Chapter 6 Port Transportation Facilities

1 General

Ministerial Ordinance

General Provisions

Article 35

1 The performance requirements for port transportation facilities shall be such that the port transportation facilities satisfy the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism so as to enable the safe and smooth usage of vehicles and ships in consideration of its facility type in light of geotechnical characteristics, meteorological characteristics, sea states and/or other environmental conditions, as well as the traffic conditions in the port and its hinterland.

2 The performance requirements for port transportation facilities shall be such that port transportation facilities have structural stability against self weight, earth pressure, water pressure, waves, water currents, earthquake ground motions, imposed loads, winds, flames and heat from fires, collision with ships and/or other actions.

Ministerial Ordinance

Necessary Items concerning Port Transportation Facilities

Article 40

The items necessary for the performance requirements of port transportation facilities as specified in this chapter by the Minister of Land, Infrastructure, Transport and Tourism and other requirements shall be provided by the Public Notice.

Public Notice

Port Transportation Facilities

Article 74

The items to be specified by the Public Notice under Article 40 of the Ministerial Ordinance concerning the performance requirements of port transportation facilities shall be provided in the subsequent article through Article 79.

Public Notice

Performance Criteria Common to Port Transportation Facilities

Article 75

The performance criteria common to port transportation facilities shall be such that port transportation facilities are appropriately located and have the required dimensions in consideration of the trip generation, the projected traffic volume, the environmental conditions to which they are subjected, smooth connection with other traffic facilities, the utilization of other traffic facilities, and others so as to secure the safe and smooth traffic in the port.

2 Roads

Ministerial Ordinance

Performance Requirements for Roads

Article 36

1 The performance requirements for roads shall be as specified in the subsequent items:

(1) Roads shall satisfy the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism so as to ensure the safe and smooth flow of traffic within the port and between the port and the hinterland in consideration of the traffic characteristics in the port.

(2) Damage due to imposed loads shall not adversely affect the continued use of the relevant roads without impairing their functions.

2 In addition to the provisions of the preceding paragraph, the performance requirements for roads having tunnel sections shall be as specified in the subsequent items:

(1) Damage due to self weight, earth pressure, water pressure, and Level 1 earthquake ground motions, and/or other actions shall not adversely affect the continued use of the relevant roads and not impair their functions.

(2) Damage due to Level 2 earthquake ground motions, flames and heat from fires, and/or other actions shall not affect restoration through minor repair works of the functions required for the roads concerned.

[Technical Note]

Tunnels

Stability of facility

It is necessary to ensure the restorability in an accidental situation regarding Level 2 earthquake ground motion and flames and heat from a fire. This is specified considering the facts that when a tunnel is heavily damaged as a result of the effect of the accidental situation, there are serious consequences on human lives, properties and/or social and economic activities and it is difficult to perform large-scale restoration work in the tunnel.

Public Notice

Performance Criteria of Roads

Article 76

The performance criteria of roads shall be as specified in the subsequent items:

(1) In the case of a road which is used by many tractor-semitrailers and others, the tractor -semitrailers may be set as the design vehicle.

(2) The pavement structure shall be appropriately specified in consideration of the traffic volume of special vehicles such as tractor-semitrailers and mobile cranes.

(3) The lanes and others shall satisfy the following criteria so as not to cause traffic congestion in the port area:

(a) The number of lanes shall be appropriately set in consideration of the projected traffic volume, which is determined by taking account of the utilization conditions of the port situated near the road concerned, and the design standard traffic volume, which is the maximum allowable vehicle traffic volume per hour on the road.

(b) The lane width shall be 3.25m or 3.5m in principle. Provided, however, that the lane width of 3.5 m shall be the standard in the case where the traffic of large vehicles is heavy, and the lane width may be reduced to 3m under unavoidable circumstances such as the constraints of topographical conditions and others.

(c) A stopping lane shall be provided in the leftmost part of the road as necessary so that it may not hinder the safe and smooth passage of vehicles.

(4) Roads that are exclusively used for pedestrians and bicycles shall have appropriate structure in consideration of the utilization conditions of the facilities of the port situated near the road concerned.

(5) In case of the roads on which special vehicles such as tractor-semitrailers carrying tall containers,

mobile cranes and others are expected to travel, the clearance limits of the road shall be appropriately set so as to secure the safe passage of these vehicles.

(6) Roads that are connected to the high earthquake-resistance facilities shall be appropriately routed so as to secure the functions required for the facilities concerned in the aftermath of the action of Level 2 earthquake ground motions.

(7) With regard to the structure, place and facilities of roads, the matters which are not prescribed in the preceding items shall be pursuant to the provisions of the Enforcement Regulations for Road Structures (Cabinet Order No. 320 of 1970) in consideration of the characteristics of the traffic generated in the port.

[Commentary]

(1) Performance Criteria of Roads

Lanes

(a) Number of lanes

1) When verifying the performance of a road, the number of lanes may be set based on the values of the design standard traffic volume according to the type of the road shown in **Attached Table 61**.

Attached Table 61 Design Standard Traffic Volume

Type of Road	Design standard traffic volume (vehicles per hour)
Roads that connect a port and a national highway	650
Other roads	500

2) Setting of the number of lanes
The number of lanes of a road for which the design hourly traffic volume (to and from) is less than the design standard traffic volume shall be two (one lane for each direction excluding climbing lanes, turning lanes and gear change lanes; hereinafter the same), and the number of lanes of a road for which the design hourly traffic volume exceeds the design standard traffic volume shall be a multiple of two which is 4 (two lanes for each direction) or more. The number of lanes of a road for which the design hourly traffic volume exceeds the design standard traffic volume may be determined based on the value which is calculated by dividing "the design hourly traffic volume for each direction" obtained by multiplying the design hourly traffic volume by the heavier-traffic directional factor representing directional characteristics by "the per-lane design standard traffic volume" shown in **Attached Table 62**.

Attached Table 62 Per-lane Design Standard Traffic Volume

Type of Road	Per-lane Design Standard Traffic Volume (vehicles per hour)
Roads that connect a port and a national highway etc.	600
Other roads	350

[Technical Note]

2.1 Fundamentals of Performance Verification

When setting the design traffic volumes for the performance verification of a road, the originating and terminating traffic volume may be generally estimated according to the characteristics of the relevant port, by categorizing the traffic volumes into the traffic volume associated with physical distribution in and around the port and the traffic volume associated with the industries located in and around the port, the traffic volume associated with such facilities as green areas and marinas.

2.2 Carriageway and Lanes

(1) In general, it is preferable to set the numbers of lanes according to the sequence shown in **Fig. 2.2.1**. 1)

Estimation of the originating and terminating traffic volume

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Estimation of the design daily traffic volume

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Estimation of the design hourly traffic volume

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Setting of the number of lanes by comparing the design hourly traffic volume with the design standard traffic volume

Fig. 2.2.1 Example of Procedure for Setting Number of Lanes

(2) Estimation of the Originating and Terminating Traffic Volume of a Road in a Port

① Basic principles for estimation

It is preferable that the trip generation and attraction, which is the base for calculating the design traffic volume, be estimated according to the characteristics of the target port. In addition, the originating and terminating traffic volume may be estimated by categorizing the traffic volumes into the traffic volume associated with physical distribution, the traffic volume associated with the industries located in and around the port, and the traffic volume associated with such facilities as green areas and marinas.

② Estimation method for the traffic volume associated with physical distribution

(a) The traffic volume associated with physical distribution may be estimated using the basic units which are obtained from the past records or forecasts of the cargo handling volume in the port (FT unit), and the number of containers handled in the port (TEU unit). It is preferable to determine the basic units based on the past records of the cargo handling volume and container handling volume in the ports of which characteristics are similar to that of the target port and the actual records of the traffic volume obtained from the actual condition survey data, and road traffic censuses. However, when it is difficult to estimate these basic units, the following estimation methods may be used as a reference.

The concept of setting the coefficient here may also apply to the setting of other coefficients in the performance verification of roads.

(b) Estimation method based on the cargoes handling volume in the port (FT/year) for the case of cargo other than containers

1) Estimation method using the total cargo handling volume in the port

The trip generation and attraction per year may be estimated using equation **(2.2.1)** based on the total cargo handling volume in the port (FT/year) at the target year.

$$\text{Trip generation and attraction per year (vehicles/year)} = \text{Total quantity of cargoes handled in the port} \cdot a_0 bc \qquad (2.2.1)$$

where,

a_0 : coefficient for conversion into the number of loaded large vehicles which carries cargoes, which cover all commodity items
a coefficient for conversion into the number of loaded large vehicles which carries cargoes (vehicles/FT), which is the reciprocal value of the capacity tonnage per a large vehicle which carries cargoes (FT/vehicle), on the assumption that most of the cargoes handled in ports are transported by large vehicles.

b : coefficient for conversion into the number of all large vehicles
the ratio of the number of all large vehicles including empties to the number of large vehicles which carry cargoes.

c : coefficient for conversion into the number of all vehicles
the ratio of the number of all vehicles including small and medium vehicles to the number of all large vehicles. The reciprocal of c represents the share of large vehicles.

2) Estimation method using the item-specific cargo handling volume in the port

In cases where the volume of certain cargo items are especially large, the annual trip generation and attraction per year may be estimated using equation **(2.2.2)** based on the item-specific cargo handling volume in the port (FT/year) at the target year.

Trip generation and attraction per year (vehicles/year)

$$= \{ \sum_{i=1}^{n} (\text{cargo handling volume by item in the port } a_i)\} bc \qquad (2.2.2)$$

where,

a_i : coefficient for conversion into the number of large vehicles which carry cargoes by item
a coefficient for conversion into the number of large vehicles which carries cargoes (vehicles/FT), which is the reciprocal value of the capacity tonnage per a large vehicle which carries item-specific cargoes (FT/vehicle), on the assumption that most of the cargoes handled in ports are transported by large vehicles.

b : coefficient for conversion into the number of all large vehicles

c : coefficient for conversion into the number of all vehicles

(c) Estimation method based on the number of containers handled in the port (TEU/year)
(for the case of container cargoes)

The trip generation and attraction per year may be estimated using equation **(2.2.3)** based on the number of containers handled in the port (TEU/year) at the target year.

Trip generation and attraction per year (vehicles/year)

$$= \text{Number of containers handled in the port} \bullet (1-T_r)F_c B_c \alpha_c \beta_c \gamma_{ci} \delta_c \qquad (2.2.3)$$

where,

T_r : Transshipment ratio
A coefficient to subtract the number of containers transshipped at the terminals from the number of containers handled in the port (TEU/year) by the subtraction (1-T_r).

F_c : Full container ratio
The ratio of the number of full containers to the number of non- transshipped containers, which is used to calculate the number of containers transported from the terminals to the hinterland.

B_c : Extension coefficient to include the flow of empty containers
The transport of a full container into or out of the port is always accompanied by the transport of an empty container. For this reason, B_c is used to convert the number of transports of full containers into the number of transports of both full and empty containers. The maximum value of 2.0 is generally set for B_c, but a smaller value may be used in cases where it is expected that the container van transport becomes more efficient. For domestic trade containers, a value between 1.0 and 1.5 may be used for B_c because empty containers are less transported.

α_c : Coefficient for conversion into the actual number of vehicles which carry containers
In a port, 20-feet containers and 40-feet containers are handled together. Normally, the transport of a 20-feet container requires one vehicle, while the transport of a 40-feet container also requires one vehicle. For this reason, α_c is used to convert the number of containers expressed in the TEU unit (i.e. twenty-foot equivalent unit) to the actual number of containers.

β_c : Coefficient for conversion into the number of all container-related vehicles
A coefficient to convert the number of vehicles which carry containers into the number of all container-related vehicles including the head vehicles and chassis tractors which do not carry containers.

γ_{ci} : Coefficient for conversion into the number of all large vehicles
A coefficient to convert the number of all container-related vehicles into the number of all large vehicles including ordinary large cargo vehicles. The coefficient γ_{ci} has the following two coefficients according to the conditions of the target area.

γ_{c0} : For cases where it is assumed that an integrated physical distribution center is not constructed

γ_{c1} : For cases where it is assumed that an integrated physical distribution center is constructed

δ_c : Coefficient for conversion into the number of all vehicles
The ratio of the number of all vehicles including small and medium vehicles to the number of all large vehicles. The reciprocal of δ_c represents the occupancy ratio of large vehicle.

③ Estimation method of the traffic volume associated with the industries located in and around the port

(a) The traffic volume associated with the industries located in and around the port may be estimated using the basic units which are obtained from the past records or forecasts, based on the lot area, total floor space, and number of employees of the industries. It is preferable to determine the basic units based on the actual conditions of the industries in the ports which are similar to the examined target port such as the lot area, total floor space, number of employees and the past results of traffic volume which are obtained from the actual condition survey data, and road traffic censuses. However, when it is difficult to estimate these basic units, the following estimation methods may be used as a reference.

(b) Estimation method using the basic units presented in the **National Survey on the Net Movement of Cargoes (Physical Distribution Census)** [3)]

The traffic volume associated with the industries located in and around the port may be generally estimated using the staged estimation method shown in **Fig. 2.2.2**.

Assumption of the lot area and number of employees of the industry by type of business

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① Estimation of the incoming and outgoing cargo volume (MT unit) using the basic units for the incoming and outgoing cargo volume per lot area (m^2) by type of business
② Estimation of the incoming and outgoing cargo volume (MT unit) using the basic unitsfor the incoming and outgoing cargo volume per one employee by type of business

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Setting of the incoming and outgoing cargo volume (MT unit) through comparative examination of the estimation results of both ① the lot areas and ② the numbers of employees

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Estimation of the annual incoming and outgoing cargo volume by type of business (MT unit) carried by automobile using the automobile transport share by type of business and the following formula:
Annual incoming and outgoing cargo volume by type of business (automobile) =
Annual incoming and outgoing cargo volume by type of business ×automobile transport share

↓

Estimation of the annual incoming and outgoing cargo volume from the annual incoming and outgoing cargo volume carried by automobile (MT unit) using equation **(2.2.4)** or **(2.2.5)**

Fig. 2.2.2 Estimation Method of the Traffic Volume associated with the Industries Located in and around the Port based on the "National Survey on the Net Movement of Cargoes"

1) In the case of an estimation intended for the total value of all items:

$$\text{Trip generation and attraction per year (vehicles/year)} = \left\{ \sum_{i=1}^{n} \text{(annual incoming and outgoing cargo volume by type of business (transported by automobile transport))} \right\} \cdot a_{MT0} bc \tag{2.2.4}$$

2) In the case of estimation intended for the values by type of business (by item):

$$\text{Trip generation and attraction per year (vehicles/year)} = \left\{ \sum_{i=1}^{n} \text{(annual incoming and outgoing cargo volume by type of business (transported by automobile)} \; a_{MTi} \right\} bc \tag{2.2.5}$$

where,

a_{MT_0} : coefficient for conversion into the number of loaded large vehicles which carry cargoes (intended for all items)
A coefficient for conversion into the number of loaded large vehicles which carry cargoes (vehicles/MT), which is the reciprocal value of the capacity tonnage per a large vehicle which carry cargoes (MT/vehicle), on the assumption that most of the incoming and outgoing cargoes are transported by large vehicles.

a_{MT_i} : coefficient for conversion into the number of loaded large vehicles which carry cargoes (intended for the values by item)
A coefficient for conversion into the number of loaded large vehicles which carry cargoes (vehicles/MT), which is the reciprocal value of the capacity tonnage per a large vehicle which carry cargoes by item (MT/vehicle), on the assumption that most of the incoming and outgoing cargoes are transported by large vehicles.

b : coefficient for conversion into the number of all large vehicles

c : coefficient for conversion into the number of all vehicles

④ Estimation method of the traffic volume associated with green areas, marinas and other facilities

(a) The traffic volume associated with green areas, marinas and other facilities may be estimated using various basic units obtained from past results and forecasts. It is preferable to determine the basic units based on the size and capacity of the existing facilities which are similar to those of the target facilities, and the past results of the traffic volume obtained from the field survey data, road traffic censuses and other sources. However, when it is difficult to estimate these basic units, the following estimation methods may be used as a reference.

(b) Estimation method of the traffic volume associated with green areas
The traffic volume associated with green areas may be estimated in terms of the peak daily traffic volume, usually using equation **(2.2.6)** and equation **(2.2.7)**.

$$\begin{aligned}&\text{Peak traffic volume per day (vehicles/day)}\\&\quad = \text{Number of peak users per day} \cdot P_a \cdot P_b \cdot\\&\qquad \text{Round trip traffic volume conversion coefficient}\end{aligned} \tag{2.2.6}$$

$$\begin{aligned}&\text{Number of peak users per day (persons/day)}\\&\quad = \text{Total area of the green areas (m}^2) \cdot \left(\frac{1}{\text{area of green area per person (m}^2)}\right)\\&\qquad \cdot \text{Turnover number}\end{aligned} \tag{2.2.7}$$

Return trip traffic volume conversion coefficient = 2

where,

P_a : Utilization rate of automobiles to visit green areas

P_b : Passenger vehicle conversion coefficient(=1 / average number of boarding persons)

(c) Estimation method of the traffic volume associated with marinas
The traffic volume associated with marinas may be estimated in terms of the daily traffic volume, usually using equation **(2.2.8)**.

$$\begin{aligned}&\text{Peak traffic volume per day (vehicles/day)}\\&= \text{Round trip traffic volume conversion coefficient} \cdot \text{Number of stored ships} \cdot\\&\text{Peak daily utilization rate} \cdot \text{Number of vehicles used per ship}\end{aligned} \tag{2.2.8}$$

(d) Traffic volume associated with ferries
With regard to the traffic volume associated with a ferry, it is necessary to estimate the peak hourly traffic volume intended for the maximum number of vehicles that disembark from the ferry. The peak hourly traffic volume may usually be obtained using equation **(2.2.9)**. The term “maximum number of disembarking vehicles in the operation cycle” stands for, for example, in cases where ferries operate several times a day, “the largest number of vehicles that disembark from a ferry during the day” or in cases where ferries operate several times a week, “the largest number of that during the week”.

$$\begin{aligned}&\text{Peak traffic volume per hour (vehicles/hour)}\\&\quad = \text{Maximum number of disembarking vehicles}\\&\qquad \text{in the operation cycle (vehicles/hour)}\end{aligned} \tag{2.2.9}$$

(e) Traffic volumes associated with other facilities
It is also necessary to set the traffic volumes associated with facilities other than those described above according to the characteristics of the target port.

(4) Estimation of the Design Daily Traffic Volumes for Roads in a Port

① Outline of the 4-stage estimation method

(a) In general, when estimating the design daily traffic volumes, it is preferable to use the 4-stage estimation method based on the incoming and outgoing traffic volume, which is a technique for traffic planning. The 4-stage estimation method is the technique to estimate traffic volumes in 4 stages as shown in **Fig. 2.2.3.** [6)]

Estimation of the incoming and outgoing traffic volume

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Estimation of the distributed traffic volume

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Estimation of the traffic volume shared by each transportation mode

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Estimation of the assigned traffic volume

Fig. 2.2.3 4-stage Estimation Method

(b) Estimation of the trip generation and attraction
In the trip generation and attraction estimation stage, the total trip number in the target area is firstly predicted, and then the trip generation and attraction (T_i,T_j) values for the individual zones in the target area are estimated. The trip generation and attraction in each zone are predicted using the basic unit method and the regression models. For the road in a port, the method presented in **(2)** may be applied.

(c) Estimation of the distributed traffic volume
In the distributed traffic volume estimation stage, the traffic volume between zone i and zone j (T_{ij}) is estimated by associating the incoming traffic volume for zone i (T_i) with the outgoing traffic volume for zone j (T_j), which were estimated in the incoming and outgoing traffic volume estimation stage. Models to estimate the distributed traffic volume are generally classified into the current pattern method and the gravity model method.

(d) Estimation of the traffic volume shared by each transportation mode
The third stage of the 4-stage estimation method is to predict the shares of each transportation mode such as automobiles and railway. However, in cases where only automobile transportation is premised from the beginning, this stage is omitted.

(e) Estimation of the assigned traffic volumes
In the assigned traffic volume estimation stage, the routes on which the previously estimated inter-zone traffic volumes occur are predicted. In this assigned traffic volume estimation process, it is necessary to set the network, the costs required for each route and the route selection criteria. The assigned traffic volumes by each route basically represent the design daily traffic volumes for the target road

② Considerations in estimation of design daily traffic volume in surrounding area as whole

First, in cases where the passing traffic volume which does not have a point of origin or terminus in the port is assumed to be large, it was considered necessary to estimate the design daily traffic volume based on a 4-stage estimation method, based on an integrated with the city plan or road plan of the hinterland city. When estimating the design daily traffic volume based on this type of integrated road network, it is necessary to consider the following points.

(a) Compatibility of assumed object day

It is the general practice to use the annual average of daily traffic volume as the daily traffic volume in city plans and road plans. In this case, the trip generation and attraction related to the port is converted to a daily unit by the method presented previously, and added to the daily traffic volume in the city plan or road plan.

However, there are cases in which it is preferable to estimate for the peak month or peak day of the week rather than the annual average of daily traffic volume. In this case, the values are converted using equation **(2.2.10)** or **(2.2.11)**, respectively, and added to the traffic volume.

Daily traffic volume (vehicles/day) in peak month
= Trip generation and attraction per year $\cdot\, m$ (2.2.10)

$$\text{Daily traffic volume (vehicles/day) on peak day of week} = \text{Trip generation and attraction per year} \cdot w \qquad (2.2.11)$$

where,

m = monthly peak ratio

w = day-of-week peak ratio

(b) Adjustment of the share of large vehicles

In general, the share of large vehicles in the port-related traffic volumes is larger than that in the traffic volumes for which the city planning or the road planning is intended. Therefore, adding of traffic volumes based on the actual number of vehicles under the condition where both shares of large vehicles differ leads to underestimation of the port-related traffic volumes. As a result, it gives the inordinate burden in excess of the actual condition to the hinterland.

Therefore, when the ratio of large vehicles to all vehicles derived in the process of estimating the incoming and outgoing traffic volume associated with ports is different from that assumed in city planning or road planning, it is necessary to correct the share of large vehicles to adjust the incoming and outgoing traffic volume associated with ports to the hinterland using equation **(2.2.12)**. In equation **(2.2.12),** coefficient for conversion of a large vehicle into passenger vehicles is 2.0.

$$\begin{aligned}&\text{Traffic volume corrected by the share of large vehicles (vehicles/day)}\\&= [\text{Daily traffic volume converted from the annual incoming and outgoing traffic volume (vehicles/day)}] \cdot \left[\left(1+\frac{T_{\text{-port}}}{100}\right)\Big/\left(1+\frac{T_{\text{-town}}}{100}\right)\right]\end{aligned} \qquad (2.2.12)$$

where,

$T_{\text{-port}}$: Share of large vehicles assumed for roads in the port(%)

$T_{\text{-town}}$: Share of large vehicles assumed for roads at the periphery of the port

(5) Estimation of the Design Hourly Traffic Volume of Roads in a Port

① Calculation method of the design hourly traffic volume

The design hourly traffic volume in both directions which is required for determining the number of lanes may be calculated from the estimated design daily traffic volume using equation **(2.2.13)**.Design hourly traffic volume (vehicles/hour)

$$= \text{Design traffic volume (vehicles/day)} \cdot \left(\frac{K}{100}\right) \qquad (2.2.13)$$

where,

K : Ratio of the design hourly traffic volume (usually the 30th hourly traffic volume) to the design daily traffic volume (annual average daily traffic volume) (%)

It is preferable to determine the value of K corresponding to the 30th per hour traffic volume (hereinafter referred to as “the K_{30} value”) based on the characteristics of each port. There are several methods to estimate the K_{30} value: the estimation using a model which includes the design daily traffic volume. The following shows the concrete techniques of each method.

② Estimation method based on measured values of similar roads or surrounding roads

In general traffic volume studies, because few 24 hour measurements and annual continuous measurements are performed, **Traffic Volume of Roads**[7)] provides equation **(2.2.14)** for estimation of the K_{30} value from ordinary observation study data. Accordingly, the value calculated from ordinary observation data of similar roads using equation **(2.2.14)** can be used as the K_{30} value.

$$K_{30} = 100\{(aQ_p + b) / Q_{12}\} \qquad (2.2.14)$$

where,

K_{30} : percentage (%) of 30th hourly traffic volume relative to design traffic volume (annual average of daily traffic volume). Provided, however, that K_{30} is 18% or less.

Q_p : peak hourly traffic volume (total of inbound and outbound) (vehicles/hour)

Q_{12} : daytime 12-hour hourly traffic volume (total of inbound and outbound) (vehicles/hour)

a, b : coefficients for calculating 30th hourly traffic volume from peak hourly traffic volume; values are shown in **Table 2.2.1**.

Table 2.2.1 Coefficients for Calculating 30th Hourly Traffic Volume from Peak Hourly Traffic Volume

Roadside condition	a	b
City	1.12	20.4
Flatland area	1.06	167.5
Mountainous area	1.01	377.6

③ Estimation method using model formula

The K_{30} value may be estimated from the annual average daily traffic volume for the road in the target port using equation **(2.2.15)**. The rationale for this calculation is described in Reference 1).

$$K_{30} = 248.9AADT^{-0.3283} \tag{2.2.15}$$

where,

$AADT$: Annual average of daily traffic volume (vehicles/day)

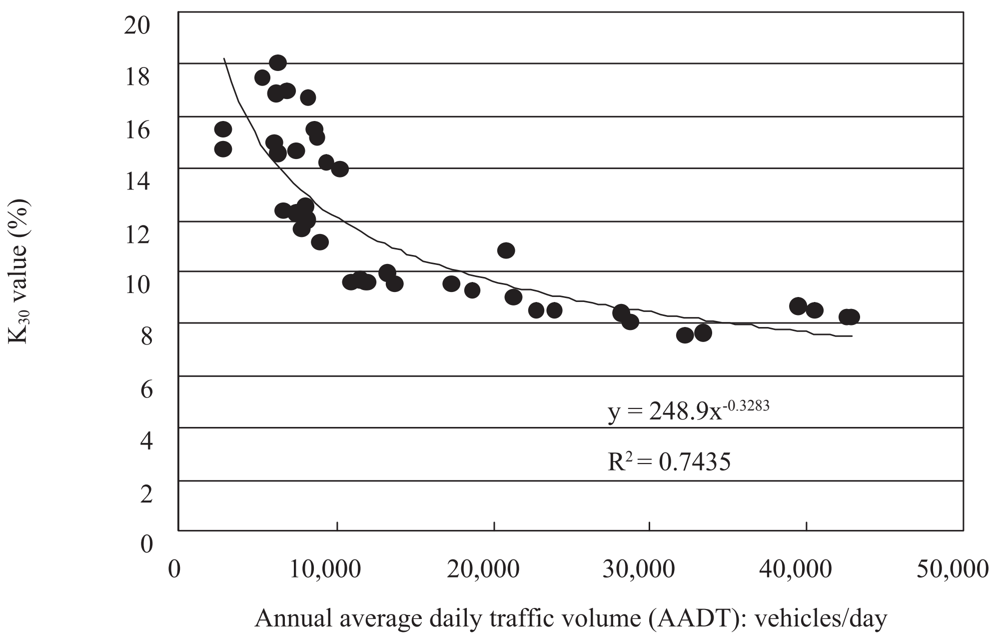

Fig. 2.2.4 Relationship between Annual Average of Daily Traffic Volume and K_{30} Value and its Model Formula

(6) Determination of the Number of Lanes of Roads in a Port

① Basic principles for determining the number of lanes of roads a port

When determining the number of lanes of roads in a port, it shall be primarily judged whether 2 lanes for both directions is sufficient to accommodate the traffic volumes, comparing the design hourly traffic volume for both directions with the design standard traffic volume. That is, if the design hourly traffic volume for both directions for the road in the target port is equal to or less than the design standard traffic volume value for 2 lanes, the number of lanes for both directions shall be 2.

If the design hourly traffic volume for both directions of the road in the target port is larger than the design standard traffic volume value for 2 lanes, the road shall have two or more lanes in each direction. In this case, the number of lanes for one direction shall be set based on comparison of the design hourly traffic volume for the heavier-traffic direction and the design standard traffic volumes for multiple lanes. The total number of lanes of a port road shall in principle be set so that the total number of lanes may be two times the number of lanes for one direction set based on the heavier-traffic direction traffic volume, because the total number of lanes is usually an even number.

② Criteria for setting 2 lanes for both directions

When setting the number of lanes, the number of lanes in the following cases shall be 2.

(a) Roads that connect a port with a national highway etc.:

Design hourly traffic volume (for both directions) (vehicles/hour)

$$\leq 650 \text{ (vehicles/hour)} \tag{2.2.16}$$

(b) Others roads:
Design hourly traffic volume (for both directions) (vehicles/hour)

$$\leq 500 \text{ (vehicles/hour)} \tag{2.2.17}$$

③ Determination method of the number of lanes for multi-lane roads (2 or more lanes in one side)

(a) Judgment as to whether multiple lanes are required
When setting the number of lanes, the number of lanes in the following cases shall be multilane, ie. 2 or more lanes in one direction. In this case, the number of lanes in one direction may be set according to the procedures described in (b) and (c).

1) Roads that connect a port with a national highway etc.:
Design hourly traffic volume (for both directions) (vehicles/hour)

$$>650 \text{ (vehicles/hour)} \tag{2.2.18}$$

2) Other roads:
Design hourly traffic volume (for both directions) (vehicles/hour)

$$>500 \text{ (vehicles/hour)} \tag{2.2.19}$$

(b) Estimation of the design direction-specific hourly traffic volumes
The design hourly traffic volume for the heavier-traffic direction may be calculated from the design daily traffic volume using equation **(2.2.20)**.

Design hourly traffic volume for the heavier-traffic direction (vehicles/hour)

$$= \text{Design daily traffic volume (for both directions) (vehicles/hour)} \cdot \left(\frac{K_{30}}{100}\right)\left(\frac{D}{100}\right) \tag{2.2.20}$$

where,

D : Ratio of the traffic volume in the heavier-traffic direction to the design hourly traffic volume (%)

If the traffic volumes are analyzed on an hour-by-hour basis, it can be seen that the peak-hour traffic volumes in both directions differ significantly. If the numbers of lanes are set based on the total value of the design hourly traffic volumes in both directions, the serviceability of the road during the peak hour is low. Therefore, it is preferable to estimate the design hourly traffic volume for the heavier-traffic direction using the D value.
In addition, it is preferable to set the D value according to the characteristics of the target ports.

(c) Determination of the number of lanes of one side
The number of lanes of one side in the case of a multi-lane road may be set comparing the design hourly traffic volume for the heavier-traffic direction with the design standard traffic volume for multi-lane roads which have 2 or more lanes in each direction described above. In principle, the integer obtained by rounding up the result of the calculation with equation **(2.2.21)** or equation **(2.2.22)** shall be used as the required number of lanes in the heavier-traffic direction.

1) Roads that connect a port with a national highway etc.:
Number of lanes in the heavier-traffic direction (lanes)
=Design hourly traffic volume for the heavier-traffic direction (vehicles/hour)
/ 600(vehicles/hour/lane) (2.2.21)

2) Other roads:
Number of lanes in the heavier-traffic direction (lanes)
=Design per hour traffic volume for the heavier-traffic direction (vehicles/hour)
/ 350(vehicles/hour/lane) (2.2.22)

The total number of lanes of a road may be set by doubling the number of lanes obtained according to the above procedures, because the number of lanes of the road should be an even number except for special cases.

④ Estimation of the D value
Procedures to estimate the D value in concrete way are as follows ; the estimation from results of continuous traffic volume observations and the estimation from actual measurements taken on the routes with similar characteristics and traffic conditions. Actual procedures are shown below.

(a) Estimation method based on the actual measurements taken on the similar roads or on the neighboring roads
Traffic Capacities of Roads [9] presents equation **(2.2.23)**, which uses heavier-traffic direction coefficients for

the peak hour of the survey day to accurately calculate the difference between the traffic volumes in the two opposite directions, thinking of the fact that the D value is almost constant during the heavy traffic hours. In equation **(2.2.23)**, the passenger vehicle equivalent number of vehicles (pcu/hour) for the 2 opposite directions is used.

$$D = 100\left\{\max\left(P_u, P_d\right) \Big/ \left(P_u + P_d\right)\right\} \tag{2.2.23}$$

where,

D : Ratio of the traffic volume in the heavier-traffic direction to the design hourly traffic volume (%)
P_u : Traffic volume in the inbound direction during the peak hour (pcu/hour)
P_d : Traffic volume in the outbound direction during the peak hour (pcu/hour)

2.3 Clearance Limits

In the case of the port road through which it is expected that special vehicles and semi-trailer trucks carrying high cube containers that are international ship containers with a height of 9 feet and 6 inches pass, the clearance limits shall be set appropriately rather than merely conforming to the Enforcement Regulations for Road Structures, because it is possible that to apply in the same clearance limits for ordinary roads to the port road would compromise safety.

2.4 Widening of the Curved Sections of Roads

In the case of the port road through which a number of large vehicles pass, the curved sections should be widened appropriately according to the design vehicles.

2.5 Longitudinal Slopes

In the case of the port road through which a number of large vehicles pass, the longitudinal slopes should be appropriately set according to the design vehicles, in careful consideration of the fact that the traveling speeds of vehicles tend to decrease as the gradient increases and this may significantly reduce the traffic capacity of the road.

2.6 Level Crossings

In the case of the port road through which a number of large vehicles pass, level crossings should be designed giving due consideration to the behavior of large vehicles which have low driving performance such as the accelerating performance at start.

2.7 Performance Verification of Pavements

(1) Basic Fundamentals for Performance Verification
Cement concrete or asphalt pavement is generally used as the pavement of a port road. It is generally preferable to verify the performance of cement concrete and asphalt pavements in accordance with the procedures shown in **Fig. 2.2.5** and **Fig. 2.2.6**, respectively.

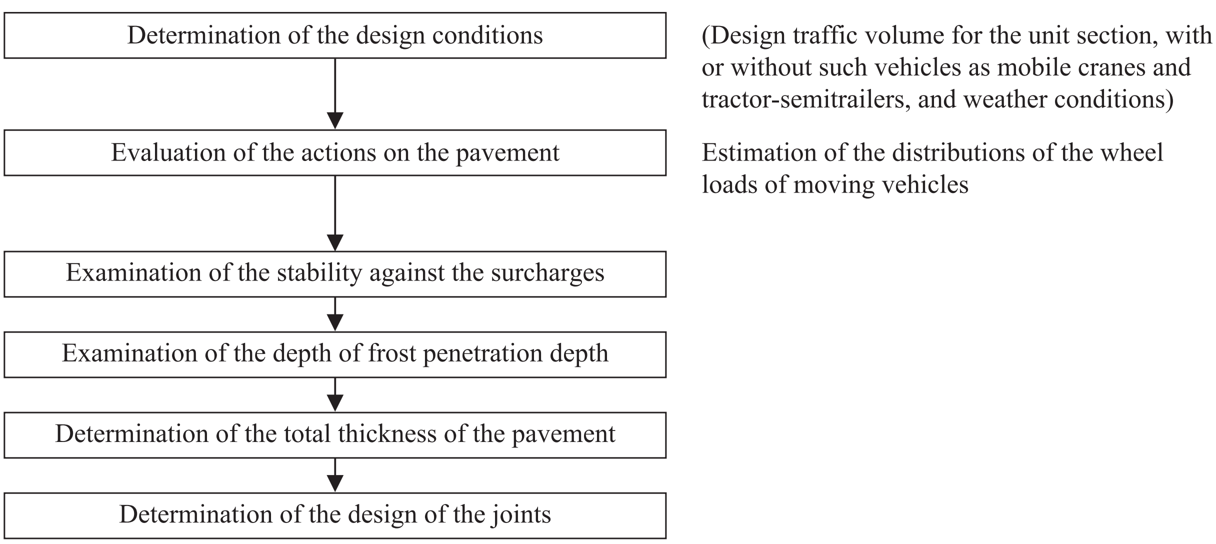

Fig. 2.2.5 Example of Performance Verification Procedure for Cement Concrete Pavements

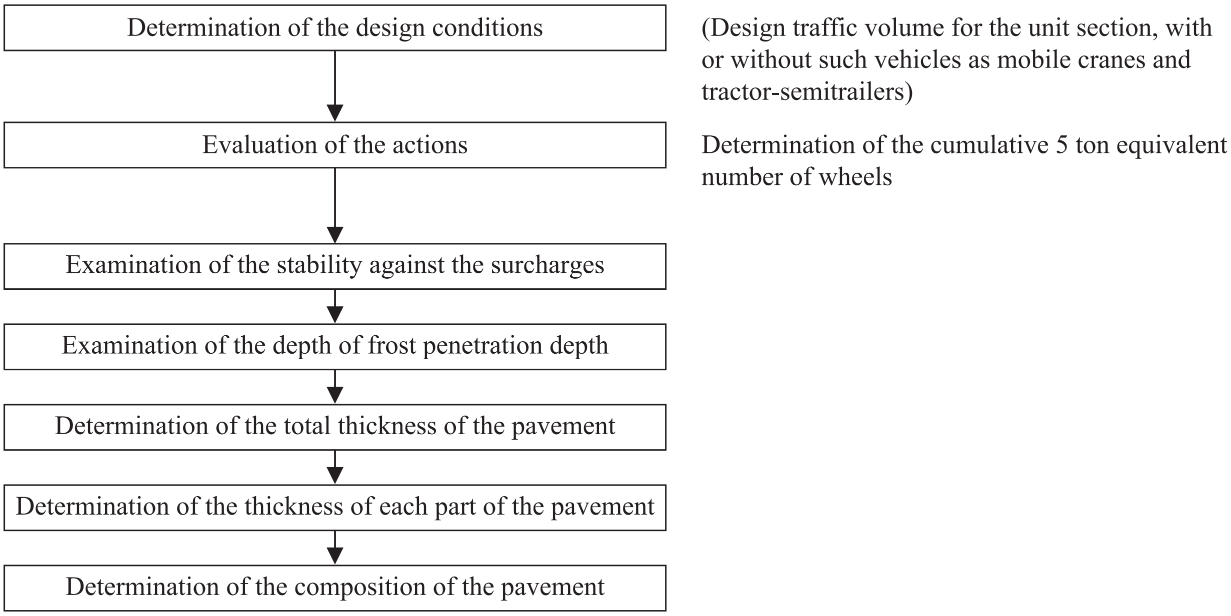

Fig. 2.2.6 Example of Performance Verification Procedure for Asphalt Concrete Pavements

(2) Performance Verification

① **The Guidelines for Designing and Constructing Pavements** [10) present, as the method of determining the traffic volumes for structural design of pavements, (a) the method based on the large vehicle traffic volume and (b) the method based on the wheel loads of moving vehicles.

(a) Method based on large vehicle traffic volume

The method based on the large vehicle traffic volume is that based on the average traffic volume of large vehicles (number of vehicles • day • direction) during the design working life and is popularly used for ordinary road pavements. The Asphalt Paving Guidelines present the following classification of design traffic volumes according to the large vehicle traffic volume:

L Traffic : the large vehicle traffic volume is less than 100 vehicles
A Traffic : the large vehicle traffic volume is less than 250 vehicles and not less than 100 vehicles
B Traffic : the large vehicle traffic volume is less than 1000 vehicles and not less than 250 vehicles
C Traffic : the large vehicle traffic volume is less than 3000 vehicles and not less than 1000 vehicles
D Traffic : the large vehicle traffic volume is 3000 vehicles or more

In the Guidelines, the term "large vehicles" stands for ordinary freight vehicles, buses and special vehicles.

(b) The method based on the wheel loads of moving vehicles

The method based on the wheel loads of moving vehicles is the method to estimate the size distribution of moving vehicles. The cumulative 5-ton-equivalent number of wheels during the design working life is calculated from the numbers of moving vehicles for each wheel load range, taking into account the rates of traffic volume increase. When converting the traffic volume (N_i) for the given wheel load (P_i) into the traffic volume (N_{i5}) for the 5-ton wheel load, the so-called "fourth power method" shown in equation **(2.2.24)** is used.

$$N_{i5} = \left(\frac{P_i}{5}\right)^4 N_i \tag{2.2.24}$$

where,

N_{i5} : traffic volume for the 5-ton wheel load (vehicles/day)
P_i : wheel load (kN)
N_i : traffic volume (vehicles/day)

② The method described in (a) above is simpler than the method described in (b). However, in cases where circumstances require, such as where it is expected that heavy vehicles such as semi-trailer trucks and mobile cranes go through, it is preferable to apply (b) in which the properties of the traffic can be considered.

References

1) Takahashi, H.: Study of designing roads in the port area A standard for designing roads in the port area : A proposal-, Research Report of National Institute for Land and Infrastructure Management No.21,2005
2) Information Management Department, policy Bureau, Ministry of Land, Infrastructure and Transport: Port Statistics (2002),, 2004
3) Ministry of Land, Infrastructure and Transport (MLIT): Survey Report of National Cargo Net Flow, MLIT, 2002
4) Traffic survey division, Urban transport Bureau, Ministry of Construction: Manual for planning of transport related to large scale development zones, Gyosei, 1999
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6) JSCE Edition: Transport Planning, New Series Civil Engineering 60, Giho-do Publishing, 1993
7) Japan Road Association: Traffic capacity of roads, Japan Roads Association, 1984
8) OKUDA, K., MURATA, T. and OKANO, H.: An Analysis on Characteristics of the Road Traffic in Port Area Based on the Yearly Traffic Observation, Technical Note of PHRI No.876, 1997
9) JSCE: Concrete Standard Specifications, Specifications for concrete (Pavement), 2002
10) Japan Rosa Association: Guideline for design and construction of pavement, 2001

3 Tunnels Constructed by the Immersed Tunnel Method

Ministerial Ordinance

Performance Requirements for Roads

Article 36

1 The performance requirements for roads shall be as specified in the subsequent items:

(1) Roads shall satisfy the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism so as to ensure the safe and smooth flow of traffic within the port and between the port and the hinterland in consideration of the traffic characteristics in the port.

(2) Damage due to imposed loads shall not adversely affect the continued use of the relevant roads without impairing their functions.

2 In addition to the provisions of the preceding paragraph, the performance requirements for roads having tunnel sections shall be as specified in the subsequent items:

(1) Damage due to self weight, earth pressure, water pressure, and Level 1 earthquake ground motions, and/or other actions shall not adversely affect the continued use of the relevant roads and not impair their functions.

(2) Damage due to Level 2 earthquake ground motions, flames and heat from fires, and/or other actions shall not affect restoration through minor repair works of the functions required for the roads concerned.

Public Notice

Performance Criterion of Underwater Tunnels

Article 77

1 The performance criteria of underwater tunnels shall be as specified in the subsequent items:

(1) Underwater tunnels shall be covered with an appropriate material of the required thickness so as to secure the integrity of the structural members and the stability of their structures against dropping and dragging of ship anchors, scouring of seabed by waves and/or currents, and others.

(2) Underwater tunnels shall be equipped with the control facilities necessary for their safe and smooth use.

(3) The degree of damage owing to the actions of Level 2 earthquake ground motions, and fires and heat by fires, which are the dominant actions in the accidental action situations, shall be less than the threshold level.

2 In addition to the provisions of the preceding paragraph, the performance criteria of underwater tunnels shall be as specified in the subsequent items:

(1) The risk of failure due to insufficient bearing capacity of the foundation ground under the permanent action situation, in which the dominant action is self weight, shall be less than the threshold level.

(2) The risk of impairing the integrity of structural members under the permanent action situation, in which the dominant action is earth pressures, shall be equal to or less than the threshold level.

(3) The risk of floating-up of the immersed tunnel elements, ventilation facilities and shafts under the variable action situation, in which the dominant action is water pressures, shall be equal to or less than the threshold level.

(4) The risk of impairing the integrity of structural members and losing the stability of immersed tunnel elements, ventilation facilities, shafts, joint sections and others under the variable action situation, in which the dominant action is Level 1 earthquake ground motions, shall be equal to or less than the threshold level.

[Commentary]

(1) Performance Criteria of Underwater Tunnels

① Common items for all underwater tunnels

(a) Covering (usability)

When determining the covering material and covering thickness in the performance verification of an underwater tunnel, appropriate consideration should be given to the stability of the underwater tunnel against uplifting, the effects of the penetration of anchors caused by casting and dragging from ships navigating over the underwater tunnel and the scouring of the covering sections due to water flows and waves.

(b) Accidental situations (restorability)

1) The settings of the performance criteria common to underwater tunnels and the design situations limiting to accidental situations are shown in **Attached Table 63**. [The reason why setting "damages" as the verification item in the **Attached Table 63** is that it aims to describe in a comprehensive manner considering that the verification items vary depending on the structure and structural type of the facility].

Attached Table 63 Settings relating to the Design Situations limiting to Accidental Situations and Performance Criteria Common to All Underwater Tunnels

Ministerial Ordinance			Public Notice			Performance requirements	Design situation			Verification item	Index of standard limit value
Article	Paragraph	Item	Article	Paragraph	Paragraph		Situation	Dominating action	Non-dominating action		
35	2	–	77	1	3	Restorability	Accidental	Flames and heat due to fires	–	Damages	–
36	2	2						L2 earthquake ground motion	Self weight, earth pressures, water pressures, surcharges		

2) Flames and heat due to fires
When verifying the performance of an underwater tunnel in the accidental situations of flames and heat due to fires, the action of flames and heat due to fires should be appropriately set according to the types of vehicles which are expected to go through the underwater tunnel, and the members of the underwater tunnel should be covered with refractory material as necessary.

② Immersed tunnels (serviceability)

(a) The performance criteria of immersed tunnels shall be pursuant to the performance criteria common to underwater tunnels. The settings of the performance criteria for immersed tunnels and the design situations (excluding accidental situations) are shown in **Attached Table-64**.

Attached Table 64 Settings relating to the Design Situations (excluding accidental situations) and Performance Criteria of Immersed Tunnels

Ministerial Ordinance			Public Notice			Performance requirements	Design situation			Verification item	Index of standard limit value
Article	Paragraph	Item	Article	Paragraph	Paragraph		Situation	Dominating action	Non-dominating action		
35	2	–	77	2	1	Serviceability	Permanent	Self weight	Water pressures, earth pressures, surcharges	Bearing capacity of the foundation ground	Bearing capacity limit value
36	2	1			2			Earth pressures	Self weight, water pressures, surcharges	Soundness of members	–
					3		Variable	Water pressures	Self weight, earth pressures, surcharges	Uplifting of immersed tunnel elements, ventilation facilities and shafts	–
					4			L1 earthquake ground motion	Self weight, earth pressures, water pressures, surcharges	Stability of immersed tunnel elements, ventilation facilities and shafts	–
										Soundness of members	–
										Stability of joint sections	–

(b) Soundness of members

When verifying the performance of members of an immersed tunnel, the performance criteria of their soundness should be appropriately set according to the structure of the immersed tunnel and the materials of the members.

(c) Stability of immersed tunnel elements, ventilation facilities and shafts

When verifying the performance of immersed tunnel elements, ventilation facilities and shafts of an immersed tunnel, the performance criteria of their stability should be appropriately set according to the structure of the immersed tunnel.

(d) Stability of joint sections

When verifying the performance of joint sections of an immersed tunnel, the performance criteria of their stability should be appropriately set according to the structure of the immersed tunnel and the materials and structures of the joint sections. The stability of joint sections shall include securing of waterproof property of joint sections.

[Technical Note]

3.1 General

(1) The explanations in this section may be used for the performance verifications of tunnels constructed of roads in a port by the immersed tunnel method (hereinafter referred to as immersed tunnels). For tunnels of other use or other type, it is necessary to apply other relevant standards.

(2) In the performance verifications of immersed tunnels for port roads, **The Technical Manual for Immersed Tunnels** [1]) may be used as a reference. When making a general study on the design, fabrication and construction of the immersed tunnel method, Reference 2) may serve as a reference. In addition, when examining the seismic-resistant performance, it is preferable to use Reference 3) as a reference.

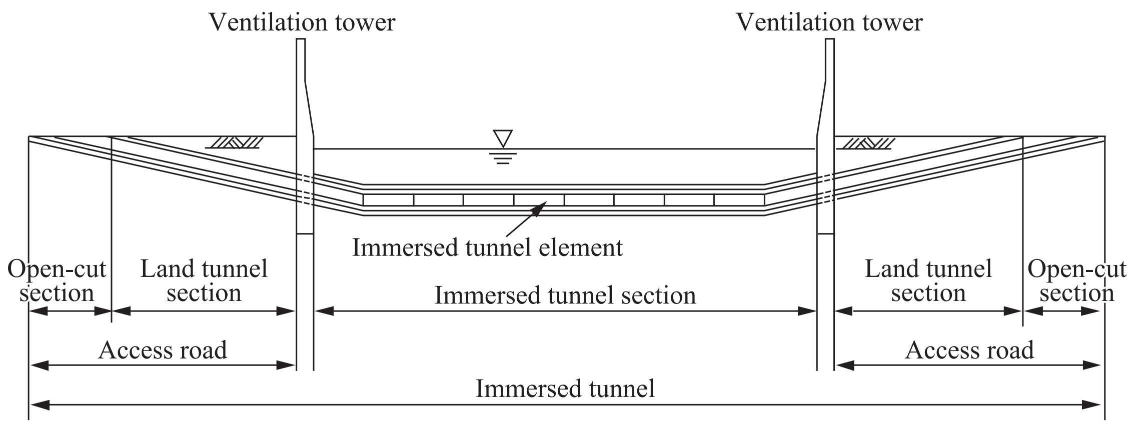

Fig. 3.1.1 Definitions of Immersed Tunnel-related Terms

3.2 Fundamentals of Performance Verification

(1) The location, alignment, and cross-sectional profile of an immersed tunnel shall be appropriately set according to the use condition, the natural conditions of water area where the tunnel is constructed.

(2) When determining the cross section of an immersed tunnel, the traffic volume of vehicles, the ratio of large vehicles in all vehicles, the need for a sidewalk, the need for a bicycle track, the types of cables and pipes in utility ducts, transport of hazardous materials, the existence or nonexistence of a toll gate, and the connections with other roads should be examined in advance.

Sufficient consideration should also be given to the future development plans of other related facilities including those concerning the possibility of deepening waterways above the immersed tunnel. In addition, it is also preferable to study adequately the future utilization plan, because it is difficult for an immersed tunnel to enhance its functions such as widening of its width once it has been completed.

(3) If pedestrian and bicycle tracks are to be installed, due consideration should be given to use by the elderly and the physically handicapped persons.

(4) Main body of an immersed tunnel shall be a fireproof structure, and safety facilities and equipment, and evacuation passages for use under fire shall be provided. In addition, evacuation passages and emergency telephones for use in the event of an accident or a disaster should be provided as necessary.

(5) The longitudinal slope of an immersed tunnel may be made as steep as possible within the restriction of design speed for the road to enable reduction of construction cost in general. However, consideration should be given to the fact that smoke and dust concentration in the exhaust gas of vehicles increases rapidly as the slope becomes steeper, thus raising the cost of ventilation equipment.

(6) Immersed Tunnel Elements

① The structural types of immersed tunnel elements are classified into steel shell type, reinforced concrete or prestressed concrete type, and composite or hybrid type. The most appropriate structure should be selected in light of their individual characteristics.

② A steel shell type immersed tunnel element is constructed by building the steel shell first and then filling the inside space of the shell with concrete. The loads that act on a completed steel shell type immersed tunnel element are basically borne by the reinforced concrete in the steel shell. Concrete type immersed tunnel elements also have a covering made of thin steel sheet for protection and waterproofing. Therefore, there is no clear essential difference between these two types. It is considered that in a composite type, concrete and steel sheet are integrated with shear connectors and that not only the concrete but also the steel sheet bears the loads.

③ Steel shell type immersed tunnel elements require a large amount of steel, but do not always require a dry dock because they can be constructed in a shipway. On the other hand, concrete type immersed tunnel elements do not require a large amount of steel, but do require a deep dry dock. When selecting the type of an immersed tunnel element in a specific case, consideration should be given to the fabrication yard, economical efficiency, and constructability.

④ Composite type elements, particularly that of steel-concrete combined structure, may be designed and constructed according to the references 4) and 5).

(7) Management Facilities and Equipment

Management facilities and equipment include the facilities and equipment for ventilation, emergency, lighting, electric-power, security and measurement, monitoring and control, and drainage. In cases where a ventilation tower is constructed as a ventilation facility, it is necessary to allocate functionally the ventilation equipment, electrical equipment, control equipment and other ancillary equipment. It is also necessary to install connection ducts that connect the ventilation tower with the main body of the tunnel, inlet ports and exhaust ports so that efficient ventilation may be achieved.

3.3 Determination of the Basic Cross Section

(1) Immersed Tunnel Elements

① The top surface of immersed tunnel elements shall be covered with appropriate material of the required thickness so that the structural safety of the elements may be ensured taking into consideration the penetration depth of anchor caused by casting and dragging of ship's anchor, the frequencies of anchoring and dragging of anchor, the buoyancy of the tunnel, and the scouring due to waves and water flows. In principle, it is preferable that the thickness of the cover layer, which includes the thickness of the concrete layers to protect the upper slab, is 1.5m or greater

② The depth of immersion shall be set appropriately in consideration of any future plan of deepening of the water in and around the tunnel.

③ The structural type and the length of an immersed tunnel element shall be determined in consideration of the sectional forces, the joint structure, the size of the fabrication yard, the tunnel element installation and joint construction methods, and the economical efficiency of the immersed tunnel structure including joints. In general, an immersed tunnel element length of around 100m is employed.

④ In accordance with the structure of an immersed tunnel element, fireproof material may be required. In such cases, the thickness of fireproof material shall be considered in determining the dimensions of inner cross section of the tunnel.

(2) Ventilation Towers

① The structures of the ventilation towers for an immersed tunnel need to be studied with an appropriate method corresponding to the characteristics of the facilities and grounds.

② Ventilation machines, electrical facilities and equipment, and control facilities and equipment should be installed functionally in a ventilation tower. Its structure should be equipped with inlet and outlet ports for efficient ventilation as well as with connecting ducts to the immersed tunnel itself.

③ Sufficient space should be provided inside a ventilation tower so that monitoring, inspection, and minor repair of the installed equipment can be performed smooth. In particular, large components such as ventilation machines should be so designed that their transport into and out of the tower is easily executed.

④ The location and structure of inlet ports should be such that the intake of exhaust gas from the outlet or from the entrance of the tunnel is kept as little as possible.

⑤ The location of outlet ports should ensure that concentration of exhaust gas at the ground level remains under a tolerable level.

⑥ A shaft generally doubles as a ventilation tower, but they can be separated.

⑦ A ventilation tower has the ventilation function and it is preferable that sufficient consideration is given to the design of the ventilation tower in harmony with the surrounding landscapes.

(3) Access Roads

① The structure of access roads shall be designed with due consideration to the traffic under planning, natural conditions, social conditions, construction methods and construction cost.

② The road surface elevations of the entry and exit sections of an access road should be determined taking into consideration the connection with other roads, the elevation of the neighboring grounds, the infiltration of seawater or river water during storm surges, and the longitudinal gradient of an immersed tunnel.

3.4 Performance Verification

(1) Examination of the Stability of the Immersed Tunnel Section

① It shall be standard to examine the structural stability of the immersed tunnel section in both the longitudinal and transverse directions of the tunnel.

② When examining the stability in the transverse direction of the immersed tunnel, its main body may be generally regarded as a rigid frame structure. In the longitudinal direction of the immersed tunnel, its main body may be regarded as a beam supported on elastic springs of the ground.

③ Whether the foundation has the sufficient capacity to support the weight of the immersed tunnel including the soil on its top should be examined. Due consideration should also be given to the settlement of foundation.

④ Ground motion can be transmitted to the immersed tunnel from every direction. However, in the performance verification, the tunnel is usually examined for two directions; the transverse direction, in which the tunnel is subjected to the maximum flexural moment and shearing force, and the longitudinal direction, in which the tunnel is subjected to the maximum axial force.

⑤ An immersed tunnel can be constructed in a soft ground. In such a case, it is necessary to confirm that no sliding will occur in the surrounding ground when subjected to ground motion. In addition, it is necessary to perform analyses and evaluations to ensure stability against liquefaction.

⑥ Appropriate materials should be selected for filling considering the safety against settlement and surfacing, liquefaction due to earthquake, and maintenance dredging to keep the depth of navigation channel.

⑦ An immersed tunnel is a structure under the seabed and is often constructed in soft ground. Sufficient examination should be made so that its functions should not be lost due to water seepage from cracks or joints.

(2) Examination of the Stability of Immersed Tunnel Elements

① Immersed tunnel elements shall have safe structure in consideration of the following factors as necessary.

(a) watertight capability
(b) cracking of the concrete
(c) uplifting of the element body due to buoyancy after installation
(d) ventilation and disaster prevention functions
(e) other functions attached in the immersed tunnel elements

② It is preferable to apply waterproof coating on the circumference of the elements to make assurance double sure on watertightness.

(3) Examination of Joints

① Joints of an immersed tunnel shall have safe structure against the stresses generated by the action of ground motion.

② The location and structure of joints of immersed tunnel elements are normally determined in consideration of the size of fabrication yard, shifting of waterways, capacity of construction machines, uneven settlement of the foundation after completion, and influence of temperature variation. However, the location and structure of joints are also important factors in assessing the earthquake resistance of an immersed tunnel. Thus, the earthquake resistance needs to be adequately examined when determining the joint location and structure.

③ A joint between an immersed tunnel element and a ventilation tower should also be analyzed and evaluated adequately in the same manner as in the case of joints between immersed tunnel elements.

④ Immersed tunnel joints are generally classified into two structural types: “continuous structure” which has the same stiffness and strength as those of the cross sections of the immersed tunnel elements so as to endure deformation, strain during the permanent actions, earthquake and other actions; and “flexible structure” which has the sufficient flexibility to absorb the deformations during the permanent actions, earthquake and other actions

⑤ The water pressure connection method and the underwater concrete casting method are popular as the connection method for connecting immersed tunnel elements together underwater and making the primary water sealing. In recent years, the water pressure connection method has been used more than the underwater concrete casting method.

⑥ For joints of the last part of an immersed tunnel, the dry work method, the waterproof panel method, the V-block method, and the key element method have been proposed. It is preferable to determine the method in consideration of the location, structure, construction method, and workability.

3.5 Structural Specifications

(1) Immersed tunnels shall be equipped with the following facilities as necessary:

(1) ventilation facilities

(2) emergency facilities

(3) lighting equipment

(4) electric power facilities

(5) security and instrumentation equipment

(6) monitoring and control facilities

(7) drainage facilities

(2) Ventilation is essential for preventing the adverse effect of exhaust gas from motor vehicles on the air inside tunnels. Although natural ventilation may be sufficient for short tunnels, ventilation facilities shall be installed for immersed tunnels of roads in a port.

References

1) Coastal Development Institute of Technology : Technical Manual for immersed tunnel (Revised Edition), 2002
2) Kiyomiya, T., K. Sonoda, M. Takahashi: Design and construction of immersed tunnels, Gihi-do Publishing, 2002
3) Earthquake Engineering Committee, Sub-committee on Earthquake-resistant performance of tunnel,: Earthquake-resistant design of tunnel and problems, 1998
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4 Parking Lots

Ministerial Ordinance

Performance Requirements for Parking Lots

Article 37

The performance requirements for parking lots shall be as specified in the subsequent items:

(1) Parking lots shall satisfy the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism for the safe parking of vehicles without hindering port utilization and the safe and smooth flow of traffic.

(2) Damage due to imposed load shall not adversely affect the function and continued use of parking lots.

Public Notice

Performance Criteria of Parking Lots

Article 78

1 The provisions in items (1) and (5) of Article 76 shall be applied to the performance criteria of parking lots with modification as necessary.

2 In addition to the provisions in the preceding paragraph, the performance criteria of parking lots shall be such that the size, location and layout of parking lots are appropriately set in consideration of the utilization conditions of the facilities concerned and the surrounding area, and others.

[Technical Note]

4.1 Examination of Size and Location of Parking Lots

(1) The size and location of a parking lot shall be determined so as not to pose any obstacle to the use of port facilities and the smooth road traffic, in consideration of the traffic generated in a port and the condition of roads in the vicinity.

(2) A parking lot shall not be located on a road. If topographical conditions or other reasons necessitate a parking lot to be located on a roads the size and location of a parking lot shall satisfy the following requirements:

① It shall not be located on a road connecting a port and a major inland highway.

② It shall not be located at a place which may hinder vehicles from going in and out the cargo handling area or sheds.

③ It shall not be located at a place adjacent to a dangerous cargo handling area, unless there are unavoidable reasons including topographical conditions.

(3) The width of roadways in the parking lot, the size of parking stalls, and the width of roadways for going in reverse and turning into parking stalls shall be determined appropriately according to the type of cars using the parking lot, the parking angle, and the parking method.

4.2 Performance Verification

(1) Design Vehicle

When setting the design vehicle in the performance verification, not only special vehicles including tractor-semitrailers and new standard vehicles but also vehicles carried on ferries, RORO vessels, PCC ships may be selected as the design vehicle.

(2) Size and Location

① When verifying the performance of a parking lot, it is necessary to determine its size and location so that the originating and terminating traffic from the objective parking lot may not hinder the smooth traffic in a port, giving proper consideration to the parking demand generated accompanying the anticipated port activities and the utilization circumstances of the surrounding roads.

② Location

In principle, parking lots shall not be located on roads taking into consideration the characteristics of the traffic in a port. Provided, however, that in cases where a parking lot has to be located on a road because of unavoidable reasons including topographical constraint, the objective parking lot shall set the following requirements regarding disposition as necessary:

- The parking lot shall not be located on arterial roads that connect the port with an inland area.
- The parking lot shall not be located at a place which may hinder vehicles from going in and out the cargo handling area or sheds.
- The parking lot shall not be located at a place adjacent to a dangerous cargo handling area.

(3) Parking Lots for Mooring Facilities for Ferries

① A parking lot for mooring facilities for ferries should have sufficient space taking into consideration the number of vehicles carried on the relevant ferries, the utilization rate and the concentration rate so as not to make the neighboring traffic conditions worse.

② When determining the area of a parking lot, it is preferable to consider the following factors:

(a) the number of berths

(b) the number of vehicles carried on a ferry (both the number of passenger cars and trucks)

(c) the arrival and departure intervals of ferries and the loading and unloading time

(d) the arrival patterns of vehicles (patterns of both passenger cars and trucks)

(e) the operation system of a parking lot

③ The area of a parking lot on a ferry wharf is sometimes determined by multiplying the area of 50m^2 required to park an 8-ton vehicle by the maximum number of 8-ton- equivalent vehicles carried on the ferry which uses the wharf. In addition, it is also necessary to take into account the ratio of the vehicles which are transported on the ferries without a driver and the ratio of trailers.

References

1) Japan Association of car park engineers: Car Park Manual, 1981, (additional Material)1990
2) Japan Road Association: Guideline and commentary for Design and construction of car park, 1992
3) Japan Road Association: Commentary of enforcement regulations for road structures and application, Maruzen Publishing, execution, pp.623-631, 2004

5 Bridges

Ministerial Ordinance

Performance Requirements for Bridges

Article 38

1 The performance requirements for bridges shall be as specified in the subsequent items:

(1) Bridges shall satisfy the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism so as to ensure the safe and smooth flow of traffic within the port and between the port and the hinterland in consideration of the characteristics of traffic in the port.

(2) Damage due to self weight, variable waves, Level 1 earthquake ground motions, imposed load, winds, and ship collisions, and/or other actions shall not adversely affect the continued use of said bridge without impairing its function.

(3) Even in cases that the functions of bridges are impaired by damage due to Level 2 earthquake ground motions, such damage shall not have a serious effect on the structural safety of the bridges. Provided, however, that as for the performance requirements for bridges which requires further improvement in earthquake-resistant performance due to environmental, social conditions and/or other conditions to which the bridges concerned are subjected, the damage shall not adversely affect the restoration through minor repair works of the functions of the bridges concerned.

2 In addition to the requirements provided in the preceding paragraphs (*1*) and (*2*), the performance requirements for the bridge constituting a part of a road which is connected to high earthquake-resistance facilities shall be such that the damage due to Level 2 earthquake ground motions and other actions do not affect restoration through minor repair works of the functions required of the bridge concerned in the aftermath of the occurrence of Level 2 earthquake ground motions. Provided, however, that as for the performance requirements for the bridge which requires further improvement in earthquake-resistant performance due to environmental, social conditions and/or other conditions to which the bridge concerned is subjected, damage due to said actions shall not affect the restoration through minor repair works of the functions of the bridge concerned and its continued use.

Public Notice

Performance Criteria of Bridges

Article 79

The performance criteria of bridges shall be as specified in the subsequent items:

(1) In the case of a bridge which overpasses the facilities to which the Technical Standards apply or equivalent facilities, the piers, girders, and others of the bridge shall be installed in such a way that they do not adversely affect the safe and smooth use of respective facilities.

(2) Fenders shall be provided as necessary to prevent the damage to piers that may be caused by the collision of ships.

(3) The degree of damage owing to the action by collision of a ship, which is the dominant action in the accidental action situation, shall be less than the threshold level.

[Commentary]

(1) Performance Criteria of Bridges

① Bridges associated with a road that connects to a high earthquake-resistance facility (restorability, serviceability)
Performance criteria shall be set to secure restorability against accidental situations associated with Level 2 earthquake ground motion. In addition, it shall also be set for the bridge which is required to have enhanced seismic resistance according to the natural and social conditions surrounding the objective bridge to ensure serviceability. Provided, however, that serviceability is a performance requirement regarding the functions which are required of the bridge after it is subjected to the action of Level 2 earthquake ground motion, and is not the performance requirement regarding the original functions required of the bridge in ordinary conditions.

② Accidental situations where the dominating action is the collision of ships against the bridge (serviceability)

The settings relating to the performance criteria and design situations limiting to accidental situations for bridges are shown in **Attached Table 65**. Damages are set as the verification item in **Attached Table 65**, because verification items vary depending on the structure and structural type of the relevant bridge.

Attached Table 65 Settings relating to the Performance Criteria and Design Situations Common to All Bridges

Ministerial Ordinance			Public Notice			Performance requirements	Design situation			Verification item	Index of standard limit value
Article	Paragraph	Item	Article	Paragraph	Paragraph		Situation	Dominating action	Non-dominating action		
38	1	3	79	1	3	Serviceability	Accidental	Collision of ships against the bridge	Self weight, earth pressures, water pressures, surcharges	Damages	–

[Technical Note]

5.1 Fundamentals of Performance Verification

(1) A bridge crossing over the space above any waterway or basin shall meet the following requirements:

① The bridge girders shall be constructed at an appropriate elevation above the highest high water level to ensure safe navigation of ships.

② The bridge piers shall neither be located near the waterway nor obstruct the navigation of ships, unless the safety of navigation is ensured otherwise.

③ Indicators or signs shall be posted as necessary to prevent ships from colliding with the bridge girders or piers.

(2) A bridge crossing over the space above any mooring equipment or cargo handling facilities shall meet the following requirements:

① The location of piers and the elevation of girders shall be set appropriately so that they may not obstruct the safe and smooth use of the mooring or cargo handling facilities.

② Indicators or signs shall be posted as necessary to prevent cargo handling equipment and vehicles from colliding with the bridge piers or girders.

(3) The base level for indicating the bridge height above the water surface shall be the nearly highest high water level. The nearly highest high water level as the reference water level was adopted in response to the decision by the International Hydrographic Organization (IHO) saying that “when graphing the height of a bridge over a navigable waterway, it must be indicated the minimum vertical clearance height.”

(4) The design of a bridge should take into consideration the future situation of the activities in the area when there is any areal development plan.

(5) When determining the clearance for the case where a bridge is constructed overpassing a ship navigating waterway, the following factors should be taken into consideration:

① Height between the water surface and the highest point of the navigating ship

② Tides

③ Trims of ships

④ Wave heights

⑤ Psychological effects on ship crew

The clearance from the nearly highest high water level should be determined by adding an allowance which is set taking into consideration the above-mentioned factors and other relevant factors to the height between the water surface and the highest point of a navigating ship. In the case of a bridge located in a river mouth area, it is preferable to pay full attention to the design river high-water level as well.

The height between the water surface and the highest point of a navigating ship should be determined appropriately on the studies regarding actual conditions and future trends of the ships entering the port, because it varies widely depending on the ship type, and ship size. A study case on the ship height by Takahashi et al.[10] may be used as a reference.

When determining the clearance for a bridge crossing over the space above high-voltage power transmission lines, more sufficient allowance should be required to prevent the electric discharge.

When planning a bridge near an airport, full attention should also be paid to the restricted surfaces laid down by the **Aviation Law**

(6) As for the scenery of a bridge, sufficient consideration should be given to the topographic features of the relevant port and the characteristics of the landscape consisting of major facilities in and around the port.

(7) Bridge piers and girders
When examining bridge piers and girders in the performance verification of a bridge, the height of the girders should be set at an appropriate height from the nearly highest high water level to ensure the safety of ships which navigate under the relevant bridge and that indicators and signs should be installed as necessary to prevent the collision of ships that navigate under the relevant bridge, cargo handling equipment, and vehicles against the piers and girders.

5.2 Ensuring of Durability

(1) Examination of bridge structure and selection of structural materials shall be made appropriately in consideration of the natural conditions surrounding the bridge.

(2) Painting or other measures should be adopted for steel bridges to prevent or reduce the corrosion of the steel members as necessary.

(3) When verifying the performance of a concrete bridge, it is necessary to appropriately evaluate timewise changes in the performance due to the deterioration of the superstructure and substructure caused by salt injury. Performance verifications of concrete bridges may follow **Chapter 2, 1.1 General**.

(4) Salt content usually comes flying through sea breeze and sea water splashes and adheres to the bridges in waterfront areas. Therefore it is necessary to pay attention to the fact that the steel members of the steel bridges in waterfront areas are more corrosion-prone than those of steel bridges located in inland areas.

5.3 Performance Verification of Fenders

(1) Consideration should be given to protection of the bridge pier and reduction of damage as a result of impact by installing fenders on bridge piers as necessary which absorb the impact force at the time of collision.

(2) It is preferable to maintain fenders in good location.

(3) When verifying the performance of a fender for a bridge pier, it should be ensured that the fender has sufficient functions at the time of collision of a ship taking into consideration the following collision conditions and fender performance, and that it also has sufficient functions against the actions of waves, water flows.

① Design ship to be considered: type and size

② Collision speed: navigation speed or drift speed

③ Mode of collision: bow collision or hull collision

④ Allowable displacement for the ship and the fender
With regard to the type and size of the design ship, it is preferable to determine the maximum ship size by ship type based on the investigation on navigating ships in the sea area where the bridge is to be constructed and to determine the ship size taking into consideration the damage of the ship at the time of collision of small ships as necessary. The collision speed is usually determined based on the ship traffic conditions and the flow conditions of the waterway. The mode of collision of ships is usually determined based on the navigating conditions around the pier for each ship type and each ship size.

(4) The performance of fenders may usually be verified assuming the absorption of the ship collision energy for bow collisions and hull collisions as follows:

① In the case of a bow collision, the collision energy is absorbed by the sum of the displacement of the fender and the crush displacement of the bow.

② In the case of a hull collision, the collision energy is absorbed by the displacement of the fender.

(a) With regard to the kinetic energy of the collided ship, **Part II, Chapter 8, 2.2 Actions Caused by Ship Berthing** may be used as a reference. Provided, however, that for bow collisions, the eccentricity factor C_e and virtual mass factor C_m may usually be set at 1.0 and 1.1, respectively, and the ship flexibility factor C_s and bridge pier shape factor C_c may usually be set at 1.0.

(b) The energy absorbed by the displacement of the fender may usually be obtained based on the following concept:

1) The energy absorbed by a rubber fender may be obtained based on the displacement restoration characteristics of the rubber fender.

2) The energy absorbed by a wire rope type fender may be obtained from the relationship between the elongation and tensile strength of the wire rope.

3) The energy absorbed by the crush displacement of the bow in a bow collision may be obtained from the relationship between the bow load and displacement.

(c) In cases where consideration should be made so that the hull of a small vessel may not break at the time of collision, it is preferable that the reactive force of a fender at the time of collision is smaller than the bow strength for the bow collision and smaller than the hull strength for the hull collision. If it is assumed that the maximum collision force is distributed across a sufficiently wide area of the exterior plate of the ship side hull, that it uniformly works on spreading to the distance between the rib centers and above, and that both ends of the exterior plate are fixed and plastic hinges come into existence at both ends of the exterior plate, the design ship hull strength of a steel ship may usually be calculated using the following equation.[17)]

$$P_{Md} = \frac{3\sigma_{yd}}{\sqrt{1-\nu+\nu^2}}\left(\frac{t}{S}\right)^2 A \tag{5.4.1}$$

where,

P_M : ship hull strength (N)
σ_y : yield stress for steel members (N/m^2)
t : thickness of the exterior plate (m)
S : distance between rib centers (m)
ν : Poisson's ratio
A : contact area(m^2)

The strength of a steel fender may be obtained from the strengths of the members that comprise the steel fender. The design value used in the equation may be calculated using the following equation:

$$\sigma_{y_d} = \gamma_{\sigma_y}\sigma_{y_k} \tag{5.4.2}$$

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6 Canals

Ministerial Ordinance

Performance Requirements for Canals

[Commentary]

Article 39

The performance requirements for canals shall be such that the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism are satisfied for the sake of securing the safe and smooth navigation of ships in harbors by taking into consideration the traffic characteristics in the port including navigating ships and others.

[Technical Note]

6.1 Performance Verification

When verifying the performance of a canal, it is preferable to observe the following items:

(1) When determining the dimensions and alignment of a canal, consideration should be given to the dimensions of the ships using the canal, the traffic volume, the navigational safety of ships and other relevant factors. In particular, attention should be paid to the reduction of current speed and keeping the water depth of a certain level and below.

(2) When determining the crown height height of a bulkhead or dike for a canal, the wave overtopping due to the ministry generated by navigating ships should be studied. In addition, in cases where a canal connects with a river, swollen water level during a flood should be examined and in cases where the canal connects to the ocean, tide levels and incoming wave height should be analyzed.

(3) Consideration should be given to the environment protection for canals, because the slow flow in a canal often leads to stagnant water and it is possible that substances which cause contamination such as nitrogen and phosphorus may flow into the canal from neighboring rivers.

Chapter 7 Cargo Sorting Facilities

1 General

Ministerial Ordinance

General Provisions

Article 41

1 The performance requirement for cargo sorting facilities shall be such that the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism are satisfied in light of geotechnical characteristics, meteorological characteristics, sea states and/or other environmental conditions, as well as the conditions of cargo handling.

2 The performance requirement for cargo sorting facilities shall be such that the facilities have stability against self weight, waves, earthquake ground motions, imposed load, winds, and/or other actions.

Ministerial Ordinance

Necessary Items Concerning Cargo Sorting Facilities

Article 44

The items necessary for the performance requirements of cargo sorting areas as specified in this Chapter by the Minister of Land, Infrastructure, Transport and Tourism and other requirements shall be provided by the Public Notice.

Public Notice

Cargo Sorting Facilities

Article 80

The items to be specified by the Public Notice under Article 44 of the Ministerial Ordinance concerning with the performance requirements for cargo sorting facilities shall be as provided in the subsequent article through Article 83.

[Technical Note]

1.1 General

(1) This chapter may be used for performance verifications of cargo sorting facilities.

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2 Stationary Cargo Handling Equipment and Rail-mounted Cargo Handling Equipment

Ministerial Ordinance

Performance Requirements for Cargo Handling Equipment

Article 42

1 The performance requirements for stationary cargo handling equipment and rail-mounted cargo handling equipment (hereinafter referred to as "cargo handling equipment") shall be such that the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism are satisfied so as to ensure the safe and smooth sorting of cargo and to keep them from interfering with the mooring of ships or berthing and unberthing of ships.

2 In addition to the provisions of the preceding paragraph, the performance requirements of the cargo handling equipment cited in the following shall be as specified in the respective items:

(1) The performance requirements for oil handling equipment shall be such that the damage due to self weight, Level 1 earthquake ground motions, winds, oil weight and pressure, and other actions do not adversely affect the continued use of the oil handling equipment concerned without impairing its function.

(2) The performance requirements for cargo handling equipment installed at high earthquake-resistance facilities shall be such that the damage due to Level 2 earthquake ground motions and other actions do not affect restoration through minor repair works of the functions of the equipment concerned.

Public Notice

Performance Criterion of Cargo Handling Equipment

Article 81

1 The performance criteria of cargo handling equipment shall be as specified in the subsequent items in consideration of the type of cargo handling equipment:

(1) Cargo handling equipment shall be arranged appropriately and provided with the necessary dimensions in consideration of the design ship, the type and volume of cargo, the structure of the mooring facilities, and the condition of cargo handling.

(2) In order to protect the environment surrounding the facilities concerned, cargo handling equipment shall be provided with the functions appropriate for prevention of dust, noise, and the like as necessary.

2 In addition to the provisions specified in the preceding paragraphs, the performance criteria for petroleum cargo handling equipment shall be as specified in the subsequent items:

(1) Under the permanent action situation in which the dominant action is self weight, the risk of impairing the integrity of structural members shall be equal to or less than the threshold level.

(2) Under the variable action situation in which the dominant actions are Level 1 earthquake ground motions, winds, and the weight and pressure of oil cargoes, the risk of impairing the integrity of structural members and losing the structural stability shall be equal to or less than the threshold level.

3 In addition to the provision in the first paragraph, the performance criterion for cargo handling equipment to be installed on the high earthquake-resistance facilities shall be such that the degree of damage owing to the action of Level 2 earthquake ground motions, which is the dominant action under the accidental action situation, is equal to or less than the threshold level.

[Commentary]

(1) Performance Criteria of Cargo Handling Equipment

① Petroleum cargo handling equipment

(a) The settings relating to the design situations, other than accidental situations, and performance criteria for petroleum cargo handling equipment limited to loading arm type only are as shown in **Attached Table 66**.

Attached Table 66 Settings for the Design Situations (excluding accidental situations) and Performance Criteria for Petroleum Cargo Handling Equipment

Ministerial Ordinance			Public Notice			Performance requirements	Design situation			Verification item	Index of standard limit value
Article	Paragraph	Item	Article	Paragraph	Item		Situation	Dominating action	Non-dominating action		
42	2	1	81	2	1	Serviceability	Variable	Self weight	Winds, earth pressures, surcharges	Soundness of members	–
					2			L1 earthquake ground motion (winds) (weights and pressures of petroleum)	Self weight, earth pressures, surcharges	Soundness of members, stability of the structure	–

(b) Soundness of members and the stability of the structure (serviceability)
When verifying the performance of members, the performance criteria regarding their soundness should be appropriately provided. When verifying the performance of petroleum cargo handling equipment with regard to their structures, the performance criteria regarding their stability should be appropriately set according to the structural type.

Cargo handling equipment installed in a high earthquake-resistance facility (restorability)
The settings relating to the design situations, limited to accidental situations only, and performance criteria for cargo handling equipment installed in a high earthquake-resistance facility are as shown in **Attached Table 67**. The reason for indicating "damages" in the "Verification item" column of **Attached Table 67** is that it is necessary to use a comprehensive term taking account that the verification items vary depending on the type, structure and structural type of the facilities.

Attached Table 67 Settings relating for Design Situations, limited to Accidental Situations, and Performance Criteria for Cargo Handling Equipment

Ministerial Ordinance			Public Notice			Performance requirements	Design situation			Verification item	Index of standard limit value
Article	Paragraph	Item	Article	Paragraph	Item		Situation	Dominating action	Non-dominating action		
42	2	1	81	3	–	Restorability	Accidental	L2 earthquake ground motion	Self weight, earth pressures	Damages	–

[Technical Note]

2.1 General

(1) The purpose of introducing cargo handling equipment in ports is to reduce labor works, to speed up cargo handling activities, and to ensure safety. The selection of the type, structure and capacity of cargo handling equipment is preferably made by sufficiently considering the design ships, the type, shape, volume, and particular of cargoes, as well as the relations with yard facilities behind, and the mode of secondary transportation.

(2) Cargo handling equipment installed in cargo handling facilities or mooring facilities shall have the required structure and capacity, and location. The equipment shall be structurally sound, be provided with anti-pollution systems against dust and noise, and ensure smooth and safe operation in cargo handling activities.

(3) Sufficient space should be secured around cargo handling equipment for its various operations by clearing the space of obstacles such as buildings and power lines. Cargo handling equipment should be designed and located so that it does not come into contact with ships at berthing and leaving or during mooring.

(4) Countermeasures against noise and dust are required for bulk cargoes handling equipment because their handling is likely to produce noise and dust. In particular, inflammable dust shall require countermeasures against blast.

2.2 Fundamentals of Performance Verification

(1) Behavior of the cargo handling equipment and mooring facilities during earthquakes and setting of the seismic-resistant performance of the cargo handling equipment

It is necessary to verify the seismic-resistance of the cargo handling equipment and the mooring facilities to ensure that the mooring facilities in which the cargo handling equipment is installed satisfies the requirements regarding its performance during earthquakes. Hence, the seismic-resistant performance of the cargo handling equipment should be defined taking into consideration the fact that deformations, rail span expansions, correspond to the defined performance requirements will occur in the mooring facilities.

(2) Verification Procedure

Verifications of the seismic-resistant performance of cargo handling equipment should take into consideration their interactions with the mooring facilities involved and be performed in accordance with the following procedure:

① Determination of the assumed Level 1 and Level 2 earthquake ground motion on the seismic bedrock

② Calculation of the changes over time in Level 1 and Level 2 earthquake ground motion at the site where the crane rails are located

- In case it is necessary to take into consideration the dynamic interactions between the cargo handling equipment and mooring facility, on a pier type quaywall the changes over time in the horizontal accelerations at the rail site are calculated taking into consideration the dynamic interactions between the crane and the pier. In the case where the installation of an earthquake-resistance crane is expected, a combination of rigidity and damping that reproduces the natural period of the earthquake-resistance container crane shall be given, (see **Fig. 2.2.1**).
- In the case of a type other than a pier type, the changes over time in the ground surface acceleration shall be calculated through a seismic response analysis of the ground and the data obtained is used as the ground motion at the crane rail site.

③ Examination regarding whether the container crane will derail

- The value obtained by dividing the maximum response acceleration of the container crane by the gravitational acceleration is adopted as the design value of the seismic coefficient, the rail span and the location of the center of gravity of the crane are to be modeled, and examination with respect to overturning is performed using the seismic coefficient method (i.e. examination regarding whether the container crane will derail).
- If the results of the examination described above indicate that the crane will overturn, recalculations will be repeated with the dimensions of the earthquake-proofing mechanism section varied until such conditions that prevent overturning or derailing are achieved.

④ Examination of the stroke of the earthquake-proofing mechanism

- After the confirmation that the crane will not overturn, the changes over time in the displacement response are calculated and examination is made as to whether the stroke of the earthquake-proofing mechanism remains within the allowable range of displacement of the earthquake proofing mechanism assumed.

- If the displacements that would occur are out of the allowable ranges, the dimensions of the earthquake-proofing mechanism section will be changed and step ③ will be performed again.

⑤ In the case where the container crane is installed on a pier:

- If there is a difference from the dimensions of the earthquake-resistance cranes assumed that were used in step ② above, the final confirmation will be made by performing step ② again.

⑥ Evaluation of the rail span displacement in relation to the displacement of the crane leg section

- The maximum rail span displacement is calculated from results of seismic response analyses of the mooring facility. Then, an evaluation is made to determine whether the maximum rail span displacement is within the sum of the elastic deformation range of the crane leg section and the displacement of the half-amplitude stroke of the earthquake-proofing mechanism, see **Fig. 2.2.2**.

(3) In the case where it is necessary to take into consideration the dynamic interactions between the cargo handling equipment and mooring facility under the action of ground motion:

In the case of cargo handling equipment installed on top of a mooring facility, the response accelerations of the cargo handling equipment during an earthquake may be amplified and the oscillation characteristic under the action of ground motion may affect the mooring facility when the scale is large, and these must be taken into consideration regardless of whether the state is a variable situation associated with Level 1 earthquake ground motion or an accidental situation associated with Level 2 earthquake ground motion.

The oscillation characteristic such as the natural period in the sea-land direction of cargo handling equipment such as cranes varies depending on the scale and type of the cargo handling equipment, but it usually falls within the range of 0.5 to 3 seconds. Container cranes equipped with an earthquake-proofing mechanism often have a long natural period of around 4 seconds. In the case where such cranes are installed on piers with a natural period of 0.5 to 2.0 seconds, it is necessary to be cautious about the possibility that coupling behaviors, dynamic interactions, may occur in the performance verification of the pier with respect to ground motion. In the case where, regardless of the structural type of the mooring facility, the predominant period of the ground motion at the location where the cargo handling equipment is installed is about 1.5 seconds or longer, it is expected that response accelerations of the cargo handling equipment will become high and thus it may become necessary to conduct a dynamic analysis-based evaluation in the performance verification of the cargo handling equipment. In either case, it is preferable to reduce the response accelerations of the cargo handling equipment through the use of an earthquake-proofing mechanism or a damping mechanism, to prevent derailing and ensure that the soundness of the members will be secured. For details of the performance verifications, explanations about performance verifications of facilities in this Part as well as the **Guide to Earthquake-resistance Design of Container Cranes** [3] may be referenced.

(4) Modeling of Cranes Installed on Piers

In the case where a crane is installed on a pier, performance verification of seismic-resistant should in principle be through dual lumped mass system analyses that use the equivalent rigidity of the piles for one block of the pier (k), the mass of the superstructure (m), the damping factor (c), the equivalent rigidity of the crane (k_c), the mass of the crane (m_c) and the damping factor for the crane (c_c). With regard to the oscillation characteristic of the crane, the natural period should be similar to that of the actual crane. With regard to the damping factor, a value between 1% and 3% should be used unless the damping factor value is specified by the crane manufacturer. The equivalent rigidity values for the pier and the crane are the values for the number of piles per block of the pier and the number of crane leg, respectively, and are represented by the mass system springs shown in **Fig. 2.2.1**. The equivalent rigidity (k) in the mass system model of the pier part is modeled on the assumption that the nonlinear stress-strain relationship used in the design of the pier applies.

(5) Modeling of Cranes Installed on Mooring Facilities other than Piers

In the case of mooring facilities other than piers, the effects of the dynamic interactions are small because the mass of the mooring facilities are large in relation to the mass of cargo handling equipment, which means that it suffices to evaluate, through dynamic analyses, the responses of the cranes themselves during earthquakes. That is, the ground surface ground motion at the location in question is entered in the single mass system that represents the crane part only as shown in **Fig. 2.2.1**.

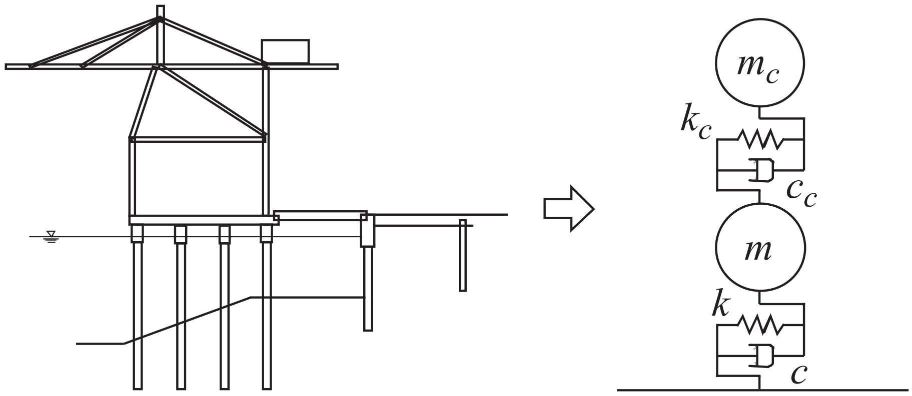

Fig. 2.2.1 Modeling of Pier and Crane

(6) Considerations on the Rail Span Displacements

In principle, the container crane leg section must not uplift during earthquakes. Therefore, it is necessary to provide a mechanism that prevents damages to the crane structure when the rail span widens during an earthquake. For example, in the case of a container crane whose span is 30.5m as shown in **Fig. 2.2.2**, the elastic deformation range of the crane leg section accommodates widening of the span up to around 700mm, that is a reference value and the actual value varies among cranes. By adding this amount of deformation, namely elastic deformation range of the crane leg section, to the displacement of half-amplitude stroke of about 300mm, that is also a reference value and the actual value varies among cranes, of the earthquake-resistance mechanism section, the allowable amount of displacement of about 1,000mm in the maximum for the crane span is obtained. Therefore, the earthquake-resistance mechanism needs to be so designed, as necessary, that it is appropriate for the amount of rail span displacement calculated from results of seismic response analyses of the mooring facility.

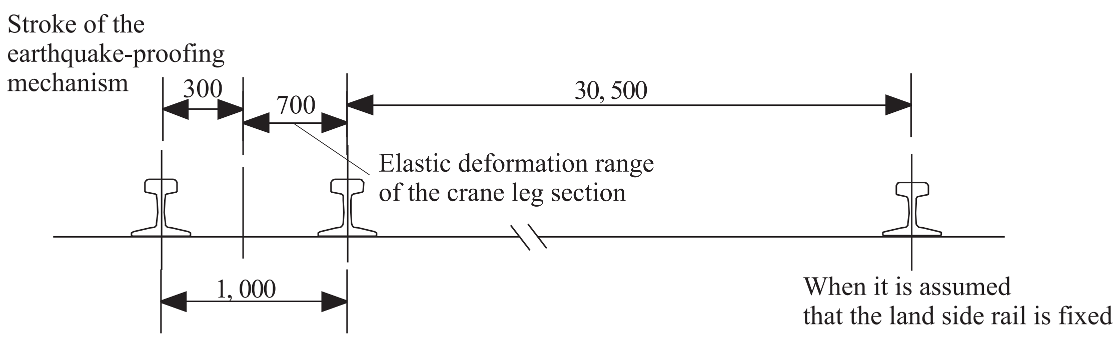

Fig. 2.2.2 Relationship between Deformations of the Crane Leg Section and Rail Span Displacements

2.3 Loading Arms (Stationary Cargo Handling Equipment)

2.3.1 Fundamentals of Performance Verification

(1) Loading arms shall be of a structure ensuring safety against the stress caused by the weight and pressure of oil within them, their self weight, and the wind pressure and the seismic force.

(2) The distance between loading arms and the face line of the mooring facilities is desired to determine appropriately in light of the length of the arms and the height of fenders so that they may cause no obstacles to oil handling.

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3 Cargo Sorting Areas

Ministerial Ordinance

Performance Requirements for Cargo Sorting Areas

Article 43

1 The performance requirements for cargo sorting areas for the safe and smooth sorting of cargo shall be as specified in the subsequent items:

(1) Cargo sorting areas shall satisfy the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism so as to ensure the safe and smooth sorting of cargo.

(2) Damage due to imposed load and other actions shall not adversely affect the continued use of the cargo sorting areas and not impair their functions.

2 In addition to the requirements specified in the preceding paragraph, the performance requirements for cargo sorting areas which need to function in an integrated manner with high earthquake-resistance facilities during disasters shall be such that the damage due to Level 2 earthquake ground motions and other actions do not affect restoration through minor repair works of the functions required of the areas concerned in the aftermath of the occurrence of Level 2 earthquake ground motions. Provided, however, that as for the performance requirements for cargo sorting areas which require further improvement in earthquake-resistant performance due to environmental, social and/or other conditions to which the cargo sorting areas concerned are subjected, the damage due to said actions shall not affect the restoration through minor repair works of the functions of the cargo sorting areas concerned and their continued use.

Public Notice

Performance Criteria of Cargo Sorting Areas

Article 82

1 The performance criteria of cargo sorting areas are as specified in the subsequent items:

(1) Cargo sorting areas shall have the appropriate shape and sizes in consideration of the types and amounts of cargoes and the way cargoes are handled.

(2) The passageways in a cargo sorting area shall have the appropriate widths and alignments so as to ensure the safe and smooth traffic of cargo handling equipment, vehicles, and/or others.

(3) Cargo sorting areas shall be equipped with the appropriate lighting facilities so as to enable the safe and smooth utilization of the cargo sorting areas in consideration of the utilization conditions of the areas concerned.

(4) In the case of cargo sorting areas that are dangerous for people to enter, the cargo sorting areas shall be provided with appropriate means to keep people off the areas.

(5) Cargo sorting areas shall have appropriate drainage facilities to prevent retention of water in the areas.

(6) The risk that a pavement in a cargo sorting area is damaged to the extent which may adversely affect cargo handling works under the variable action situation, in which the dominant action is imposed load, shall be equal to or less than the threshold level.

(7) Cargo sorting areas which deal with cargoes that may be scattered by winds shall be provided with appropriate means to prevent scattering of cargoes.

(8) In the case of a cargo sorting area that is used to handle lumber, the following requirements shall be satisfied:

(a) Appropriate facilities and equipment to dispose of bark shall be provided as necessary.

(b) Appropriate means to prevent lumber from drifting away shall be provided for the cargo sorting area on the water.

2 In addition to the provisions in the preceding paragraph, the performance criteria of the cargo sorting area that shall function in combination with the high earthquake-resistance facilities during disasters shall be such that the degree of damage owing to the action of Level 2 earthquake ground motions, which is the dominant action in the accidental action situation, is equal to less than the threshold level corresponding to the performance requirements.

[Commentary]

(1)Performance Criteria of Cargo Sorting Areas

① Pavements in cargo sorting areas (serviceability)
The settings relating to the design situations, except accidental situations, and performance criteria for pavements in cargo sorting areas are as shown in **Attached Table 68**. The reason for indicating "damages" in the "Verification item" column of **Attached Table 68** is that it is necessary to use a comprehensive term taking account that the verification items vary depending on the type, structure and structural type of the facilities.

Attached Table 68 Settings for to the Design Situations (excluding accidental situations) and Performance Criteria for Pavements in Cargo Sorting Areas

Ministerial Ordinance			Public Notice			Performance requirements	Design situation			Verification item	Index of standard limit value
Article	Paragraph	Item	Article	Paragraph	Item		Situation	Dominating action	Non-dominating action		
43	1	2	82	1	6	Restorability	Accidental	L2 earthquake ground motion	Self weight, earth pressures	Damages	

② Cargo sorting areas that need to function in combination with a high earthquake-resistance facility during disasters
The settings relating to the design situations, limited to accidental situations only, and performance criteria for cargo sorting areas that need to function in combination with a high earthquake-resistance facility during disasters are as shown in **Attached Table 69**. The reason for indicating "damages" in the "Verification item" column of **Attached Table 69** is that it is necessary to use a comprehensive term taking account that the verification items vary depending on the structure and structural type of the facilities.

Attached Table69 Settings for to the Design Situations, limited to Accidental Situations only, and Performance Criteria for Cargo Sorting Areas

Ministerial Ordinance			Public Notice			Performance requirements	Design situation			Verification item	Index of standard limit value
Article	Paragraph	Item	Article	Paragraph	Item		Situation	Dominating action	Non-dominating action		
43	2	–	82	2	–	Restorability	Accidental	L2 earthquake ground motion	Self weight, surcharges	Damages	

[Technical Note]

3.1 General

(1) Cargo sorting areas shall be paved appropriately in respect of their purposes and the ways they are used. With regard to the structures of pavements, **Part III, Chapter 5, 9.14 Aprons** may be referenced.

(2) The widths and curves of passageways shall allow safe and smooth operation of vehicles and cargo handling equipment.

(3) With regard to lighting facilities of cargo sorting areas that are operated at night, the provisions of **Chapter 5, 9.3 Lighting Facilities** may be referenced.

(4) A cargo sorting area that is dangerous for the public is necessary to take appropriate measures to prohibit the entrance of public with provisions of signs, boards, and fences.

3.2 Timber Sorting Areas for Timber Sorting

(1) The appropriate location and size of the land or water surface shall be secured for a timber sorting area to enable safe and smooth timber sorting.

(2) In timber sorting areas for timber, it is preferable to take measures allowing incineration as necessary, including the installation of special plants for bark incineration, and measures providing appropriate safety means to prevent lumber from drifting away or settling down, and appropriate environmental protection means to prevent from scattering bark.

(3) Timber sorting ponds should be located in calm water areas.

(4) It is preferable for timber sorting ponds to be equipped with facilities preventing the drifting of timbers.

(5) It is preferable for timber sorting water area to be so located that the waterway connecting the basin for timber rafts and the sorting pond or timber yard will not obstruct the navigation of by crossing major waterways or basins.

(6) In respect of a breakwater for the timber sorting ponds, **Chapter 4, 7 Breakwaters for Timber Sorting Facilities** can be used as a reference

3.3 Cargo Sorting Facilities for Marine Products

(1) Cargo sorting facilities for marine products shall be designed to ensure synergistic relations among their functions.

(2) Marine product handling facilities consist of marine product sorting areas and related ancillary facilities. Marine product sorting areas deal with all activities ranging from the water-washing to carrying-out of the catch, and are covered with roofs for the preservation of freshness, the prevention of pollution, and the preservation of working conditions. Ancillary facilities include loading area, icehouse, bidding room, and the other facilities, wastewater treatment facilities and freezer facilities which contribute to enhancement of the functions of marine product sorting areas.

3.4 Cargo Sorting Facilities for Hazardous Cargoes

In the case where the cargoes sorted are not hazardous cargoes but are subject to fumigation requirements, it is preferable to provide signs and/or notice boards around the cargo sorting area in which the fumigation is performed and the associated shed indicate that they are dangerous and prohibiting unauthorized entry.

3.5 Container Terminal Areas

3.5.1 General

The scales and types of container terminals vary depending on such factors as the port to be developed, the shipping company that uses the port, the shipping routes, the volume and types of cargoes and the modes of transportation used to haul cargoes into the port behind. Terminals in which containers are handled can be classified into 2 types; wharfs in which only container cargoes are handled, specialized wharfs, and wharfs in which container cargoes as well as other types of cargoes are handled, namely multi-purpose wharfs. In principle, the explanations in this section cover specialized wharfs only.

3.5.2 Performance Verification

(1) Basic principles for performance verifications of container terminal areas
Fig. 3.5.1 [8] shows a typical performance verification procedure for container terminal areas with respect to their scales.

(2) When calculating or determining the scale of a container terminal area, the basic principles described in (3) to (8) below, which are proposed by Takahashi, [8] may be adopted.

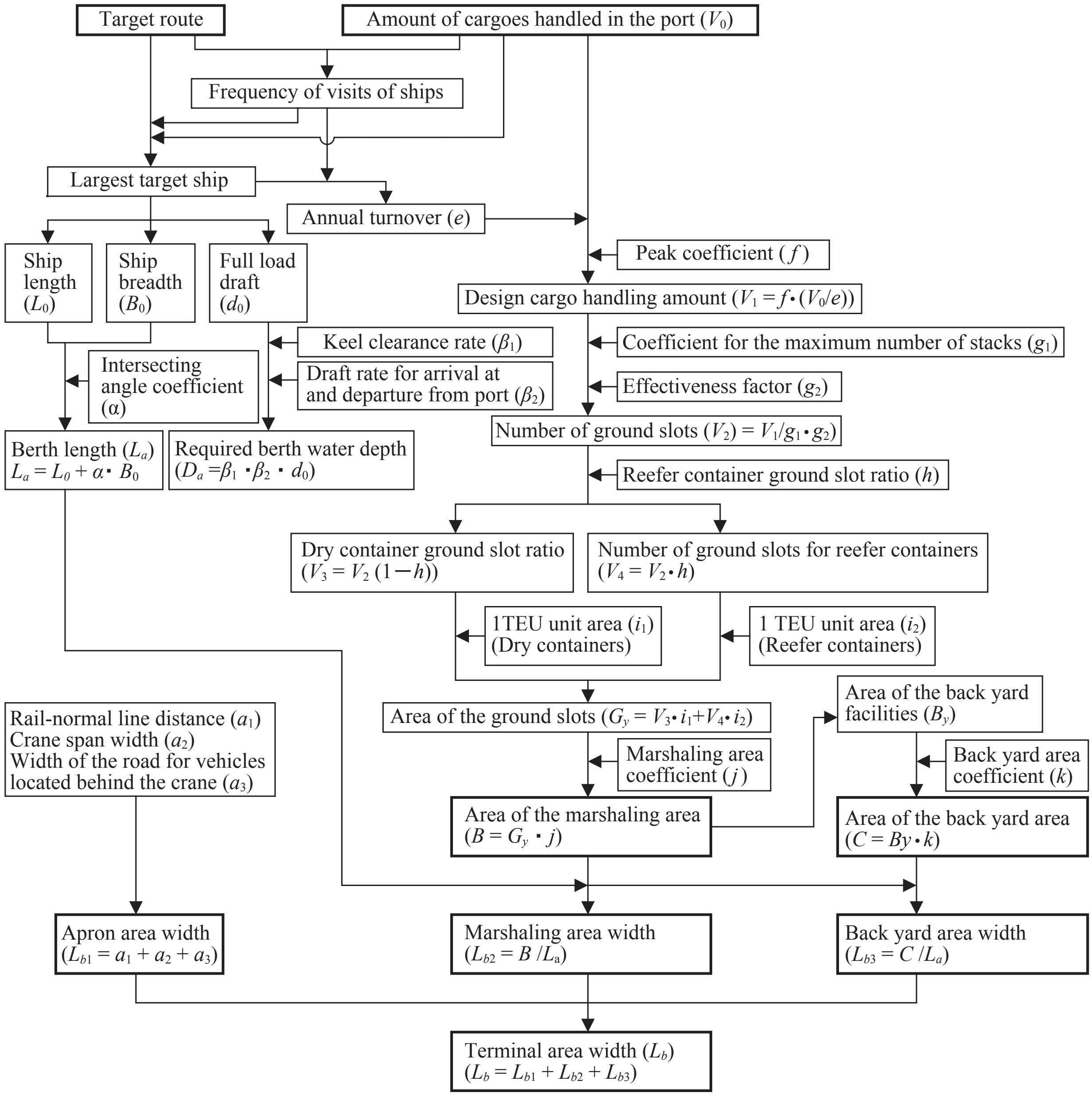

Fig. 3.5.1 Size Estimation Model for Typical Container Berth Terminal Area [25]

(3) Elements of Container Terminals
The main elements of a container terminal are berth, apron area, marshaling area and back yard area. **Fig. 3.5.2** [8] shows a plan view of a typical container terminal area.

① Berths
A berth is an area used to berth and moor container ships in order to handle their cargoes at the container terminal. The size of a berth is set by the berth length L_a and the water depth D_a.

② Apron areas

(a) An apron area is an area in which container cranes and vehicles for cargo handling travel and containers hatch covers of container ships are temporarily stored. The L_{b1} in **Fig. 3.5.2** [8] represents the apron area width.

(b) The apron area width L_{b1} may usually be determined from the rail-normal line distance, the rail span of gantry crane and the width of the strip for the vehicle traveling.

③ Marshaling areas

(a) A marshaling area is an area in which containers to be loaded onto and containers unloaded from container ships are arranged. The L_{b2} in **Fig. 3.5.2** 8) represents the marshaling area width.

(b) With regard to the width of the marshaling, a width of L_{b2} that is appropriate in relation to the berth length may usually be adopted according to the required marshaling area size.

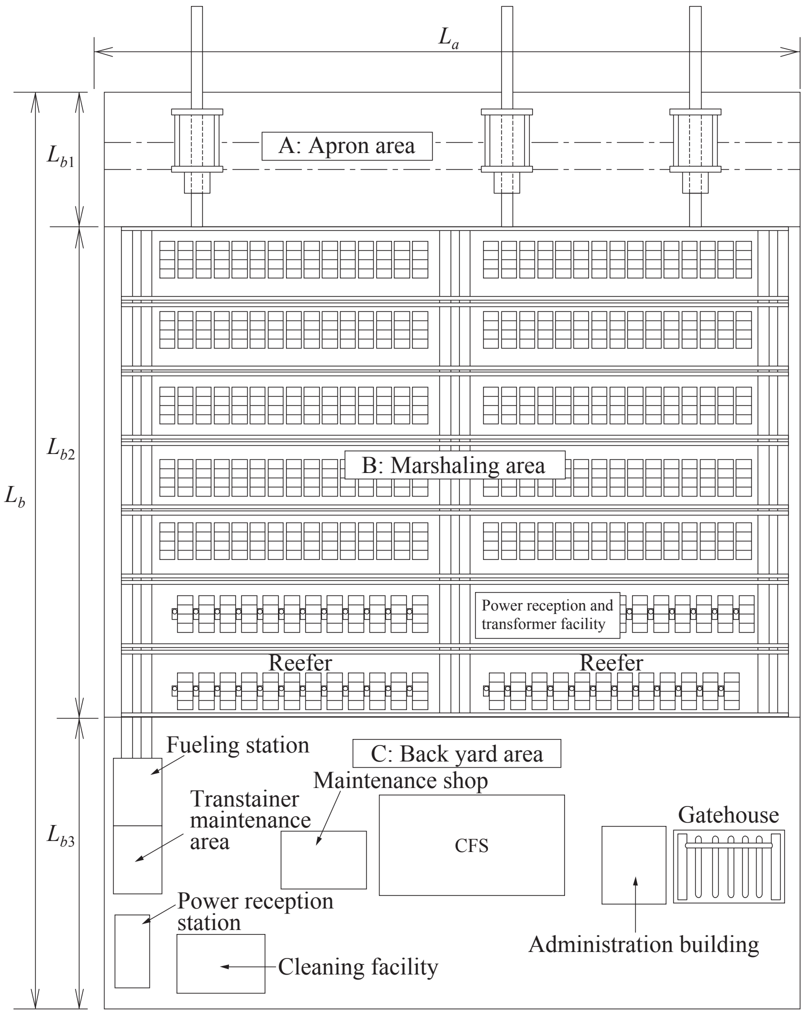

Fig. 3.5.2 Typical Container Terminal 8)

④ Back yard areas

(a) A back yard area is an area that has container freight stations, maintenance shops, an administration buildings, and gates. The L_{b3} in **Fig. 3.5.2** 8) represents the back yard area width. Brief explanations about typical facilities of a back yard area are given below. The term “back yard area” is not a commonly used term; in many cases, the term “container terminal” is used to refer collectively to the marshaling area and the back yard area. However, this section treats the back yard area separately in order to allow quantitative performance verifications of container terminal areas with respect to their sizes.

1) Container freight stations
A container freight station is a building where small-lot consignment cargoes, which individually do not fully occupy a container, are received, stored and delivered and cargoes are packed into and taken out of containers.

2) Maintenance shops
A maintenance shop is a building where inspections of containers and repairs of damaged containers and cleaning of containers before and after use are performed.

3) Administration buildings
An administration building is a building used to centrally direct and control all operations performed in the yard by, for example, planning operations to be performed in the yard, issuing directions and supervising the implementation of the container arrangement plans.

4) Gates
A gate is a place where containers and container cargoes are received and delivered.

(b) With regard to the width of the back yard area, a width of L_{b3} that is appropriate in relation to the berth length may usually be adopted according to the required back yard area size.

(4) Berths

① Berth length
With regard to the berth length of a container terminal, **Chapter 5, 2.1 Common Items for Wharves** may be referenced.

② Berth water depth
With regard to the berth water depth of a container terminal, **Chapter 5, 2.1 Common Items for Wharves** may be referenced.

(5) Apron Areas

① The apron area width L_{b1} may be calculated by equation **(3.5.1)**.

$$L_{b1} = a_1 + a_2 + a_3 \tag{3.5.1}$$

where,
a_1 : rail-quaywall faceline distance
a_2 : rail span width
a_3 : width of the strip for the vehicle traveling behind the crane

② Rail-quaywall faceline distance (a_1)
The determination of the distance between the sea side rail and the faceline of the quaywall should preferably take into consideration the locations of the mooring posts, cable grooves for containers, cable winders and stairways that serve as an access to moored container ships, as well as the characteristics of the container terminal in question. When determining the distance between the sea side rail and the faceline of the quaywall, a value of a_1=3m may be used as a reference value.[9)]

③ Rail span width (a_2)
The rail span width should preferably be a width equal to or larger than the total width of the lanes required to accommodate for the cranes used container handling plus one additional crane. In addition, it is preferable to add 5 to 10m for the passage of personnel and miscellaneous operation vehicles. When determining the required width per lane beneath crane, a value of 5.0m/lane or 5.5m/lane may be used as a reference value for tractor-trailers or straddle carriers, respectively [9)].

Under the above-mentioned guidelines, it may be considered that the rail span width a_2 for the case where 3 cranes are used per ship and straddle carriers are used can be calculated as follows:

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

If the rail span determined based on the structural dimensions of the crane is larger than the required lane width mentioned above, it is necessary to use the former value.

④ Determination of the width of the strip for the vehicle traveling behind the crane (a_3)
The width of the strip for the vehicle traveling behind the crane should preferably be determined appropriately with consideration given to the dimensions of the cranes, and the allowance width.

In the case where tractor-trailers are used, the width of the strip for the vehicle traveling behind the crane may be calculated by adding an allowance width of 3m to the sum of the total width of the temporary storage areas for hatch covers (4 rows:11m; 5 rows:13.5m) [9)] and the minimum lane width of 3.5m.[9)] For example, if the number of rows of hatch cover storage areas is 5, a strip width of 20m is obtained. In the case where straddle carriers are used, a strip width of 37m which is calculated by adding an allowance width of 15m to the width of 22m [9)] for the turning of carriers may be used.

⑤ Standard values for the apron area width L_{b1}
The standard value range for the apron area width is L_{b1}=50 to 80m.
In the case where 3 cranes are used per ship and straddle carriers are used, it may be considered that L_{b1} can be calculated as follows:

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

(6) Marshaling Areas

① The area of a marshaling area may usually be calculated using the procedure shown in **Fig. 3.5.4** based on the design handling volume (V_0 (TEU)).

Calculation of the number of containers handled for marshaling area design (V_1):equation **(3.5.2)**

↓

Calculation of the number of ground slots (V_2):equation **(3.5.3)**

↓

Calculation of the number of dry container ground slots (V_3):equation **(3.5.4)**

↓

Calculation of the number of reefer container ground slots (V_4):equation **(3.5.5)**

↓

Calculation of the ground slot area (G_y):equation **(3.5.6)**

↓

Calculation of the area of the marshaling area (B):equation **(3.5.7)**

Fig. 3.5.4 Example of a Procedure for Performance Verifications with respect to the Area of the Marshaling Area

The area of a marshaling area may usually be calculated using equations **(3.5.2)** through **(3.5.7)**:

$$V_1 = fV_0 / e \tag{3.5.2}$$

$$V_2 = V_1 / \left(g_1 g_2\right) \tag{3.5.3}$$

$$V_3 = V_2 \left(1 - h\right) \tag{3.5.4}$$

$$V_4 = V_2 h \tag{3.5.5}$$

$$G_y = V_3 i_1 + V_4 i_2 \tag{3.5.6}$$

$$B = G_y j \tag{3.5.7}$$

where,

V_0 : design handling volume (TEU)
V_1 : number of containers handled for marshaling area design (TEU)
e : annual turnover (number of times / year)

$$e = D_y / D_t \tag{3.5.8}$$

D_y : annual number of operation days (days)
D_t : average period of storage in the yard (days)
f : peak coefficient
V_2 : number of ground slots (TEU)
g_1 : coefficient for the maximum number of stacks
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 : ground slot area (m^2)
i_1 : floor area per one TEU of dry container (m^2)
i_2 : floor area per one TEU of reefer container (m^2)
B : area of the marshaling area (m^2)
j : marshaling area coefficient

The marshaling area width L_{b2} may be calculated by equation **(3.5.9)** from the area of the marshaling area.

$$L_{b2} = B/L_a \tag{3.5.9}$$

where,

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

L_a : berth length (m)

② The specific settings of the individual coefficients may be referenced in References 8) and 9).

D_t = 2 to 7 days [9)]
D_t = 3 to 9 days [9)]
f = 1.2 to 1.3 [8)]
g_1 = transfer crane = 4 to 5 piles [9)]
straddle carrier = 3 to 4 piles [9)]
g_2 = 0.7 to 0.8 [9)]
h = 0.05 to 0.15 [8)]
i_1 = (8 feet × 20 feet) = 14.9 m^2 [8)]
i_2 = 19.5 m^2 (set based on actual records in Japanese ports)
j = 2.0 to 3.0 (for berth water depth less than 15 m)
j = 2.5 to 3.5 (for berth water depth 15 m or more)D_t=2 to 7 days [9)]
D_t = 3 to 9 days [9)]
f = 1.2 to 1.3 [8)]
g_1 = transfer crane = 4 to 5 piles [9)]
straddle carrier = 3 to 4 piles [9)]
g_2 = 0.7 to 0.8 [9)]
h = 0.05 to 0.15 [8)]
i_1 = (8 feet × 20 feet) = 14.9 m^2 [8)]
i_2 = 19.5 m^2 (set based on actual records in Japanese ports)
j = 2.0 to 3.0 (for berth water depth less than 15 m)
j = 2.5 to 3.5 (for berth water depth 15 m or more)

③ Reference values in respect to setting of coefficient

In general, since settings of individual e, f, g_1, g_2 are difficult, $f/(eg_1g_2)$ can be set as a coefficient by integrating them.

In reference 8), $f/(eg_1g_2)$ = 0.05 to 0.020 is indicated.

④ Reference values in respect to marshaling areas

Number of ground slots (V_2)

In reference 8), the following values are indicated as numbers of ground slots.

V_2 = 1,500 to 2,000TEU (for berth water depth less than 15 m)
V_2 = 1,500 to 2,500TEU (for berth water depth 15 m or more)

Area of marshaling area (B)

In reference 8), the following values are indicated as area of marshaling area..

B = 40,000 to 90,000 m^2 (for berth water depth less than 15 m)
B = 70,000 to 110,000 m^2 (for berth water depth 15 m or more)

⑤ Standard value of marshaling area width

In reference 8), the following values are indicated as standard value of marshaling area width.

L_{b2} = 150 to 250 m (for berth water depth less than 13 m)
L_{b2} = 200 to 300 m (for berth water depth 13 m or more but less than 15.5 m)
L_{b2} = 250 to 330 m (for berth water depth 15.5 m or more)

(7) Back Yard Area (C)

① The area of a back yard area may usually be calculated by equation **(3.5.10)**.

$$C = B_y k \tag{3.5.10}$$

where,

B_y : total area of the back yard area facilities (i.e. total floor area of the container freight stations, maintenance shops, administration buildings, gates, constructed in the back yard area) (m^2)

k : back yard area coefficient

The back yard area widthL_{b3} may be calculated by equation **(3.5.11)** from the area of the back yard area.

$$L_{b3} = C/L_a \tag{3.5.11}$$

where,
C : area of the back yard area (m^2)
L_a : berth length

② With regard to the specific settings of the individual coefficients, Reference 8) may be referenced.

1) Total area of the back yard area facilities (B_y)
$B_y = 7{,}500\ m^2$ (for area of marshaling area: less than 90,000 m^2)
$B_y = 9{,}000\ m^2$ (for area of marshaling area: 90,000 m^2 or more)

2) Back yard area coefficient (k)
k = 4.0 to5.0 [8)]

③ Standard value of back yard area width L_{b3}
In reference 8), L_{b3} =90 to130 m is indicated as standard value of back yard area width.

(8) Container Terminal Area Width

① The container terminal area width L_b may be calculated by equation **(3.5.12)**.

$$L_b = L_{b1} + L_{b2} + L_{b3} \tag{3.5.12}$$

where,
L_{b1} : apron area width
L_{b2} : marshaling area width
L_{b3} : back yard area width

② Standard values for the container terminal area width L_b
When determining the container terminal area width L_b, Reference 8) may be referenced. The following standard value ranges for the container terminal area width which are based on the berth water depth are specified:

L_b = 300 to 400m (when the berth water depth is less than 15m)
L_b = 350 to 600m (when the berth water depth is 15m or more)

References

1) Fujino, S. and Y. Kawasaki: New Series Civil Engineering 81, Giho-do Publishing, pp 184-189, 1981
2) JSCE: Civil Engineering Handbook: Part 37, Ports and Harbours, Giho-do Publishing,, pp. 1605, 1989
3) Japan Fishing Port Association: Handbook for fish port planning (1992), pp.109-135,1992
4) Sato, T: .Utilization planning (4)of land area for fish port facilities, Fish Port, Vol. 13 No. 4, pp 51, 1971
5) Sato, T: .Utilization planning (5)of land area for fish port facilities, Fish Port, Vol. 14 No. 4, pp 42, 1972
6) Sato, T: .Utilization planning (11)of land area for fish port facilities, Fish Port, Vol. 16 No. 2, pp.28-33, 1972
7) Fujino, S. and Y. Kawasaki : Port Planning, New Series Civil Engineering 81, Giho-do Publishing, pp.191-193, 1981
8) Takahasi, H.: A model for estimation scales of container terminal areas at the stage of port and harbour planning- A standard for designing principal size in container terminals : A proposal-, Research Report of National Institute for Land and Infrastructure Management No,10,2003
9) Port and Harbour Bureau Ministry of Transport and Over seas Coastal Area Development Institute of Japan: Report of container terminal facility plans, 1993

4 Sheds

Public Notice

Performance Criteria of Sheds

Article 83

1 The provisions of the first paragraph of the previous article (Items (1) through (4) only) shall also be used as performance criteria for sheds.

2 For sheds, the following performance criteria shall be used in addition to the performance criteria specified in the previous paragraph.

(1) Sheds in which dusts are generated as a result of the handling of cargoes shall have appropriate ventilation facilities and equipment.

(2) Sheds into which water may enter as a result of storm surges shall be provided with appropriate facilities and equipment to prevent ingress of water as necessary.

4.1 General

(1) Sheds shall meet the following requirements to ensure smooth cargo handling before the entrance and after the departure of ships.

(a) The size of a shed shall be determined appropriately by considering the kinds and quantities of cargoes and their handling conditions.

(b) The widths and curves of passageways in a shed shall be determined to allow safe and smooth operation of cargo handling equipment.

(2) With regard to lighting facilities of sheds in which cargoes are handled at night, the provisions of **Chapter 5, 9.4 Lighting Facilities** may be referenced.

Sheds shall be equipped with the provisions of appropriate signs and broads to ensure safe and smooth use as necessary.

Chapter 8 Storage Facilities

1 General

Ministerial Ordinance

Performance Requirements for Storage Facilities

Article 45
The performance requirements for storage facilities shall be such that the storage facilities satisfy the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism so as to enable the safe and appropriate storage of cargo in consideration of geotechnical characteristics, meteorological characteristics, sea states and/or other environmental conditions, as well as the conditions of cargo handling.

Ministerial Ordinance

Necessary Items concerning Storage Facilities

Article 46
The items necessary for the performance requirements of storage facilities as specified in this Chapter by the Minister of Land, Infrastructure, Transport and Tourism and others shall be provided by the Public Notice.

Public Notice

Storage Facilities

Article 84
The items to be specified by the Public Notice under Article 46 of the Ministerial Ordinance concerning the performance requirements for storage facilities shall be as provided in the subsequent article through Article 87.

2 Warehouses

Public Notice

Performance Criteria of Warehouses

Article 86
The provisions in Article 83 shall be applied to the performance criteria of warehouses with modification as necessary.

[Technical Note]

The structure and location of warehouses shall be set appropriately in accordance with the requirements specified in **Chapter 7, 3 Cargo Sorting Areas** and **4 Sheds** and Article 3 of the **Enforcement Rules for the Warehousing Business Law** (Ministerial Ordinance of the Ministry of Transport No.59 of 1956) as a reference.

3 Open Storage Yards

Public Notice

Performance Criteria of Open Storage Yards, Timber Storage Yards and Ponds and Coal Storage Yards

Article 85
The provisions in item i) of Article 82 shall be applied to the performance criteria for open storage yards, timber storage yards and ponds, and coal storage yards with modification as necessary.

[Technical Note]

Open storage yards are subject to the requirements specified in **Chapter 7, 3 Cargo Sorting Areas.** With regard to calculations of the areas of open storage yards, Reference 1) may be used as a reference.

4 Timber Storage Yards and Ponds

Public Notice

Performance Criteria for Open Storage Yards, Timber Storage Yards and Ponds and Coal Storage Yards

Article 85

The provisions in paragraph 1 of Article 82 shall be applied to the performance criteria for open storage yards, timber storage yards and ponds and coal storage yards with modification as necessary.

[Technical Note]

The requirements specified in **Chapter 7, 3 Cargo Sorting Areas** shall be applied to the timber storage yards and ponds.

5 Coal Storage Yards

Public Notice

Performance Criteria for Open Storage Yards, Timber Storage Yards and Ponds, and Coal Storage Yards

Article 85

The provisions in paragraph 1 of Article 82 shall be applied to the performance criteria for open storage yards, timber storage yards and ponds and coal storage yards with modification as necessary.

[Technical Note]

The requirements specified in **Chapter 7, 3 Cargo Sorting Areas** shall be applied to the coal storage yards.

6 Hazardous Materials Storage Facilities

Public Notice

Performance Criteria of Hazardous Materials Storage Facilities and Oil Storage Facilities

Article 87

1 The provisions in Article 83 or paragraph 1 of Article 82 shall be applied to the performance criteria of hazardous materials storage facilities and oil storage facilities with modification as necessary.

2 In addition to the provisions in the preceding paragraph, the performance criteria of hazardous materials storage facilities and oil storage facilities shall be as specified in the subsequent items:

(1) Hazardous materials storage facilities and oil storage facilities shall be located in such a way that they are not scattered over an area. However, noncompliance with this requirement may be permitted in the case where compliance is impossible because of the topography or other reasons.

(2) Hazardous materials storage facilities shall be surrounded by a band of vacant land having an appropriate width in consideration of the types of the hazardous cargoes, the structures of the facilities and other relevant conditions.

7 Oil Storage Facilities

Public Notice

Performance Criteria of Hazardous Materials Storage Facilities and Oil Storage Facilities

Article 87

1 The provisions in Article 83 or paragraph 1 of Article 82 shall be applied to the performance criteria of hazardous materials storage facilities and oil storage facilities with modification as necessary.

2 In addition to the provisions in the preceding paragraph, the performance criteria of hazardous materials storage facilities and oil storage facilities shall be as specified in the subsequent items:

(1) Hazardous materials storage facilities and oil storage facilities shall be located in such a way that they are not scattered over an area. However, noncompliance with this requirement may be permitted in the case where compliance is impossible because of the topography or other reasons.

(2) Hazardous materials storage facilities shall be surrounded by a band of vacant land having an appropriate width in consideration of the types of the hazardous cargoes, the structures of the facilities and other

relevant conditions.

References

1) JSCE: Civil Engineering Handbook, Part 11, Port and harbours, Giho-do Publishing, pp.1606, 1989

Chapter 9 Facilities for Ship Service

1 General

Ministerial Ordinance

Performance Requirements for Facilities for Ship Service

Article 47

1 The performance requirements for ship service facilities shall be such that the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism are satisfied for the provision of safe and smooth services to ships in light of geotechnical characteristics, meteorological characteristics, sea states and/or other environmental conditions, as well as the conditions of ship entry.

2 The performance requirements of water supply facilities for ships shall be such that the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism are satisfied for the sanitary supply of water to ships.

3 The performance requirements for ship storage facilities shall be as specified in the subsequent items:

(1) The requirements specified by the Minister of Land, Infrastructure, Transport and Tourism are satisfied so as to enable the safe bringing-in and bringing-out of ships.

(2) The requirements specified by the Minister of Land, Infrastructure, Transport and Tourism are satisfied so as to enable the proper fixing of ships.

Ministerial Ordinance

Necessary Items concerning Facilities for Ship Service

Article 48

The items necessary for enforcement of the performance requirements for ship service facilities as specified in this Chapter by the Minister of Land, Infrastructure, Transport and Tourism and other requirements shall be provided by the Public Notice.

Public Notice

Facilities for Ship Service

Article 88

The items to be specified by the Public Notice under Article 48 of the Ministerial Ordinance concerning the performance requirements of ship service facilities shall be as specified in the subsequent article.

2 Water Supply Facilities to Ships

Public Notice

Performance Criteria of Water Supply Facilities for Ships

Article 89

The performance criteria of water supply facilities for ships shall be as specified in the subsequent items:

(1) The facilities shall be installed at appropriate locations, corresponding to the condition of use by ships.

(2) The facilities shall have an appropriate capacity of water supply corresponding to the dimensions of the design ship.

(3) The facilities shall have a structure which is capable of preventing water pollution, and the water hydrants shall be maintained in a sanitary condition.

[Technical Note]

(1) The layout and capacity of hydrants shall be determined appropriately according to the type of vessels.

(2) Water supply facilities shall meet the following sanitation requirements:

① The hydrants of water supply facilities shall be of a construction that can prevent contamination of water.

② Periodic and ad-hoc water quality tests shall be conducted and the hygiene of the hydrants of the water supply facilities shall be appropriately maintained.

(3) Intakes of hydrants should be so located that intake hoses can be easily attached and shall be so constructed that contamination of water can be prevented. In addition, means to drain water shall be provided in the case where they are buried beneath the apron floor. Intakes need to be equipped with caps.

(4) Water Supply Volume
With regard to the water supply volume to ships, the values shown in **Table 2.1** may be used as reference values. In the case of large ships, the capacities of water tanks are in many cases around 800m^3 because such ships have their own fresh water production equipment.

Table 2.1 Hydrants and Water Supply Volume

Tonnage of ship (gross tonnage)	Required water supply volume (m^3)	Time required to supply water (h)	Hydrant spacing (m)	Number of hydrants per berth (number of points)	Water supply capacity of each hydrant (m^3/h)
500	40	5	30	2	4
1,000	80	5	30–40	2	8
3,000	250–300	5	40–50	3–4	16
5,000	500	5	40–50	4	18
10,000	800	5	40–50	4	28

Chapter 10 Other Port Facilities

Ministerial Ordinance

Necessary Items concerning Other Port Facilities

Article 53
The items necessary for the performance requirements for fixed and movable passenger boarding facilities, waste disposal seawalls, beaches, and plazas and green space as specified in this chapter by the Minister of Land, Infrastructure, Transport and Tourism and other requirements shall be provided by the Public Notice.

Public Notice

Other Port Facilities

Article 90
The items to be specified by the Public Notice under Article 53 of the Ministerial Ordinance concerning the performance requirements for fixed and movable passenger boarding facilities, waste disposal seawalls, beach and plaza, and green spaces shall be as provided in the subsequent article through Article 95.

1 Fixed and Movable Passenger Boarding Facilities

1.1 Fixed Passenger Boarding Facilities

Ministerial Ordinance

Performance Requirements for Fixed and Movable Passenger Boarding Facilities

Article 49

The performance requirement of the fixed and movable passenger boarding facilities shall be as specified in the subsequent items for the safe and smooth embarkation and disembarkation of passengers in consideration of its structure type:

(1) The requirements specified by the Minister of Land, Infrastructure, Transport and Tourism shall be satisfied so as to enable the safe and smooth embarkation and disembarkation of passengers.

(2) Damage due to self weight, Level 1 earthquake ground motions, imposed load, winds, and/or other actions shall not adversely affect the continued use of the fixed or movable passenger boarding facilities and not impair their functions.

Public Notice

Performance Criteria of Fixed Passenger Boarding Facilities

Article 91

The performance criteria of fixed passenger boarding facilities shall be as specified in the subsequent items:

(1) Passageways of fixed passenger boarding facilities shall satisfy the following requirements so that they allow passengers to embark and disembark in the safe and smooth manner:

(a) The passageway shall have an appropriate width and gradient.

(b) The passageway shall be provided with the means for preventing slipping or constructed with materials that are not prone to slipping.

(c) The passageway shall have side walls, railing, or the like on both sides.

(2) The facilities shall not have a staircase. However, in the case where it is unavoidable to provide a staircase, consideration shall be given to the safety of passengers in setting the rises of its steps and provision of landings as necessary.

(3) The facilities shall not be used for dual services for both passengers and vehicles. However, this requirement does not apply in the case where their structures allow the traffic of passengers and the traffic of vehicles to be separated from each other.

(4) The allowable range of vertical movement of the tip section of a movable bridge of the passenger boarding facilities shall be appropriately set by taking into consideration the tide levels, the changes in ship draft and the ship movements.

(5) The risk of impairing the integrity of structural members shall be equal to or less than the threshold level under the permanent action situation in which the dominant action is self weight.

(6) The risk of impairing the integrity of structural members and the risk of losing the stability of the foundation section shall be equal to or less than the threshold level under the variable action situation in which the dominant actions are Level 1 earthquake ground motions, imposed load, and winds.

[Commentary]

(1)Performance Criteria of Fixed Passenger Boarding Facilities

① Stability of facility

(a) The settings relating to the design situations excluding accidental situations and performance criteria of fixed passenger boarding facilities are as shown in **Attached Table-70**.

Attached Table 70 Settings for the Design Situations (excluding accidental situations) and Performance Criteria for Fixed Passenger Boarding Facilities

Ministerial Ordinance			Public Notice			Performance requirements	Design situation			Verification item	Index of standard limit value
Article	Paragraph	Item	Article	Paragraph	Item		Situation	Dominating action	Non-dominating action		
49	1	2	91	1	5	Safety	Permanent	Self weight	Surcharges, earth pressures, water pressures	Structural soundness of the members, stability of the foundation section	–
					6		Variable	L1 earthquake ground motion (Surcharges) (Winds)	Self weight, surcharges, earth pressures, water pressures (Self weight, earth pressures, water pressures) (Self weight, surcharges, earth pressures, water pressures)	Structural soundness of the members, stability of the foundation section	–

[Technical Note]

1.1.1 Fundamentals of Performance Verification

(1) The provisions in this section can be applied to the performance verification of fixed and movable passenger boarding facilities (hereinafter referred to as "passenger boarding facilities").

(2) Passenger boarding facilities should have functions allowing passengers to embark/disembark safely and smoothly. In principle, they should be separated from boarding facilities for vehicles.

(3) Passenger boarding facilities should not cause passengers to feel danger. They should also have a stable structure against ship oscillations and winds.

(4) Structural Types

① The structure of passenger boarding facilities shall meet the following requirements.

(a) The passages of the passenger boarding facility shall be an appropriate width of about 75cm or more. Considering the fact that such passages are used by senior citizens and physically handicapped people as well, it is preferable to have a width of 1.2m or more.

(b) A passageway shall have ancillary provisions such as the side wall and hand rail on both sides, and a skid proof agent shall be applied or a non-slippery material shall be used on the surface of passageway.

(c) The rises of the steps of the staircases of fixed passenger boarding facilities shall be set giving out consideration to the safety of passengers. In addition, landings shall be provided as necessary. The rise of each step may usually be set at around 16cm, and the step width may usually be set at 30cm or more. In the case where the height of such a staircase exceeds 3m, it is preferable to provide, for every 3m (or less) of height of the staircase, a landing with width of 1.2m or more.

(d) The boarding facility shall not be used both for passengers and vehicles. If passengers can be separated from vehicles, however, the facility may be used for both passengers and vehicles.

(e) The inclinations of passages of the passenger boarding facilities shall be ones that are appropriate in terms of the safety of passengers. The inclinations of passages of the passenger boarding facilities shall normally be 12% or less. However, considering the fact that such passages are used by senior citizens, and physically handicapped people as well, it is preferable to use slopes between 5% and 8%.

② The allowable range of vertical movement of the tip section of a movable bridge of the passenger boarding facility shall be set taking into consideration the tide range, the changes in ship draft and the ship oscillations. The range of vertical movement of the tip section of a movable bridge may be calculated by adding 1.0m to the mean monthly tide range.

③ When designing the passenger boarding facilities that are to be used for public traffic, the fact shall be taken into consideration that they will be used by senior citizens and physically handicapped people as well and sufficient consideration shall be given to ensuring that they allow people in wheelchairs to move safely on them.

1.2 Movable Passenger Boarding Facilities

Ministerial Ordinance

Performance Requirements for Fixed and Movable Passenger Boarding Facilities

Article 49

The performance requirement of the fixed and movable passenger boarding facilities shall be as specified in the subsequent items for the safe and smooth embarkation and disembarkation of passengers in consideration of its structure type:

(1) The requirements specified by the Minister of Land, Infrastructure, Transport and Tourism shall be satisfied so as to enable the safe and smooth embarkation and disembarkation of passengers.

(2) Damage due to self weight, Level 1 earthquake ground motions, imposed load, winds, and/or other actions shall not adversely affect the continued use of the fixed or movable passenger boarding facilities and not impair their functions.

Public Notice

Performance Criteria of Movable Passenger Boarding Facilities

Article 92

1 The provisions in the preceding article except those in item (6) shall be applied to the performance criteria of movable passenger boarding facilities with modifications as necessary, in consideration of the type of the facilities.

2 In addition to the provisions in the preceding paragraph, the performance criterion of movable passenger boarding facilities shall be such that the risk of losing the stability of the facilities due to uplifting of the leg section of the facilities shall be equal to or less than the threshold level under the variable action situation in which the dominant actions are Level 1 earthquake ground motions, imposed load, and winds.

[Commentary]

(1)Performance Criteria of Movable Passenger Boarding Facilities

① Stability of facilities

(a) Stability of the leg section (serviceability)

The settings relating to the design situations except accidental situations and performance criteria of movable passenger boarding facilities are as shown in **Attached Table 71**. When verifying the performance of a movable passenger boarding facility with respect to the risk of uplifting of the leg section, appropriate performance criteria regarding its stability shall be established.

Attached Table 71 Settings relating to the Design Situations (excluding accidental situations) and Performance Criteria of Movable Passenger Boarding Facilities

Ministerial Ordinance			Public Notice			Performance requirements	Design situation			Verification item	Index of standard limit value
Article	Paragraph	Item	Article	Paragraph	Item		Situation	Dominating action	Non-dominating action		
49	1	2	91	1	5	Serviceability	Permanent	Self weight	Surcharges, earth pressures, water pressures	Structural soundness of the members, stability of the foundation section	–
					6		Variable	L1 earthquake ground motion (Surcharges) (Winds)	Self weight, surcharges, earth pressures, water pressures (Self weight, earth pressures, water pressures) (Self weight, surcharges, earth pressures, water pressures)	Structural soundness of the members, stability of the foundation section	–
			92	2				L1 earthquake ground motion (Surcharges) (winds)	Self weight, surcharges, earth pressures, water pressures (Self weight, earth pressures, water pressures) (Self weight, surcharges, earth pressures, water pressures)	Uplifting of the leg section	–

References

1) Transport Ecology and mobility Foundation: Guideline of the facilities for elderly and handicapped people in public transport terminals, 2001
2) Japan Road Association: Specifications and Commentary for Highway Bridges, Maruzen Publications, 2002
3) Japan Road Association: Technical Standards and commentary of grade separation facilities for pedestrians, 1979

2 Waste Disposal Sites

Ministerial Ordinance

Performance Requirements for Waste Disposal Sites

Article 50

1 The performance requirements of waste disposal sites shall be such that the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism are satisfied so as to appropriately dispose waste materials and protect disposal sites.

2 The provisions of Article 16 shall be applied correspondingly to the performance requirements for waste disposal sites.

Public Notice

Performance Criteria of Waste Disposal Sites

Article 93

1 The provisions in Article 39 shall be as applied to the performance criteria of waste disposal sites with modifications as necessary.

2 In addition to the provisions in the preceding paragraph, the performance criteria of waste disposal sites shall be such that waste disposal sites are appropriately located with the necessary dimensions so as to prevent washing out of the wasted materials by waves, storm surges, tsunamis, and others by taking into consideration the environmental conditions to which the facilities concerned are subjected.

[Technical Note]

2.1 General

(1) Wastes disposal sites are classified, according to what types of wastes are disposed of, into three types: (a) inert type wastes disposal sites where inert type industrial wastes, dredged material and excavated soil from construction site are dumped, (b) controlled type disposal sites where municipal solid wastes and controlled industrial wastes are disposed of, (c) strictly controlled type wastes disposal sites in which harmful specially controlled industrial wastes are sealed.

(2) The purposes of constructing wastes disposal seawalls are to ensure the availability of wastes disposal and to utilize completed disposal sites. The area and location of the wastes disposal sites shall be determined in consideration of the demands of the land use and the constraint to be imposed under the Wastes Management and Public Cleaning Law when it is applicable.

(3) No wastes disposal sites has been constructed in areas other than sea areas and it is expected that most of the wastes disposal sites that will be constructed in the future will also be located in sea areas. Therefore, the term “wastes disposal sites” here refers only to be sites constructed in seas. The characteristics of the wastes disposal sites are; ① to take into consideration the actions of waves and seismic motion, ② in the case of a site for controlled disposal area, to ensure the stability of the seawall and seepage control work by controlling the water levels of the retained water.

2.2 Purposes of Wastes Disposal Seawalls

(1) The purposes of wastes disposal seawalls are to develop a wastes disposal sites and to protect the disposal site and the area behind it from storm surges, tsunamis and waves and to utilize reclaimed land after wastes disposal is completed.

(2) To ensure the environmental safety and suitability of the wastes disposal sites, it is essential not only to ensure that it meets the performance requirements but also to ensure that the dumping of wastes is appropriately controlled. Therefore, it is necessary to ensure that appropriate coordination is achieved, with regard to the adequate inspection and control of the receiving of wastes, in cooperation with the organizations responsible for controlling the disposal of wastes.

2.2.1 Inert-type Wastes Disposal Sites

Inert type wastes disposal sites are facilities to create a reclaimed land by using inert type industrial wastes excavated soil from construction seawalls and dredged material.

2.2.2 Controlled-type Wastes Disposal Sites

As in the case of inert type wastes disposal sites, controlled type wastes disposal sites need to have functions to prevent the wastes from being washed out. In addition, they need to have the required seepage controlling capability so that the retained water in the site will not leak out.

2.2.3 Strictly Controlled-type Wastes Disposal Sites

Because the wastes to be disposed of is harmful substances, strictly controlled type wastes disposal sites need to have a structure that completely isolates the site from the outside.

2.3 Fundamentals of the Performance Verification

(1) Unlike in the case of revetments of protective facilities for harbors, the purpose of wastes disposal seawalls is to dump wastes and such sites usually have a long reclamation period and often remain in a structurally unstable state for a long period of time. Therefore, it is necessary to pay particular attention to ensuring the structural safety during the construction period. One effective approach is to give priority to the wastes dumping behind the seawalls of the sites so that sufficient structural stability is achieved early.

(2) If wastes are dumped at a rapid rate near a seawall, a circular slip failure may occur in the cohesive soil ground and this may impair functions of the wastes disposal sites. Therefore, when determining the areas where wastes to be dumped and the rates of dumping, attention should be paid to the changes in the strength of the ground due to consolidation settlement.

(3) The wastes disposal sites are desired to ensure that wastes will not be washed out offshore when the site is subjected to variable or permanent actions. In addition, it is desirable to ensure that the site has a structure, for example seawalls of the site or seepage control work, that can prevent wastes from being washed out offshore when the site is subjected to actions of Level 2 earthquake ground motion.

2.4 Performance Verification

(1) When verifying the performance of a site of a controlled type wastes disposal site, the seawall may be considered as a kind of revetment and **Chapter 4, 12.1.3 Performance Verification** may be referenced. In addition, the following may be applied.

(2) The requirements for seepage control work specified in the Ministerial Ordinance Determining Engineering Standards Pertaining to Final Disposal Site for Municipal Solid Wastes and Final Disposal Site for Industrial Wastes which apply to seawalls for controlled type coastal disposal sites are as follows:

① The case where no seepage control work is required;
If a landfill site has continuous layer whose thickness is 5m or more and whose coefficient of permeability is $k = 1 \times 10^{-5}$cm/s or less (an impermeable layer) at the bottom and at the sides of the site, it is not necessary to provide any seepage control work.

② The case where there is no impermeable layer that covers the entire bottom of the landfill site;
It is regulated that, if there is no impermeable layer, seepage control work that satisfies the requirements given below (this is called surface seepage control work) or seepage control work having the equivalent or better seepage control capability be provided. In addition, wastes disposal seawalls located in areas where deteriorations of impervious sheets due to sunlight may occur are subject to the surface seepage control work protection requirements including spreading of the light-blocking nonwoven fabric.

(a) The impervious sheet is laid on the surface of a layer of clay or other material having a thickness of 50cm or more and a coefficient of permeability of $k = 1 \times 10^{-6}$cm/s or less.

(b) The impervious sheet is laid on the surface of a layer of asphalt concrete of a thickness of 5cm or more and a coefficient of permeability of $k = 1 \times 10^{-7}$cm/s or less.

(c) Double impervious sheets are laid on the surface of a non-woven fabric or any other material. A non-woven fabric or any other material which has a sufficient thickness and strength for preventing simultaneous damage of both impervious sheets is provided between the impervious sheets.

③ The case where there is a impermeable layer that covers the entire bottom of the landfill site;
It is regulated that, if there is a impermeable layer, seepage control work that satisfies the requirements given below or seepage control work having the equivalent or better seepage control capability be provided. It is also required that such seepage control work reach the impermeable layer.

(a) The ground around the landfill site is solidified to impermeable layer to a Lugeon value of 1 or less by grouting of chemicals.

(b) There is provided a wall of a thickness of 50cm or more and a coefficient of permeability of $k = 1 \times 10^{-6}$cm/s or less around the landfill site to the impermeable layer.

(c) There are provided steel sheet piles (limited to those which have measures taken to prevent leaching of retained water or the like from the part of joint with the other sheet piles) around the landfill site to the impermeable layer.

(d) Seepage control work that satisfies the requirements specified in (a) to (c) of ② above.

(3) In the case of inland wastes disposal sites, it is often the case that impervious sheets are used to ensure that sufficient seepage control performance of the bottom is achieved. On the other hand, in the case of wastes disposal sites located in areas in seas, it is often the case that cohesive soil below the bottom is used to ensure that sufficient seepage control performance of the bottom is achieved. In such a case, it is necessary to confirm whether a layer of cohesive soil which is equivalent to an impermeable layer exists at the bottoms of the disposal sites located in seas and to confirm that the strata of cohesive soils have a impermeability equivalent to that of an impermeable layer specified in the Ministerial Ordinance Determining Engineering Standards Pertaining to Final Disposal Site for Municipal Solid Wastes and Final Disposal Site for Industrial Wastes.

It can be considered that a stratum having a seepage control capability equivalent to that of an impermeable layer is evaluated by the permeation time. The permeation time can usually be calculated by equation (**2.4.1**).

$$t = \frac{L^2}{kh} \qquad (2.4.1)$$

where,

t : permeation time (s)
L : permeation distance (thickness of layer) (cm)
k : coefficient of permeation (cm/s)
h : water level difference in the layer, see **Fig. 2.4.1** (cm)

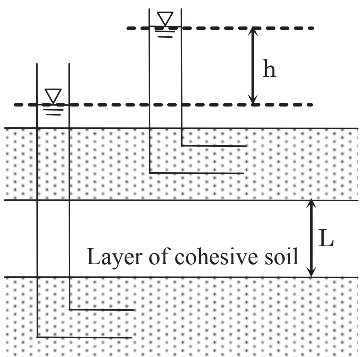

Fig. 2.4.1 Permeation Distance and Water Levels

Calculations of the thicknesses of layers which are equivalent in terms of the permeation time to a impermeable layer whose thickness is 5m or more and coefficient of permeability is $k = 1 \times 10^{-5}$cm/s or less using equation (**2.4.1**) result in a layer thickness of 1.6m or more in the case of a layer of a cohesive soil whose coefficient of permeability is $k = 1 \times 10^{-6}$cm/s. The layer thickness and continuity of an impermeable layer shall be confirmed through a boring survey. When determining the layer thickness, it is desirable to add an allowance taking into consideration the non-uniformity of the soil layer.

(4) To prevent leaching of the retained water from the inside of a costal wastes disposal site, it is preferable to maintain the water level of the retained water low.

(5) Controlled type wastes disposal sites retain their seepage control capability after the wastes disposal areas cease to be used, and it is possible that the structural stability of seawalls for controlled type wastes disposal site may be impaired when the level of the retained water exceeds the control water level as a result of rain etc. Therefore, it is necessary to confirm during the performance verification the stability of the seawalls of which the level of the retained water reaches the expected highest level after the disuse of the wastes disposal site.

References

1) Port and harbour Bureau, Ministry of Transport: Manual for design, construction and maintenance of revetment of controlled disposal (Under preparation for publishing)

3 Beaches

Ministerial Ordinance

Performance Requirements for Beaches

Article 51

1 The performance requirements for the beaches shall be as specified in the subsequent items to facilitate the maintenance of the port and harbor environment:

(1) Beaches shall satisfy the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism so that they will contribute to the development of the port and harbor environments.

(2) Beaches shall be capable of maintaining a stable state over a long term against variable waves and water flows.

2 In addition to the requirements specified in the preceding paragraph, the beaches which are utilized by an unspecified large number of people shall satisfy the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism so as to ensure the safety of the users of the beaches concerned.

Public Notice

Performance Criteria of Beaches

Article 94

1 The performance criteria of beaches shall be as specified in the subsequent items:

(1) Beaches shall be appropriately located with the necessary dimensions so as to ensure the safe and comfortable use by people and to contribute to the enhancement of good port environments.

(2) The risk of losing the stability of the beach profiles and plan shape shall be equal to or less than the threshold level under the variable action situation in which the dominant actions are variable waves and water flows.

2 In addition to the provisions in the preceding paragraph, the beaches which are utilized by an unspecified large number of people shall be provided with the dimensions required for securing the safety of the users by taking into consideration the environmental conditions to which the facilities concerned are subjected and the utilization conditions.

[Commentary]

(1)Performance Criteria of Beaches

① Stability of facility (serviceability)
The settings relating to the beach performance criteria and the design situations excluding accidental situations are as shown in **Attached Table-72**. When verifying the performance of a beach with respect to its shape, appropriate performance criteria regarding its stability shall be set.

Attached Table-72 Settings relating to the Performance Criteria of Beaches and the Design Situations (excluding accidental situations)

Ministerial Ordinance			Public Notice			Performance requirements	Design situation			Verification item	Index of standard limit value
Article	Paragraph	Item	Article	Paragraph	Item		Situation	Dominating action	Non-dominating action		
51	1	2	94	1	2	Serviceability	Variable	Variable waves, water flows	–	Stability of the beach in terms of its shape	–

[Technical Note]

3.1 General

(1) Beaches can be classified into two types according to the grain size distribution of the sediment; beaches of that consist of mud, sand, and gravel and beaches that consist of base rock and rocky reefs . Each beach can be zoned into the backshore, foreshore, tidal flat and shoal zones, which are defined based on their relative height to intertidal zone. Each beach can also be zoned into seagrass meadows and coral reefs based on the types of ecosystems of floras and faunas. **Fig. 3.1.1** shows a cross section of a typical sandy beach.

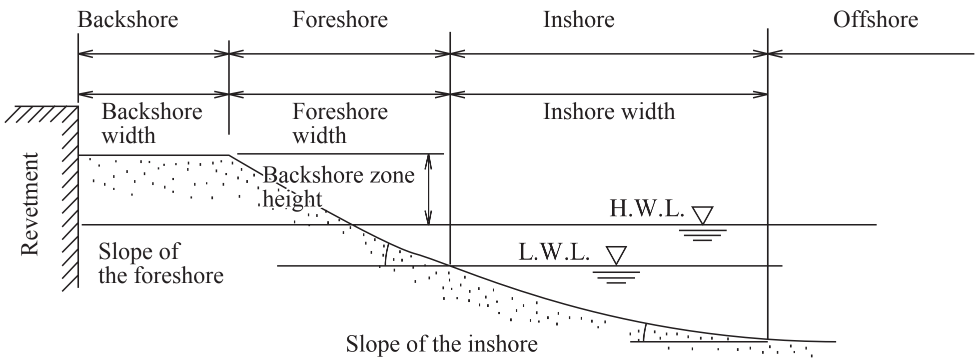

Fig 3.1.1 Cross Section of a Typical Beach

(2) Tidal flats are muddy sand beaches that are exposed during low tide.[1)] Tidal flats often form complex and valuable natural environments because a variety of dominant forces and actions occur concurrently in and around tidal flats, including the cycle of ebb and flow, changes in salinity due to river discharges and changes in topograph caused by waves and water flows. Seagrass meadows are shallow sea areas in which macrophytes and seagrass grow densely to form their colonies. Such colonies are formed at water depths between several tens of centimeter and ten meters plus several meters. Coral reefs are topographic features that are formed by hermatypic organisms such as corals.

(3) Beach nourishment defined as supplying sand along shores to help development of beaches. Constructed beaches should be appropriately designed in terms of the grain size and the slope. In the case of a beach without continuous supply of sediment, jetties and detached breakwaters should be placed to maintain a stable state of the beach under such conditions.

(4) Beaches usually refers not only to constructed beaches, but also to naturally developed beaches. Here, the beaches refers to constructed beach and natural beaches to be maintained and restored.

3.2 Purposes of Beaches

(1) Beaches as a kind of shore protection facilities are developed for the purposes of protecting shores from being damaged by tsunamis, storm surges, waves, and other phenomena relating to fluctuations of sea water or grounds and facilitating appropriate development, as well as to conserve shore environments and to provide proper uses of shores by the general public. The main purpose of such beaches is shore protection. On the other hand, beaches which are facilities for enhancement of port environments are developed mainly for the purpose of maintaining comfortable living spaces having intimacy with water. Such beaches serve the purpose of ensuring safe and comfortable use of shore and conserving natural environments in addition to protecting shores.

(2) The functions of intimacy with water include; (a) recreational areas for such activities as shellfish gathering, swimming and fishing, (b) recreational areas for playing beach volleyball etc., (c) space for agriculture or fishery activities and (d) spaces for environmental education.

(3) Natural environment conservation functions of beaches include the function of (a) habitats creation for a variety of organisms by forming good biological environments for organisms to live and grow, (b) the function of purifying sea water through physical and biological actions of beaches and (c) the function of producing organisms which is supported by primary production.

(4) In addition to the intimacy with water, beaches have the function of reducing wave overtopping rates by damping the energy of the incident waves through wave breaking and the function of preventing the scouring of toe sections of dikes.

3.3 Fundamentals of Performance Verification

(1) Each beach has one or more of the functions such as intimacy with water, habitat development function, sea water purification function, organism production function. Because these functions may be complementary to each other or conflict with each other, it is necessary, when examining the construction of beaches, to establish appropriate objectives first. When establishing such objectives, it is important to identify the past and existing relationships between the natural environments and the ways the area in question is used by the local residents. This information is useful in consulting among the parties concerned and deciding on plans based on the sharing of feelings regarding the roles of the nature in relation to humans. All analyses and evaluations should take into consideration the fact that these functions are affected by the stability and level of maturity of each ecosystem and environmental changes.

3.4 Landscape of Beaches

(1) With regard to long-term changes in beach, morphology it can be said that a constructed beach is stable in the long term if the beach is stable against the prevailing waves immediately after its completion. Short-term changes in landscape is affected mainly by the littoral drift in the shore-offshore direction. Therefore it is necessary to examine appropriate measures such as; (a) examine stabilization measures by means of jetty and detached breakwaters, (b) select sand grain sizes for the beach which are appropriate in relation to the characteristics of the waves, and (c) replenish the beach with sand so that the loss of sand is canceled out.

(2) Materials to be used for beach nourishment need to be selected carefully because such materials constitute an important factor that affects, together with the beach morphology, the performance and stability of the beach. When performing analyses and evaluations relating to a beach nourishment-based beach management, it is necessary to take into consideration the fact that the grain size distribution of a nourished beach affects not only the stability and cross section of the beach but also the degrees of satisfaction of beach users and the levels of quality of habitats of organisms in and around the beach nourishment site. In addition, it is necessary, when selecting materials to be used for beach nourishment, to exercise due care, because, if sediments are washed away by waves, waters adjacent to the beach nourishment site may be adversely affected.

(3) When developing a plan to provide a structure or facility made of a stone in a tidal flat or rocky shore, it is necessary to give sufficient consideration to locating it appropriately so that the safety of users and the stability of the facilities are ensured.

(4) Jetty and detached breakwaters should preferably be so located that the stability of the beach in terms of its shape is ensured and sea water can circulate without becoming excessively stagnant so that deterioration of the sea water quality will be mitigated.

(5) With regard to landscape of beaches, verifications regarding the dimensions of each beach including width, height and length and the grain size are necessary. In addition, when determining the structural dimensions, the methods described below may be used as a guide.

① Crest height and crest width of the backshore
The crest height of the backshore should be determined based on measurements taken at the site or at a similar coast located near the site or using the proposed estimation formulas.[1), 4), 5)] The crest width of the backshore should be determined taking into consideration the amount of short-term regression of the shoreline during high wave periods that is estimated by using numerical calculations or the historical data.

② Slope of the foreshore
The slope of the foreshore, which is one of the essential dimensions of a beach, should be determined by using the proposed estimation formulas [1), 4), 5)] or based on measurements taken at the site or at a similar coast located near the site taking into consideration the changes in grain size and the wave conditions. The sea bottom slope of a tidal flat is often not gentler than that of a beach. (See **Fig. 3.4.1**.)

③ Sediment grain size
The sediment grain size affects not only the stability and cross sectional slope of the beach [1), 4), 5)] but also the degrees of satisfaction of beach users about their uses of the beach, the distribution of habitats of organisms, the environment purification functions and the permeability or water retention characteristic.[1), 5)] The grain size distribution of the sediment should be appropriately determined taking into consideration these factors.

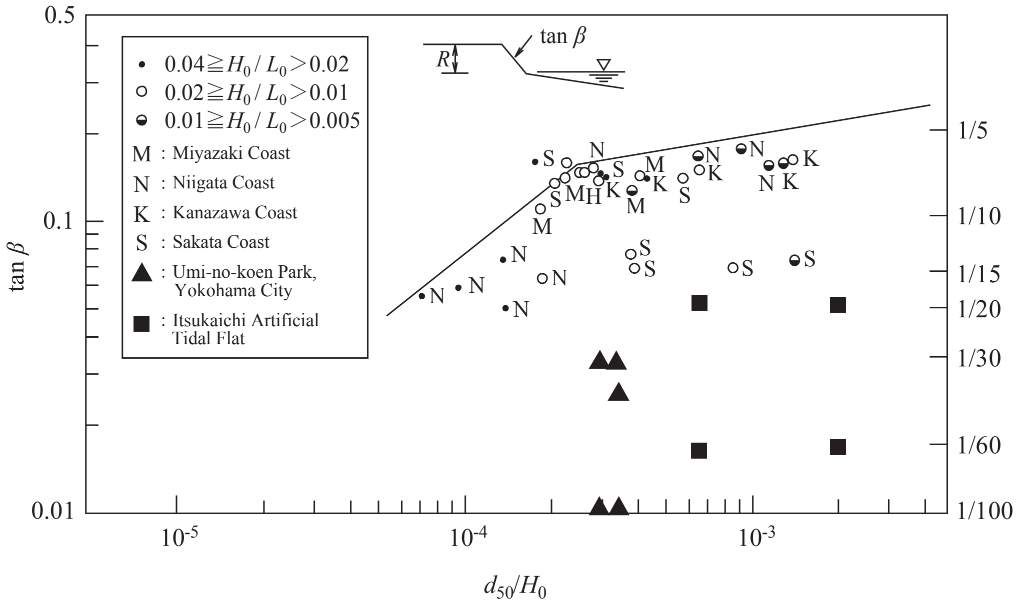

Fig. 3.4.1 Relationship between Sea Bottom Slope and Sediment Grain Size [4)]
(tanβ, d_{50} and H_0 denote the sea bottom slope, median grain size and deepwater wave height, respectively.)

(6) In a verification of stability, it is necessary to predict the short- and long-term changes of the shoreline or the changes in water depth and the sediment transport amount by using appropriate numerical calculations and estimation formulas taking into consideration the effects of the facilities for wave control and sediment movement control facilities.[2), 4)] The initial shoreline configuration shall remain similar to the shape of the shoreline of the landscape of the beach after stabilization that is determined based on the actions of waves and the locations of jetties and detached breakwaters.

(7) When examining a project to constructing or restoring a tidal flat, it is necessary to; (a) give consideration to ensuring that the landscape of the tidal flat will remain stable and the functional requirements established during the planning phase will be satisfied, and (b) devise measures to allow organisms desirable for the area to live in the area. In other words, it is necessary to examine the basic facilities to maintain the landscape of the tidal flat and measures to allow desirable organisms to live in the tidal flat area, and to facilitate the succession of such organisms. With regard to this, the following basic principles may be used as a source of reference:

① In principle, the crest height of the backshore should be the H.W.L. or higher.

② The crest height of the backshore of a tidal flat and the inclination of the foreshore of the tidal flat is determined based on the actions of waves.

③ The foreshore and backshore of a tidal flat should be located in such a way that they will not be frequently subjected to high waves, so that the stability of the landscape of the beach will be ensured.

④ It is difficult to fix the landscape of the inshore of a tidal flat by waves because the inclinations of the inshore of tidal flats are very gentle.

⑤ In the case of a river mouth tidal flat, the stability of the sediment against the water flow is sometimes taken into consideration. There is sometimes the case that changes in salinity affect habitats and activities of organisms.

⑥ In the case of a foreshore tidal flat, consideration should be given to ensuring the stability of the basic facilities by, for example, making the beach as flat as possible and so designing the foreshore section that its length is sufficient. The numbers of organisms that live in the area are sometimes affected by whether the silty clay contents of the tidal flat and beach are appropriate and whether the water retention capability is appropriate.

⑦ The landscape of the foreshore of a foreshore tidal flat sometimes consists of both flat sections and multi-step bar trough sections. There is sometimes the case that many benthoses such as shellfish and sand lugworms live in the water depth below the M.W.L.

(8) In a lagoon tidal flat where the surrounding environment becomes important, the sea water circulation and the sea water quality maintenance will be an important point for the performance verification. The height and slope of the ground and the settings relating to vegetation are determined based on such considerations. In such a case, the following basic principles may be used as a source of reference:

① With regard to introduction of sea water, it should be ensured that connection with the surrounding waters is maintained by channels or training jetties.

② Introduction of sea water to exchanged is an essential measures of controlling the water levels, salinity, nutrients and dissolved oxygen. Sluice gates are sometimes used to control these conditions. In such a case, examinations regarding the water balance are performed that take into consideration the freshwater inflows, sea water exchanges, sea water circulation, vaporization, precipitation, overflows and underseepage.

③ Sea water circulations are essential also from the perspective of ensuring that larvae of transport and recruitment to and from rivers and the open sea.

④ To avoid the formation of hypoxic water masses near the bottom of a lagoon, it is advisable to be set the ground height that the water depth will not exceed 1m during lowest tide periods.

⑤ When making the landscape by soil dumping, the height of the land shall be determined taking into consideration of the settlement of the land.

⑥ Certain kinds of birds have preferences in respect of the water depths of tidal flats and the slope of beaches. Snipes and plovers prefer water depths of 0.4m or less, and ducks prefer water depths of 0.5m or more.

(9) There are two methods to maintain beaches. One is the sand bypass method which makes the sediment accumulated on the upstream side of a coast structure flow continuously to the downstream side. The other one is the sand back pass method which moves the sediment to eroded areas located upstream of the coast structure.

3.5 Amenity

(1) Beaches should be appropriately evaluated in relation to the requirements of the amenity function with the frequencies of their use for swimming, shellfish gathering and other purposes taken into consideration.

(2) Beaches should be appropriately provided with resting areas and planted vegetation according to their purposes. When examining the plant vegetation, it is necessary to perform sufficient analyses taking into consideration the fact that coastal areas are subjected to special environmental conditions such as strong winds, salt water splashes and saline soils.

(3) It is necessary to take into consideration the fact that the main purpose of beaches is human use and give sufficient consideration to ensuring the safety of the users so that accidents due to beach deformations should be avoided. Once a newly constructed or restored beach is opened for public use, it is necessary to conduct periodic patrols and inspections to confirm that the safety measures are functioning properly. In particular, it is important to take measures to prevent sand outflows from nourished beaches, which may cause collapses or create cavities that cannot be recognized from the surface of the ground, and to continuously check for and monitor phenomena that may affect the safety of the users by conducting periodic patrols and inspections after the beach is opened for public use.

(4) Beaches provide spaces where people can relax and enjoy recreational activities. However, the safety of beach users is occasionally threatened by tidal waves, storm surges and tsunamis. Therefore, beaches should be provided as necessary with emergency communication equipment such as alarm equipment and telephones that is necessary to allow the beach users to evaluate whether their safety is being secured.

3.6 Conservation of Natural Environments

(1) Beaches have natural environment conservation functions such as the function of developing habitats for organisms, the function of purifying sea water and the function of producing organisms.

(2) Beaches can be broken down into such constituents as seaweed colony areas, tidal flats and coral reefs based on the types of ecosystems of floras and faunas.

References

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4 Plazas and Green Spaces

Ministerial Ordinance

Performance Requirements for Plazas and Green Spaces

Article 52

The performance requirements for the plazas and green spaces shall be as specified in the subsequent items to facilitate development of port environments as well as the restoration and reconstruction of the port and its surrounding areas:

(1) The plazas and green spaces shall satisfy the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism so that they contribute to the development of good port environments and to ensure the safety of the users of the plazas and green spaces.

(2) The plazas and green spaces shall satisfy the requirements specified by the Minister of Land, Infrastructure, Transport and Tourism so that they can be utilized as a base for the restoration and reconstruction of the port and its surrounding areas in the aftermath of the occurrence of Level 2 earthquake ground motions.

(3) The damage due to Level 2 earthquake ground motions and other actions shall not affect restoration through minor repair works of the functions required of plazas and green spaces in the aftermath of the occurrence of Level 2 earthquake ground motions.

Public Notice

Performance Criteria of Plazas and Green Spaces

Article 95

The performance criteria of plazas and green spaces shall be as specified in the subsequent items:

(1) Plazas and green spaces shall be appropriately located with the necessary dimensions so as to ensure the safe and comfortable use by people and to contribute to the enhancement of good port environments.

(2) Plazas and green spaces shall be capable of being utilized as the bases for restoration and reconstruction of ports and their surrounding areas after they are subjected to Level 2 earthquake ground motions, and shall be provided with the dimensions necessary for ensuring smooth transport of goods and materials and providing the areas for refuges.

(3) The degrees of damage by the action of Level 2 earthquake ground motions, which are the dominant action in the accidental action situation, shall be equal to or less than the threshold limit.

[Commentary]

(1)Performance Criteria of Plazas and Green Spaces

① Stability of facility (restorability)

The settings relating to the design situations limited to the accidental situations only and the performance criteria of plazas and green spaces are as shown in **Attached Table-73**. The reason for indicating “damages” in the “Verification item” column of **Attached Table-73** is that it is necessary to use a comprehensive term taking account that the verification items vary depending on the type, structure and structural type of the facilities.

Attached Table 73 Settings for the Design Situations limited to the Variable Situations only and Performance Criteria of Plazas and Green Spaces

Ministerial Ordinance			Public Notice			Performance requirements	Design situation			Verification item	Index of standard limit value
Article	Paragraph	Item	Article	Paragraph	Item		Situation	Dominating action	Non-dominating action		
52	1	3	95	1	3	Restorability	Accidental	L2 earthquake ground motion	Self weight, surcharges	Damages	

[Technical Note]

(1) Development of Good Port Environments
Plazas and green spaces should preferably be appropriately provided with rest areas and planted vegetation according to their purposes.

References

1) Bureau of Port and Harbours, Ministry of Transport (Edition) and Waterfront Vitalization and Environment Research Center: Design and construction of manual for the arrangement of garden plants on port green belt, 1999
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