Chapter 2 Specialized Wharf

1 Container Wharf

1.1 Basic Policy of Design

[Basic point]

Given that a container wharf is a facility that plays a pivotal role in marine container transportation, it shall be developed with consideration to the trend of container transportation (future cargo volume, construction trend of container ships, intention of shipping companies, etc.), the relationship to the hinterland and connecting transportation facilities, the area of the securable lot, etc. Moreover, a wharf shall have facilities for smooth and efficient delivery, sorting, and storage of container cargos and containers, together with container ships and connecting transportation facilities. These facilities shall be arranged in a manner that allows them to function efficiently; accordingly, the wharf shall have sufficient width.

[Commentary]

(1) The container wharf is a nodal point of marine transportation and land transportation in the marine container transportation system, which is also called an intermodal transportation system. The container wharf shall be developed by considering the container cargo demand in Japan and its hinterlands, the operation of the container route network in liner shipping, the traffic network in the hinterlands, and the conditions of container wharf development in neighboring ports. Furthermore, wharfs shall be arranged in locations where they can be efficiently utilized.

(2) Container wharfs differ in scale and form depending on the port to be developed, shipping companies using the port, container routing, cargos types and items, type of transportation facilities to hinterlands, etc.

Terminals that handle containers are divided into the following: container terminals, which are terminals that handle container cargos only, and logistics terminals, which are terminals that handle container cargos and cargos in other packing styles. This chapter provides a fundamental Commentary of container terminals. It can be used as a reference when designing a facility that also handles container cargos and other style cargos such as a logistics terminal. However, it is required to separately examine the facility according to the situation of cargos.

(3) High earthquake-resistance facilities shall be arranged appropriately because the container terminals in Kobe Port damaged by the Great Hanshin-Awaji Earthquake greatly affected the economy and lives of citizens.

(4) Considering that the container terminals in every port in the Tohoku district were damaged by a tsunami in the Great East Japan Earthquake, protection against tsunamis is required. The damages caused by tsunamis are serious, particularly for the inundated traveling part of cargo handling equipment (e.g., container cranes) and for container terminal facilities, owing to the collision of drifting ships or drifting containers. To reduce such damages, waterproofing the structure of the traveling portion of container cranes and others or increasing the higher attachment position of parts to reduce the possibility of inundation may be considered. Moreover, it is effective to improve the spare parts inventory system so that replacement parts can be obtained easily if original parts are damaged. Furthermore, given that the damage to a container crane by empty drifting containers can also be serious, only the minimum required number of empty containers should be stored in the marshaling area around the apron.

(5) A container wharf performs an advanced flow operation together with container ships and connecting transportation facilities. The container wharf comprises a container terminal that unifies the mooring facilities, container yard, cargo handling equipment and management facilities etc., access roads, and logistics-related facilities located in the hinterland such as warehouses, container freight station (CFS), comprehensive logistics center, storage of empty container/chassis according to its functions for smooth delivery, sorting, and storage of container cargos and containers. The function of the container wharf is fully exerted only when these facilities are operated efficiently.

[Reference]

(1) In a container wharf, the following are performed: stevedoring work of containers; storage and delivery of cargos and containers for smooth cargo handling; and inspection and repair of containers, vehicles, and cargo handling equipment. In addition to these tasks, the collection of cargo, the arrangement planning of container ships, and the operation planning of containers may also be performed.

(2) The container wharf is a nodal point of marine transportation and land transportation, and its locational conditions consider the following:

① Trend of container transportation, expansion of the hinterland, and relation to industry and consumption activities in the hinterland

② Relation to infrastructure that provides access to hinterlands such as roads, coastal transportation, and railroads (i.e., cargo transportation network)

③ Relation to the industry that performs port cargo handling

④ Sufficient size of land and water areas and depth of water area

⑤ Status of development of container wharfs in neighboring ports

⑥ Consistency of container orientation at the times of container ship cargo handling, yard storage and cargo storage and transportation, consistency of flow lines, arrangement of facilities, equipment, etc.

The important items among these are as follows: trend of container transportation and relation to the hinterland area and others, evaluation of accumulation or the possibility of the future accumulation of economic/industrial activities in the hinterland that generate sufficient container cargo volume to justify the development of a container wharf, and an analysis of whether the conditions for shipping companies to call at a port in the container transportation network. When analyzing the accumulation of cargos, it is preferable to take into consideration the business practice in international cargo logistics and trade and maritime transportation. Furthermore, it is necessary to consider the whereabouts of the permission organization to obtain information about the port entrance and leaving, customs clearance, and export and import quarantine of animals and plants.

(3) The key items that must be taken into consideration when determining the scale and facility arrangement of a wharf are as follows:

① Sufficient function for efficiently handling and processing cargos

② Economic efficiency of the whole container transportation system such as land–sea intermodal transportation, particularly efficient cooperation with access to land

③ Flexible support of future expansion and innovation in transportation and cargo handling methods

(4) The key items that should be examined in the master plan of facilities in a container wharf are as follows:

① Planned cargo handling volume

② Cargo characteristics (export–import cover ratio, rate of transit, etc.)

③ Allocation interval and type of container ships

④ Management/administration system of a terminal

⑤ Cargo handling method at the quaywall and yard

⑥ Area and form of available land

⑦ Situation of storage facilities in a direct hinterland area

⑧ Circumstance of transportation to hinterlands, traffic condition of roads, etc.

⑨ Usage condition of the surrounding land and ship navigation condition

⑩ Situation of neighboring container wharfs

(5) For the efficient planning and design of wharfs, the movement of container ships, behavior of container cargos and containers at the terminal, and situation of container movement in the hinterlands shall be adequately analyzed. The key items that should be examined are as follows:

① System characteristics of the container terminal

(a) In-service time of the terminal (annual and daily in-service time of gates and container yard)

(b) Arrival characteristics of container ships (arrival distribution)

(c) Distribution of container ships' loading ratios and number of loading and unloading containers

(d) Types of handling containers (ratio of dry, reefer, and special containers; ratio of 40 foot containers and 20 foot containers, etc.) and mode of cargos (ratio of full container load (FCL) cargo (i.e., cargo occupying a full container that is individually transported by land by a trailer) and less than container load (LCL) cargo [i.e., a small lot cargo that does not occupy a full container). LCL cargo is usually loaded in a container with other cargo, and the container is loaded on a ship, packed in a container, or unpacked from a container at the container freight station (CFS) in the container terminal. It is then transported by land as a small cargo.)

(e) Collection and delivery characteristics of a container (carrying in and out distribution)

(f) Container storage characteristics in the container terminal

(g) Moving situation of empty containers

② Characteristics of container handling work plans such as yard storage plans and stevedoring work plans, available number of cargo handling equipment, and work efficiency

③ Facilities in the wharf and container terminal and the principal items of equipment

④ Development cost of container terminals, cargo handling equipment and related equipment, and total cost required for the administration of terminals

⑤ Congestion in gates

Considering the above factors, the whole scale of container terminals, arrangement of facilities, scale of each facility, and the optimum number of cargo handling equipment shall be examined by considering the characteristics of cargo handling methods from the viewpoint of the evaluation of efficiency and safety of terminal use and the cost of cargo handling. In this case, a simulation method that can reflect the cargo handling method, cargo handling equipment, and flow of containers inside and outside of a wharf may be used.

To reduce the waiting time for containers, the transportation cost, and others, it is important to introduce a cargo handling method that contributes to the use efficiency of container wharfs and a wharf operation system that is suitable for the local characteristics.

Moreover, given that container transportation as an intermodal transportation is configured as a system by container ships, container wharfs, trailers, trucks, railroads, coastal marine transportation, and others, each transportation and the scale of transportation facilities are mutually and closely related. Therefore, it is important to evaluate the scale and arrangement of the facilities concerned and to improve the efficiency of the whole transportation system.

Fig. 1.1.1 shows an example of a facility arrangement of foreign trade container terminals.

Oi Container Terminal

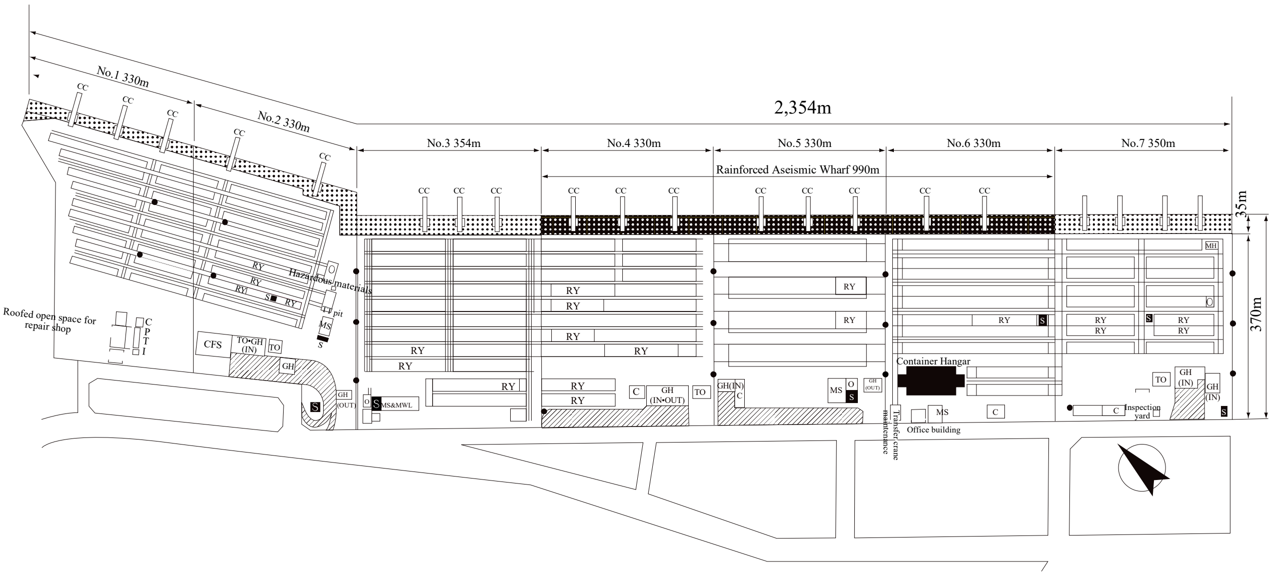

Fig. 1.1.1 Example of a Facility Arrangement of Foreign Trade Container Terminals (Tokyo Port)

1.2 Design of Mooring Facilities

1.2.1 Length and Water Depth of Berths

[Basic point]

The length and water depth of a berth where container ships are moored shall be determined so that the target container ships can use it safely and smoothly.

[Reference]

(1) The ship classes that can carry containers are LO/LO ships, RO/RO ships, semi-container ships, and others. These ship classes have their own features depending on the type of ship. Moreover, even ships of the same class can have different features depending on the type of ship of operating shipping companies. Therefore, when the target type of ship has been identified, the length of a berth and the depth of water shall be determined according to the ship design. However, when the principal dimensions of the design ship cannot be set at the design stage of facilities, the values in **Table 2.1.1** of **Part III, Chapter 5, 2.1.1 Specifications of Quaywall** may be used.

(2) The standard values of the primary specifications of the berth in **Table 2.1.1** of **Part III, Chapter 5, 2.1.1 Specifications of Quaywall** have been determined on the basis of **Part II, Chapter 8, 1 Primary Specifications of Design Ships** conforming to **Part III, Chapter 5, 2.1.1 Specifications of Quaywall (2)**.

(3) Container ships vary significantly in their principal dimensions by operating company, construction date, and navigation channel operation even if they have the same deadweight tonnage (DWT) compared with a general cargo ships. Therefore, even if a facility with a berth length of 350 m and water depth of 15.0 m, a ship with 60,000 DWT or more may be able to dock at it.

1.2.2 Mooring Equipment

[Basic point]

The mooring equipment shall be installed by considering the type of target container ships and by conforming to **Part III, Chapter 5, 9.1 Mooring Post and Mooring Ring**.

[Commentary]

Considering that container ships have higher gross tonnage to DWT ratio than general cargo ships that dock at a quaywall of the same scale in terms of berth length or water depth and given that they load containers on decks, the projected area on the water surface is larger. Therefore, the structure of mooring equipment needs to be defined considering that the heavy pressure area of the wind on the water surface of container ships is generally larger.

1.2.3 Fender Equipment

[Basic point]

The fender equipment shall be installed by considering the type of target container ships and by conforming to **Part III, Chapter 5, 9.2 Fender Equipment**.

[Commentary]

Given that container ships have more displacement tonnage to DWT ratio than general cargo ships with regard to the length or water depth of the same berth, it is necessary to determine the specifications of the fender equipment on the basis of this fact.

Compared with general cargo ships, container ships have different ship types for transporting large quantities of cargos rapidly and smoothly. Therefore, because the contact mode of container ships and fender equipment is considered different from that of general cargo ships, the arrangement of fender equipment needs sufficient consideration.

1.3 Design of Land Facilities

1.3.1 Apron

[Basic point]

The scale and facilities of an apron shall be appropriately determined and designed respectively so that the temporary storage of containers and hatch covers of container ships and the operation of cargo handling vehicles and equipment can be performed safely and smoothly.

[Reference]

(1) For the handling of container cargo in a wharf, the required scale (width) of the apron differs on the basis of the type and quantity of quaywall cranes and the cargo handling method used in the container yard.

(2) The width of an apron is often set to approximately 40 to 70 m in consideration of the rail width of the container crane in a container terminal, vehicle passing width, etc.

(3) The pavement of an apron shall be designed with consideration to the wheel loads of running vehicles and cargo handling equipment. It is common to pave an apron with concrete or asphalt.

Refer to Part III, Chapter 5, 9.18 Apron for pavement.

1.3.2 Container Crane

[Basic point]

A container crane shall have suitable processing capability that is suitable for the type of target container ships, size and type of containers, handling number of containers, quaywall structure, cargo handling method in the yard, type of yard cargo handling facilities and machines, etc.

[Commentary]

(1) Considering that the container crane is a primary cargo handling equipment for loading or unloading cargos from a ship and that its capability becomes a primary element of the handling capability of a wharf, its primary quantity and capability must be defined so that the capability of cranes matches the handling capability of the yard for the docking ships, containers to handle, cargo handling method of the yard, etc.

(2) The container cranes shall be designed according to **Part III, Chapter 7 Sorting Facilities** and this section.

[Reference]

(1) The required number of container cranes differs according to the type of container ships, required cargo handling capability at the quaywall, etc. Two or three container cranes per berth are common in Japan.

(2) When designing a container crane, the items to consider as area conditions are as follows:

① **Type of the target container ship**

Given that the specifications of a container crane are determined by the maximum type of a design ship, the target type of a ship shall be set adequately by considering the water depth and length of the quaywall.

② **Required processing capability**

The processing capability of a container crane shall fully correspond to the frequency of container ships' arrival in a port and the number of loading and unloading containers per container ship. Its processing capability must harmonize with the container processing capability of the yard.

Given that the processing capability of a container crane depends on the speed of main operations (winding up/down and traversing), these speeds shall be determined appropriately.

③ **Rated load of a crane**

The rated load shall be adequately determined on the basis of the expected mass to be handled by the container cranes (e.g., containers, hatch covers of a container ship, and other heavy load carried by container ships).

④ **Earthquake-resistant performance**

Refer to **Part III, Chapter 7 Sorting Facilities** for the earthquake-resistant performance of container cranes.

⑤ **Consideration of aviation restrictions**

According to the Civil Aeronautics Act, an airplane warning light is obliged to be installed for buildings that are 60 m or higher. Moreover, height is restricted so that collision with the level surface and transitional surface near the airport can be avoided. In such a case, a device to fold the derricking boom of a container crane in two steps (folding crane) is needed.

(3) Determination of Specifications of a Container Crane

① **Traversing**

Outreach shall be determined so as to sufficiently support the maximum target type of a ship by considering the molded breadth of a design ship, contact distance between trajectory face lines, height of a fender, inclination of a ship during cargo handling, etc. When setting the distance between trajectory face lines, the following shall be fully considered: contact of the ship to the container crane, size of a mooring post, electric supply cable trench to the crane, structure of the quaywall, and others. The back reach shall be determined by considering the location where containers are temporarily stored and where hatch covers are stored during cargo handling work.

② **Net lifting height**

The net lifting height shall be determined so as to sufficiently support the maximum target type of a ship by considering the draft of design ships, depth of holds, number of container stacks on the deck, inclination during cargo handling, tide level, etc.

③ **Rail span**

The container cargo handling work in an apron usually uses a chassis or a straddle carrier. The rail span width shall be determined so as to perform such cargo handling work smoothly. The number of lanes required for the passage of these vehicles and cargo handling equipment shall be determined by the flow line with consideration to the number of container cranes used for one ship. Therefore, the rail span shall be determined by considering the required number of lanes, required lane width of the type of cargo handling equipment that runs on the lanes, quaywall structure, safety and economic efficiency of a crane, attaching/detaching work of instruments to fix container to be stacked on a deck, etc.

The rail span of a domestic container crane is usually 16 or 30 m. When considering the stability of the crane in case of an earthquake, a larger rail span is better. Container cranes that support 13 rows or more usually have a rail span of 30 m.

④ **Effective space between legs**

The effective space between legs is an inside dimension space of the leg pillar seen from the perpendicular direction of the quaywall face line. This space shall be determined so that the object to be handled with the container crane (e.g., a container hatch cover) can safely pass through between legs.

The effective width between the legs of almost all domestic container cranes is 17.0 m to 18.0 m, including whirling with hanging a container and allowance.

⑤ **Full width**

Considering that two or more container cranes are used for one ship to do neighboring work, a narrower width is preferable as long as it is structurally reasonable.

⑥ **Under beam height**

This shall be high enough for cargo handling equipment such as a chassis or straddle carrier, which runs within the rail span so that it can pass safely.

The under beam height of almost all domestic container cranes is 14 to 15 m because many of them considered the case wherein a straddle carrier passes. The crane shakes less as the under beam height decreases.

⑦ **Critical surfaces on the sea side and on the land side**

To avoid the contact of a container crane with the container ship moored to a quaywall, it is required to examine the critical surface on the sea side of a container crane. This limit size is determined by the quaywall surface height; high tide level; height of a fender; and dimensions of the design ship, particularly the height and width of the navigation bridge wing and draft of the design ship.

The inside of the critical surface on the sea side of the container crane needs to be set so that the crane can move in an inactive condition (condition where the derricking boom is standing) without contacting the ship. Moreover, the width of stairs going up and down from the ship shall be taken into consideration. Examples wherein passenger ships are moored to a container berth resulting from the enlargement of passenger ships in recent years and ships other than container ships shall also be taken into consideration if needed.

Moreover, to avoid the contact of a container crane with cargo handling equipment and others, the critical surfaces on the land side of the container crane is also needed to be examined. The width between legs, under beam height, and marginal surface where cargo handling equipment cannot enter in the back of a container crane shall be determined.

⑧ **Cable reel**

There was an accident wherein the contact of container ships and others with the container crane damaged a cable reel. When installing the cable reel perpendicular to the quaywall face line as a means to avoid this accident, attention should be paid to the following. When introducing a cable reel perpendicular to the quaywall, its weight and others shall be taken into consideration because it should be originally installed on a horizontal brace so that it will not interfere with the cargo handling equipment. Considering that the direction of the cable veered out from the cable reel is required to be changed from the direction perpendicular to the quaywall face line to a direction parallel to the quaywall face line, a flat cable shall be changed to a round cable, and a guide roller shall be installed. The cable trench and cable anchor drum in the cable pit shall be made to support the round cable.

(4) Installation of Monitoring System

It is preferable to have a monitoring system for the efficient operation of cranes and terminals.

In general terms, the monitoring system comprises a failure monitoring function to monitor the control system of cranes, a maintenance function to monitor the condition of portions that need maintenance, and an operation management function to collect track records such as the number of containers, weight, and cycle time.

(5) Installation of Attachment Devices (Fixed Device, Turnover Prevention Apparatus, End Stopper, Jack-Up Plate, Rail Clamp, etc.)

Cranes shall have a crane foundation and a crane anchoring structure so that they stop at the specified position when inactive or during a storm to avoid overrunning or overturning. Moreover, cranes shall be equipped with a rail clamp or others so as not to overrun in unexpected situations, such as during a gust of wind, when cranes are at any position on the rail.

An end stopper shall be equipped at the end edge of the guideway so that the crane does not deviate from a rail. Moreover, a jack-up plate shall be equipped at a predetermined position of the crane foundation so that the crane can be jacked-up when exchanging a running wheel. The predetermined position shall be taken into consideration to avoid contact with arriving or leaving ships.

(6) **Fig. 1.3.1** shows an example of a container crane.

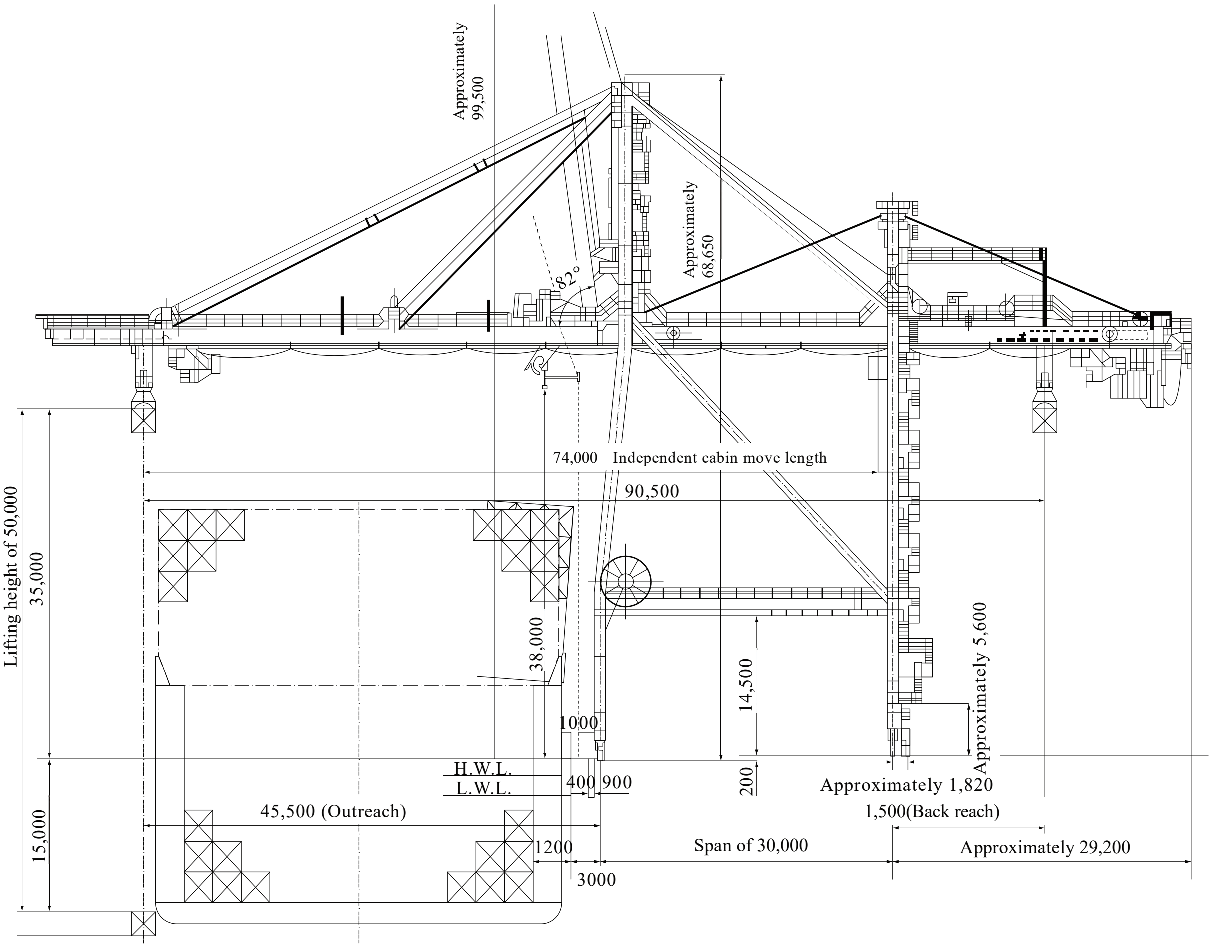

Fig. 1.3.1 Example of a Container Crane

1.3.3 Container Yard

[Basic point]

The cargo handling method, scale, and arrangement of the container yard shall be determined to facilitate the storage and delivery of containers, and facility planning in the yard shall be performed.

[Commentary]

The container yard has a storage function for the efficient cargo handling work of containers unloaded from the ship and containers to be loaded in the ship and has a storage function for empty containers for the efficient handling of empty containers. The scale and arrangement planning of the container yard, facility planning of the yard, and others shall be conducted so that these functions can be performed smoothly.

[Reference]

(1) Fundamentally together with an apron, the container yard loads and unloads containers to/from container ships and visiting chassis, transports, and stores containers. The container yard has a marshaling area wherein cargo handling work such as the transport, cargo handling, or storage of containers is performed and a backyard wherein the gate, administration building, maintenance shop, gas station, parking lot, and others are located. Moreover, empty containers are stored for the use of shipping companies.

(2) The container yard shall be planned by considering two elements: loading and unloading of containers to/from ships and transporting containers to/from the hinterland. The primary items to consider are the ① arrival interval of container ships, ② number of containers to load to and unload from container ships, ③ type and quantity of handled containers such as the classification of loaded or empty containers and classification of dry or reefer, ④ container handling method at the quaywall and in the yard and collection and delivery form of containers, ⑤ storage characteristics of containers in the yard, number of stacks, etc.

(3) The storage form of containers differs by the cargo handling method used in the container yard. Moreover, given that the transport method of containers differs by the cargo handling equipment used, the arrangement and necessary area of a passage differ. Therefore, it is necessary to have a facility plan that corresponds to the cargo handling method in the container yard.

The cargo handling method in the container yard differs according to the number of containers handled. Examples are shown in the following:

① **Terminals where a large number of containers are handled such as international container strategic ports and international base ports**

Many containers in the yard flow in either of the following methods:

(a) Container crane → yard chassis → transfer crane → visiting chassis

(b) Container crane → straddle carrier → visiting chassis

The top lifter, reach stacker, and others are used in the storage yard to process empty containers and the like.

② **Terminals where a small number of containers are handled such as local important ports**

Many containers in the yard flow in either of the following methods:

(a) Container crane → straddle carrier → visiting chassis

(b) Container crane → (yard chassis) → reach stacker → visiting chassis

The top lifter and others may be used in the storage yard to handle empty containers and similar objects.

Equipment in parenthesis may not be used.

Moreover, it is possible to install a multistory container storage facility in a terminal where many containers are handled, but a storage yard has no margin and no room for an extension. This is a facility that has shelves for storing containers in the building and a distribution warehouse with an overhead traveling crane and chassis storage. Given that this enables increased storage capability via the installation of more shelves than the number of stacks in the yard and via the selection of container from the shelf, easing can be expected in terms of the reduction in the cargo handling capability when nearing the limit of the storage capability.

The primary cargo handling methods in the yard are as follows:

1) Transfer crane method

This method uses a yard chassis for container transport in the container yard and uses a transfer crane for loading and unloading containers. This method is classified into a rail type and a tire type according to the type of transfer crane. Considering that containers are placed directly on the ground and can be stacked, the land-use efficiency of the container yard is high.

Moreover, it easily supports the remote control and automation of cargo handling.

However, its early capital investment is larger than other methods.

Considering that the transfer crane is heavy, its guideway shall be equipped with a rail foundation for rail type and shall usually be paved with prestressed concrete or reinforced concrete for tire type. Moreover, although the trailer guideway needs to be heavily paved, if a concrete slab (container mat) is laid in the installation part of the lowest stack container, a low-cost pavement is enough for other portions.

Given that facilities may be installed in the earth for remote control, automatic driving, or others, consideration is required during paving. Furthermore, the space wherein facilities that supply electric power (e.g., a bus bar) are installed is needed when introducing an electric crane.

This method is often adopted in a container yard where a large number of containers are handled.

2) Straddle carrier method

This is a method that uses a straddle carrier with emphasis on carrying. A straddle carrier allows containers to be freely carried anywhere in a container yard.

The advantages of this method include mobility in the transport of containers, capability of stacking, and highly efficient land use of the container yard. Moreover, the initial investment is not that large.

The disadvantage is that when taking out a low-stacked container, its movement is limited only to the lengthwise direction along the row and is restrained more than that in the transfer crane method. Moreover, although the straddle carrier can run freely, it is necessary to focus on the safety of workers in the yard.

The whole guideway needs to be heavily paved because the straddle carrier runs lengthwise and breadthwise. Moreover, the specified guideway in the container storage may be paved with semiflexible material or high standard asphalt to prevent rutting.

This method is often adopted in a container yard wherein a medium number of containers are handled.

3) Reach stacker method

This is a method that uses a reach stacker for cargo handling in a yard. A reach stacker can carry containers freely anywhere in the container yard, similar to the straddle carrier.

The advantage of this method is the mobility in the transport of containers. Although inferior to the straddle carrier method, it is capable of stacking, and the land-use efficiency of the container yard is high to a certain extent. Moreover, the initial investment is not that large.

The disadvantage is that in the makeshift of cargos to take out a low-stacked container, the containers before the row must be moved and restrained more than in the straddle carrier method when taking out a low-stacked container in the second row or after. Moreover, although the reach stacker can run freely, it is necessary to secure the safety of workers in the yard.

The whole yard needs to be heavily paved because the reach stacker can run freely. Moreover, the place where the visiting chassis and reach stacker hand over the containers may be paved with concrete to prevent rutting.

This method is often adopted in a container yard where a small number of containers are handled.

4) Forklift method

A small-scale container yard that is handling a small number of containers may use 1) to 3) and the forklift method. Although this method is simple but inefficient when handling a large number of containers, the operation work area becomes large and the container storage efficiency becomes low.

This method is often used for the storage of empty containers.

There are examples wherein several cargo handling methods are used in separated areas in a yard on the basis of the advantage of each yard cargo handling method.

5) Automated operation method

Some overseas and domestic terminals introduce remote controlled or automated cargo handling equipment to load, unload, and carry containers. The development of unmanned operation in the yard can be achieved by enabling remote control or automatic operations, improving safety in a yard and work environment, and equalizing cargo handling efficiency. **Tables 1.3.1** and **1.3.2** show examples of overseas container yards that are adopting automated operation method.

Table 1.3.1 Examples of Ports Where Automated Stacking Cranes Have Been Introduced in the Storage Yard Crane

Port	Terminal	Operator	Introduced in	Storage direction	Storage yard crane		Container transport vehicle
					Number	Manufacturer	
Rotterdam	Delta	ECT	1993	Vertical	137	Cargotec	AGV
Hamburg	CTA	HHLA	2001	Vertical	52	Kunz	AGV
Virginia	Portsmouth	APMT	2007	Vertical	30	Kone	SC
Antwerp	AGW	DPW	2007	Vertical	14	Gottwald	SC
Hamburg	CTB	HHLA	2008	Vertical	63	Cargotec	SC
Rotterdam	Euromax	ECT	2008	Vertical	58	ZPMC	AGV
Algeciras	Hanjin	TTI	2010	Vertical	32	ZPMC	SC
Khalifa	ADPC	ADPC	2012	Vertical	30	Kone	SC
Pusan New	HPNT	HMM	2012	Vertical	38	ZPMC	SC

Port	Terminal	Operator	Introduced in	Storage direction	Storage yard crane		Container transport vehicle
					Number	Manufacturer	
Port South							
New Jersey	GCT	GCT	2012	Vertical	40	Kone	SC
Barcelona	BEST	HPH	2013	Vertical	36	Kone	SC
London	LGW	DPW	2013	Vertical	40	Cargotec	SC
Sydney	SICTL	HPH	2014	Vertical	6	Kone	SC
Brisbane	DPW Brisbane	DPW	2014	Vertical	14	Cargotec	SC
Los Angeles	MOL	TraPac	2014	Vertical	10	Cargotec	Unmanned SC
Rotterdam	RWG	DPW	2014	Vertical	50	Gottwald	Battery AGV
Rotterdam	MV2	APMT	2015	Vertical	48	Kunz	Battery AGV

Note: ASC: Automated Stacking Crane; AGV: Automated Guided Vehicle; SC: Straddle Carrier

Table 1.3.2 Examples of Ports Where Storage Yard Cranes and Container Transport Vehicles Have Been Remote Controlled or Automated

Port	Terminal	Operator	Introduced in	Storage direction	Storage yard crane			Container transport vehicle
					Method	Number	Manufacturer	
Singapore	PPT	PSA	1998	Horizontal	OHBC	44	MES	Chassis
Brisbane	Patrick	Patrick	2002	Vertical	-	-	-	Unmanned SC (27)
Nagoya	Tobishima South	TCB	2005	Horizontal	RTG	24	MHI	AGV
Pusan New Port North	PNC	DPW	2006	Horizontal	RMG	31	Doosan	Chassis
Pusan New Port North	Hanjin	Hanjin	2006	Horizontal	RMG	42	ZPMC	Chassis
Taipei	Taipei New Port	TPCT	2009	Horizontal	RMG	20	ZPMC	Chassis
Pusan New Port South	Hundai Merchant Marine	HMM	2010	Horizontal	RMG	37	ZPMC	Chassis
Kaohsiung	MYL	YML	2011	Horizontal	RMG	22	ZPMC	Chassis
Sydney	Patrick	Patrick	2015	Vertical	-	-	-	Unmanned SC (44)

Note: OHBC: Overhead Bridge Crane; RTG: Rubber Tired Gantry crane; RMG: Rail Mounted Gantry crane

(4) The arrangement method of the container storage in a container yard differs on the basis of the cargo handling method. The intensity required for the pavement of the yard differ by container storage method, cargo handling equipment, passage, passing method, etc.

Although the yard is completely paved for the storage of containers, running of vehicles and cargo handling equipment, drainage, and others, it is generally paved with asphalt because of the differential settlement of the foundation, maintenance repair, etc. However, in consideration to the severe loading condition, countermeasures against rutting, wear, oil, and others shall be taken. If necessary, semiflexible pavement, reinforced concrete pavement, or prestressed concrete pavement shall be used. Given that the utility form of the container yard is relatively clear, the storage condition of containers, characteristics, run frequency, and others of running vehicles and cargo handling equipment shall be fully examined. Furthermore, the loading conditions shall be set, and the rational design shall be conducted according to the conditions.

Moreover, as stated in (3), the container mat made of prestressed or reinforced concrete slabs are often installed with consideration to the concentration load applied to stacked container corners.

(5) For cargo handling at night, install a lighting facility at a suitable location so that the container yard surface is illuminated at 20 lx (lux) or brighter. In this case, there are methods for centralizing or diverging equipment. When installing a lighting facility, do not dazzle the ship operator entering or leaving a port and the cargo handling equipment operator in the yard at night.

Moreover, consider the illuminance and arrangement required for security and management. A power receptacle and an inspection stand shall be installed if necessary in a reefer container storage. Furthermore, a fence shall be installed as a security facility around the foreign trade container terminal.

1.3.4 Container Freight Station

[Basic point]

A CFS shall be constructed if needed, considering the handling of small lot cargos in the yard. The location shall be determined on the basis of the traffic stream line in the yard. Furthermore, the scale of facilities and the cargo handling equipment to be used shall be determined, and the facilities shall be designed so that the sorting and temporary storage of cargos are performed safely and smoothly.

[Commentary]

Although the CFS is where small lot cargos are loaded to or unloaded from containers, sorted, and stored, the necessity of construction in the yard differs by yard users. Therefore, consider the users' handling method of small lot cargos, and execute constructions if needed.

[Reference]

(1) Given that not only vehicles dedicated to containers but also trucks for general use enter in and out the CFS, its location shall be determined by considering smooth cargo handling activities at a wharf and the flow line of related vehicles.

(2) Although the CFS in a container terminal has a short conveying distance for containers, it is not necessarily located in a container terminal or a wharf but may be constructed in the hinterland. Therefore, consider the handling method used by wharf users for small lot cargos.

(3) The CFS is a building similar to a shed, and the inside and outside of small lot cargos and containers generally face across the freight sorting area. The floor height of the freight sorting area shall be approximately 1.2 to 1.3 m to match the height of the bed of trucks and the floor of the container loaded on a chassis and shall be paved with concrete or asphalt. Moreover, a slip way or lifter shall be installed at a suitable place to facilitate the use of cargo handling equipment, such as a forklift, to the freight sorting area.

The pillar interval shall not obstruct the cargo handling in consideration of containers, vehicles, etc.

(4) The area (length and width) of the CFS shall be set so that the sorting and temporary storage of cargos are performed smoothly on the basis of the arrival interval of container ships, number of containers to be loaded or unloaded, type of containers, ratio of containers going through the CFS, quantity and type of cargos to load and unload from containers, cargo storage characteristics in the CFS, in-service time of the CFS, working time per container, etc.

Moreover, given that the CFS may be used as an inspection station for the import and export of container cargos containing animals and plants, consider setting a scale if necessary.

(5) The width of the space in front of the CFS for the ingress and egress of vehicles shall be approximately 25 m and 15 m if used by a container chassis and trucks, respectively.

1.3.5 Maintenance Shop

[Basic point]

The location and scale of a maintenance shop shall be determined so that the check and repair of containers and the inspection, management, and repair of vehicles and cargo handling equipment are performed smoothly.

[Reference]

(1) The maintenance shop is where the inspection of containers, cleaning before and after use, repair of damages, and maintenance and repair of vehicles and cargo handling equipment used in the container terminal or wharf are performed. It is usually located inside a building.

(2) Although the area of the maintenance shop differs according to the number of containers in a terminal; the type, scale, and inspection frequency of the vehicles and cargo handling equipment used in a terminal; the level of repair performed at the maintenance shop concerned; and others, approximately 800 to 2,000 m^2 per berth is needed in the foreign trade container terminal.

(3) The height of the entrance shall be at least that of vehicles and cargo handling equipment to be accommodated, and an overhead traveling crane is required as an ancillary facility. Furthermore, the power receptacle for reefer containers, compressors, welding machines, chargers, and others shall be installed.

The floor surface is usually paved with concrete.

(4) The width of the space in front of the maintenance shop shall need approximately 10 m if trailers go in and out and approximately 15 m if straddle carriers go in and out.

1.3.6 Administration Building

[Basic point]

The location and scale of an administration building shall be determined so that the administration and operation of the container terminal are performed smoothly.

[Reference]

(1) The administration building is where the administrative operation of container wharfs such as the administration of terminals, processing and management of information concerning cargos, and operation of container ships are performed. Specifically, the storage plan of containers in the terminal, cargo handling plan of container ships, cargo handling work plan and operation plan of cargo handling equipment in the yard, delivery operation of cargos and containers, management of cargo handling equipment, management of empty containers, and others are performed.

A container terminal for international trade generally has a scale of 1,000 to 5,000 m^2 and is usually two to four stories.

(2) A control tower from which it possible to oversee the entire container yard shall be erected so as to allow persons in charge to issue instructions to operators of cargo handling equipment and effectively manage cargo handling works. The control tower shall be established on the highest floor of the administration building.

1.3.7 Gate

[Basic point]

The location and scale of a gate shall be determined so that the three-point check of drivers who go in and out the container terminal, the inspection of containers, the weight measurement, and the transfer of documents are performed smoothly.

[Reference]

(1) The gate is where drivers, containers, and cargos that go in and out the container terminal are confirmed, where the container seal number is confirmed, where containers are inspected, where container weight is measured, where the required documents are transferred, and where the storage location of containers is directed. The foreign trade terminal shall have a gate house, an elevated passage for inspection, and usually one or two approximately 50-ton truck scales if necessary.

Moreover, a common gate jointly used by several terminals may be installed. This is considered to be effective in saving the gate area, improving the work efficiency, and others because the gate operation is aggregated in one location.

(2) The number of gates needs to be determined by considering the quantity of containers handled in the container terminal, the in-service time of a gate, the distribution of carried in and out containers, and the processing time of containers at the gate. The gate is often installed by dividing carrying in and out containers or loaded containers, empty containers, and general trucks.

The confirmation work at the gate may be performed before passing the gate as a prior check gate. This is considered effective to mitigate the traffic congestion resulting from a temporary increase in the number of vehicles passing the gate.

It is also necessary to select the location with consideration to the traffic movement in the container terminal and traffic on the secondary roads.

1.3.8 Other Attached Equipment

[Basic point]

Washing facilities, sewage disposal, gas station, substation equipment, parking lot, chassis storage, and others shall be constructed in the container terminal if necessary.

[Commentary]

Although this section is described on the basis of the feature of a container wharf, **Part III, Chapter 5, 9 Attached Equipment and Others of Mooring Facilities** shall be applied for the attached equipment not stated in this section.

[Reference]

(1) The washing facilities are where containers, vehicles, cargo handling equipment, and other equipment are washed, and the floor surface shall be paved with concrete. The sewage disposal is where sewage from washing facilities, maintenance shop, gas station, and others is oil separated and where effluent is treated. The final effluent must conform to a predetermined standard.

(2) The gas station is where vehicles, cargo handling equipment, and others are refilled with gas, and the floor surface shall be paved with concrete.

(3) The substation equipment provides electric power to the container terminal. Its capability determines the capacity of the substation equipment considering that all pieces of the electric apparatus do not often operate simultaneously and the demand factor, which considers the characteristics, quantity, frequency of use, and others of the electric apparatus versus the load equipment capacity.

Since cold storage facilities in summer usually require a constant power supply, sufficient planning is necessary.

Moreover, it is preferable to have an auxiliary circuit in preparation for an unexpected situation because the interruption of electric power supply due to power failure accidents paralyzes the functions of the container terminal.

(4) Securing sufficient waiting spaces (e.g., parking lot) outside of a gate is needed to eliminate the impacts of trailers waiting for gate passage on general traffic or obstacles to the smooth flow of port cargos in other terminals, particularly in ports where a lot of containers are handled. Furthermore, it is preferable to secure chassis storage for the purpose of improving the efficiency of the inland transportation of containers as a countermeasure for congestion in situations wherein chassis are left in a wharf.

Parking lots and chassis storage shall be placed at a suitable location in the container terminal or container wharf.

1.4 Estimation of the Scale of Container Terminal Area

[Basic point]

(1) The container terminal is located in a port as a nodal point of the marine transportation and land transportation of containers. It is an area for stevedoring work in container ships, temporary storage for cargo handling, storage and delivery of cargo and containers, and an area for loading and unloading cargos to/from containers and for cargo handling equipment required for containers and related facilities.

[Reference]

(1) Scale Estimation of Container Terminal Area

Fig. 1.4.1[1)] shows the procedure for the scale estimation of container terminal area.

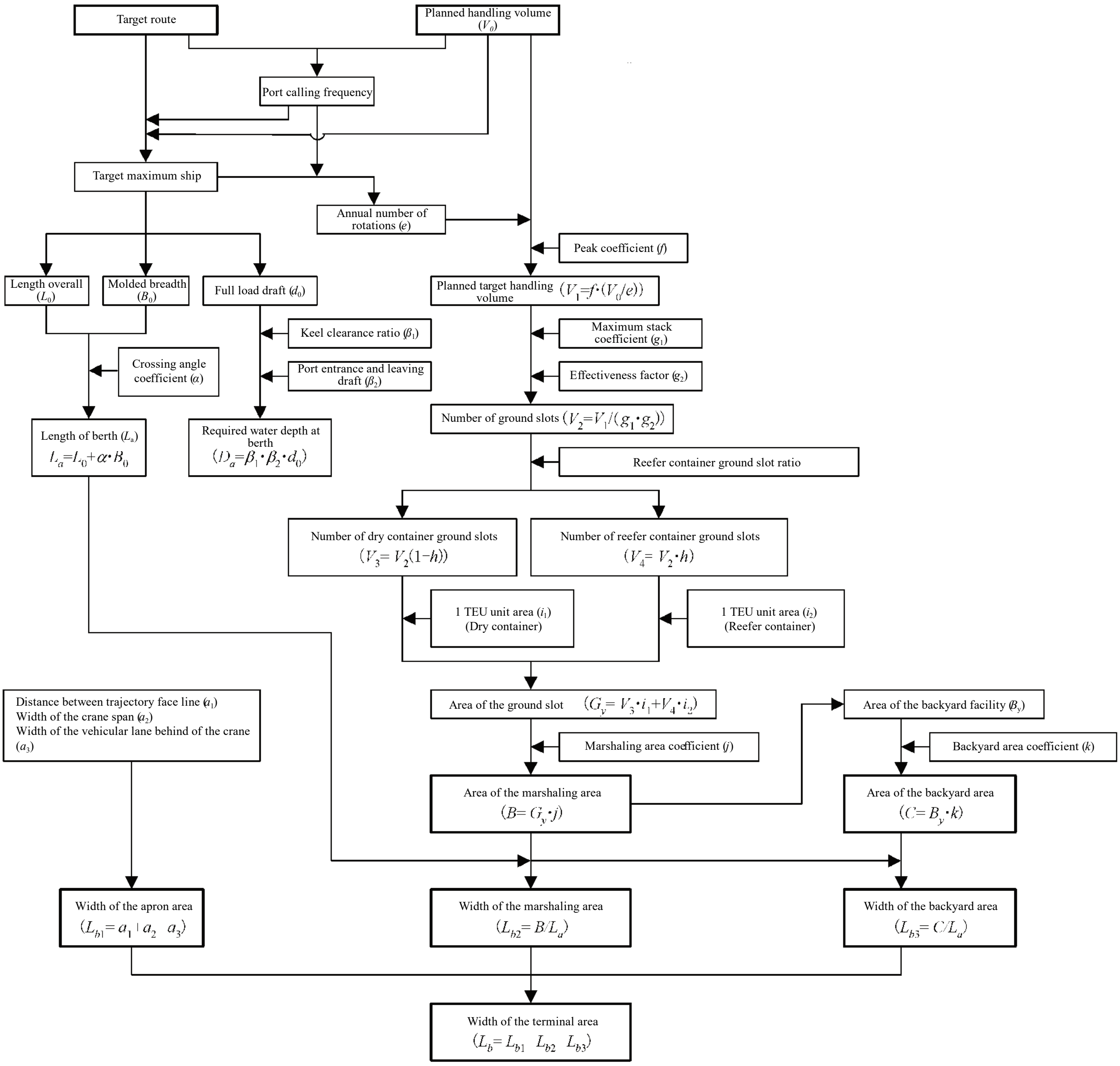

Fig. 1.4.1 Standard Scale Estimation Model of the Container Berth Terminal Area[1)]

(2) Methods (3) to (8), which were reported by Takahashi,[1)] can be used to calculate or set the scale of a container terminal area.

(3) Elements of Container Terminal

The container terminal mainly comprises the berth, apron area, marshaling area, and backyard area. Although two or more berths often share the backyard area, **Fig. 1.4.2**[1)] shows an example of a plan of a container terminal area where all elements are in one terminal.

① **Berth**

A berth is a predetermined place for container ships to berth and anchor to handle cargos in the container terminal, and its scale is set by the berth length L_a and water depth at berth D_a.

② **Apron area**

(a) The apron area is where container cranes and vehicles for cargo handling run, containers, and hatch covers of container ships are temporarily stored. Here L_{b1} in **Fig. 1.4.2**[1)] is the width of the apron area.

(b) The width of the apron area L_{b1} can generally be set from the distance between trajectory face lines, rail span of the container crane, and vehicular lane width.

③ **Marshaling area**

(a) The marshaling area is where the containers to be loaded to or unloaded from container ships are aligned. Here, L_{b2} in **Fig. 1.4.2**[1)] is the width of the marshaling area. The block in which containers are flatly stored according to their size is set in this marshaling area. This is called the ground slot and is set like an intersection on a go board (**Fig. 1.4.2**).[1)] The numbers are given to the blocks and containers are arranged at a predetermined grid according to the loading plan. There are areas for dry containers and for reefer containers that need power supply for freezing in this ground slot.

(b) The width of the marshaling area L_{b2} corresponding to the berth length can generally be set on the basis of the required scale of marshaling area, available land, number of stacks and equipment.

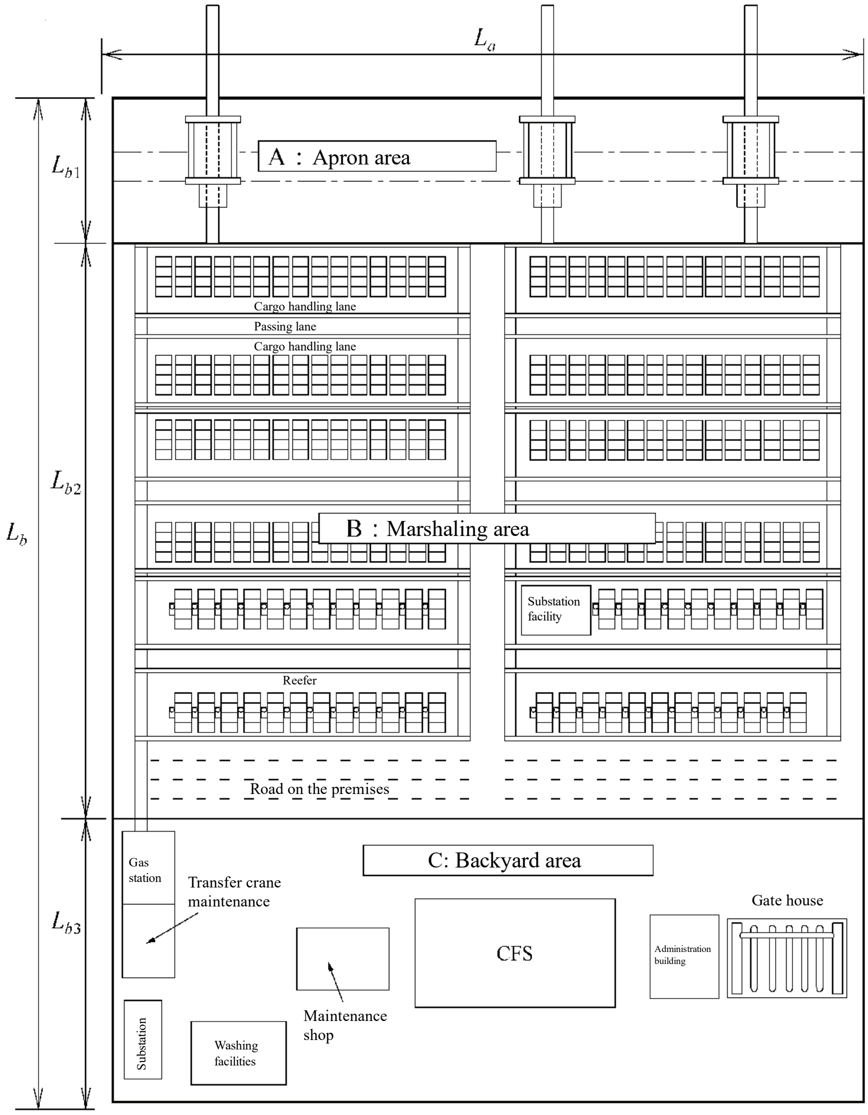

Fig. 1.4.2 Example of a Container Terminal[1)]

④ **Backyard area**

(a) The backyard area is where facilities such as the maintenance shop, administration building, and gate are located. Furthermore, the CFS may be located in this area. Here, L_{b3} in **Fig. 1.4.2**[1)] is the width of the backyard area. The outline of each facility is shown below. The expression “backyard area” is not common but is usually expressed as “container terminal” together with the marshaling area in many cases. However, the backyard area is set here to verify the performance concerning the scale of the container terminal area.

1) Container freight station

This is a building for delivery, temporary storage, loading to and unloading from containers, and other tasks involving small lot cargos. In the case of large-scale terminals, this is not often located in a container terminal but is owned by public carriers near the terminal.

2) Maintenance shop

A building where containers themselves are inspected and where damaged parts are repaired, cleaned before and after use, etc.

3) Administration building

A building where work in the whole yard such as direction, supervision, and others of the work plan in the yard and container arrangement plan are integrated and employed.

4) Gate

A facility where documents for carrying in and out container cargos to/from the container terminal, container number, port security information, damage to containers, and others are checked.

A facility where the yard carrying-in location of containers are indicated, and these data are registered in the terminal management system.

(b) The width of the backyard area L_{b3} corresponding to the berth length can generally be set on the basis of the required scale of the backyard area.

⑤ **Empty container storage**

The empty container storage is where empty containers for lending to or returned from shippers are stored. Although the empty container storage is included in the marshaling or backyard area, its area is not wider than the surplus of each area. If the required number is as many as the loaded containers, an area outside of the terminal shall be assumed.

(4) Berth

① **Length of the berth**

Refer to **Part III, Chapter 5, 2.1 Items Common to Quaywall** for the berth length of the container terminal.

② **Water depth at berth**

Refer to **Part III, Chapter 5, 2.1 Items Common to Quaywall** for the water depth at the berth of the container terminal.

(5) Apron Area

① The width of an apron area L_{b1} can be calculated by **equation (1.4.1)**.

$$L_{b1} = a_1 + a_2 + a_3 \tag{1.4.1}$$

where

a_1 : distance between trajectory face lines

a_2 : width of the rail span

a_3 : width of the vehicular lane behind the crane

② **Distance between trajectory face lines (a_1)**

The distance from the rail on the sea side to the quaywall face line shall be preferably set on the basis of the characteristics of the target container terminal by considering the installation of mooring posts, cable trench for container crane, cable winding equipment, hatchway of a moored container ship, etc. When performing the setting operation, a_1 = 3 to 4 m can be used as a reference value.[4)]

③ **Rail span width (a_2)**

It is preferable that a sufficient width for the same number of lanes as that of cranes used for container cargo handling plus one additional spare lane shall be secured as the rail span. Furthermore, it is preferable to add approximately 5 to 10 m as a pass for pedestrians and miscellaneous-use vehicles. Here, 5.0 m/lane for yard chassis and 5.5 m/lane for straddle carriers can be used as a reference value when setting the required width per lane under the crane.[4)]

When using three cranes per ship and a straddle carrier, the rail span width a_2 can be considered as follows:

a_2 = (3 + 1) lanes × 5.5 m/lane + 8 m (margin width) = 30 m

If the rail span set from the structure aspect of the crane is larger than this required lane width, it is necessary to set that value.

④ **Setting of the vehicular lane width behind the crane (a_3)**

It is preferable to appropriately set the vehicular lane width behind the crane considering specifications, margin width and others of the crane.

For example, in the case of a yard chassis, the vehicular lane behind the crane can be set as the value of the temporary storage of hatch covers (four rows: 11 m; five rows: 13.5 m)[4)] and the minimum lane width of 3.5 m[4)] plus the margin width of 3 m (for example, 20 m in the case of a five-row hatch cover). In the case of a straddle carrier, it may be 37 m (carrier revolution width of 22 m[4)] plus the margin width of 15 m).

⑤ **Standard value for the width of the apron area L_{b1}**

The apron area width L_{b1}, excluding the various conditions concerning the backyard area, can be set by referring to **Fig. 1.4.3**,[3)] which shows the track record value in domestic container terminals. In reference 3), an L_{b1} of 40 to 60 m when the water depth is less than 13 m and 50 to 80 m when the water depth is 13 m or more can be considered the standard value for the width of the apron area.

L_{b1} can be considered as follows when using three cranes per ship and a straddle carrier.

$L_{b1} = a_1 + a_2 + a_3$ = 3 m + 30 m + 37 m = 70 m

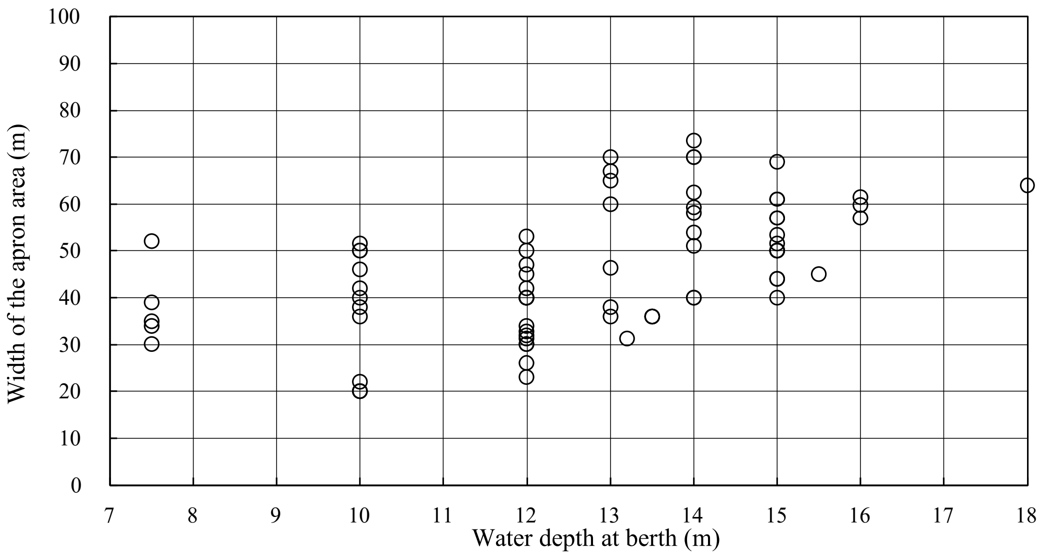

Fig. 1.4.3 Width of the Apron Area (L_{b1})[3)]

(6) Marshaling Area

① The area of the marshaling area can generally be calculated by the procedure shown in **Fig. 1.4.4** on the basis of the planned handling volume: V_0 (TEU).

Calculation of the number of target containers (V_1) to plan the marshaling area: **Equation (1.4.2)**

↓

Calculation of the number of ground slots (V_2): **Equation (1.4.3)**

↓

Calculation of the number of dry container ground slots (V_3): **Equation (1.4.4)**

↓

Calculation of the number of reefer container ground slots (V_4): **Equation (1.4.5)**

↓

Calculation of the area of the ground slot (Gy): **Equation (1.4.6)**

↓

Calculation of the area of the marshaling area (B): **Equation (1.4.7)**

Fig. 1.4.4 Example of the Procedure for Verifying the Performance of Area of the Marshaling Area

The area of the marshaling area can generally be calculated by following **equations (1.4.2)** to **(1.4.7)**.

$$V_1 = fV_0 / e \tag{1.4.2}$$

$$V_2 = V_1 / (g_1 g_2) \tag{1.4.3}$$

$$V_3 = V_2 (1 - h) \tag{1.4.4}$$

$$V_4 = V_2 h \tag{1.4.5}$$

$$G_y = V_3 i_1 + V_4 i_2 \tag{1.4.6}$$

$$B = G_y j \tag{1.4.7}$$

where

V_0 : planned handling volume (TEU)

V_1 : number of target containers to plan the marshaling area (TEU)

e : annual number of rotations (time/year)

$$e = D_y / D_t \tag{1.4.8}$$

where

D_y : annual number of work days (day)

D_t : average storage days in the yard (day)

f : peak coefficient

V_2 : number of ground slots (TEU)

g_1 : maximum stack coefficient

g_2 : effectiveness factor

V_3 : number of dry container ground slots (TEU)

h : reefer container ground slot ratio

V_4 : number of reefer container ground slots (TEU)

G_y : area of the ground slot (m^2)

i_1 : floor area per 1 TEU dry container (m^2)

i_2 : floor area per 1 TEU reefer container (m^2)

B : area of the marshaling area (m^2)

j : marshaling area coefficient

The width of the marshaling area L_{b2} can be calculated by **equation (1.4.9)** from the area of the marshaling area.

$$L_{b2} = B/L_a \quad \textbf{(1.4.9)}$$

where

B : area of the marshaling area (m^2)

L_a : length of the berth (m)

② It is preferable to set specific coefficients on the basis of the characteristics of the target container terminal. Refer to **Figs. 1.4.5**[3)] and **1.4.6**,[3)] which show the track record value in domestic container terminals, when performing the setting operation. References 1) and 4) show the following values for each coefficient:

D_t = 2 to 7 days (export)[3)];

D_t = 3 to 9 days (import)[3)]

f = 1.2 to 1.3[1)];

g_1: transfer crane = four to five stacks[3)];
straddle carrier = three to four stacks[3)];
reach stacker = two to three stacks[3)];
(Applicable to small-scale terminals with few annual handling volume and a water depth at berth of less than 13 m)

g_2: transfer crane 0.6 to 0.8[3)];
straddle carrier and reach stacker 0.65 to 0.8[3)];

h = 0.05 to 0.20[3)];

i_1 = (8 feet × 20 feet =) 14.9 m^2 [1)];

i_2 = 19.5 m^2 (set from the track record of domestic ports)[1)];

j = 2.0 to 4.0[3)].

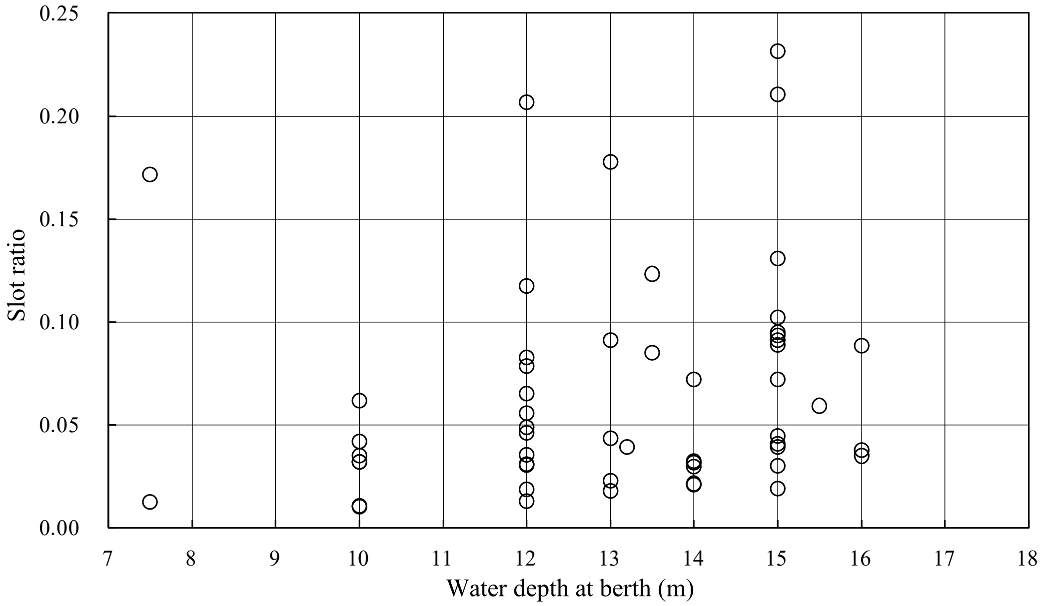

Fig. 1.4.5 Reefer Container Ground Slot Ratio (h)[3)]

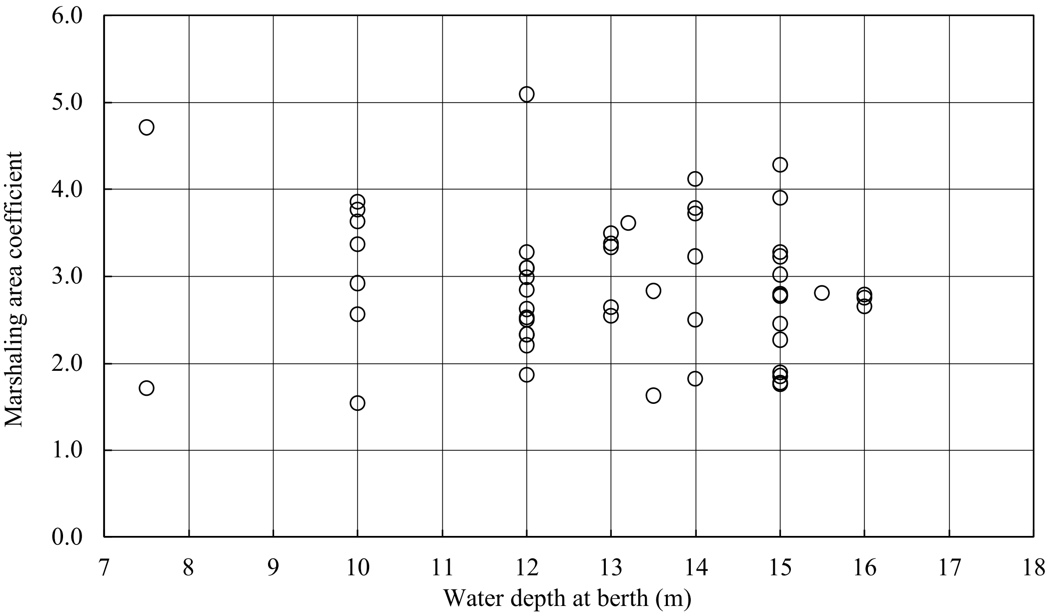

Fig. 1.4.6 Marshaling Area Coefficient (j)[3)]

③ **Reference values concerning the coefficient setting**

Given that it is not easy to set e, f, g_1, and g_2 separately, $f/(eg_1g_2)$, which unifies these, can generally be set as one coefficient.

It is preferable to set specific coefficient values on the basis of the characteristics of the target container terminal. Refer to **Fig. 1.4.7**,[3)] which shows the track record value in domestic container terminals, when performing setting operation. Reference 3) shows that $f/(eg_1g_2) = 0.005$ to 0.020.

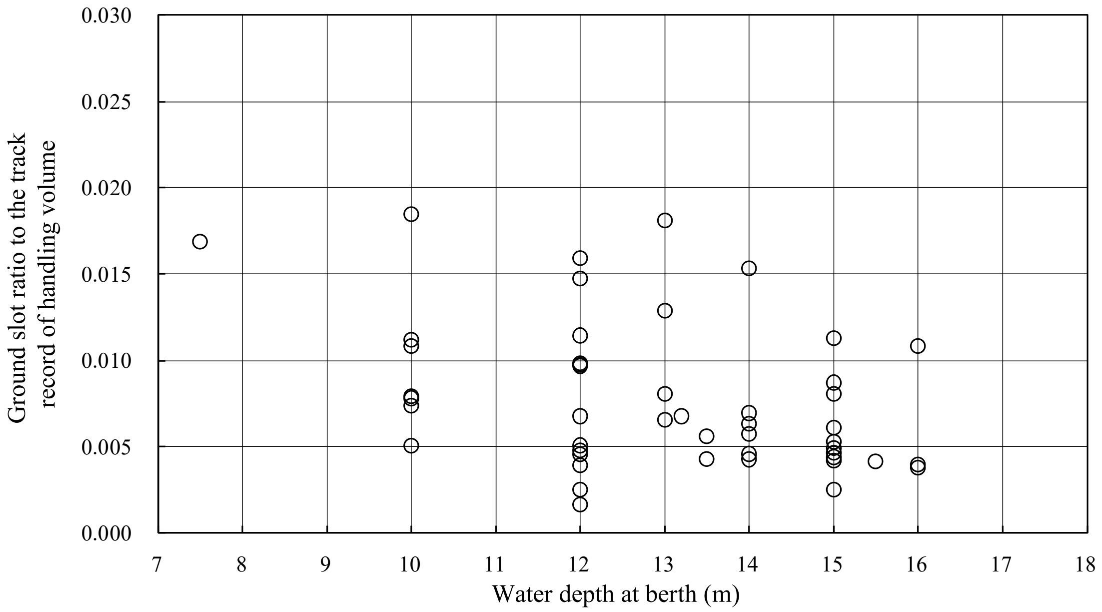

Fig. 1.4.7 Ground Slot Ratio (f/eg_1g_2) to the Track Record of Handling Volume[3)]

④ **Reference value concerning marshaling area**

The values that can be referred to when setting the marshaling area are shown below:

(a) Number of ground slots (V_2)

Fig. 1.4.8,[3)] which shows the track record value in domestic container terminals, may be referred to when setting the number of ground slots (V_2). Reference 3) shows the following values as the number of ground slots:

V_2 = 1,500 to 2,500 TEU (water depth at berth: less than 15 m);

V_2 = 1,500 to 3,000 TEU (water depth at berth: 15 m or more).

The following value can be referred to for a small-scale terminal:

V_2 = 500 to 1,500 TEU (small-scale terminal).

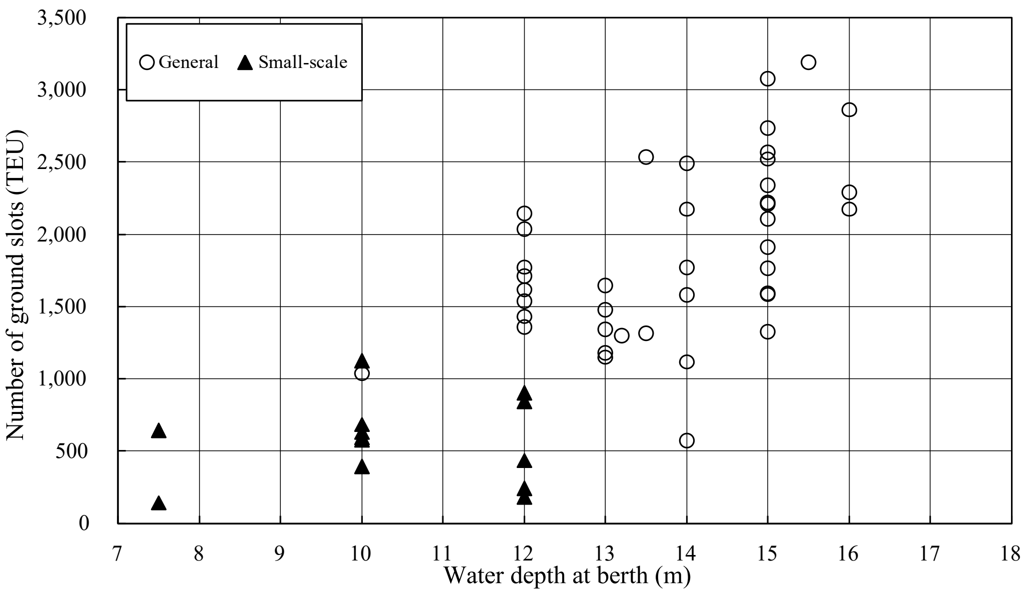

Fig. 1.4.8 Number of Ground Slots (V_2)[3)]

(b) Area of the marshaling area (*B*)

Fig. 1.4.9,[3] which shows the track record value in domestic container terminals, may be referred to when setting the area of the marshaling area B. Reference 3) shows the following values as the area of the marshaling area:

B = 40,000 to 100,000 m^2 (water depth at berth: less than 15 m);

B = 70,000 to 120,000 m^2 (water depth at berth: 15 m or more).

The following value can be referred to for a small-scale terminal:

B = 20,000 to 40,000 m^2 (small-scale terminal).

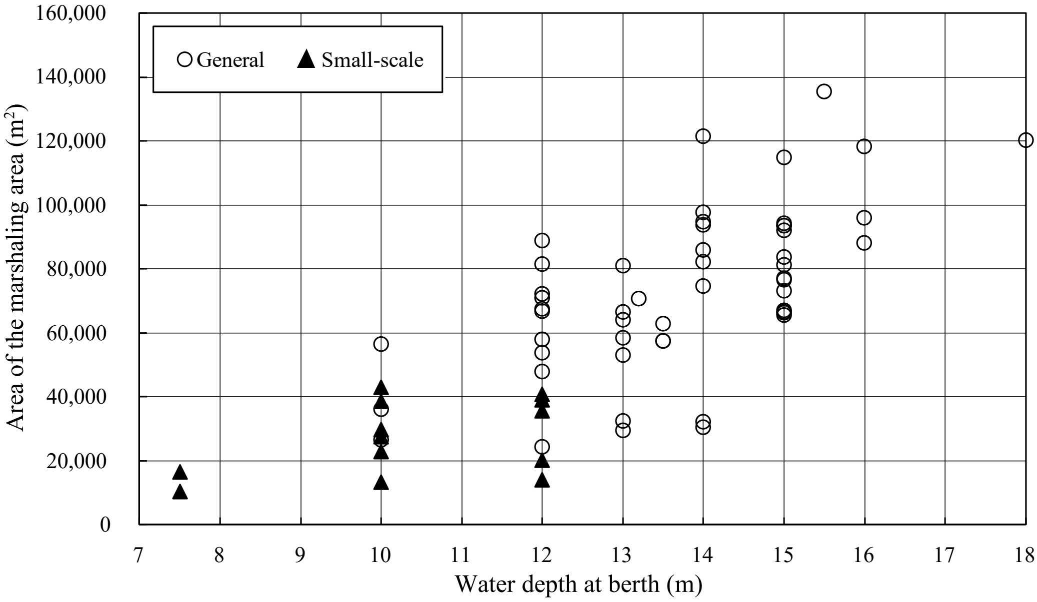

Fig. 1.4.9 Area of the Marshaling Area (*B*)[3]

⑤ **Standard value for marshaling area width L_{b2}**

The marshaling area width L_{b2}, excluding various conditions concerning the marshaling area, can be set by referring to **Fig. 1.4.10**,[3] which shows the track record value in domestic container terminals. **Reference 3)** shows the following value as the standard value for the width of the marshaling area:

L_{b2} = 150 to 350 m (general terminal).

The following value can be referred to for a small-scale terminal:

L_{b2} = 100 to 200 m (small-scale terminal).

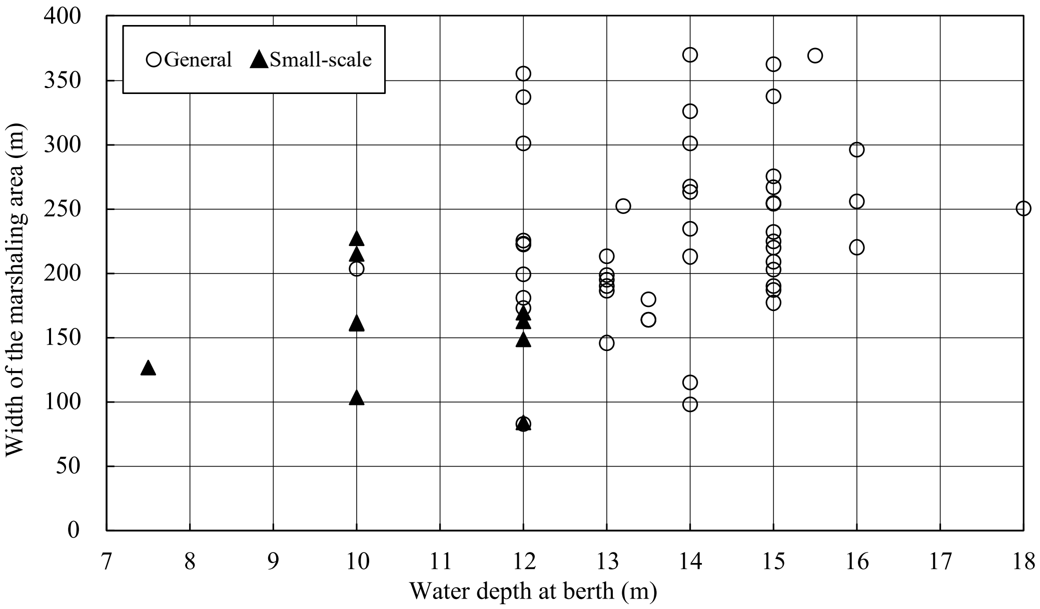

Fig. 1.4.10 Width of the Marshaling Area (L_{b2})[3)]

(7) Backyard Area

① The area of the backyard area can generally be calculated by the following:

$$C = B_y k \tag{1.4.10}$$

where

B_y : area of the backyard area facilities (floor area of CFS, maintenance shop, administration building, gate and others built in the backyard) (m^2)

k : backyard area coefficient

The width of the backyard area L_{b3} can be calculated by **equation (1.4.11)** from the area of the backyard area.

$$L_{b3} = C / L_a \tag{1.4.11}$$

where

C : area of the backyard area (m^2)

L_a : length of the berth

② It is preferable to set specific coefficients on the basis of the characteristics of the target container terminal. Refernces 1) and 2) show the following values for the area of the backyard area facilities B_y.

(a) Area of the backyard area facilities (B_y):

B_y = 7,500 m^2 (area of the marshaling area: less than 90,000 m^2);

B_y = 9,000 m^2 (area of the marshaling area: 90,000 m^2 or more);

B_y = 0.05B + 4,000 m^2 (when area of the marshaling area B is significantly larger than 90,000 m^2).

The following values can be referred to concerning the area of the area in each facility B_y[3) 4)]:

CFS: width (30 to 60 m) × length (100 to 180 m);

Maintenance shop: 800 to 1,000 m^2;

Administration building: 1,000 to 2,000 m^2;

Gate: 300 to 1,500 m^2.

(b) Backyard area coefficient (*k*):

k = 4.0 to 5.0[1].

③ **Standard value for the area of the backyard area *C***

The area of the backyard area C, excluding various conditions concerning the backyard area, can be set by referring to **Fig. 1.4.11**,[3] which shows the track record value in domestic container terminals. Literature 3) shows the following values as a standard value for the area of the backyard area:

C = 10,000 to 20,000 m^2 (water depth at berth: less than 13 m);

C = 10,000 to 60,000 m^2 (water depth at berth: 13 m or more).

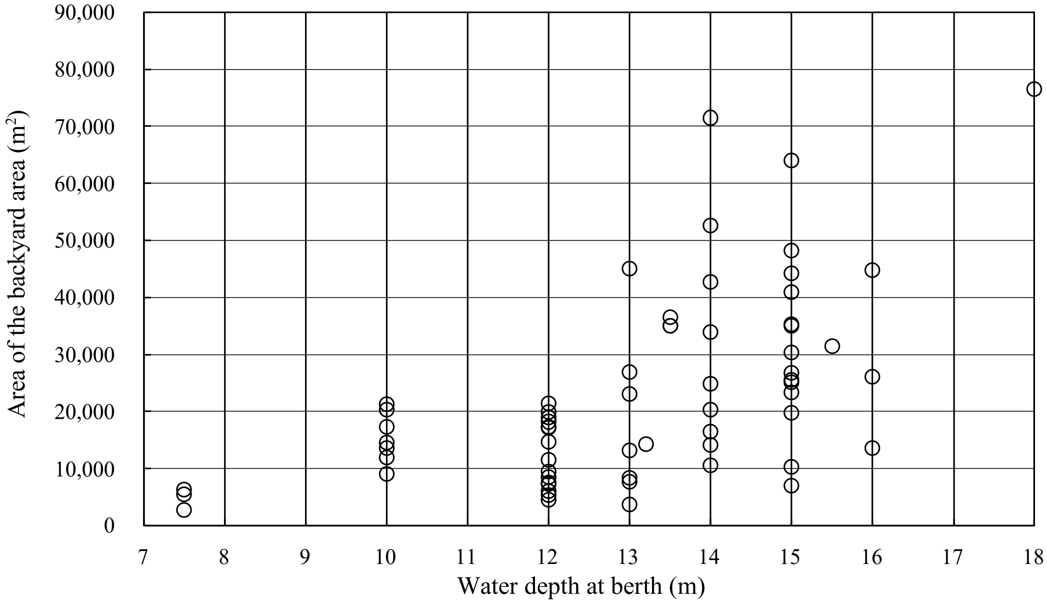

Fig. 1.4.11 Area of the Backyard Area (C)[3]

④ **Standard value for the width of the backyard area L_{b3}**

The width of the backyard area L_{b3}, excluding various conditions concerning the backyard area, can be set by referring to **Fig. 1.4.12**,[3] which shows the track record value in domestic container terminals. **Reference 3)** shows L_{b3} = 90 to 150 m as a standard value for the width of the backyard area.

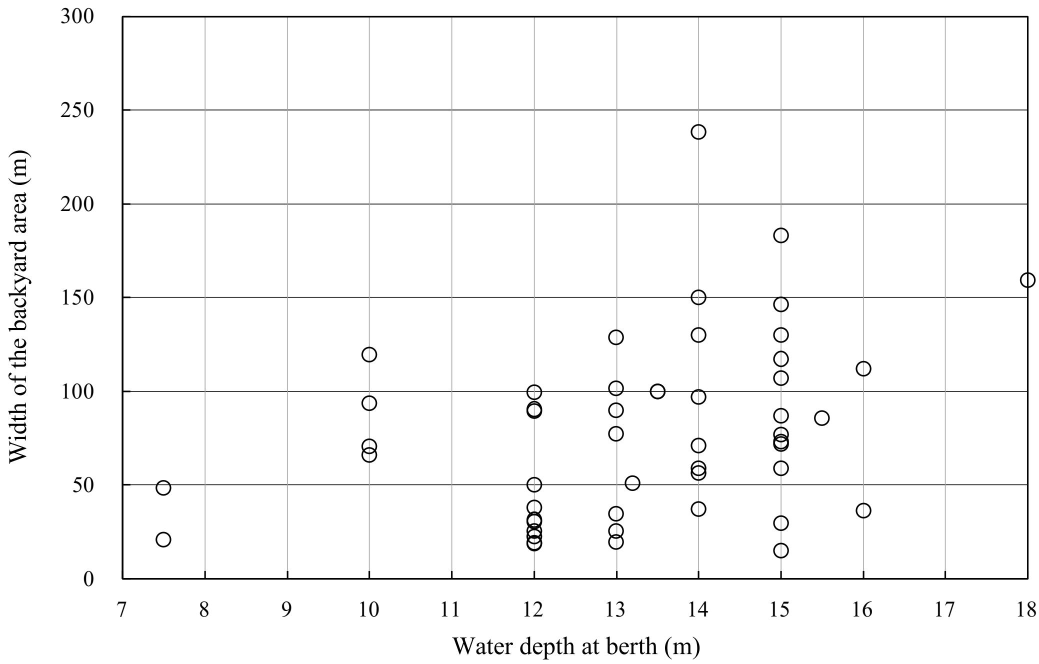

Fig. 1.4.12 Width of the Backyard Area (L_{b3})[3)]

(8) Width of the Container Terminal Area

① The width of the container terminal area L_b can be calculated by the following:

$$L_b = L_{b1} + L_{b2} + L_{b3} \tag{1.4.12}$$

where

L_{b1} : width of the apron area

L_{b2} : width of the marshaling area

L_{b3} : width of the backyard area

② **Standard value for the width of the container terminal area L_b**

The width of the container terminal area L_b, excluding various conditions concerning the container terminal area, can be set by referring to **Fig. 1.4.13**,[3)] which shows the track record value in domestic container terminals. **References 2)** and **3)** show the following values as a standard value for the width of the container terminal area corresponding to the water depth at berth:

L_b = 300 to 600 m (general terminal: water depth at berth: 16 m or less);

L_b = 400 to 700 m (water depth at berth: more than 16 m).

The following value can be referred to for a small-scale terminal:

L_b = 200 to 400 m (small-scale terminal).

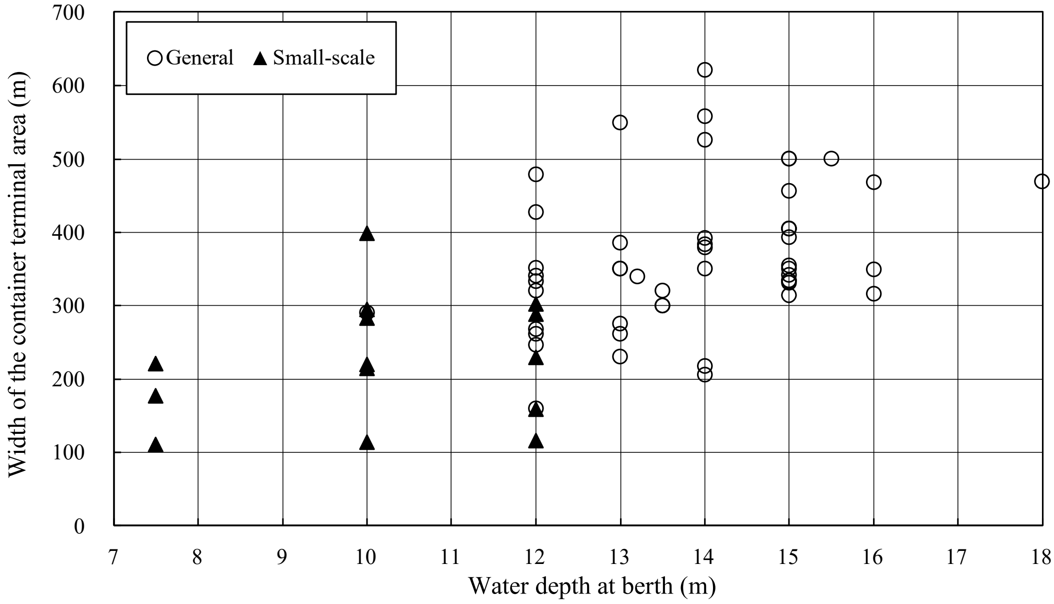

Fig. 1.4.13 Width of the Terminal Area (L_β)[3)]

[References]

1) Hironao Takahashi "A Model for estimating Scales of Container Terminal Areas at the Stage of Port and Harbor Planning- A Standard for Designing Principal Sizes in Container Terminals:A Proposal -",Research Report of NILIM No.10 June 2003

2) Yasuhiro Akakura "Dimension of Mega Container Ship and Berth Dimension / Container Terminal Area Compatible", Research Report of NILIM No.45 March 2011

3) Shoichi Emoto, Soichi Yamagata "An Analysis of the Container Terminal Areas",Technical Note of NILIM No.992 October 2017

4) "Report of Container Terminal Equipments Planning", Ports and Harbours Bureau, Ministry of Transport, Japan and OCDI, 1993

2 Cruise Wharves

(English translation of this section from Japanese version is currently being prepared.)

2.1 Purpose, Functions and Definition of Cruise Wharves

(English translation of this section from Japanese version is currently being prepared.)

2.2 Functions and Characteristics of Main Facilities as Constituent Parts of a Cruise Wharf

(English translation of this section from Japanese version is currently being prepared.)

2.3 Basic Concept of Required Performance

(English translation of this section from Japanese version is currently being prepared.)

2.4 Important Points to Consider in Determining the Layout and Sizes of Facilities as Constituent Parts of a Cruise Wharf

(English translation of this section from Japanese version is currently being prepared.)

2.5 Points to Consider for Improving Existing Facilities for Use with Cruise Ships

(English translation of this section from Japanese version is currently being prepared.)

2.5.1 General

(English translation of this section from Japanese version is currently being prepared.)

2.5.2 Points to Consider for Improving Mooring Facilities

(English translation of this section from Japanese version is currently being prepared.)

2.5.3 Other Facilities

(English translation of this section from Japanese version is currently being prepared.)

3 Ferry Wharves

(English translation of this section from Japanese version is currently being prepared.)

3.1 Purpose, Functions and Definition of Ferry Wharves

(English translation of this section from Japanese version is currently being prepared.)

3.2 Functions and Characteristics of Facilities Subject to the Technical Standards and Main Facilities as Constituent Parts of a Ferry Wharf

(English translation of this section from Japanese version is currently being prepared.)

3.3 Basic Concept of Required Performance and Other Requirements

(English translation of this section from Japanese version is currently being prepared.)

3.4 Important Points to Consider in Determining the Layout and Sizes of Facilities as Constituent Parts of a Ferry Wharf

(English translation of this section from Japanese version is currently being prepared.)

4 Marinas

(English translation of this section from Japanese version is currently being prepared.)

4.1 General Information about Marinas

(English translation of this section from Japanese version is currently being prepared.)

4.2 Basic Concept of Required Performance and Other Requirements for Various Facilities of Marinas

(English translation of this section from Japanese version is currently being prepared.)

4.3 Important Points to Consider in Determining the Layout and Sizes of Facilities as Constituent Parts of a Marina

(English translation of this section from Japanese version is currently being prepared.)

4.4 Design, Construction and Maintenance of Marinas and Required Considerations

(English translation of this section from Japanese version is currently being prepared.)

4.5 Countermeasures to be Taken at Marinas against Disasters

(English translation of this section from Japanese version is currently being prepared.)

5 Facilities for Very Large Crude Oil Carriers

(English translation of this section from Japanese version is currently being prepared.)

5.1 General Rules

(English translation of this section from Japanese version is currently being prepared.)

5.1.1 Scope of Application

(English translation of this section from Japanese version is currently being prepared.)

5.1.2 Definition

(English translation of this section from Japanese version is currently being prepared.)

5.2 Selection of Locations and Planning of Facilities

(English translation of this section from Japanese version is currently being prepared.)

5.2.1 Selection of Locations

(English translation of this section from Japanese version is currently being prepared.)

5.2.2 Face Lines of Berths

(English translation of this section from Japanese version is currently being prepared.)

5.2.3 Axes, Widths and Depths of Navigation Channels

(English translation of this section from Japanese version is currently being prepared.)

5.2.4 Areas of Basins

(English translation of this section from Japanese version is currently being prepared.)

5.3 Determination of Sizes

(English translation of this section from Japanese version is currently being prepared.)

5.4 Structural Types

(English translation of this section from Japanese version is currently being prepared.)

5.5 Basic Design Policies

(English translation of this section from Japanese version is currently being prepared.)

5.6 Design of External Forces and Loads

(English translation of this section from Japanese version is currently being prepared.)

5.6.1 Types of External Forces and Loads

(English translation of this section from Japanese version is currently being prepared.)

5.6.2 Berthing Forces of Ships

(English translation of this section from Japanese version is currently being prepared.)

5.6.3 Actions by Moored Ships

(English translation of this section from Japanese version is currently being prepared.)

5.6.4 Wind Pressure

(English translation of this section from Japanese version is currently being prepared.)

5.6.5 Wave Force

(English translation of this section from Japanese version is currently being prepared.)

5.6.6 Current Force

(English translation of this section from Japanese version is currently being prepared.)

5.6.7 Seismic Force

(English translation of this section from Japanese version is currently being prepared.)

5.6.8 Earth Pressure and Water Pressure

(English translation of this section from Japanese version is currently being prepared.)

5.6.9 Self-weight and Load

(English translation of this section from Japanese version is currently being prepared.)

5.7 Design of Stationary Mooring Facilities

(English translation of this section from Japanese version is currently being prepared.)

5.7.1 General

(English translation of this section from Japanese version is currently being prepared.)

5.7.2 Layout and Crown Height of a Dolphin

(English translation of this section from Japanese version is currently being prepared.)

5.7.3 External Force and Load Acting on a Dolphin

(English translation of this section from Japanese version is currently being prepared.)

5.7.4 External Force and Load acting on a Pier-type Mooring Facility

(English translation of this section from Japanese version is currently being prepared.)

5.7.5 Design of Piles

(English translation of this section from Japanese version is currently being prepared.)

5.7.6 Design of Jackets, Steel Sheet Piles and Caissons

(English translation of this section from Japanese version is currently being prepared.)

5.7.7 Fender Equipments

(English translation of this section from Japanese version is currently being prepared.)

5.7.8 Mooring Ship Facilities

(English translation of this section from Japanese version is currently being prepared.)

5.8 Design of Floating Mooring Facilities

(English translation of this section from Japanese version is currently being prepared.)

5.8.1 Design Procedures

(English translation of this section from Japanese version is currently being prepared.)

5.8.2 External Force and Load Acting on Floating Mooring Facilities

(English translation of this section from Japanese version is currently being prepared.)

5.8.3 Buoy Stabilization

(English translation of this section from Japanese version is currently being prepared.)

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(English translation of this section from Japanese version is currently being prepared.)

5.8.5 Design of Anchor Chains

(English translation of this section from Japanese version is currently being prepared.)

5.8.6 Fender Equipments

(English translation of this section from Japanese version is currently being prepared.)

5.9 Design of Sorting Facilities

(English translation of this section from Japanese version is currently being prepared.)

5.9.1 Loading Arms

(English translation of this section from Japanese version is currently being prepared.)

5.9.2 Design of Rubber Hoses

(English translation of this section from Japanese version is currently being prepared.)

5.9.3 Oil Pipes

(English translation of this section from Japanese version is currently being prepared.)

5.10 Design of Major Ancillary Facilities

(English translation of this section from Japanese version is currently being prepared.)

5.10.1 Fire Extinguisher Facilities

(English translation of this section from Japanese version is currently being prepared.)

5.10.2 Leaked Oil Treatment Facilities

(English translation of this section from Japanese version is currently being prepared.)

5.10.3 Stagnant Oil Removal and Replacement Equipments

(English translation of this section from Japanese version is currently being prepared.)

6 Submarine Pipelines

(English translation of this section from Japanese version is currently being prepared.)

6.1 General Rules

(English translation of this section from Japanese version is currently being prepared.)

6.1.1 Scope of Application

(English translation of this section from Japanese version is currently being prepared.)

6.1.2 Definition

(English translation of this section from Japanese version is currently being prepared.)

6.2 Selection of Routes

(English translation of this section from Japanese version is currently being prepared.)

6.3 Basic Design Policies

(English translation of this section from Japanese version is currently being prepared.)

6.4 Design External Forces and Loads

(English translation of this section from Japanese version is currently being prepared.)

6.4.1 Types of External Forces and Loads

(English translation of this section from Japanese version is currently being prepared.)

6.4.2 Wind Pressure

(English translation of this section from Japanese version is currently being prepared.)

6.4.3 Wave Force and Current Force

(English translation of this section from Japanese version is currently being prepared.)

6.4.4 Seismic Force

(English translation of this section from Japanese version is currently being prepared.)

6.4.5 Earth Pressure

(English translation of this section from Japanese version is currently being prepared.)

6.4.6 Water Pressure

(English translation of this section from Japanese version is currently being prepared.)

6.4.7 Self-weight and Surcharge

(English translation of this section from Japanese version is currently being prepared.)

6.4.8 Internal Pressure

(English translation of this section from Japanese version is currently being prepared.)

6.4.9 Impact Load Caused by Anchoring

(English translation of this section from Japanese version is currently being prepared.)

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(English translation of this section from Japanese version is currently being prepared.)

6.4.11 Effects of Temperature Change

(English translation of this section from Japanese version is currently being prepared.)

6.4.12 Load during Laying Operation

(English translation of this section from Japanese version is currently being prepared.)

6.5 Materials

(English translation of this section from Japanese version is currently being prepared.)

6.6 Design of Pipes

(English translation of this section from Japanese version is currently being prepared.)

6.6.1 Minimum Wall Thicknesses of Pipes

(English translation of this section from Japanese version is currently being prepared.)

6.6.2 Allowable Stress of Pipes

(English translation of this section from Japanese version is currently being prepared.)

6.6.3 Calculation of Intensity of Stress on Pipes

(English translation of this section from Japanese version is currently being prepared.)

6.6.4 Buckling

(English translation of this section from Japanese version is currently being prepared.)

6.6.5 Design of Pipe Joints

(English translation of this section from Japanese version is currently being prepared.)

6.6.6 Design of Bends

(English translation of this section from Japanese version is currently being prepared.)

6.6.7 Design of Valves

(English translation of this section from Japanese version is currently being prepared.)

6.6.8 Design of Risers

(English translation of this section from Japanese version is currently being prepared.)

6.7 Corrosion Control

(English translation of this section from Japanese version is currently being prepared.)

6.7.1 Coating

(English translation of this section from Japanese version is currently being prepared.)

6.7.2 Cathodic Protection

(English translation of this section from Japanese version is currently being prepared.)

6.8 Laying of Pipes

(English translation of this section from Japanese version is currently being prepared.)

6.8.1 General

(English translation of this section from Japanese version is currently being prepared.)

6.8.2 Crossing of Pipes

(English translation of this section from Japanese version is currently being prepared.)

6.8.3 Horizontal Distances to Existing Pipes

(English translation of this section from Japanese version is currently being prepared.)

6.8.4 Laying Depth

(English translation of this section from Japanese version is currently being prepared.)

6.8.5 Measures for Scour Prevention

(English translation of this section from Japanese version is currently being prepared.)

6.8.6 Dredging and Backfilling

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6.8.7 Prevention of Flotation

(English translation of this section from Japanese version is currently being prepared.)

6.8.8 Unburied Pipes

(English translation of this section from Japanese version is currently being prepared.)

6.9 Tests and Inspections of Pipes

(English translation of this section from Japanese version is currently being prepared.)

6.9.1 Non-destructive Inspection of Welds

(English translation of this section from Japanese version is currently being prepared.)

6.9.2 Pressure Test

(English translation of this section from Japanese version is currently being prepared.)

6.9.3 Evaluation of Integrity of Existing Submarine Pipelines

(English translation of this section from Japanese version is currently being prepared.)