponding to a load of 120kg/m^2 pressure of water.
Wind load : 150km/hr, corresponding to a wind load of 130kg/m^2.
Seismic load : 6% (with importance factor of 1.5) on dead load, and
50% of live load.
Carriageway : 1t/m^2
Operating pressure of pipeline : 10kg/cm^{2}G (Design pressure=19kg/cm^{2}G)
Operating temperature : 20-40℃ (Design temperature=50℃)

Figure 12.4.4 shows a schematic diagram of oil pipelines on the new trestle for a case of post replacement of pipelines. According to MBPT, they wish to complete this project by the year of 2003.

(3)Modernization of MOT Jetties

Extension of MOT jetties and construction of mooring dolphins have been studied by

MBPT in order to accommodate much larger tankers of 70,000DT (LOA upto 229m) at Jetties 1 and 3, and 48,000DT (LOA upto 183m) at Jetty 2. This study, however, is only for future program and not authorized.

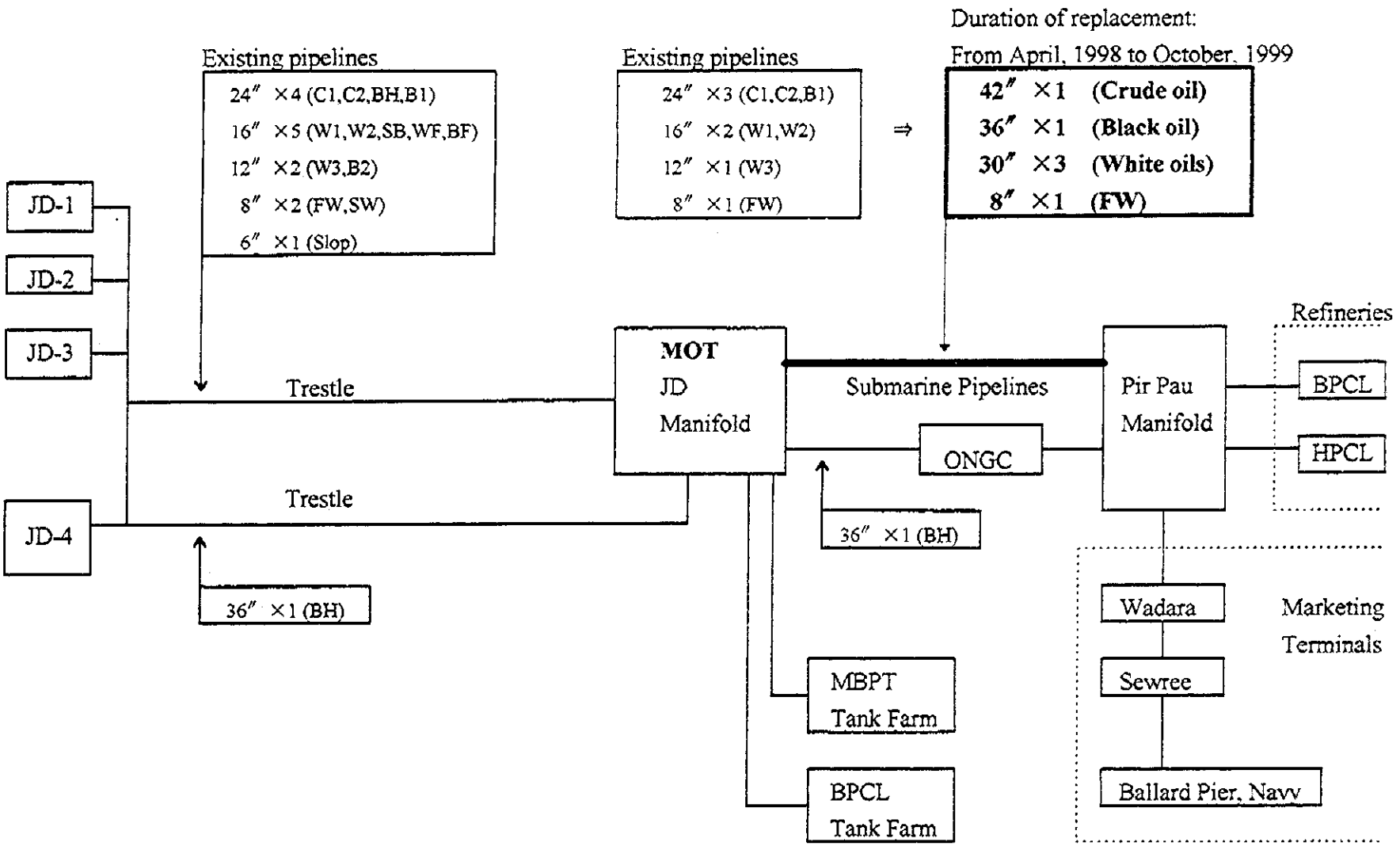


Figure 12.4.3 Replacement of Submarine Pipelines, Projected by MBPT

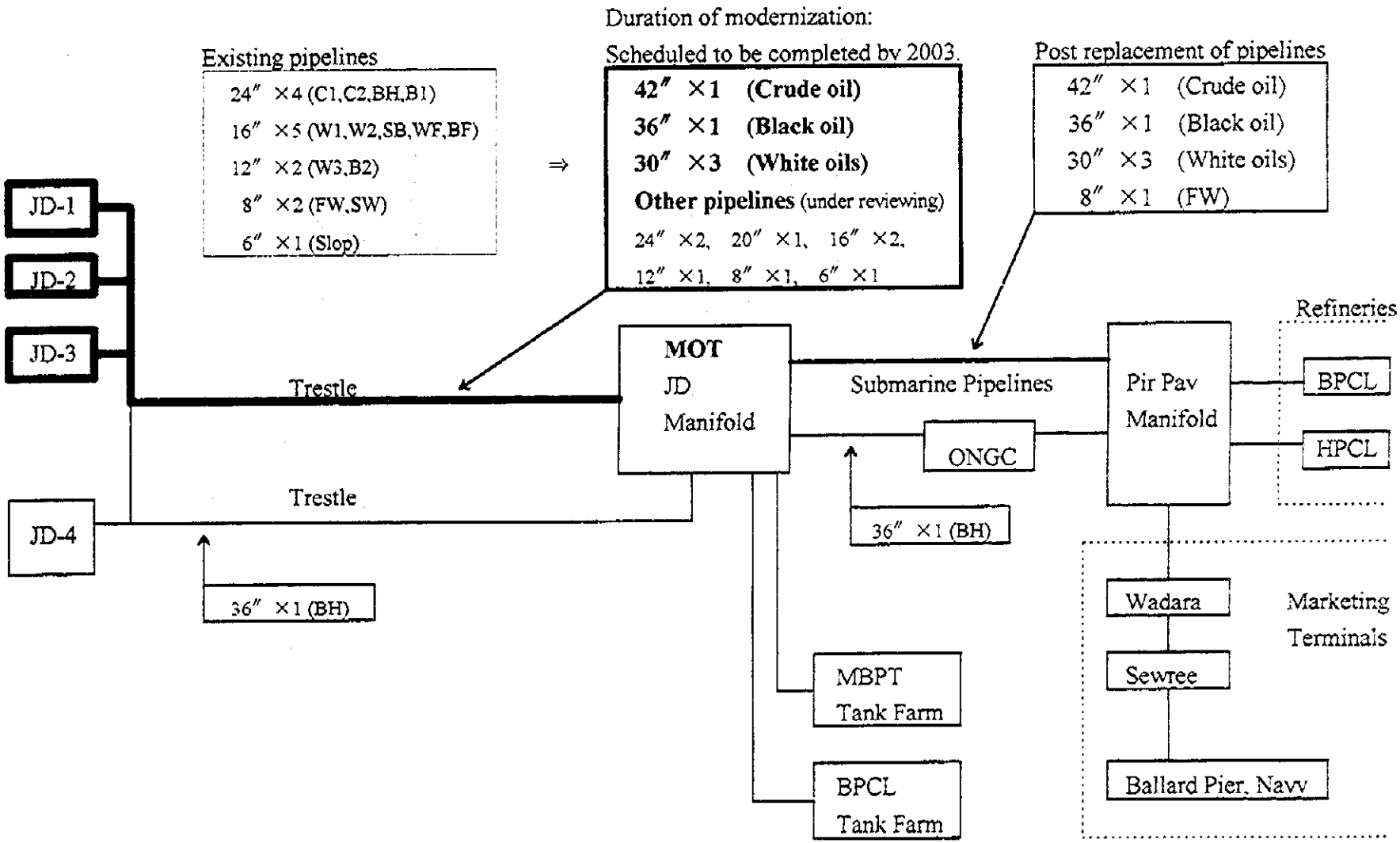


Figure 12.4.4 Modernization of MOT Berths and Trestle, Future Plan by MBPT

12.4.4 Examination of MOT Capacity in 2017 with Replaced Pipelines

Total MOT works out with JD Nos. 1 to 3 with replaced pipelines, JD-No.4 and New Pir Pau. The number of pipelines linking JD manifold and Pir Pau manifold should be adequate to serve all the possible usage combination of three berths, JD Nos. 1 to 3 by crude oil tankers, POL (black oil) tankers and POL (white oil) tankers. Theoretically required number of the pipelines is nine; three for crude oil, three for POL (black oil) and three for POL (white oil) so as to accommodate three same type tankers simultaneously. However, MBPT examined the minimum possible number of pipelines with acceptable inconvenience within the limited budget and resulted in five pipelines; one for crude oil, one for POL (black oil) and three for POL (white oil) (see Figures 12.4.3 and 12.4.4).

Annual numbers of crude oil tankers, POL tankers and chemical tankers are estimated as 310, 530 and 39 respectively. The computer simulation is used to estimate ship-waiting time and berth occupancy ratio when handling the target volume of liquid bulk cargo on the conditions shown in Table 12.4.5. Additionally, JD-1 and 3 are assumed to be used by both crude oil tankers and POL tankers, JD-2 is assumed to be used by POL tankers only, and JD-4 is assumed to be used by larger crude oil tankers only.

Table 12.4.5 Summary of the Liquid Bulk Cargo Handling Productivity

	Crude Oil		POL		Chemical
	JD-4	JD-1,-2,-3	JD-1,-2,-3	New Pir Pau	New Pir Pau
1. Target Volume in 2017 (thousand tons/yr.)	18,891		17,605 (white:13,093, black:4,512)		393
	12,940	5,951			
2. Forecast Number of Vessel Calls in 2017 (vessels/yr.)	200	110	530		39
	Tankers are assumed to arrive based on Poisson's distribution.				
3. Average Loaded Volume per Vessel (tons/vessel)	65,000	54,000	33,000	33,000	10,000
4. Nominal Productivity (tons/hr./vessel)	5,000	5,000	2,000	2,000	800
5. Effective Factor	0.85	0.85	0.75	0.75	0.75
6. Berthing/un-berthing Time (hrs./vessel)	12	12	12	12	12
7. Gross Productivity (tons/hr./vessel)	2,186	2,186	971	971	349

Remarks) (1) One crude oil tanker can be handled simultaneously at JD-1,-2 and -3. (2) One POL (black) tanker can be handled simultaneously at JD-1,-2 and -3. (3) Three POL (white) tankers can be handled simultaneously at JD-1,-2 and -3.

Ship-waiting time for crude oil tankers, POL tankers and Chemical are estimated as 55.0 hours/vessel, 9.0 hours/vessel and 7.2 hours/vessel respectively. Since JD-4 is only a deep berth which can accommodate 120,000 DWT-class tankers and there is no alternate berth for larger crude oil tankers, this results in longer ship-waiting time of 55.0 hours/vessel for larger crude oil tankers.

Average berth occupancy ratio for JD-1, -2 and -3 is estimated as 65.0%. Berth occupancy ratios for JD-4 and New Pir Pau are 67.5% and 51.0% respectively.

Both ship-waiting time and berth occupancy ratio estimated by computer simulation remain within a reasonable range. Therefore, no additional change is required for Marine Oil Terminal as a long-term basis.

12.4.5 Liquid Bulk Cargo Handling Equipment

The major cargo handling equipment at an oil terminal is cargo hoses or marine loading arms. It is recommended to provide marine loading arms instead of rubber hoses for the purpose of saving time for connection/disconnection activities, and also relieving workers of a burden of handling heavy rubber hoses.

In the project of modernization of MOT berths, MBPT intends to provide the marine loading arms with the following specification.

Number in each jetty	:	3 units
Length of each arm	:	15m
Diameter of each arm	:	12″
Capacity of each arm	:	2,000m^3/hr While loading/unloading white oils, the pumping rate should not exceed 1,000m^3/hr in order to keep the velocity below 5m/s.
Type of service	:	Crude, Black, White oils
Operating Conditions	:	Pressure 10kg/cm^2G (Design 19kg/cm^2G) Temperature 20-40℃ (Design 50℃)
Wind loads	:	70km/hr during operation 150km/hr under stowed condition
Accessories	:	Emergency release coupler Limit switches to monitor movements within working area and shall give audio-visual signals at control panel.

The required fire-fighting facilities shall be designed in conformity with OISD Guidelines-156; "Fire Protection Facilities for Port Oil Terminals(1992)", OISD Standard-177; "Fire Protection Facilities for Petroleum Depots and Terminals", etc.

It is also recommended to provide an oil skimmer boat, oil fence extension boat, and fire-fighting boat from the safety and environmental standpoints.

12.5 The Master Plan for Port Traffic Facilities

12.5.1 Present Port-related Cargo Traffic in and around MBP

The daily traffic volume of port-related cargo vehicles on week day (Monday) at five points in and around MBP was counted on both 29th of September and 13th of October, 1997. Five monitoring points were selected so as to grasp port-related cargo traffic by vehicle type such as conventional cargo trucks, container trailers and POL lorries. Target traffic for each monitoring points are summarized in Table 12.5.1 (see Section 23.5 in detail).

Table 12.5.1 Traffic Monitoring Points in and around MBP

Monitoring Point	Target Traffic for Monitoring
1. P D'Mello Road	Conventional cargo trucks in/out Dock Area
2. Link Road	Container trailers between off-dock CFSs and Dock Area
3. Cotton Green	Conventional cargo trucks in/out Dock Area and in/out off-dock CFSs
4. Wadala Fly-over Point	Container trailers between off-dock CFSs and hinterland, Conventional cargo trucks in/out off-dock CFSs, and POL tank lorries
5. Everard Nagar Junction (Chembur Point)	All the port-related traffic through Eastern Express Highway, and Other cargo trucks

Monitoring point locations and present flow pattern are presented in Figure 12.5.1. Measured average daily traffic volume of vehicles at each monitoring points are summarized in Table 12.5.2.

Table 12.5.2 Average Daily Traffic (Two-Directional) of Port-related Cargo by Vehicle Type

(unit: vehicles/day)

Monitoring Point	**Trucks + Lorries**	**Containers**	Tempos	Cars + Taxi	Auto Rikshaw	Two-Wheelers	Buses	Grand Total
1. P D'Mello Road	**11,616**	**2,157**	4,703	10,020	594	5,478	907	35,475
2. Link Road	**2,064**	**4,898**	49	5,272	0	3,865	4	16,152
3. Cotton Green	**11,461**	**966**	3,277	3,277	155	4,390	52	23,578
4. Wadala Flyover*	**5,901***	**2,131***	1,143*	10,123*	235*	4,241*	1,344*	25,118*
5. Everard Nagar Jnc. (Cembur Point)	**22,697**	**3,308**	8,570	26,424	10,833	9,763	12,270	93,865

Remarks) * represent data on 29th of September, 1997, because data on 13th of October seems outlier.

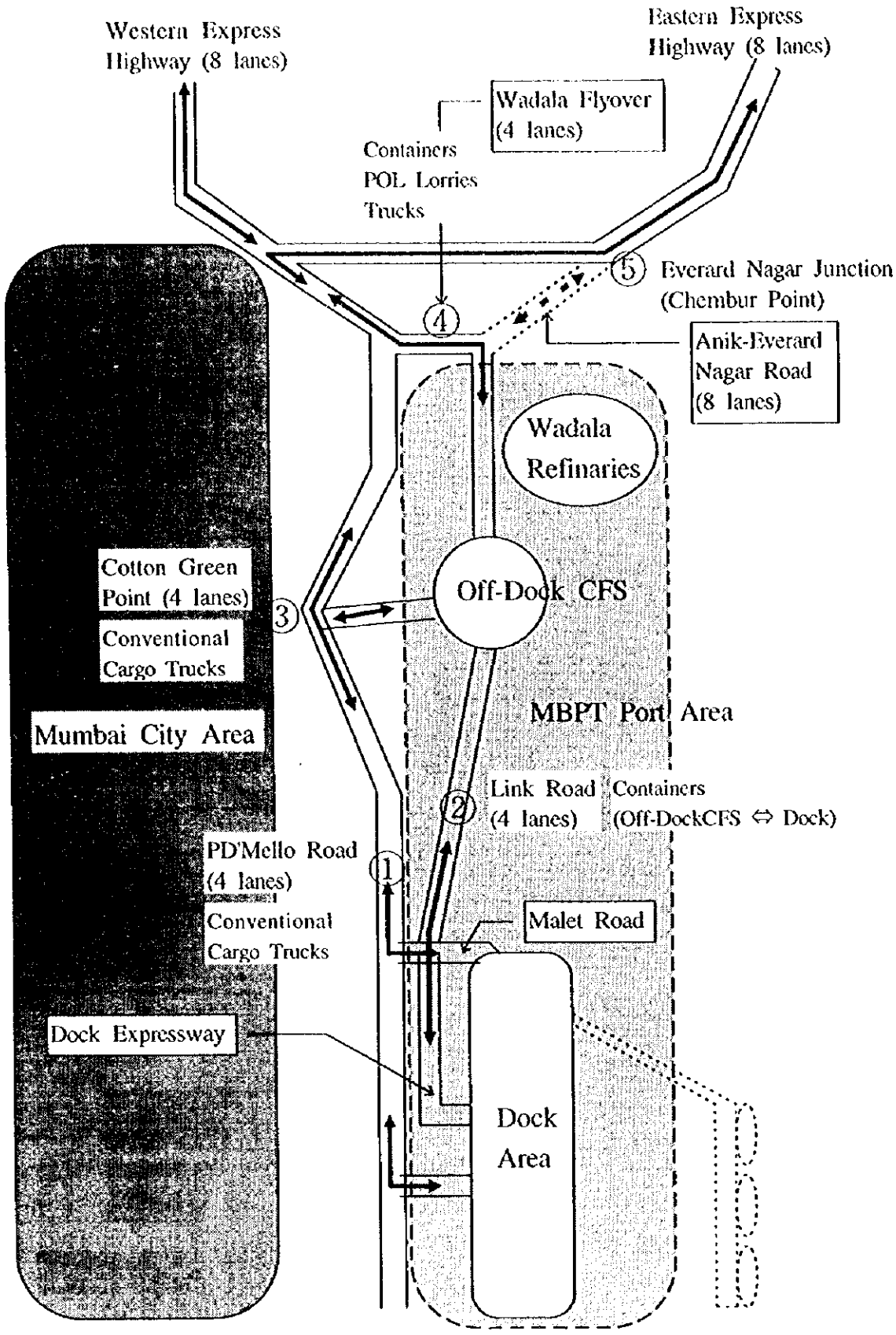


Figure 12.5.1 Present Port-related Cargo Traffic Flow Pattern in and around MBP

12.5.2 Forecast Port-related Cargo Traffic and Flow Assignment in and around MBP

Peaking daily traffic volume of port-related cargo in 2017 is estimated by using computer simulation based on the future volume of container cargo, break and dry bulk cargo to be handled at MBP taking account of modal split between road and rail (see Section 12.5.4), and assigned to each roads. All the port-related cargo traffic is assigned to container-dedicated road, Link Road and Anik-Everard Nagar Road up to Everard Nagar Junction without merging city traffic. Estimated results are summarized and compared with the counted daily traffic volume in Table 12.5.3.

Table 12.5.3 Estimated Peaking Daily Traffic (Two-directional) in 2017 in and around MBP

(unit: vehicles/day)

	Estimated Volume	① P D'Mello	② Link Road	③ Cotton Green	④ Wadala Fly-over	⑤ Everard Nagar Junction (Chembur)
1. Container-trailer (LCL) (Off-dock CFS⇔Docks)	4,206	-	4,206	-	-	-
2. Container-trailer (FCL) (Out-of-port⇔Docks)	3,744	-	3,744	-	-	3,744
3. Loose Cargo Trucks to/from CFS (Out-of-port⇔Off-dock CFS)	4,214	-	-	-	-	4,214
4. Break and Dry Bulk Cargo Trucks (Out-of-port⇔Docks)	10,184		10,184	-	-	10,184
5. POL Lorries (Out-of-Port⇔Wadala)	4,861	-	-	-	-	4,861
Number of Containers in 2017		-	7,950	-	0	3,744
Number of Containers in 1995-96		-	4,898	-	2,131	0
Number of Trucks and Lorries in 2017		0	10,184	0	0	19,259
Number of Trucks and Lorries in 1995-96		11,616	2,064	11,461	5,901	0
Number of Port-related Traffic in 2017			18,134	-	-	23,003
Number of Port-related Traffic in 1995-96		-	6,962	-	-	0

(1) P D'Mello Road (see Figure 12.5.2)

P D'Mello Road is currently heavily used by both port-related cargo traffic and city traffic, resulting in tremendously heavy traffic congestion. Total daily traffic at P D'Mello Road is counted as 35,475 (vehicles/day). Conventional cargo trucks of 11,616 (vehicles/day) are major port-related cargo traffic on this road which accounts for 33% of the total traffic. Port-related cargo traffic will be shifted to the dedicated road for ordinary cargo traffic up to Link

Road, which is planned under the elevated container-dedicated road and proceed to Everard Nagar Junction.

(2) Link Road (see Figure 12.5.2)

Link Road is located within MBPT's premises and used exclusively by container traffic between off-dock CFSs and the docks. Total daily traffic on Link Road is estimated as 18,134 (vehicles/day) which is more than 2.6 times of the volume in 1995-96. Container trailers of 7,950 (vehicles/day) and general cargo vehicles of 10,184 (vehicles/day) account for the total traffic.

(3) Cotton Green (see Figure 12.5.2)

Cotton Green point is currently used by both port-related traffic and city traffic, resulting in heavy traffic congestion. Total daily traffic at Cotton Green point is counted as 23,578 (vehicles/day). Conventional cargo trucks of 11,461 (vehicles/day) which jointly come from P D'Mello Road and from off-dock CFSs are major port-related traffic on this road which accounts for 49% of the total traffic. Port-related cargo traffic will be shifted to Anik-Everard Nagar Road up to Everard Nagar Junction.

(4) Wadala Flyover (see Figure 12.5.2)

Wadala Flyover point is mainly used by FCL container trailers, conventional cargo trucks to/from off-dock CFSs, and POL lorries to/from Wadala refineries. Total daily traffic at Wadala Flyover point was counted as 25,118 (vehicles/day). All the port-related cargo traffic will be shifted to Anik-Everard Nagar Road up to Everard Nagar Junction.

(5) Everard Nagar Junction (Chembur point) (see Figure 12.5.2)

Everard Nagar Junction is being constructed and going to be completed hopefully by the end of 1998. Total peaking daily traffic of 23,003 (vehicles/day) consisting of container trailers

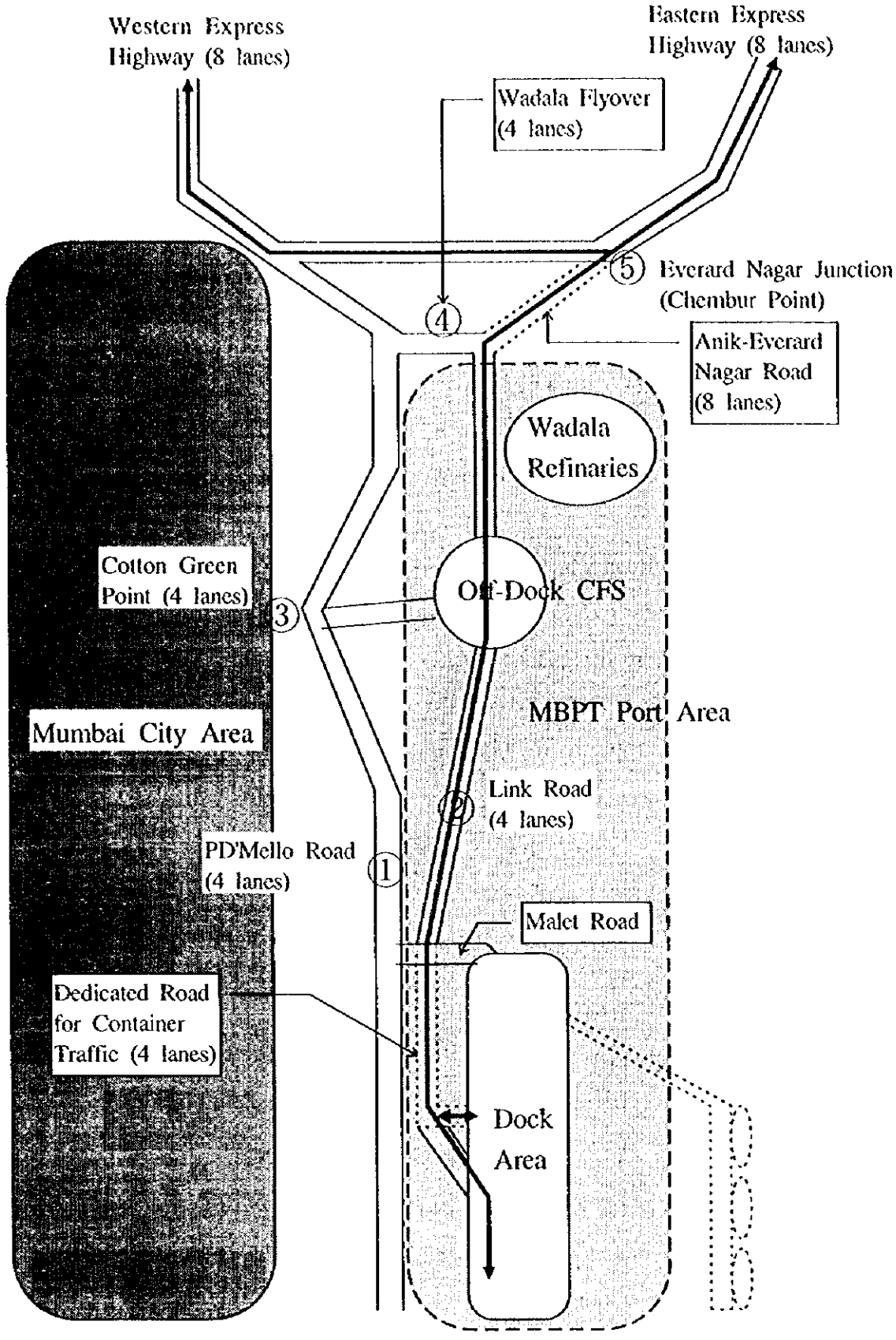


Figure 12.5.2 Port-related Cargo Traffic Flow Assignment Plan in and around MBP

of 3,744 (vehicles/day), general cargo trucks of 14,398 (vehicles/day) and POL lorries of 4,861 (vehicles/day) will be shifted to Anik-Everard Nagar Road up to Everard Nagar Junction which is a starting point to upcountry.

12.5.3 On-going Port Traffic Project around MBP

(1) Anik-Everard Nagar Road Project

Port-related traffic from MBP area to upcountry currently flows through Wadala flyover, then merges with city traffic resulting in tremendously heavy traffic congestion at Kings Circle and Sion Circle. This traffic then diverts to Western Express Highway and Eastern Express Highway.

Anik-Everard Nagar Road which is designed as eight lane-road with about 40 meters in width will connects Eastern Express Highway will Wadala area hopefully by the end of 1998 (see Figure 12.5.1). This road is planned and being implemented by MMRDA. MBPT is in charge of only a small part of the road connected with MBPT's premise. Wadala truck terminal is also planned as a total capacity of 3,000 trucks and 80 hectares in area. First phase of the truck terminal plan (25 hectares in area) will be completed jointly with Anik-Everard Nagar Road.

Once this road is completed, all the port-related cargo traffic from MBP area to upcountry would divert to Anik-Everard Nagar Road. Consequently, tremendously heavy traffic congestion at Kings Circle and Sion Circle is expected to be relieved to a certain extent.

(2) Mumbai Trans-Harbour Link Project

There are two optional alignments, North Alignment (Sweree-Nhava) and South Alignment (Colaba-Uran) for Mumbai Trans-Harbour Link Project. Feasibility study is currently being conducted due to World Bank's assistance. Therefore, this project is not authorized yet for implementation.

12.5.4 Modal Split of Road and Railway Concerning Container Traffic to/from MBP

(1) Railway Traffic Capacity between MBP and Upcountry of India

According to the interview survey with CONCOR[1], railway tracks between MBP and the north Mumbai is used by both passenger and cargo trains. Only a limited time (11:30 - 16:30 and 21:00 - 6:00) is available for freight trains. Consequently, freight train capacity of handling containers is estimated and summarized in Table 12.5.4.

Table 12.5.4 Freight Train Capacity between MBP and North India

	No. of Trains/day (Two-way)	No. of Wagons / Train	No. of TEUs / Wagon	Capacity
	(trains/day)	(wagons/train)	(TEUs/wagon)	(TEUs/year)
MBP - Upcountry	6	40	2	175,200

Source) Interview Survey with CONCOR

(2) Modal Split of Road and Railway Concerning the Container Traffic

RCD container share which handled through MBP and JNP to/from those hinterland at present is summarized in Table 12.5.5. Sixty eight thousand TEUs of containers, which account for 13% of the total containers handled through MBP, are transported by rail between MBP and north India.

Table 12.5.5 RCD Container Share through MBP and JNP to/from Hinterland in 1995/96

Port	RCD Containers Handled	RCD Share	Total Containers Handled
	(thousand TEUs)	(%)	(thousand TEUs)
MBP	68	13	518
JNP	70	22	325
Grand Total	138	16	843

Source) Administration Reports 1995-96 of MBPT and JNPT.

[1] Container Corporation of India Ltd.

Future rail share of containers to be handled through MBP largely depends on the freight train capacity between MBP and north India. The future rail share of containers is estimated as 17.5% (=175,200 TEUs / 1,000,000 TEUs) of the total containers to be handled through MBP in 2017.

(3) Examination of Container handling Capacity at RCD

The present layout of RCD is presented in Figure 12.5.3. The number of required reach stackers to handle the forecast number of containers in 2017 can be estimated using the following factors.

1) Estimated Volume of Containers in 2017: 175,200 (TEUs/year) [480 (TEUs/day)]

2) Train Capacity: 480 (TEUs/day)

= 3 (TEUs/wagon) * 20 (wagons/train) * 4 (trains/day) * 2 (load+unload)

3) Container Stacking Capacity: Approximately 1,440 (TEUs) {> 480TEUs = 3*20*4*2}

4) Train Cycle: 1.25 hrs/train (in-coming)+2.5 hrs/train (load/unloading)+1.25 hrs/train (out-going) = 5 hrs/train

5) TEU/Box Ratio: 1.44 (TEU/Box)

6) Handling Productivity: 20 (box/hr/reach stacker)

7) Number of Required Reach Stackers: 2 > 1.67= {480/1.44}/{2.5 * 4 *20}

The number of required reach stackers is estimated as two mentioned above. Since MBPT presently owns two reach stackers at RCD, however, there is no need for additional reach stacker to handle 175,200 TEUs of containers at RCD in 2017.

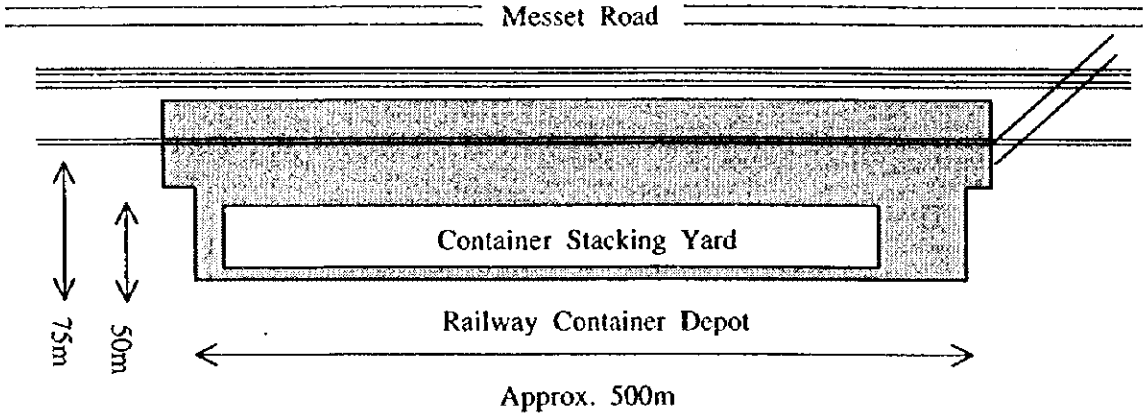


Figure 12.5.3 Present Layout of Railway Container Depot (RCD) at MBP

12.5.5 Dedicated Road to Evacuate Containers from Dock Area

Dedicated road for container traffic would be essential to smoothly flow container traffic between on-dock container yard and off-dock CFS and empty container yard. The dedicated road starts from the gate of Victoria Dock Container Yard and extends to and connects with the Link Road. The fly-over structure is adopted for the dedicated road to cross over Malet Road so as to smoothly evacuate containers out of the dock area. Heavy traffic congestion currently seen at the junction of Dock Expressway and Malet Road is expected to reduce drastically by fly-over road (see Section 12.2.5).

Dedicated road for ordinary port-related traffic along the container-dedicated road is planned within the port area to flow port-related traffic including general cargo trucks. This could also reduce traffic congestion on P D'Mello Road where heavy congestion by both port-related traffic and city traffic is always seen currently.

However, Mumbai Metropolitan Region Development Authority (MMRDA) is planning to build "East Island Freeway" along the Link Road and Dock Expressway within the MBPT's landed estate as an extension of Eastern Express Highway to the Gateway of India. "East Island Freeway" is planned basically to flow city traffic rather than port-related traffic. Since the above-mentioned container-dedicated road could reduce city traffic congestion and MBPT's landed estate has to be utilized basically for dealing port-related activities, precious space for the container-dedicated road should be reserved for this Master Plan.

12.5.6 Examination of Lane Capacity of Elevated Container-dedicated Road, Link Road and Anik-Everard Nagar Road

(1) Elevated Container-dedicated Road

Peaking daily container traffic volume is estimated as 7,950 (vehicles/day) for the container-dedicated road in 2017. Minimum number of lanes is calculated and shown in Table 12.5.6. However, required number of lanes for the dedicated road for container traffic is set as 4 lanes (2 lanes for each direction) to secure availability of at least one lane for each direction taking account of any emergency. The container-dedicated road is planned to provide 4 lanes, which would be adequate up to the year 2017, compared with requirement of port-related

cargo traffic.

Table 12.5.6 Required Number of Lanes for Elevated Container-dedicated Road

	Peaking daily traffic volume	Peaking factor to average hourly traffic volume	Peaking hourly traffic volume	Maximum hourly traffic volume per lane	Minimum number of lanes
	(vehicles/day)		(vehicles/hour)	(vehicles/hour/lane)	(lanes)
Elevated Container-dedicated Road	7,950	2.5	828	600	1.38 < 4

(2) Link Road

Peaking daily traffic volume is estimated as 18,134 (vehicles/day) for Link Road in 2017. Minimum number of lanes is calculated and shown in Table 12.5.7. Required number of lanes for Link Road is set as 4 lanes. Link Road currently provides 4 lanes in service, which will be adequate up to the year 2017.

Table 12.5.7 Required Number of Lanes for Link Road

	Peaking daily traffic volume	Peaking factor to average hourly traffic volume	Peaking hourly traffic volume	Maximum hourly traffic volume per lane	Minimum number of lanes
	(vehicles/day)		(vehicles/hour)	(vehicles/hour/lane)	(lanes)
Link Road	18,134	2.5	1,889	600	3.15 < 4

(3) Anik-Everard Nagar Road

Peaking daily traffic volume is estimated as 23,003 (vehicles/day) for Anik-Everard Nagar Road in 2017. Minimum number of lanes is calculated and shown in Table 12.5.8. Required number of lanes for Anik-Everard Nagar Road is set as 4 lanes. Anik-Everard Nagar Road is planned to provide 8 lanes, which would be adequate up to the year 2017, compared with requirement of port-related cargo traffic.

Table 12.5.8 Required Number of Lanes for Anik-Everard Nagar Road

	Peaking daily traffic volume	Peaking factor to average hourly traffic volume	Peaking hourly traffic volume	Maximum hourly traffic volume per lane	Minimum number of lanes
	(vehicles/day)		(vehicles/hour)	(vehicles/hour/lane)	(lanes)
Anik-Everard Nagar Road	23,003	2.5	2,396	600	3.99 < 8