CHARTING THE FUTURE

ClassNK

Guidelines for Container Stowage and Securing Arrangements (Edition 3.1)

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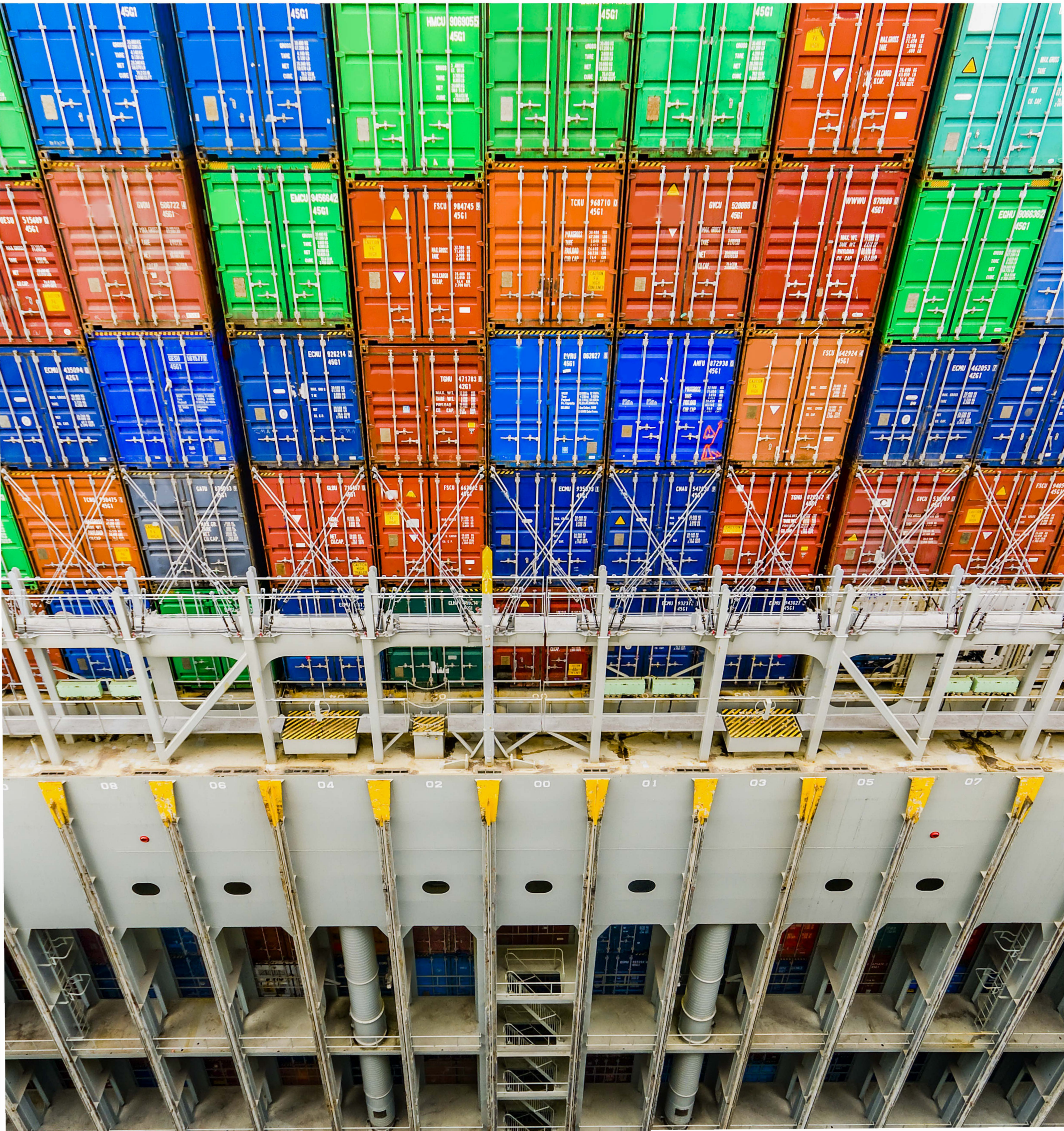

Introduction

The main aim of merchant ships is to transport various goods by sea to their destinations safely without any loss or damage in route. For this purpose, it is essential to take adequate countermeasures to prevent cargo shifting and overloading in addition to ensuring proper ship operation.

Recently, the amount of freight containers has significantly increased and container carriers have been getting larger for more effective transportation. Furthermore, various new technologies regarding securing arrangements, methods and devices have been developed to enhance the efficiency of loading containers on board. Accordingly, it has become more important to evaluate the adequacy of such container stowage and securing arrangements.

ClassNK has published "Guidelines for Container Stowage and Securing Arrangements" in October 2009. After that, Class NK has published 2nd edition of the guideline to define notations for a container ship with lashing calculation program and in compliance with the guidance on providing safe working conditions for securing of containers on deck in CSS Code (Code of Safe Practice for Cargo Stowage and Securing) Annex 14.

This 3rd edition of the guideline has been published for the growth of a container ship size and evolution of lashing technique, taking findings of Comprehensive Renewal of Part C and R&D results in ClassNK Research Institute into consideration.

It would be our great pleasure if the guidelines could provide useful information and contribute to the safe and rational stowage and securing of containers.

February 2023

Nippon Kaiji Kyokai (ClassNK)

Guidelines for Container Stowage and Securing Arrangements

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Guidelines for Container Stowage and Securing Arrangements

Chapter 1 OVERVIEW OF CONTAINER STOWAGE AND SECURING ARRANGEMENTS

1.1 Overview of Transportation and Securing of Cargo at Sea

-1. Static loads, dynamic loads, wind loads, etc. are external loads that act upon cargo loaded onto ships. It is necessary for cargo to be appropriately stowed and lashed in designed positions in order to prevent any damage to such cargo and any collapse or loss as a result of these external loads.
-2. Cargo was conventionally shipped by general cargo ships. However, the introduction of specialized containers and container ships meant that there was basically no longer any need to lash each piece of loaded cargo directly to the ship. In addition, the use of standardized containers for shipping allowed the use of standardized securing devices. Such standardized devices allowed for steadier and more effective lashings than those previously used.
-3. The outline of the marine transportation patterns and lashing methods used in general cargo ships and special ships is given in **Table 1.1.**

Table 1.1 Securing of Cargo Loaded onto Ships

Cargo		General cargo ships	Special ships	
Grouping	Packing type, Category	Securing type	Ship type	Securing method/device
General cargo	Blocks	Ropes, nets, blocks	Container ships	Cargo is loaded into containers, and containers are then secured by using dedicated devices such as stackers, twistlocks, lashing rods and turnbuckles.
	Drums	Same as above		
	Steels	Same as above		
	Bags	Nets		
Special cargo	Containers	Ropes, blocks		
	Cars	Same as above	Car carriers Car ferries	Secured by dedicated securing devices such as textile belts and D-rings.
	Heavy cargo	Ropes, chains, blocks	Heavy cargo carriers	Secured by dedicated wires
	Logs	Ropes, chains, stanchions	Lumber carriers	Secured by dedicated wires
	Ores	No need to be secured; however, cargo trimming is needed.	Ore carriers	No need to be secured
			Bulk carriers	No need to be secured. However, cargo is to be trimmed as necessary.
	Coals	Same as above		Same as above
	Grains	Same as above		Same as above
	Liquid cargo	No need to be secured	Tankers	No need to be secured

1.2 Overview of Container Ships

1.2.1 Types of Container Ships

In general, a container ship is specifically built for transporting containers and has cargo holds and exposed decks that are designed for the effective stowage of such containers. Container ships can be categorized by ship size, container stowage methods, loading and unloading facilities, etc. The typical categories of container ships are as follows:

(1) Categorization by Ship Size

(a) Panamax Type Container Ships

Container ships that are of the maximum dimensions capable of passing through the Panama Canal (32.3*m* in breadth as of 2014) are called Panamax type container ships. Panamax ships can normally stow containers between 2,000TEU to 4,800TEU. Up to 13 rows of containers can be stowed transversely, up to 7 tiers can be stowed vertically on exposed decks, and up to 11 rows and 8 tiers can be stowed in cargo holds in general.

(b) Over-Panamax Type Container Ships

Since this type of container ship has wider breadth and higher transverse metacentric height compared to Panamax type container ships, over-Panamax ships are not as limited as Panamax ships regarding the stability effects of container stowage. Accordingly, containers can be stowed in higher positions, and some of the recent ships called Ultra Large Container Ships (ULCS) are designed to stow up to more than 20,000TEU containers.

(2) Categorization by Loading and Unloading Facilities

(a) Container Ships with Cargo Gear

The majority of this type of container ship can stow containers less than 3,000TEU. Since these container ships have cranes such as jib cranes for cargo handling, containers can be shipped to ports that have no cargo handling capability. However, in container dedicated terminals, such onboard cranes may cause some instability or get in the way of the cargo handling equipment used in such terminals.

(b) Gearless Container Ships

This type of container ship is not installed with onboard cargo handling cranes. Containers are handled by the cargo handling equipment located on the quays of container terminals. Gearless container ships are not able to conduct cargo handling in quays that are not equipped with cargo handling equipment. However, since these ships are designed to maximize cargo handling efficiency in container terminals, most container ships built these days are gearless container ships.

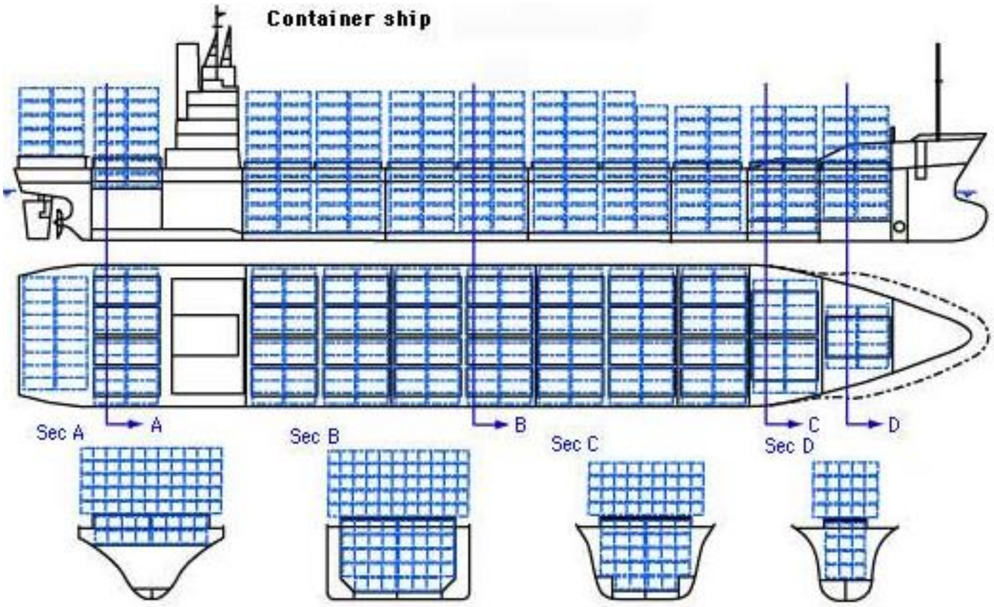


Fig.1.1 Gearless Container Ships

(c) Hatch Coverless Container Ships (Open-top Container Ships)
This type of container ship is not equipped with any hatch cover except at the ship bow. In this type of ship, containers stowed on exposed decks are fixed by cell guides projecting through the deck. Cell guides are devices that support 4 container corner posts and are aimed for increasing the number of container stowage tiers. Since containers stowed on exposed decks are supported by cell guides, the work required for lashing and the opening and closing of hatch covers can be reduced. In addition, cargo handling efficiency and shipping efficiency increase due to fewer constraints on the mixed stowage of high-cube containers. However, there is a need for special countermeasures to take into account the possible ingress of sea water into cargo holds that do not have a hatch cover.

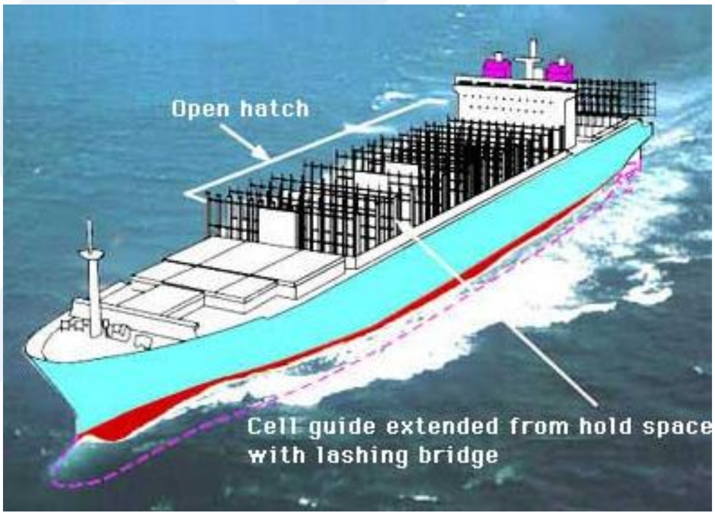


Fig.1.2 Open-top Container Ships

1.2.2 Current Trends in Container Ships

-1. Growing Size of Container Ships

Growth in the volume of containers shipped in recent years has led to an increase in the size of container ships. Accordingly, this increase in ship size has led to fewer stability constraints regarding the number of containers stowed on exposed decks, and containers can be stowed in the position higher than before.

-2 Installation of Lashing Bridges

Lashing bridges are usually installed onboard so that securing work becomes more efficient and the weight of laden contents in containers increases. Due to the installation of lashing bridges, containers can be lashed from higher places and thus resulting in a reduction of the force acting on containers and devices and increase in the weight of laden containers. In recent years, lashing bridges that have the height of 2 or 3 tiers of containers have been installed, and lashing bridges for only outboard stacks that have a height greater than that for inboard stacks are sometimes installed in order to withstand wind loads.

Fig.1.3 Lashing Bridges

-3. Introduction of “Girderless Design”

Recent container ships have adopted the so-called “Girderless design” in which deck girders are not provided at hatch openings. This allows the number of containers stowed in cargo holds to be increased.

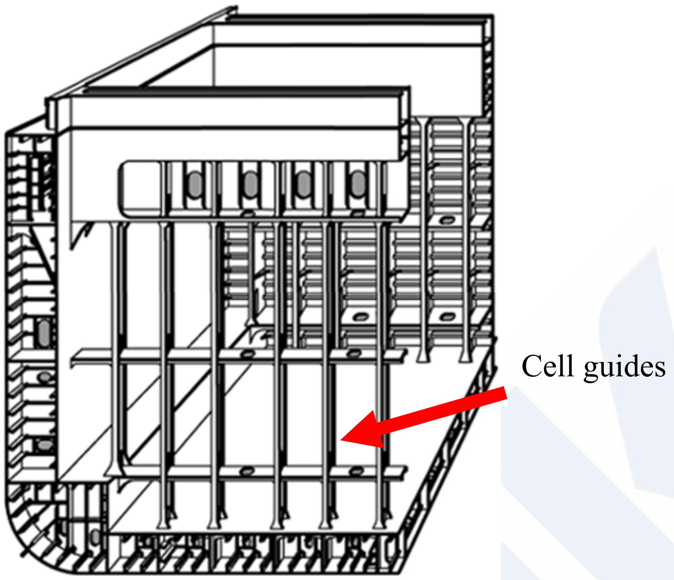


Fig.1.4 Cargo Hold Construction of Girderless Container Ships

1.3 Overview of Freight Containers

1.3.1 Types of Freight Containers

Containers used for marine transportation are defined according to the terms and definitions provided by the ISO (International Organization for Standardization), the JIS (Japanese Industrial Standards), and so on. The principle terms and definitions specified by the ISO regarding containers used for marine transportation are showed in **Table 1.2.**

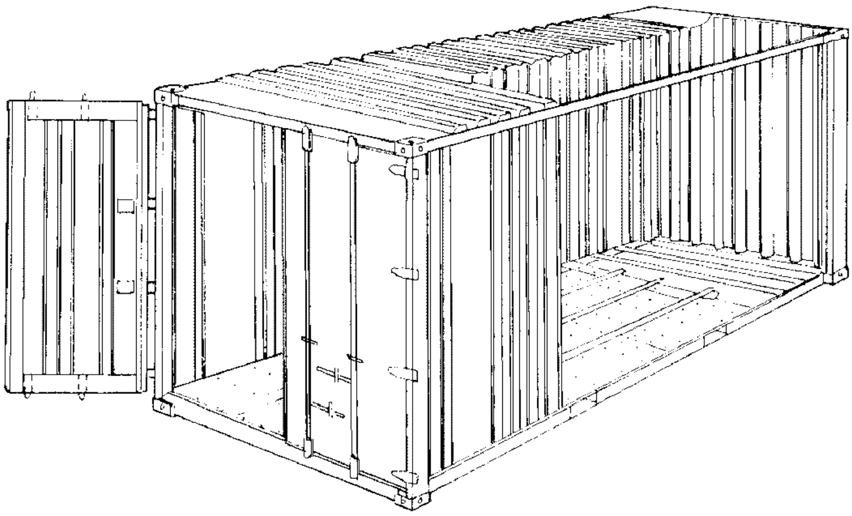


Fig.1.5 General Cargo Containers

Table 1.2 Terms and Definitions of ISO Containers (taken from ISO standards)

Terms	Definitions
General Cargo Container	Freight container that is not intended for use in air transport, nor primarily intended for the carriage of a particular category of cargo such as a cargo, requiring temperature control, liquid or gas cargo, dry solids in bulk or cargoes such as automobiles (cars) or livestock
General Purpose Container	General cargo container that is totally enclosed and weather-proof, having a rigid roof, rigid side walls, rigid end walls and a floor, having at least one of its end walls equipped with doors and intended to be suitable for the transport of cargo of the greatest possible variety (See **Fig.1.5**)
Specific-purpose Container	General cargo container that has constructional features either for the "specific purpose" of facilitating packing and emptying other than by means of doors at one end of container, or for other specific purposes such as ventilation
Open-top container	Specific-purpose container that has no rigid roof but may have a flexible and movable or removable cover, made e.g. of canvas or plastic or reinforced plastic material, normally supported on movable or removable roof bows
Platform Container	Specific-purpose container that has no superstructure whatever, but has the same length, width, strength requirements and handling and securing features as required for interchange of its size within the ISO family of containers
Platform-based Container with Incomplete Superstructure and Fixed Ends	Platform-based container without any permanently fixed longitudinal load-carrying structure between ends other than at the base.
Thermal Container	Freight container built with insulating walls, doors, floor and roof designed to retard the rate of heat transmission between the inside and the outside of the container
Refrigerated Container	(1) Mechanically Refrigerated Container Thermal container fitted with a refrigeration unit and a heat-producing appliance (2) Refrigerated and Heated Container Thermal container fitted with a refrigerating appliance (mechanical or expendable refrigerant) and heat-producing appliance
Tank Container	Freight container which includes two basic elements, the tank or tanks and the framework

1.3.2 Size and Strength of Containers

The scantlings and strength of freight containers are specified by the International Organization for Standardization (ISO). Most containers used for marine transportation are examined and manufactured in accordance with ISO standards. Details regarding the values of the scantlings and strength of containers given in the ISO standards are described in **"Chapter 2 STRENGTH OF CONTAINERS AND SECURING DEVICES"**.

1.4 Stowage Methods of Containers

1.4.1 General

-1. As shown in **Fig.1.6**, container ships take maximum advantage of space on exposed decks and in holds for container stowage.
-2. Containers stowed on exposed decks are generally secured by securing devices such as lashing rods. In addition, containers stowed in cargo holds are fixed by cell guides.

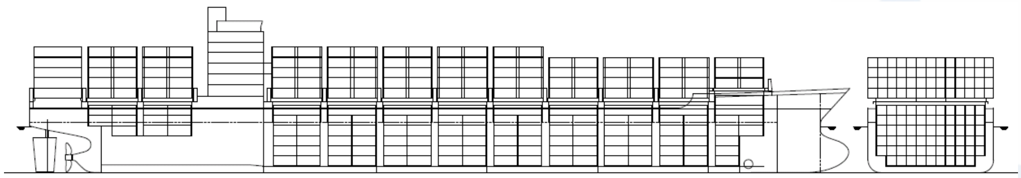


Fig.1.6 Container Stowage Example

1.4.2 Stowage on Exposed Decks

-1. Container Securing
In general, there is a need for containers to be secured in order to prevent them from moving and falling down since general container ships do not have cell guides on their exposed decks and hatch covers, and are not equipped with equipment for container fixing on exposed decks.
-2. Overview of Container Securing
The basic concept regarding container securing is shown in **Fig.1.7**. Containers are stowed on deck sockets installed on exposed decks and hatch covers. Vertical and horizontal movements of containers are prevented by twistlocks fitted between deck sockets and the first tier containers or connections between containers. Furthermore, containers are secured by lashing rods and turnbuckles by using eye plates, fixed on exposed decks and hatch covers, and the corner fittings of end walls.
-3. Overview of Container Securing Devices
Representative devices for container securing are shown in **Table 1.3**.
-4. Lashing Methods for Containers Stowed on Exposed Decks.
(1) Lashing method that uses lashing rods at an angle are usually adopted. Containers are lashed from lashing bridges that are the height of 1 tier or 2 tiers of containers. In addition, outboard stacks of containers may be secured from lashing bridges that are higher than those used for inboard stacks.
(2) Lashing examples in cases where containers are stowed on exposed decks are shown in **Fig.1.8** to **1.10**.

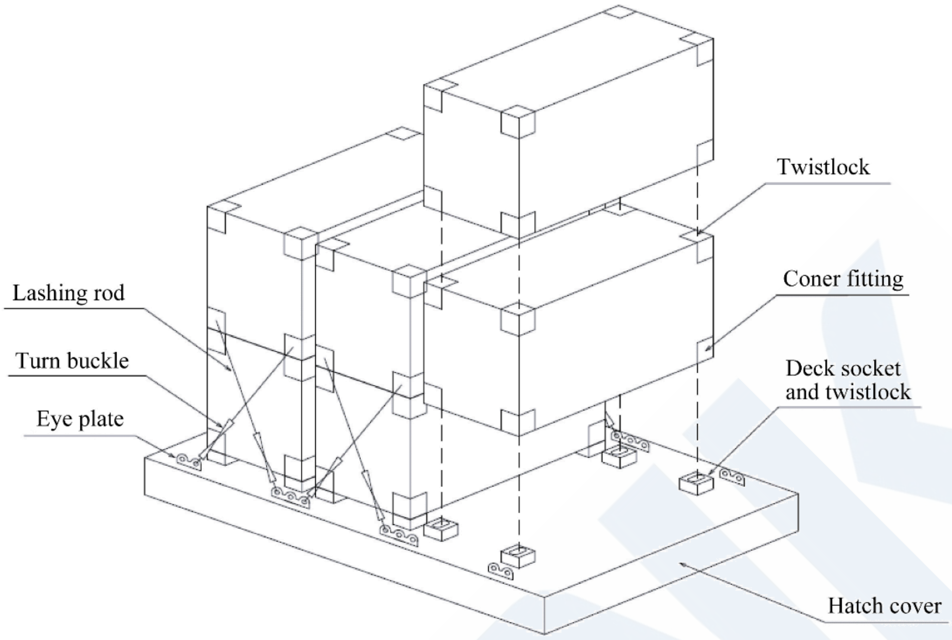
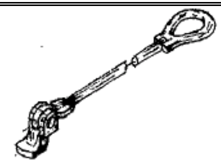
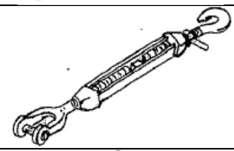
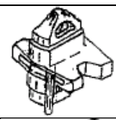
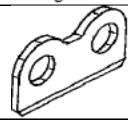
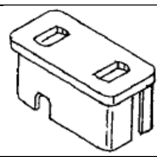


Fig.1.7 Basic Concept of Container Securing

Table 1.3 Overview of Container Securing Devices

Description	Overview of Securing Device	Schematic
Lashing Rod	Lashing rods secure onto the end walls of containers and are used with securing turnbuckles.	
Turnbuckle	Turnbuckles remove slack from securing devices such as lashing rods and apply tension for securing.	
Twistlock	Twistlocks fix the 4 corners between upper and lower containers and prevents containers from moving vertically and horizontally.	
Eye Plate	Eye plates are fitted on the hull side of lashing devices and are installed on lashing bridges and hatch covers.	
Lashing Bridge	Lashing bridges allow securing from higher places and reduce the force acting on containers, and are securing devices for the purpose of increasing container weight.	
Hatch Cover	Hatch covers act as platforms for receiving container loads, and securing devices such as container sockets and eye plates are installed on hatch covers.	
Deck Socket	Deck sockets are installed on exposed decks and hatch covers and secure bottom containers stowed on exposed decks by using twistlocks.	

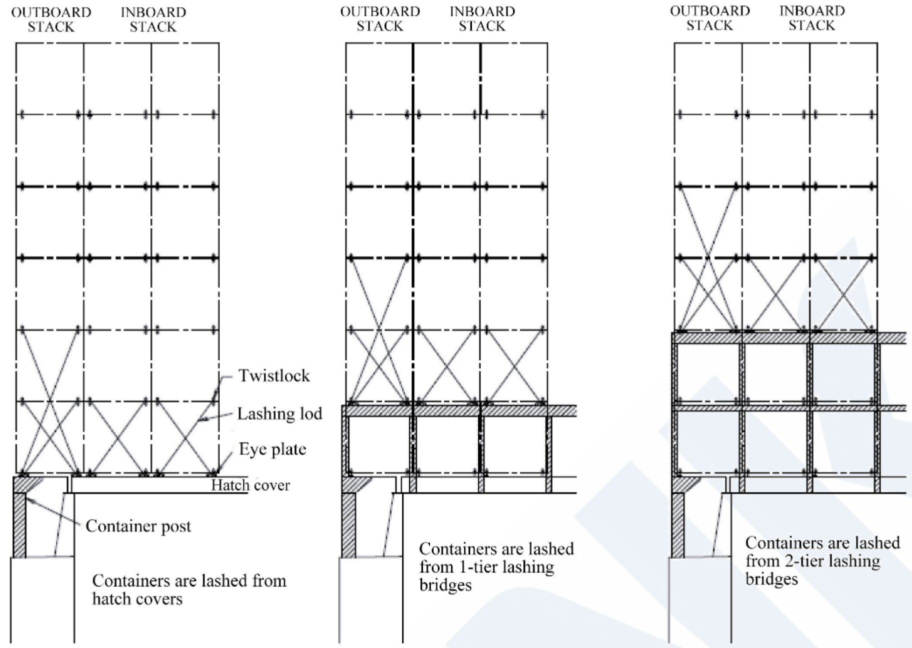


Fig.1.8 Cross Lashing (Single)

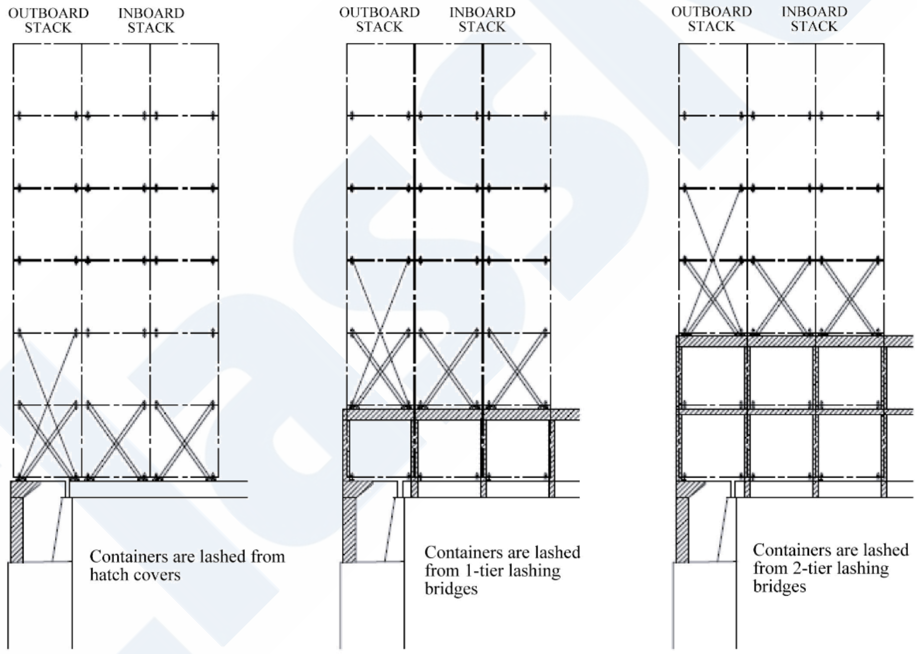


Fig.1.9 Cross Lashing (Parallel)

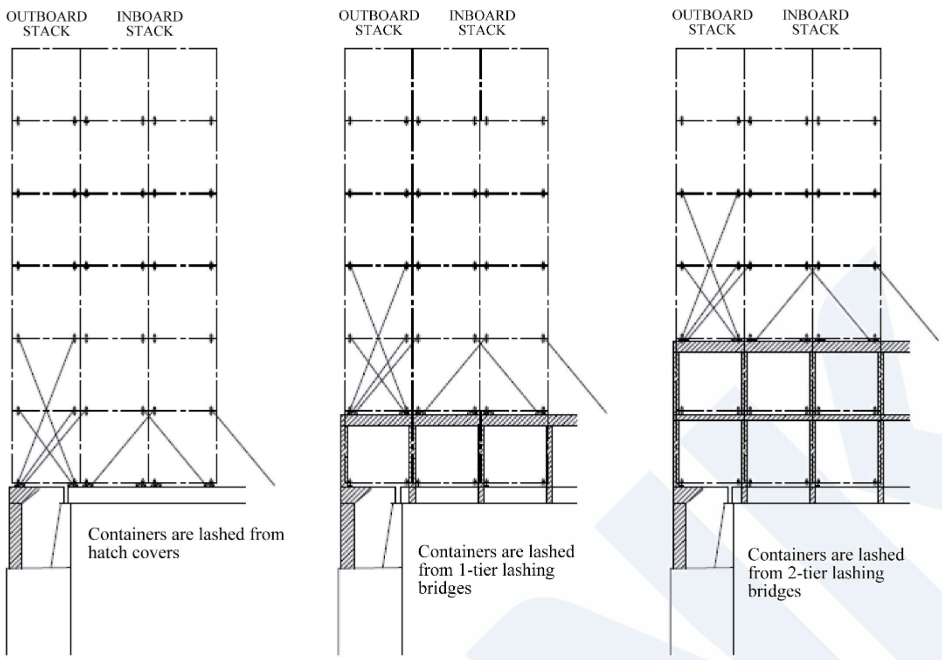


Fig.1.10 External Lashing

-5. Precautions Regarding Container Stowage on Exposed Decks

(1) Container Strength

Requirements regarding maximum container weight and container strength are specified in ISO standards, etc. It is necessary that such requirements be satisfied in order to prevent container damage.

(2) Container Securing Strength

Since containers stowed on exposed decks are not supported by cell guides, they are secured by using securing devices such as twistlocks and lashing rods. However, it is possible that securing devices and containers may be damaged due to ship motion if proper stowage and securing are not carried out. Accordingly, strength deliberations for containers, corner fittings and securing devices need to be conducted, and container stowage and securing methods also need to be planned. In addition, as shown in Fig.1.11, consideration needs to be given to wind loads in addition to inertia forces due to ship motions for container stacks adjacent outboard stacks.

(3) Hatch Cover Strength

Since many containers stowed above exposed decks are stowed on hatch covers, hatch covers are to be strengthened based on the planned stacking loads of containers. Accordingly, containers stowed on exposed decks need to be stowed within the allowable range of such stacking loads.

(4) Stability

Since it is possible to impair ship stability by raising the center of gravity of container stacks due to container stowage on exposed decks, it is necessary to confirm that sufficient stability is ensured if containers are stowed on exposed decks.

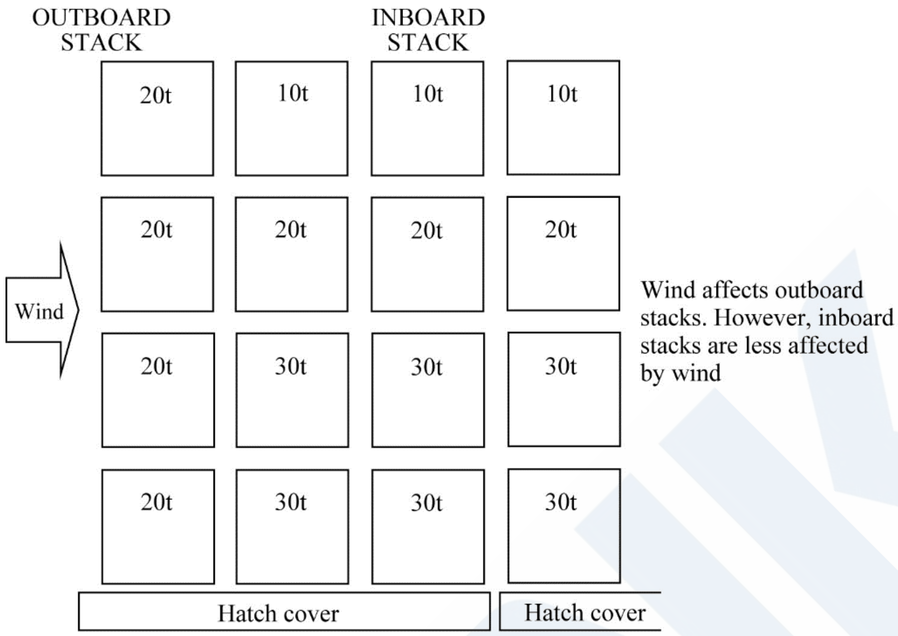


Fig.1.11 Containers Stowed on Exposed Decks and Wind Loads

(5) Navigation Bridge Visibility

Containers stowed on exposed decks need to be stowed in such a way so that they do not hinder vision from the Navigation Bridge. In general, requirements regarding navigation bridge visibility are specified in SOLAS (the International Convention for the Safety of Life at Sea). In **Fig.1.12**, the area designated by A is to be ensured by more than two ship lengths, or 500m, whichever is less. Furthermore, there are also requirements regarding navigation bridge visibility for navigating through the Panama Canal in addition to the SOLAS requirements. The requirements for navigating the Panama Canal are stricter than the SOLAS requirements.

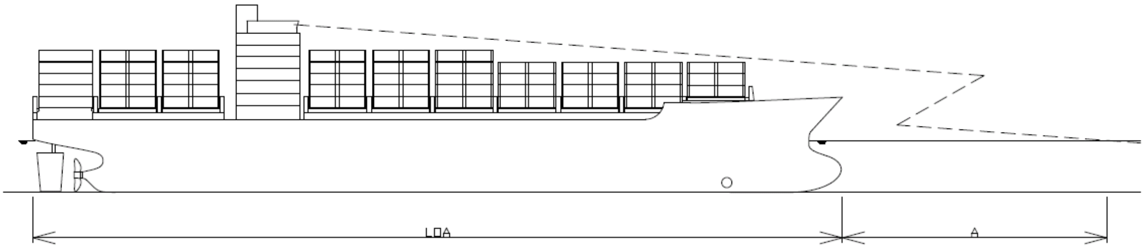


Fig.1.12 Navigation Bridge Visibility

(6) Port Facility Restrictions on Container Stowage

Cargo handling on container ships is usually carried out using the gantry cranes in quays of container terminals. As a result, it is possible that the height of container stacks may be restricted due to structural specifications such as the air draft and reach of such gantry cranes. In addition, it is necessary to take care and avoid contact between gantry cranes and any superstructures.

1.4.3 Stowage in Cargo Holds

-1. Stowage in Cargo Holds

As shown in **Fig.1.13**, the cargo holds of container ships adopt cell guides construction designed according to container size (20' containers, 40' containers, etc.). Containers are stowed by using cell guides. Since containers stowed in cargo holds are fixed and forth to back and left to right movement can be prevented by cell guides, stowed containers do not need to be secured.

-2. Overview of Cell Guide Construction

Cell guide construction consists of angle bars that fix the 4 corners of containers. Cell guides work as guides for container stowage during cargo handling and fix the containers during voyage. In addition, devices that make container handling into cell guides easy, called entry guides, are attached to the top of cell guides. Cell guides are firmly fixed onto the ship by cell guide supports. Loads received from containers are to be withstood by such construction.

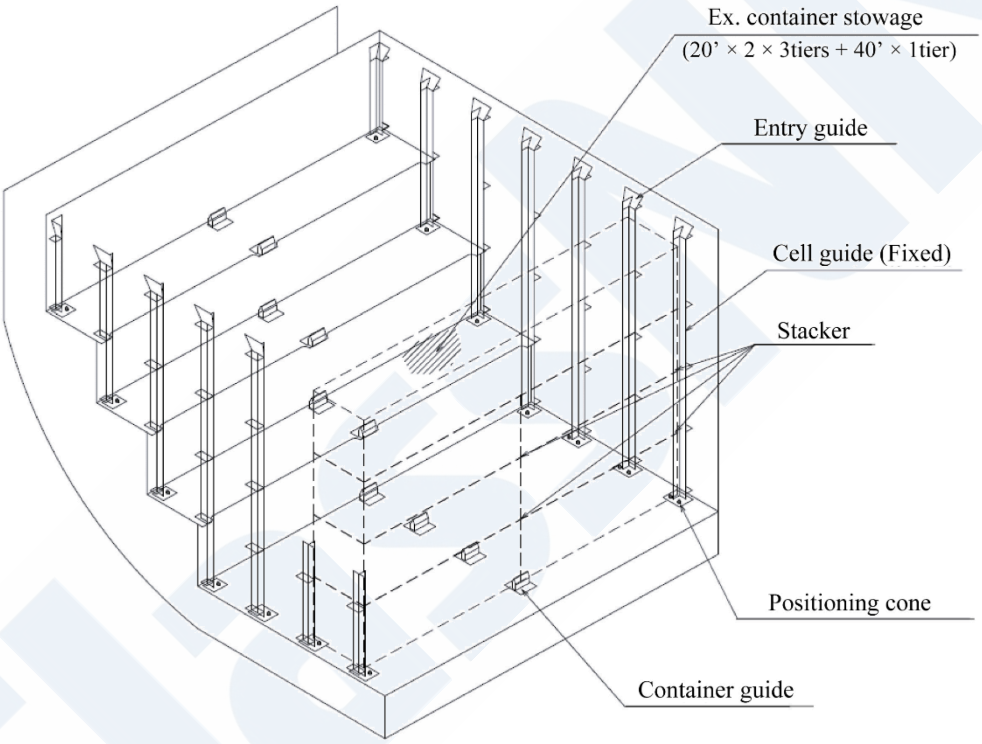


Fig.1.13 Basic Concept of Cell Guide Construction

-3. Overview of Fixed Container Securing Devices

Overview of the fixed container devices shown in **Fig.1.13** is shown in **Table 1.4**.

-4. Stowage of 20' Containers and 40' Containers in 40' Container Bays

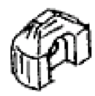
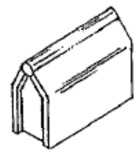
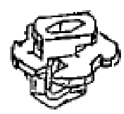
(1) In the past, because container transportation was usually carried out using 20' containers, container bays dedicated for 40' containers were specially needed in order to stow 40' containers on container ships. However, improvements made to container transportation had led to an increase in the use of 40' containers. Consequently, in recent years, the number of container bays dedicated for 20' container stowage has decreased while the stowage of 20' containers in 40' container bays has increased.

(2) 40' container bays are long enough to stow two 20' containers in a longitudinal direction. In cases where two 20' containers are stowed in a longitudinal direction in such bays, container corners not supported by cell guides need to be fixed using container guides and stackers in

order to prevent the horizontal movement of containers. In addition, at least one or more tiers of 40’ containers are generally stowed on the top of 20’ container stacks in order to prevent the deformation of 20’ containers.

(3) Stowage examples in cargo holds of 40’ containers into 40’ container bay, 20’ containers into 20’ container bays and 20’ containers and 40’ containers into 40’ container bays are respectively shown in **Fig.1.14**, **Fig.1.15** and **Fig.1.16**.

Table 1.4 Overview of Fixed Securing Devices Used in Cargo Holds

Description	Overview of Securing Device	Schematic
Cell Guide	Cell guides are about 12～15mm in plate thickness, and about 150mm in width with a length that covers the lowest container to highest container in cargo holds. Cell guides are firmly fixed onto ships by cell guide supports.	
Entry Guide	Entry guides are securing devices installed on the top of cell guides. Entry guides configurations opened in longitudinal and transverse directions and are used for making container handling into cell guides easy during cargo handling.	
Positioning Cone	Positioning cones are securing devices attached to the 4 lower corners of the lowest container and fix the lowest container. Positioning cones are mainly used where two 20’ containers are stowed in a longitudinal direction in a 40’ container bay.	
Container Guide	In cases where two 20’ containers are stowed in a longitudinal direction in 40’ container bay, container guides are equipped at the places where the lowest 20’ containers can face each other. Container guides are securing devices that prevent the movement of end walls on 20’ containers not supported by cell guides.	
Stacker	In cases where two 20’ containers are stowed in a longitudinal direction in a 40’ container bay, stackers are equipped for connection at the 4 corners between the upper and lower 20’ containers. Stackers are securing devices that prevent the horizontal movement of 20’ containers.	

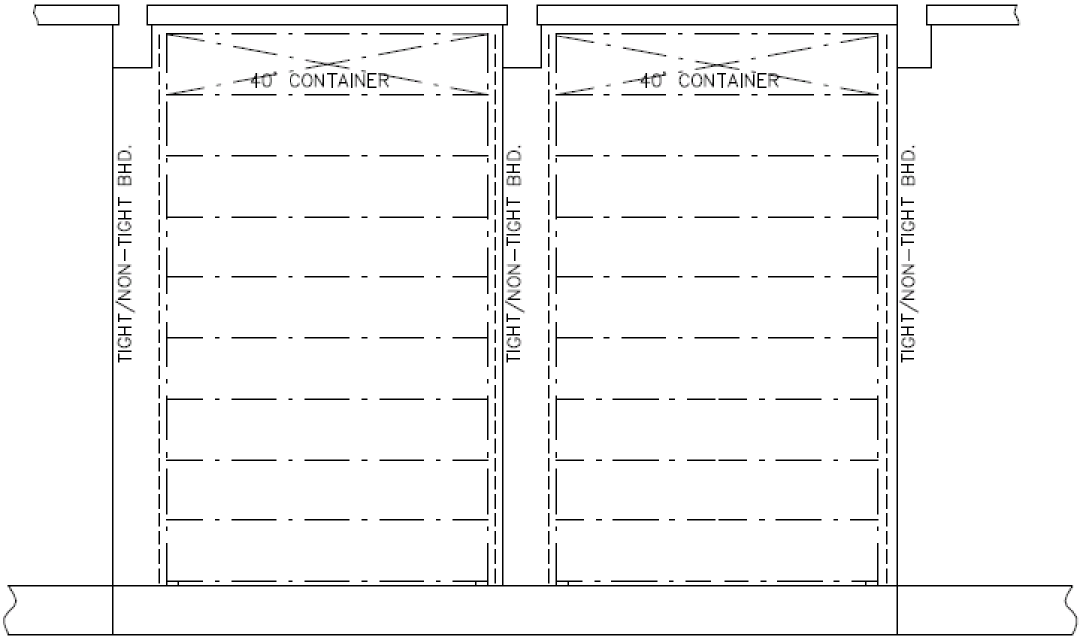


Fig.1.14 Stowage Example of 40' Containers into 40' Container Bays

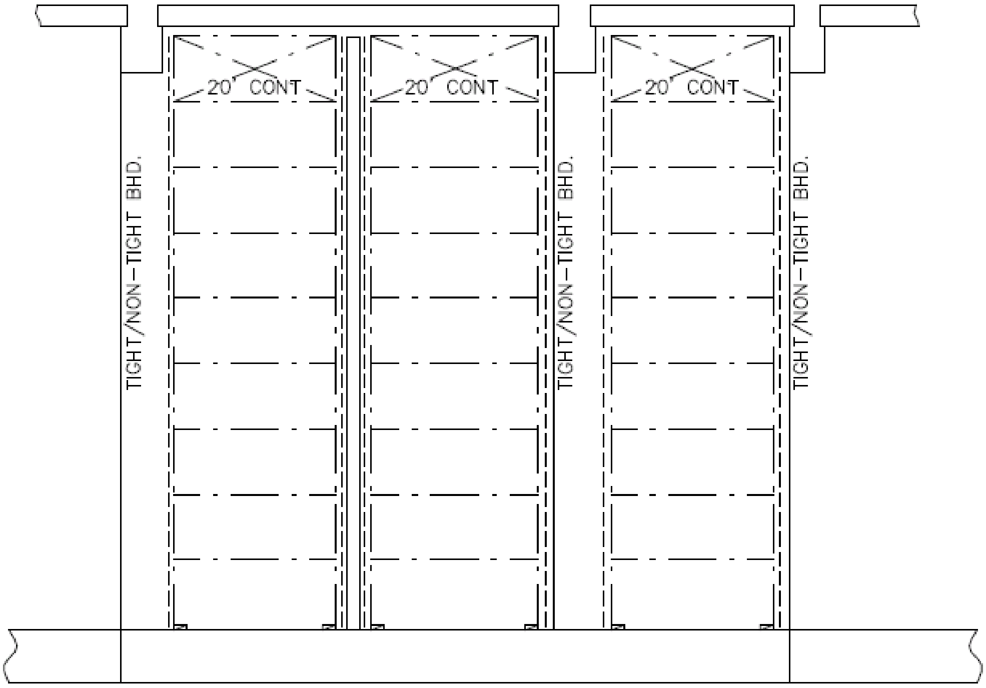


Fig.1.15 Stowage Example of 20' Containers into 20' Container Bays

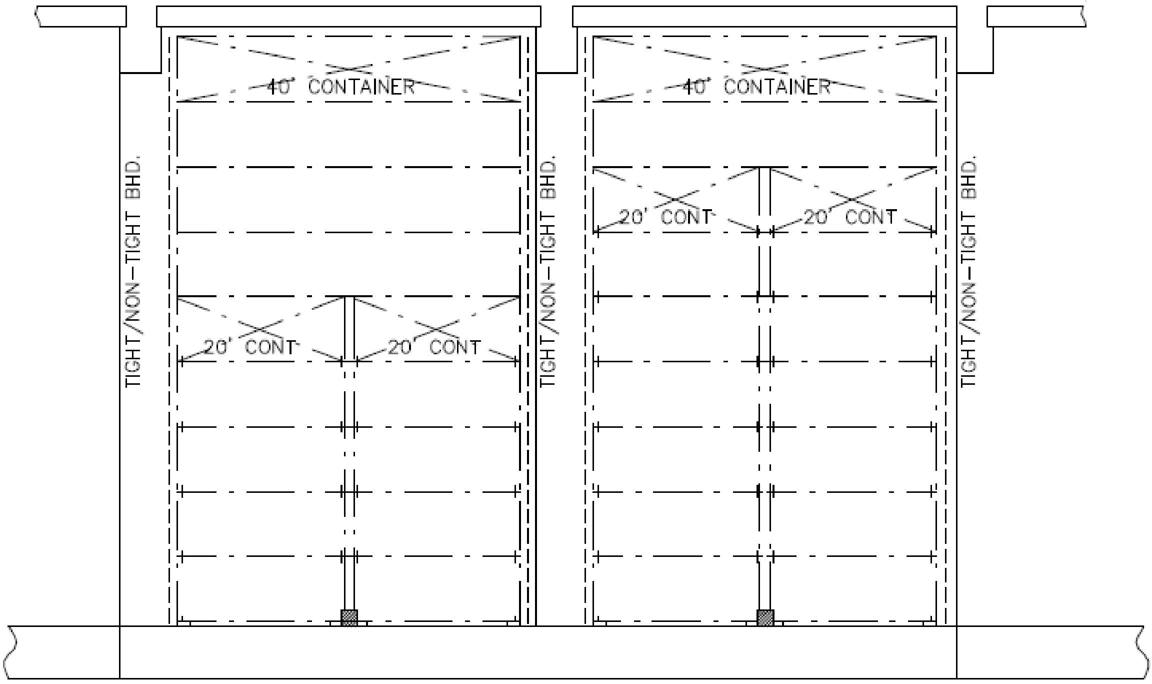


Fig.1.16 Stowage Example of 20' Containers and 40' Containers into 40' Container Bays

-5. Precautions Regarding Container Stowage in Cargo Hold

(1) Container Strength

The requirements regarding maximum container weight and container strength are specified in ISO standards, etc. Such requirements need to be satisfied in order to prevent container damage.

(2) Stowage of 20' Containers in 40' Container Bays

Since the 4 corners of containers are fixed by cell guides in cargo holds, special consideration need not be paid to the racking of containers. However, in cases where two 20' containers are stowed in a longitudinal direction, it is necessary to arrange fixed container securing devices in order to prevent container deformation due to inertial forces based on ship motion since the end walls of 20' containers of center sides of 40' container bays are not supported by cell guides.

(3) Double Bottom Strength

Since containers stowed in cargo holds are stowed on double bottoms and tiered stands, the construction of double bottoms and tiered stands are to be strengthened based on stacking loads of container stacks. Accordingly, in cases where containers are stowed in holds, containers need to be stowed within the range of such stacking loads.

(4) Container Stowage Height

The stowage height of containers stowed in cargo holds is restricted due to hatch covers, etc. In particular, in cases where high-cube containers that have a height that is 1ft greater than the height of normal containers are stowed in cargo holds, precautions need to be paid to the stowage height restrictions.

Chapter 2 STRENGTH OF CONTAINERS AND SECURING DEVICES

2.1 Overview

This chapter describes typical standard values related to strength of containers and securing devices.

2.2 Size and Strength of Containers

2.2.1 Container Standards

-1. The standards of freight containers are specified by the International Organization for Standardization (ISO), and the standard values regarding the size, strength, etc. are displayed on containers.

-2. A container is designated according to its purpose and type in ISO standards. A 40' container with a height of 8 ft. 6 in. is designated as "1AA," and a similar 20' container as "1CC." A 40' high-cube container with a height of 9 ft. 6 in. is designated as "1AAA," while a 20' high cube container of similar height is designated as "1CCC."

-3. **Table 2.1** and **Fig.2.1** show the dimensions and maximum container weight of each type of container according to ISO standards. The maximum container weight refers to the sum of the weight of the container itself and the weight of contents that can be loaded in the container.

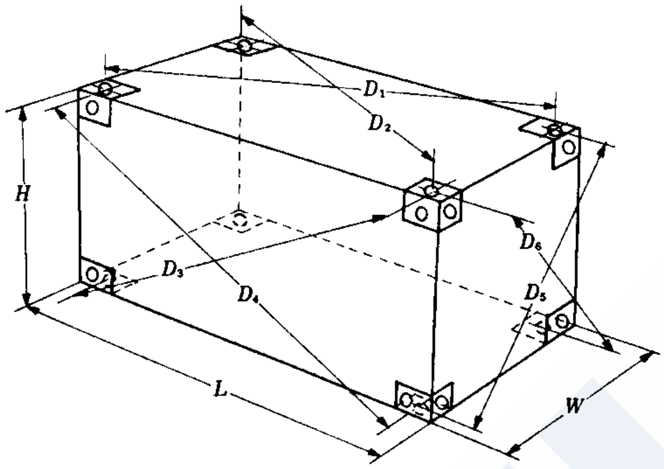
Table 2.1 External Dimensions of Containers
(ISO 668 Series 1 Freight Containers – Classifications, Dimensions and Ratings)

Freight container designation	Length, *L* dim.	Length, *L* tol.	Width, *W* dim.	Width, *W* tol.	Height, *H* dim.	Height, *H* to	Max. container weight, *R*	Tolerance on diagonal line (See **Fig.2.1**) K_1	Tolerance on diagonal line (See **Fig.2.1**) K_2
	mm		*mm*		*mm*		*kg*	*mm*	
1EEE	13,716	0 -10	2,438	0 -5	2,896	0 -5	30,480	19	10
1EE					2,591	0 -5			
1AAA	12,192	0 -10	2,438	0 -5	2,896	0 -5	30,480	19	10
1AA					2,591	0 -5			
1A					2,438	0 -5			
1AX					<2,438				
1BBB	9,125	0 -10	2,438	0 -5	2,896	0 -5	30,480 (25,400)	16	10
1BB					2,591	0 -5			
1B					2,438	0 -5			
1BX					<2,438				
1CC	6,058	0 -6	2,438	0 -5	2,591	0 -5	30,480 (24,000)	13	10
1C					2,438	0 -5			
1CX					<2,438				
1D	2,991	0 -5	2,438	0 -5	2,438	0 -5	10,160	10	10
1DX					<2,438				

(Notes)

1. The above table is based on ISO 668 fifth edition issued in 1995.
2. Underlined parts show changes made by amendment up to 2014. Values shown in parentheses are values based on ISO668-1:1995 before the amendments.
3. Freight container designations given in the above table are as follows:

1EEE, 1EE:	45' Containers
1AAA, 1AA, 1A, 1AX:	40' Conatiners
1BBB, 1BB, 1B, 1BX:	30' Containers
1CC, 1C, 1CX:	20' Containers
1D, 1DX:	10' Containers
1EEE, 1AAA, 1BBB:	High cube containers (with a height of 2,896*mm* (9ft 6in))
1EE, 1AA, 1BB, 1CC:	Containers with a height of 2,591*mm* (8ft 6in)
1A, 1B, 1C, 1D:	Containers with a height of 2,438*mm* (8ft)
1AX, 1BX, 1CX, 1DX:	Containers with a height less than 2,438*mm* (8ft)



(Note) D_1, D_2, D_3, D_4, D_5, D_6: represent diagonal lines between the hole centers of corner fittings

$K_1 = |D_1 - D_2|$ or $|D_3 - D_4|$

$K_2 = |D_5 - D_6|$

Fig.2.1 Tolerance on Diagonal Line

2.2.2 Strength of Containers

ISO standards specify the strength of each part of the container considering that the container is to be stowed in ships and other transport machinery. The strength of general cargo containers, etc. is specified in "ISO1496-1 Series 1 freight containers – Specification and testing –". The strength requirements of general cargo containers specified in ISO standards are as follows:

(1) Stacking Load (or Superimposed Load)

Stacking load refers to the static and dynamic loads acting vertically downward on a stowed container. The allowable value of such stacking loads according to ISO was 3,392kN. This allowable value assumes a load that is acting on the lowermost container in a 9-tier container stack and considered 0.8g for the dynamic load.

$$24 \times 8 \times 1.8g = 3{,}392kN$$

ISO standards were revised various times up to 2014. As part of those revisions, the stacking load for containers of sizes 20' and above became 3,767kN. At the same time, requirements related to 45' containers were also added.

(2) Lifting Force

Lifting force refers to the force acting on a corner fitting of containers when lifting a container using upper or lower corner fittings. For the lifting force, the design load is taken as twice the maximum container weight considering the dynamic load when a container with the maximum container weight is lifted and lowered using a crane.

(3) Restraint Force

Restraint force refers to the dynamic load acting in the longitudinal direction on a corner fitting when the lower corner fitting is restrained by a twistlock.

(4) Racking Force

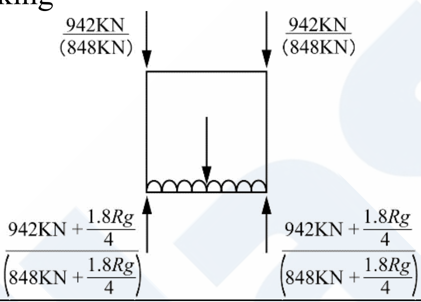
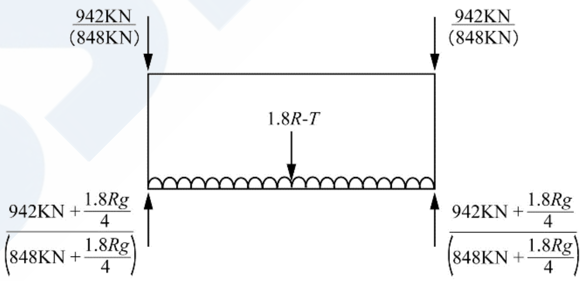
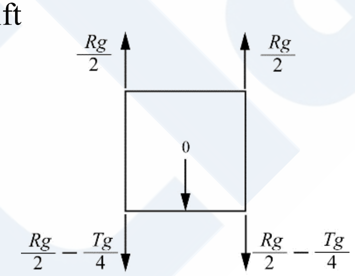
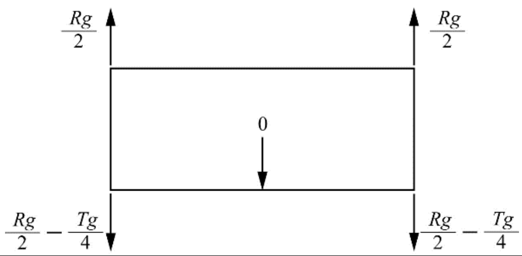
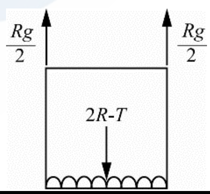
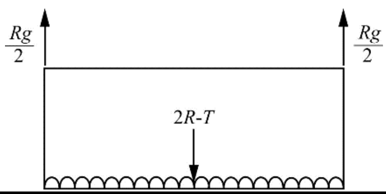
Racking force refers to the load in the horizontal direction received by the end walls and side walls of the container from containers stowed on top of it and from internally loaded cargo due to ship motions, etc. Since the lateral sliding load of a container stowed on upper tier acts as a racking force, precautions need to be paid to the strength limits of containers when containers are stowed in multi-tiers.

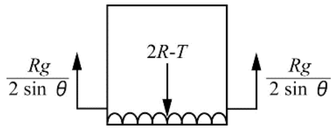
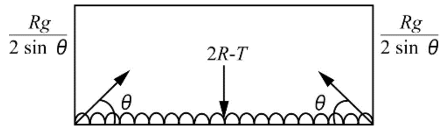
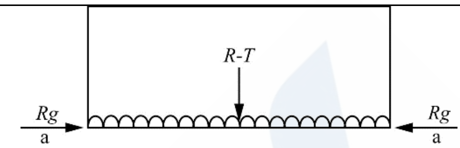
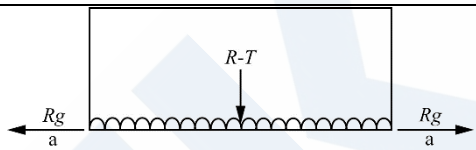
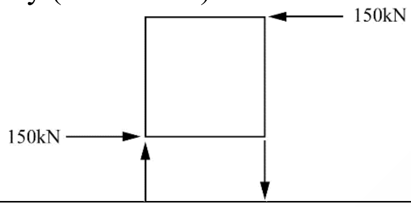
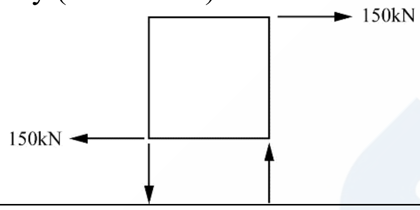
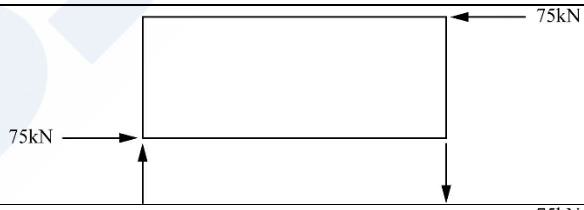
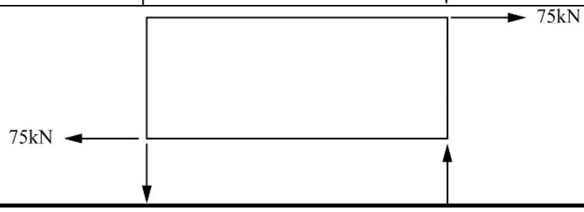
Table 2.2 Forces to be Applied in Stacking Tests
(ISO 1496-1 Series 1 Freight Containers – Specification and Testing –)

Container Designation	Test Force per Container (All Four Corners Simultaneously)	Test Force per Pair of End Fittings	Superimposed Mass Represented by Test Force (Static Load)
	kN	*kN*	*kg*
<u>1EEE, 1EE</u>	<u>3,767</u>	<u>1,883</u>	<u>213,360</u>
<u>1AAA</u>, 1AA, 1A, 1AX	<u>3,767</u> (3,392)	<u>1,883</u> (1,696)	<u>213,360</u> (192,000)
<u>1BBB</u>, 1BB, 1B, 1BX	<u>3,767</u> (3,392)	<u>1,883</u> (1,696)	<u>213,360</u> (192,000)
1CC, 1C, 1CX	<u>3,767</u> (3,392)	<u>1,883</u> (1,696)	<u>213,360</u> (192,000)
1D, 1DX	896	448	50,800

(Notes)
1. The above table is based on ISO 1496-1 fifth edition issued in 1990.
2. Underlined parts show changes made by amendment up to 2014. Values shown in parentheses are values based on ISO1496-1:1990 before the amendments.

Table 2.3 Test Forces to be Applied to Containers
(ISO 1496-1 Series 1 Freight Containers – Specification and Testing –)

	End Elevations	Side Elevations
1	Stacking 	
2	Top Lift 	
3	Top Lift 	

	End Elevations	Side Elevations
4	Bottom Lift 	
5	Restraint (Longitudinal)	
6	Restraint (Longitudinal)	
7	Rigidity (Transverse) 	
8	Rigidity (Transverse) 	
9	Rigidity (Longitudinal)	
10	Rigidity (Longitudinal)	

(Notes)

1. The above table is based on ISO 1496-1 fifth edition issued in 1990.
2. Underlined parts show changes that have been made by amendment up to 2014. Values shown in parentheses are values based on ISO1496-1:1990 before the amendments.
3. Definitions of the symbols used in the above table are as follows:
   - R: Sum of the weight of the container itself and the weight of contents that can be loaded in the container
   - T: Weight of the container itself
   - g: Acceleration of gravity

2.3 Types and Strength of Container Securing Devices

2.3.1 Overview of Container Securing Devices

-1. Container securing devices may be broadly classified into fixed devices and loose devices, and many types of each of these categories have been developed and are being used. **Table 2.4** and **Table 2.5** show the types of general securing devices and working loads, etc. for fixed and loose securing devices respectively.

-2. Although **Table 2.4** and **Table 2.5** show the general working loads and breaking loads of various types of securing devices, many manufacturers and tests may be conducted based on different working loads and breaking loads according to the type of device from the general working loads. In the strength assessments of container securing systems, such assessments are, in principle, performed using working loads stated on the certificates of securing devices.

2.3.2 Types of Fixed Securing Devices

-1. Deck Socket

This is a device for positioning a container. It has a hole with the same shape as that of a container corner fitting, and it connects decks and containers using a twistlock. There are two kinds of deck sockets: pedestal types and flush types.

-2. Sliding Base

This is a device for positioning a container. It is used when the container is to be stowed at a low position. However, since the shape differs according to manufacturer, the types of loose devices that can be actually used are limited.

-3. Eye Plate

This is installed on the hull side such as on the deck or a hatch cover. It is a plate with holes that can be used for connecting securing devices to restrict container movement. The number of holes and the pitch of the holes depend on the securing method. Types of eye plate include fixed types and collapsible types.

-4. Positioning Cone

This is a device for positioning a container. It is smaller than the hole of container corner fittings and has a similar shape to the hole of such corner fittings.

-5. Container Guide

This is a device installed at the central part of the 40’ container bay when two 20’ containers are to be stowed in the longitudinal direction using the cell guides of a 40’ container bay. It prevents the lateral movement of 20’ containers.

2.3.3 Types of Loose Securing Devices

-1. Manual Twistlock

This is a device for connecting upper and lower containers. Using the hole in the container corner fitting, it prevents the upper container from separating from the lower container, and also prevents the horizontal movement of the container.

-2. Semi-automatic Twistlock

This has the same functions as a manual twistlock, and connects upper and lower containers automatically when stowing containers.

-3. Fully Automatic Twistlock

This is a twistlock that not only connects upper and lower containers automatically when stowing containers but also unlocks automatically without requiring manual unlocking operation. However, special attention needs to be paid to fully automatic twistlocks especially regarding deformation and damage due to corrosion etc. and if they are fitted in accordance with the proper fitting procedure. This is because; unlike for manual or semi-automatic twistlocks, the performance of connected fully automatic twistlocks is highly influenced by the fitting procedure of the twistlocks and the shape of the container corner fittings and twistlocks themselves. It is also necessary to remember that vertical and horizontal separation of fully automatic twistlocks may occur, depending on the product.

-4. Lashing Rod

This is a device for lashing the container to prevent it from racking and lifting. Normally, a pulling device such as turnbuckle is assembled on a rod, and it is used on the diagonal line in the end wall of the container. The shape may be changed depending on the required strength, but its weight must be such that it accounts for handling during securing work.

-5. Turnbuckle

This is a device that retains the tension in the lashing rod if necessary when securing a container.

-6. Adjusting Hook

This is a device for adjusting the lashing length and is used between the lashing rod and the turnbuckle.

-7. Vertical Stacker

This is a device for positioning a container, and it prevents the horizontal movement of a container using the hole in the container corner fitting.

-8. Twist Stacker

This has the same functions a vertical stacker, and it does not easily detach from container corner fittings.

Table 2.4 Typical Fixed Securing Devices

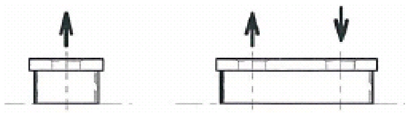
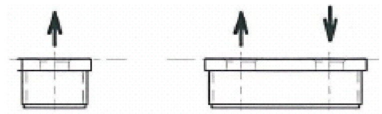
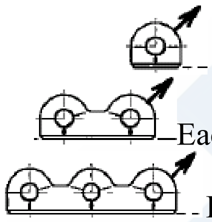
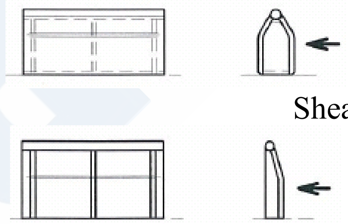
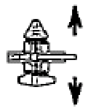
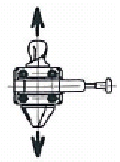
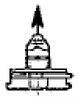
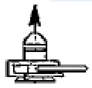
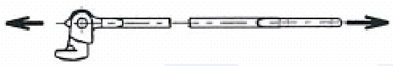
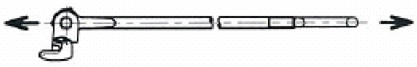
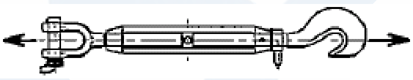
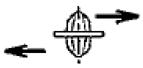
No	Description	Load Direction	Working Load (*kN*)	Breaking Load (*kN*)
1	Deck Socket (Pedestal Type)		250	500
2	Deck Socket (Flush Type)		250	500
3	Sliding Base		245	490
4	Eye Plate (Fixed Type)	 Each hole Each hole	245	490
5	Eye Plate (Collapsible Type)		100	400
6	Positioning Cone	 Shearing	200	400
7	Container Guide	 Shearing	420	840

Table 2.5 Typical Loose Securing Devices

No.	Description	Load Direction	Working Load (*kN*)	Breaking Load (*kN*)
1	Manual Twistlock		250	500
2	Semi-automatic Twistlock		250	500
3	Sliding Twistlock		245	490
4	Twistlock		200	400
5	Lashing Rod (Short Type)		225	450
6	Lashing Rod (Long Type)		178	352
7	Turnbuckle		225	450
8	Adjusting Hook		225	450
9	Vertical Stacker (Single type)	 Shearing	150	300
10	Twist Stacker (Drop off type)	 Shearing	150	300

Chapter 3 PRECAUTIONS FOR HULL STRENGTH RELATED TO STOWAGE AND SECURING ARRANGEMENTS

3.1 General

-1. Hull structures such as cargo holds, hatch covers, hatch coamings and decks are strengthened in consideration of stowage conditions starting with stacking loads, which are the total weight of each stack of containers. During actual operations, containers need to be stowed to satisfy the range of designed stowage conditions.

-2. In cases where containers are to be stowed on deck, the stacking load of containers and the weight distribution in the stack become design conditions for the structural strength of hatch covers and container posts.

-3. Even when containers are to be stowed in holds, the stacking load of containers becomes a design condition for structures such as double bottoms. Moreover, strength deliberations for cell guides, supports that support cell guides and ship construction are conducted considering designed container stowage conditions.

3.2 Precautions for Container Stowage on Deck

-1. Hatch Cover and Container Post

Hatch covers and container posts are strengthened in consideration of the loads from containers stowed on deck. Hatch coamings and installations related to hatch covers on hatch coamings are designed to withstand the total load on the hatch cover including the loads of stowed containers.

-2. Container Stacking Load

Hatch covers, container posts and hull structures such as hatch coamings and decks that support these structures are strengthened in consideration of the stacking loads of containers, thus, containers need to be stowed within the allowable values of stacking loads, as shown in **Fig.3.1**.

-3. Height of the Center of Gravity of Stacks and Weight Distribution

Loads also act in the horizontal direction on container dues to ship motion during voyages. Therefore, the loads on hatch covers or container posts from container corner fittings in the first tier of container stacks are not uniform. As shown in **Fig.3.2**, it acts as a moment on the panel face of the hatch cover. For this reason, the structure of hatch cover panels is also strengthened to withstand moment.

The magnitude of such moment depends on the height of the center of gravity of a container stack, so, the stack height and load distribution of a stack may be specified as a design condition of hatch covers.

-4. Load Due to Lashing

Containers stowed on deck are secured by lashing rods, etc. The tension acting on such lashing rods is transmitted to the hull through the lashing bridges and the eye plates on hatch covers. Eye plates and the surrounding members are strengthened in consideration of the designed lashing pattern. Accordingly, if actual stowage differs from planned stowage, then precautions need to be paid.

-5. Stiffness of Lashing Bridges

Lashing bridges may deform due to the effect of ship motions etc. Since tension acting on lashing rods may increase or decrease depending on the deformation of the lashing bridges, lashing bridges need to be designed to have sufficient stiffness.

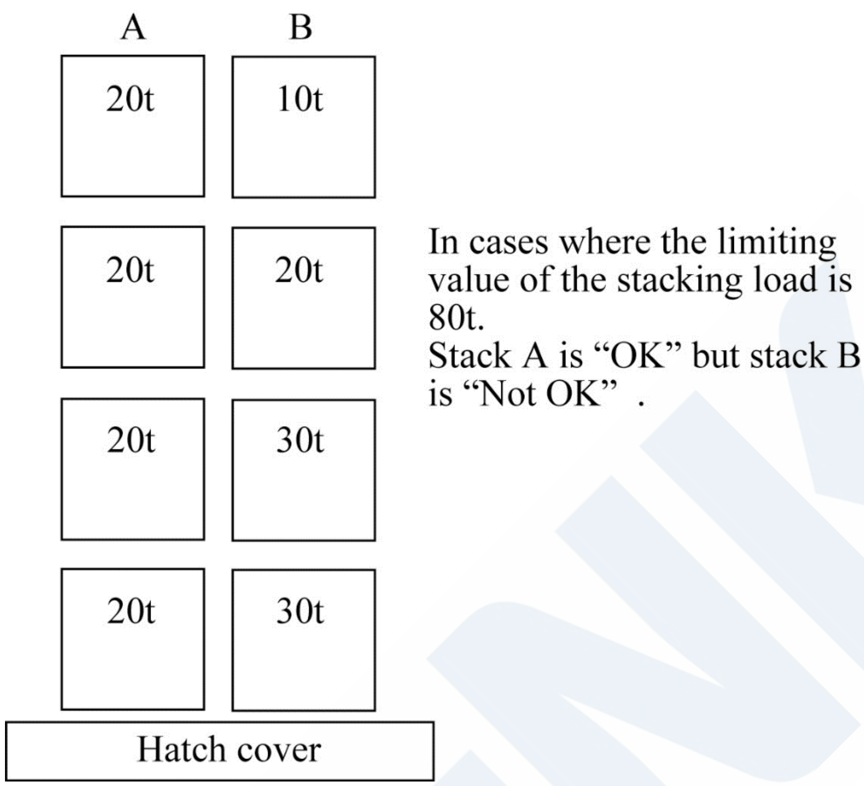


Fig.3.1 Stacking Load on Deck

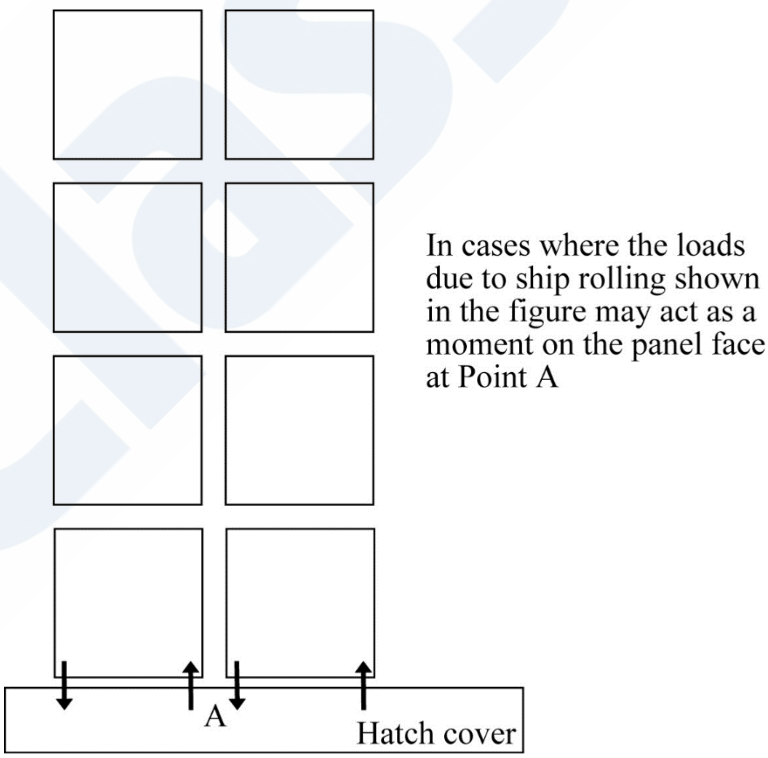


Fig.3.2 Moment Acting on Hatch Covers

3.3 Precautions for Container Stowage in Hold

-1. Cell Guides and Cell Guide Supports

From the containers stowed in cargo holds, vertical loads are received by double bottoms and horizontal loads are supported by cell guides. Loads acting on cell guides are transmitted to hull structures through cell guide supports.

Cell guides and cell guide supports are designed so that container loads are effectively transmitted to double bottom structures, side shell structures and transverse bulkheads. Double bottoms, cell guides and transverse bulkhead structures are also strengthened to withstand container loads. Precautions need to be paid to cell guides that support containers stowed at positions distant from the center of ship motion since the inertial force due to ship motion may become large.

-2. Container Stacking Load

The lower structure in cargo holds is strengthened in consideration of container stacking loads.

Generally, containers stowed on deck are subject to stowage restrictions due to strength related to stowage and securing arrangements. However, since containers within cargo holds are fixed in place by cell guides, restrictions due to ship motion, etc., are reduced. Accordingly, the value obtained by multiplying the standard values regarding container weight for each container by the number of stowage tiers is considered as the design load of double bottoms for container stacking loads.

-3. Stowage of Containers with Different Height

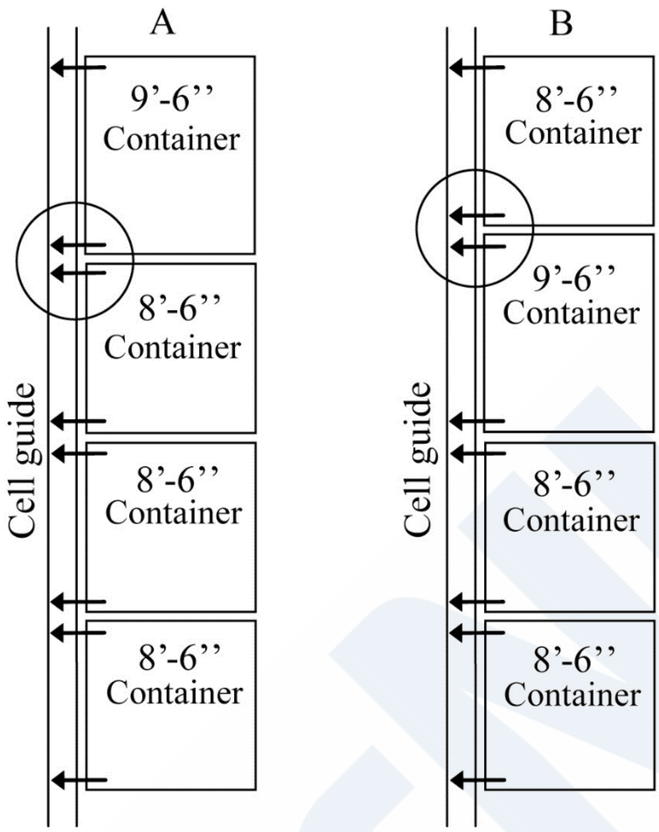
Because cell guides receive transverse loads from containers at the position of container corner fittings, loads at positions not expected during the design stage may act depending on the stowage pattern when containers with different height (8ft 6in and 9ft 6in containers (high-cube containers)) are stowed together as shown in **Fig.3.3**. Since cell guide support positions as well as transverse bulkheads, on which such supports are fitted, are strengthened taking into consideration the loads received from containers, precautions need to be paid regarding the cell guide strength in case of restrictions on stowage positions of high-cube containers.

-4. Stowage of 20' Containers in 40' Container Bays

When two 20’ containers are stowed in a longitudinal direction, the total size becomes practically the same size as one 40’ container. It is often the case that 20' containers are stowed in a 40’ container bay. However, as shown in **Fig.3.4**, the double bottom, etc., at the central part of the 40’ container bay needs to be strengthened for the stowage of 20’ containers. Therefore, locations in the lower structures of such cargo holds requiring strengthening are greater compared to those in cargo holds in which only 40’ containers are stowed.

-5. Strength of Cell Guides and Cell Guide Supports

Loads due to inertial force acting on containers are supported by hull construction via cell guides and cell guide supports. Therefore, cell guides and cell guide supports need to be provided with strength sufficient enough to withstand such inertial force.



Positions where load act on cell guides are different in Patterns A and B

Fig.3.3 Difference of Loaded Position Due to Stowage of Containers Differ in Height

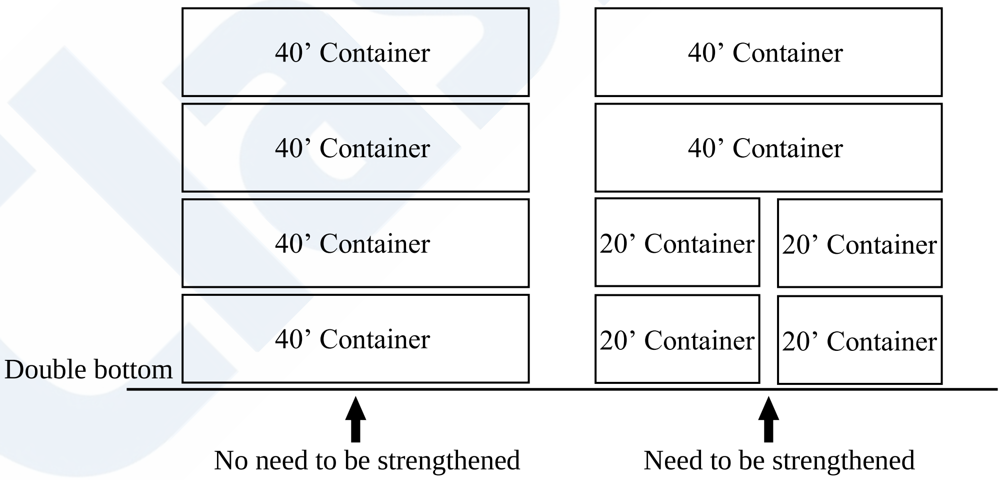


Fig.3.4 Stowage of 20' Containers in 40' Container Bay

Chapter 4 STRENGTH EVALUATION METHODS FOR STOWAGE AND SECURING ARRANGEMENTS

4.1 General

-1. **Fig.4.1** shows a flowchart of the strength evaluation methods for container stowage and securing arrangements.
-2. The strength evaluation method in "Guidelines for Container Stowage and Securing Arrangements" (hereinafter referred to as "the Guideline") consists of two parts: estimation of loads acting on the container and strength evaluation related to stowage and securing arrangements. Each part is described in **"Chapter 5 DESIGN LOADS FOR STRENGTH EVALUATION OF CONTAINER STOWAGE AND SECURING ARRANGEMENTS"** and **"Chapter 6 STRENGTH EVALUATION OF CONATINER STOWAGE AND SECURING ARRANGEMENTS".**

4.2 Determination of Loads Acting on Each Container

-1. Static loads, dynamic loads and wind loads are considered as loads acting on containers.
-2. Ship motions are calculated from the principal particulars of the examined ship, and ship accelerations are determined based on these motions. Using the ship accelerations, the inertial forces acting on each container are calculated from the stowage position of the container and the container weight.
-3. Wind load acts only on containers stowed in outboard stacks on deck, and positive and negative wind pressures are considered to act on the containers. Positive pressure acts so as to push against the wall surfaces of containers, while negative pressure acts so as to pull on the wall surfaces of containers.

4.3 Overview of Strength Evaluation of Container Stowage and Securing Arrangements

-1. In addition to container strength, strength evaluation criteria include strength of container securing devices for containers stowed on deck and stacking loads on double bottoms for containers stowed in hold.
-2. Criteria for the strength evaluation of containers stowed on deck are racking loads, shear loads, compressive loads and lifting loads, while those for container in holds are racking loads and compressive loads.
-3. Container stacks stowed on deck usually are secured using lashing rods. Therefore, lashing forces due to lashing rods are considered, and the loads acting on each part of the container are calculated.
-4. Stowage of containers and securing methods are evaluated to judge whether the loads acting on each part of the container satisfy the allowable values specified by each strength evaluation criteria.

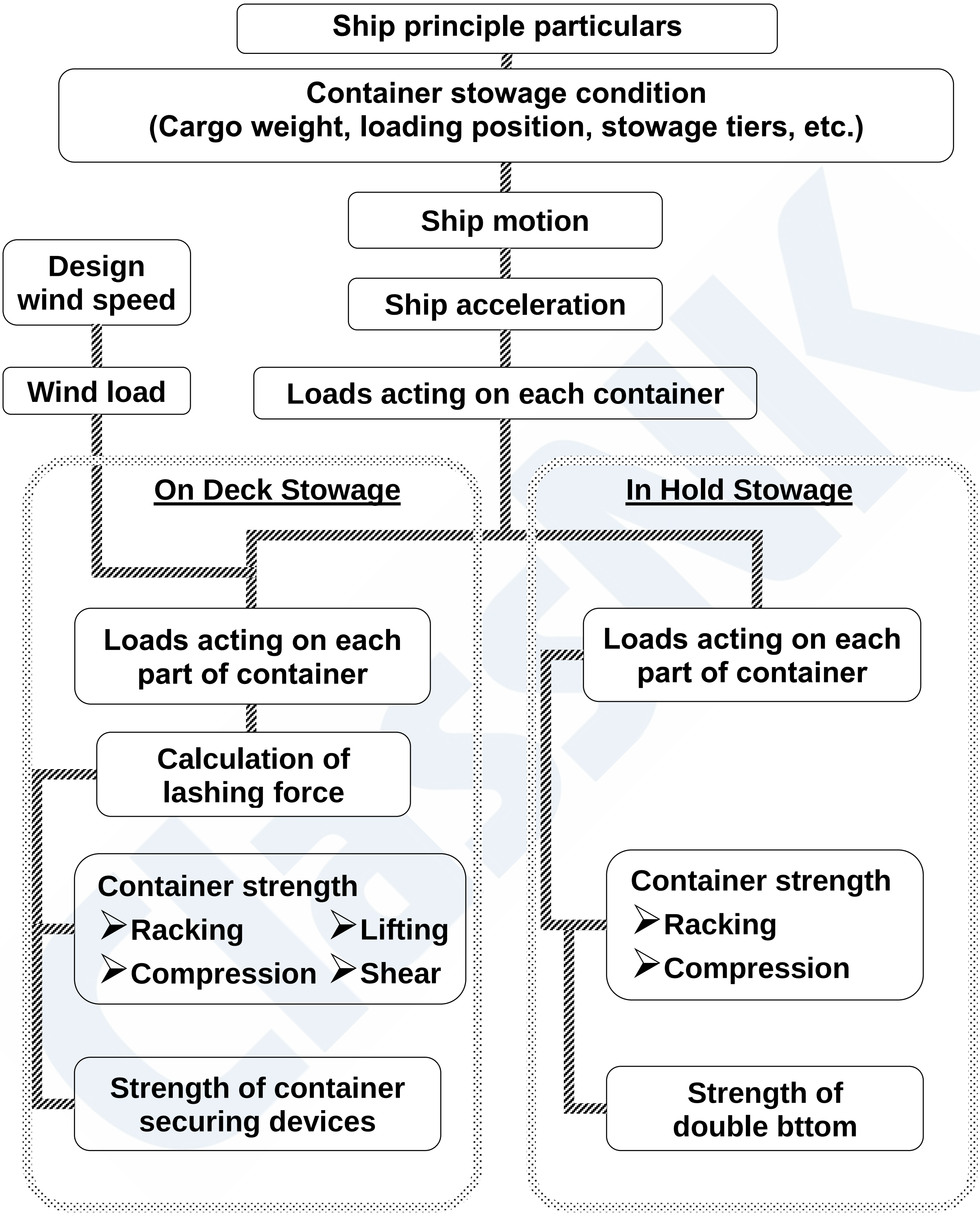


Fig.4.1 Flowchart of Strength Evaluation Methods for Container Stowage and Securing Arrangements

Chapter 5 DESIGN LOADS FOR STRENGTH EVALUATION OF CONTAINER STOWAGE AND SECURING ARRANGEMENTS

Symbols

L_{pp}	: Length of ship (distance on the designed maximum load line from the fore side of the stem to the center of the rudder stock)	*m*
L_C	: Length of ship (distance measured on the waterline at the scantling draught on the forward side of the stem to the after side of the rudder post in ships with a rudder post, or to the center of the rudder stock in ships without a rudder post). However, L_C is to be not less than 96% and need not exceed 97% of the extreme length on the waterline at the scantling draught.	*m*
B	: Breadth of ship	*m*
D	: Depth for strength computation	*m*
d_f	: Design draught of ship	*m*
d_i	: Draught amidships for the relevant loading condition	*m*
C_B	: Block coefficient at the scantling draught	-
C_{B_LC}	: Block coefficient for the relevant loading condition. May be obtained by the following formula. $$C_{B\_LC} = C_B - 1.03(1 - \frac{C_B}{C_W})(1 - d_i/d_f)$$	
C_W	: Waterplane coefficient at the scantling draught	
C_{W_LC}	: Waterplane coefficient for the relevant loading condition. May be obtained by the following formula. $$C_{W\_LC} = C_W - 1.42(1 - \frac{C_B}{C_W})(1 - d_i/d_f)$$	
C_{VP_LC}	: Vertical prismatic coefficient for the relevant loading condition; to be obtained by the following formula $$C_{VP\_LC} = C_{B\_LC}/C_{W\_LC}$$	
V	: Design speed	*knots*
g	: Acceleration of gravity (= 9.81)	m/s^2
U	: Design wind speed of wind load acting on containers	m/s
K_{xx}	: Roll radius of gyration	*m*
GM	: Metacentric height	*m*
GM_{min}	: Minimum metacentric height for calculating the roll angle; to be obtained by the following In the case of $B < 40\ m$, $GM_{min} = 0.002B^2$ In the case of $B > 40\ m$, $GM_{min} = [0.002 - 10^{-5} \times (B - 40)]B^2$	*m*
T_{Pitch}	: Natural period of pitch motion	*sec.*
T_{Roll}	: Natural period of roll motion	*sec.*
ϕ	: Pitch angle	*rad*
θ	: Roll angle	*rad*
a_{pitch}	: Acceleration at the center of gravity of the ship due to pitch motion	rad/s^2
a_{roll}	: Acceleration at the center of gravity of the ship due to roll motion	rad/s^2
a_{heave}	: Acceleration at the center of gravity of the ship due to heave motion	m/s^2
S_θ	: Sea route correction factor (roll angle)	-
S_P	: Sea route correction factor (pitch acceleration)	-
S_H	: Sea route correction factor (heave acceleration)	-
F_λ	: Longitudinal load due to ship acceleration	*kN*

F_t	: Transverse load due to ship acceleration	kN
F_v	: Vertical load due to ship acceleration	kN
M	: Container weight	ton
p	: Wind pressure acting on containers	kN/m^2
P	: Wind load acting on containers	kN

5.1 General

-1. Loads used for the strength evaluation of container stowage and securing arrangements are calculated based on static loads, dynamic loads due to ship motion, and wind loads in this chapter.
-2. The ship motions and ship accelerations shown in this chapter are determined based on the direct strength analysis results for a series of container ships using wave data of the North Atlantic Ocean specified by IACS. Notwithstanding the method shown in this chapter, ship motions and ship accelerations for any sea route may also be determined by considering the direct strength analysis results for individual ships and wave data for each sea area.
-3. The application of these Guidelines is premised on the assumption that parametric rolling will be avoided by the appropriate judgment and seamanship of the captain.
-4. The application of these Guidelines is premised on the assumption that large inclination due to synchronous rolling will be avoided by the appropriate judgment and seamanship of the captain.
-5. In the application of these Guidelines, ship motions and accelerations can be corrected considering the effects of the sea route and the season, at the judgment of the captain, in accordance with 5.3.

5.2 Ship Motions and Ship Accelerations

-1. This section provides the ship motions and accelerations for calculating the accelerations acting on containers used in strength evaluations of container stowage and securing arrangements. The maximum values of the motions and accelerations provided in this chapter assume that appropriate seamanship is performed to avoid synchronous period, etc., so that excessive ship motions and accelerations will not occur. Separate consideration of ship motions and accelerations is necessary for ships having L_C of less than 90 m.

-2. The roll angle and roll period are shown in **Table 5.1**, and the pitch angle and pitch period are shown in **Table 5.2**. Although the roll angle shown in **Table 5.1** is calculated by using the loaded metacentric height in operation, the roll angle is not to be taken less than the roll angle calculated for the metacentric height of GM_{min}. However, when calculating the roll angular acceleration, the loaded metacentric height in operation is to be used.

Table 5.1 Roll Period T_θ and Roll Angle θ

Period (s)	Roll angle (rad)
$T_\theta = 2\pi\sqrt{\dfrac{L_C B d_i C_{B\_LC} {K_{xx}}^2 + A_\theta}{g L_C B T_{LC} C_{B\_LC} \cdot GM}}$	$\theta = 2.53 \times C_{BK} C_{40} R_4 H_{S\_\theta}$

(Notes)

K_{xx} : Radius of gyration (m) around the X-axis. The value calculated based on the weight distribution corresponding to the loading condition under consideration may be used. However, if K_{xx} cannot be given, K_{xx} is to be taken as $0.35B$.

A_θ : As given by the following formula:

$$A_\theta = L_C B^4 {C_{W\_LC}}^{2.25}\left(-0.06\frac{z_G}{B} + 0.013 - \frac{0.006B}{z_G - 0.69B}\right)$$

z_G: Z coordinate (m) of the center of gravity of the ship. The value in the loading condition under consideration, which is described in the loading manual, is to be adopted.

GM : Metacentric height (m). The roll angle is not to be taken less than the roll angle calculated assuming $GM = GM_{min}$.

C_{BK} : Coefficient considering the effect of the bilge keel (5), to be taken as follows. It is assumed that the bilge keel is installed appropriately at a position which is effective for damping rolling motion.

For $\ell_{BK}/L_C \geq 0.3$, $C_{BK} = 1.0$
For $\ell_{BK}/L_C < 0.3$, $C_{BK} = 1.2 - \frac{2}{3}\frac{\ell_{BK}}{L_C}$

ℓ_{BK}: Length (m) of bilge keel. However, for ships without a bilge keel, to be taken as 0.

C_{40} : Conversion factor for short-crested irregular waves, as given by the following formula:

$C_{40} = C_{41}C_{42}$

C_{41}, C_{42} : As given by to the following formulae:

$C_{41} = 0.12$

$$C_{42} = 1.43\left(\frac{1}{L_C B d_i C_{B\_LC}}\right)^{0.04}$$

R_4 : Coefficient representing the ship motion in regular waves, to be taken as:

$$R_4 = 1.41\left(\frac{1}{{T_\theta}^2 B}\right)^{0.3}$$

H_{S_θ} : Significant wave height (m), given by the following formula, but not to be less than 2.0.

$H_{S\_\theta} = -0.21{T_{Z\_\theta}}^2 + 5.07T_{Z\_\theta} - 15.7$

T_{Z_θ} : Average zero up crossing wave period (s), to be taken as:

$T_{Z\_\theta} = 0.71T_\theta + 1.5$

Table 5.2 Pitch Period T_ϕ and Pitch Angle ϕ

Period (s)	Pitch angle (rad)
$T_\phi = \sqrt{\frac{2.6\pi L_C}{g}}$	$\phi = 2.85 \times C_{50}R_5H_{S\_\phi}$

(Notes)

C_{50} : Conversion factor for short-crested irregular waves, to be taken as:

$C_{50} = C_{51}C_{52}$

C_{51}, C_{52} : As given by the following formulae:

$C_{51} = 0.12(L_C B C_{W\_LC})^{0.05}$

$C_{52} = 0.97$

R_5 : Coefficient representing the ship motion in regular waves, to be taken as:

$$R_5 = C_{53}\frac{3.5}{L_C C_{W\_LC}}$$

C_{53} : As given by the following formula:

$$C_{53} = 1.5\left(\frac{B}{L_C {C_{B\_LC}}^2}\right)^{0.25}$$

H_{S_ϕ} : Significant wave height (m) given by the following formula, but not to be less than 2.0.

$H_{S\_\phi} = -0.21{T_{Z\_\phi}}^2 + 5.07T_{Z\_\phi} - 15.7$

T_{Z_ϕ} : Average zero up crossing wave period (s), to be taken as: $$T_{Z\_\phi} = 2.6\left(\frac{1}{L_C B C_{W\_LC}}\right)^{0.13} T_\phi$$

-3. Heave acceleration, roll angular acceleration, and pitch angular acceleration are shown in **Tables 5.3, 5.4**, and **5.5**, respectively.

Table 5.3 Heave Acceleration a_{heave} at the Center of Gravity of the Ship

Heave acceleration a_{heave} (m/s^2)
$a_{heave} = 2.85 C_{30} R_{a3} H_{S\_a3}$
(Notes) C_{30} : Conversion factor for short-crested irregular waves, to be taken as: $C_{30} = C_{31} C_{32}$ C_{31}, C_{32} : As given by the following formulae: $C_{31} = 0.03(L_C B C_{W\_LC})^{0.18}$ $C_{32} = 0.72$ R_{a3} : Coefficient representing acceleration in regular waves, to be taken as: $R_{a3} = 1.29 \dfrac{g}{B {C_{B\_LC}}^{0.12} {C_{W\_LC}}^{0.55}} \exp\left(\dfrac{2\pi}{\lambda_{a3}} d_i C_{VP\_LC}\right)$ λ_{a3} : Wavelength (m), to be taken as: $\lambda_{a3} = \dfrac{2\pi}{C_{W\_LC}}\left(d_i C_{B\_LC} + 0.11\pi B \dfrac{2{C_{W\_LC}}^2}{C_{W\_LC}+1}\right)$ H_{S_a3} : Significant wave height (m), given by the following formula, but not to be less than 2.0. $H_{S\_a3} = -0.21{T_{Z\_a3}}^2 + 5.07 T_{Z\_a3} - 15.7$ T_{Z_a3} : Average zero up crossing wave period (s), to be taken as: $T_{Z\_a3} = 4.4\left(\dfrac{1}{L_C B C_{W\_LC}}\right)^{0.16} \cdot \sqrt{\dfrac{2\pi\lambda_{a3}}{g}}$

Table 5.4 Roll Angular Acceleration a_{roll} at the Center of Gravity of the Ship

Roll angular acceleration a_{roll} (rad/s^2)
$a_{roll} = \theta\left(\dfrac{2\pi}{T_\theta}\right)^2$
(Notes) θ, T_θ : As specified in **Table 5.1**. The roll period is to be a value calculated by using the loaded metacentric height in operation.

Table 5.5 Pitch Angular Acceleration a_{pitch} at the Center of Gravity of the Ship

Pitch angular acceleration a_{pitch} (rad/s^2)
$a_{pitch} = \phi\left(\dfrac{2\pi}{T_\phi}\right)^2$

(Note)

ϕ, T_ϕ : As specified in **Table 5.2**.

5.3 Correction of Ship Motions and Ship Accelerations According to Sea Route and Season

5.3.1 General

Stowage of containers and securing methods according to sea routes may be examined by applying the correction method for ship motions and ship accelerations shown in this section.

5.3.2 Sea Route Correction Factors

-1. Ship motions and accelerations for the sea route of a ship can be calculated by multiplying the ship motions and accelerations specified in **Tables 5.1** to **5.5** by the sea route correction factor.

-2. In the application of the above -1., the sea route correction factor C_{route} is derived by a long-term prediction of the ship motions and accelerations based on wave data for the object route. This correction factor is to be the ratio (shown by the following formula) of "value $a_{\mathrm{route}}^{\mathrm{encounter}}$ determined by long-term prediction based on encountered wave data for the object route" to "value obtained by multiplying the value a_{Rec34} determined by long-term prediction based on wave data for the North Atlantic Ocean specified in IACS Recommendation No. 34 (2001) by 0.85." Here, "value determined by long-term prediction" means a value having an exceedance probability of 10^{-8} (value equivalent to the maximum expected value in a 25 year period).

$$C_{\mathrm{route}} = \frac{a_{\mathrm{route}}^{\mathrm{encounter}}}{0.85 \times a_{\mathrm{Rec34}}}$$

When obtaining the encountered wave data mentioned here, in addition to appropriate consideration of variations in the data, due consideration must also be given to the wave model used and to events that are not taken into account in that wave model.

-3. As an alternative to the long-term prediction in the above -2., the sea route correction factor may also be obtained by using the probability of occurrence of the significant wave height in the oceanographic conditions of the object route. In this case, the correction factor is to be the ratio of "value of the significant wave height of the marine phenomenon at which the exceedance probability becomes 10^{-5} in the encountered wave data for the object route" to "value obtained by multiplying the significant wave height of the marine phenomenon with an exceedance probability of 10^{-5} in the wave data for the North Atlantic Ocean specified in IACS Recommendation No. 34 (2001) by 0.85." When obtaining the encountered wave data mentioned here, in addition to appropriate consideration of variations in the data, due consideration must also be given to the wave model used and to events that are not taken into account in that wave model.

-4. In cases where the marine phenomena that occur on the ship's route are affected by seasonal conditions, wave data for the season when the ship will navigate that route may be used in obtaining the sea route correction factor by applying the above -2. and -3. If the voyage will be carried out over multiple seasons, the largest ship motions and accelerations that occur during those seasons are to be adopted. The sea route correction factor considering seasonal conditions is not needed to be larger than one that does not consider seasonal conditions.

-5. The sea route correction factor obtained by applying the above -2. and -3. is not to exceed 1.0, and is not to be less than 0.65.

-6. In applying the above -2., ship motions and accelerations that take into account the ship type and loading condition are to be adopted. When determining the appropriate ship motions and accelerations, a direct loading analysis or other evaluation method deemed appropriate by the Society may be used.

-7. The ship motions and ship accelerations in **Tables 5.1** to **5.5** are to be corrected as follows, using the sea route correction factor determined by the methods provided in the above -1. to -6. Here, S_p and S_θ are coefficients considering the effects of ship operation on pitch angular acceleration and the roll angle (heel angle during rolling), respectively, and S_H is equivalent to S_p for design condition i and S_θ for design condition ii in 5.4-1.When a ship is to be operated on a specific route in **Fig.5.1**, the sea route correction factors shown in **Table 5.6** may be used.

- Pitch angle: $S_P \times \phi$
- Roll angle: $S_\theta \times \theta$
- Pitch acceleration (acceleration at ship center of gravity due to pitch):

$$S_P \times a_{pitch}$$

- Roll acceleration (acceleration at ship center of gravity due to roll):

$$S_\theta \times a_{roll}$$

- Heave acceleration (acceleration at ship center of gravity due to heave):

$$S_H \times a_{heave}$$

Figure 5.1 Representative Specific Sea Routes

Table 5.2 Correction Factors for Representative Specific Sea Routes

Representative Specific Sea Route	East Asia - Europe	North America - Europe	East Asia - Australia	Japan - Hong Kong	East Asia - North America	South America - Europe	South Africa - Europe
S_P	$1.022 - 5L_C \cdot 10^{-4}$	1.00	$1.020 - 7L_C \cdot 10^{-4}$	$1.075 - 8L_C \cdot 10^{-4}$	$1.036 - 2L_C \cdot 10^{-4}$	$0.992 - 2L_C \cdot 10^{-4}$	$0.977 - L_C \cdot 10^{-4}$
S_θ	$0.956 - 2B \cdot 10^{-3}$	1.00	$(1.05 - 0.11 f_T) - 4B \cdot 10^{-3}$	$(1.12 - 0.16 f_T) - 4B \cdot 10^{-3}$	$1.018 - 13B \cdot 10^{-4}$	$0.967 - 8B \cdot 10^{-4}$	$0.958 - 9B \cdot 10^{-4}$

(Note)

f_T: Ratio between draught amidships for relevant loading condition and design draught, taken as d_i/d_f.

5.4 Loads Acting on Each Container

-1. The dynamic loads acting on containers are considered for the following two conditions, representing combinations of ship motions, such as pitch, roll, heave, etc., based on the ship motions and ship accelerations specified in 5.2.

Design Condition i: Combination of Pitch and Heave (Head Sea)
Design Condition ii: Combination of Roll and Heave (Beam Sea or Quarter Sea)

-2. The dynamic loads based on design conditions i and ii can be calculated by the combination of directions of the vertical acceleration due to heave and directions of the rotational acceleration due to pitch or roll. Considering possible combinations of acceleration, four cases of the combination of directions of vertical acceleration and directions of rotational acceleration can be considered as follows.

① Vertical acceleration (heave) in the ascending direction+
Rotational acceleration (pitch, roll) in the ascending direction
② Vertical acceleration (heave) in the ascending direction+
Rotational acceleration (pitch, roll) in the descending direction
③ Vertical acceleration (heave) in the descending direction+
Rotational acceleration (pitch, roll) in the ascending direction
④ Vertical acceleration (heave) in the descending direction+
Rotational acceleration (pitch, roll) in the descending direction

-3. **Table 5.3** shows the loads acting on each container according to the combination of design conditions and accelerations. The loads in **Table 5.3** include static and dynamic loads.

-4. Among the cases of combinations of loads in **Table 5.7**, cases where it is considered that the combination of loads is not controlling the strength of container stowage and securing arrangements, depending on the weight of the containers and the method of lashing, may be excluded from the objects of strength evaluation.

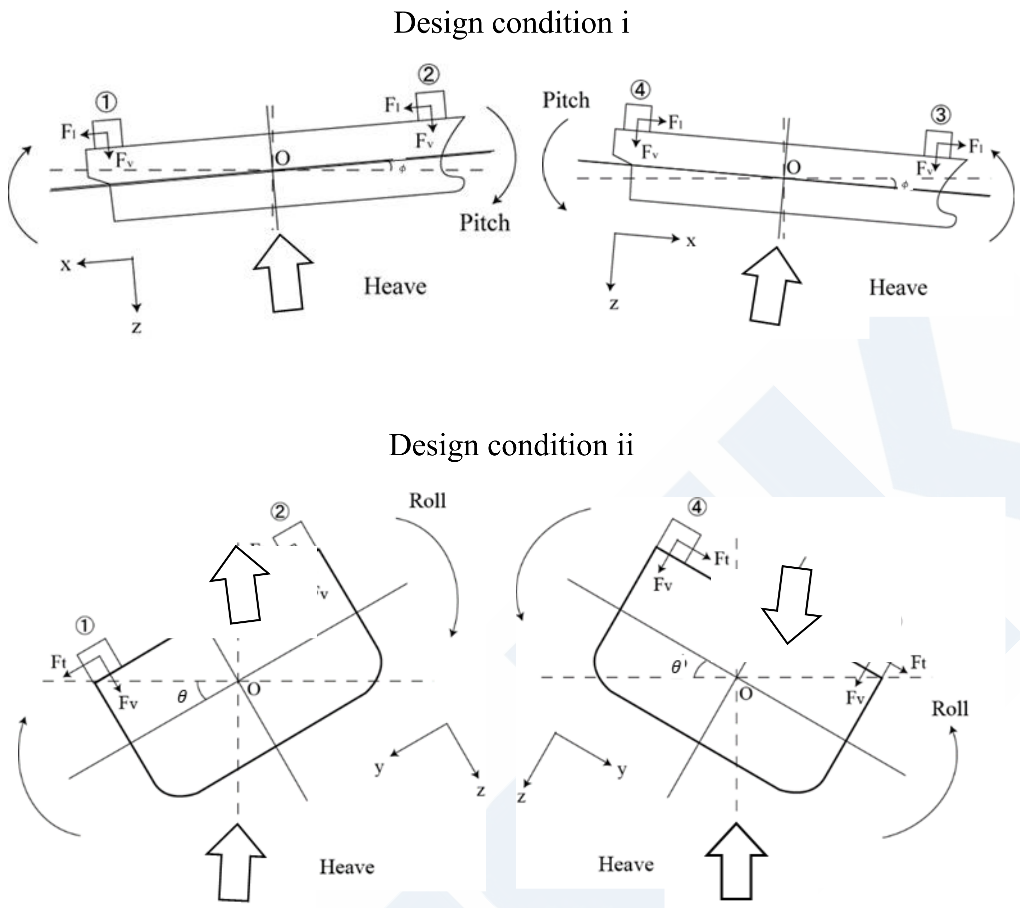


Fig.5.2 Design Condition i and Design Condition ii

Table 5.3 Loads Acting on Each Container

	Design Condition i (*kN*)	Design Condition ii (*kN*)
①	$F_v = M\left[g\cos\phi + a_{heave} + \lvert x_i - x_{pc}\rvert a_{pitch}\right]$	$F_v = M[g\cos\theta + 0.1a_{heave} + \lvert y_i\rvert a_{roll}]$
	$F_\ell = M\left[g\sin\phi + (z_i - z_{rc})a_{pitch}\right]$	$F_t = M[g\sin\theta + (z_i - z_{rc})a_{roll}]$
②	$F_v = M\left[g\cos\phi + a_{heave} - \lvert x_i - x_{pc}\rvert a_{pitch}\right]$	$F_v = M[g\cos\theta + 0.1a_{heave} - \lvert y_i\rvert a_{roll}]$
	$F_\ell = M\left[g\sin\phi + (z_i - z_{rc})a_{pitch}\right]$	$F_t = M[g\sin\theta + (z_i - z_{rc})a_{roll}]$
③	$F_v = M\left[g\cos\phi - a_{heave} + \lvert x_i - x_{pc}\rvert a_{pitch}\right]$	$F_v = M[g\cos\theta - 0.1a_{heave} + \lvert y_i\rvert a_{roll}]$
	$F_\ell = M\left[g\sin\phi + (z_i - z_{rc})a_{pitch}\right]$	$F_t = M[g\sin\theta + (z_i - z_{rc})a_{roll}]$
④	$F_v = M\left[g\cos\phi - a_{heave} - \lvert x_i - x_{pc}\rvert a_{pitch}\right]$	$F_v = M[g\cos\theta - 0.1a_{heave} - \lvert y_i\rvert a_{roll}]$
	$F_\ell = M\left[g\sin\phi + (z_i - z_{rc})a_{pitch}\right]$	$F_t = M[g\sin\theta + (z_i - z_{rc})a_{roll}]$

(Notes)

x_{pc}: Longitudinal distance from the aft perpendicular (AP) to the center of rotation of the pitch motion of the ship (center of flotation). Its value can be set to $0.45L_C$ (*m*) when its value corresponding to the loading condition is unknown.

x_i: Longitudinal distance from AP to the center of gravity of the container (*m*)

y_i: Transverse distance from the centerline of the hull to the center of gravity of the container (*m*)

z_{rc}: Vertical distance from the ship bottom to the center of rotation of the roll motion of the ship of the loading condition. Its value can be set to 0.5(*D*/2+d) or *D*/2, whichever is greater (*m*), when the value of the loading condition is unknwon.

z_i: Vertical distance from the ship bottom to the center of gravity of the container (*m*)

5.5 Wind Loads Acting on Containers

5.5.1 General

-1. Wind loads are considered to act on containers stowed on deck only in the transverse direction of such containers.

-2. Wind loads acting on containers stowed in the inboard stacks are considered very small, therefore, wind loads are considered to act only on containers stowed in outboard stacks.

5.5.2 Wind Loads

-1. The wind pressure p acting on a container is given by the following formula:

$$p = 0.611 C_p U^2 \cdot 10^{-3} \quad (kN/m^2)$$

C_p: Pressure coefficient according to **Table 5.4** depending on the wind direction

U: Design wind speed, a value specified by the operator of the ship considering the condition of the ship and the waters in which it is navigating. If not particularly specified, to be taken as 36 m/s. However, when higher wind speeds are forecast, an appropriate value is to be used.

Table 5.4 Pressure Coefficient C_p of Wind Load Acting on Container Wall Surfaces

Exposed wall surfaces	C_p
Windward side (Positive pressure)	1.0
Leeward side (Negative pressure)	0.5

(Note)

Negative pressure acts so as to pull on the wall surfaces of the container.

-2. The wind load P acting in transverse direction of the container is given by the following:

$$P = pA\cos\theta \quad (kN)$$

A: Area of side face of container (m^2)

5.5.3 Direction of Action of Wind Loads

The direction of action of wind loads is taken as given below, with positive or negative pressure acting on the container according to the combination of directions of vertical acceleration and directions of rotational acceleration indicated in **5.4-3.**, in consideration of the dominant conditions for the strength of container stowage and securing arrangements (see **Fig.5.3**).

① Vertical acceleration (heave) in the ascending direction +
Rotational acceleration (roll) in the ascending side: Wind load (negative pressure)

② Vertical acceleration (heave) in the ascending direction +
Rotational acceleration (roll) in the descending side: Wind load (positive pressure)

③ Vertical acceleration (heave) in the descending direction +
Rotational acceleration (roll) in the ascending side: Wind load (negative pressure)

④ Vertical acceleration (heave) in the descending direction +
Rotational acceleration (roll) in the descending side: Wind load (positive pressure)

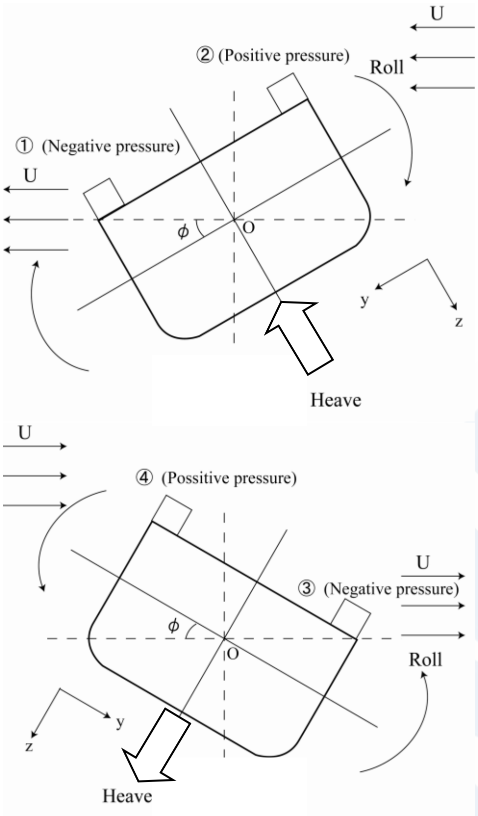


Fig.5.3 Direction of Action of Wind Loads Depending on The Combination of Accelerations

Chapter 6 STRENGTH EVALUATION OF CONTAINER STOWAGE AND SECURING ARRANGEMENTS

Symbols

F_t	: Transverse load acting on each container	*kN*
F_v	: Vertical load acting on each container	*kN*
F_{tti}	: Transverse load acting on top corner of the end walls of container in ith tier	*kN*
F_{tbi}	: Transverse load acting on bottom corner of the end walls of container in ith tier	*kN*
F_{vi}	: Vertical load acting on one corner post of container in ith tier	*kN*
h_i	: Ratio of the height of the center of gravity of container in ith tier to its height	-
P	: Wind load acting on containers	*kN*
P_i	: Wind load acting on one side of the end walls of container in ith tier	*kN*
W	: Breadth of containers	*m*
H_i	: Height of container in ith tier	*m*
Z_i	: Height from bottom of container stack to top of container in ith tier	*m*
k_C	: Stiffness constant for containers against racking	*kN/mm*
k_L	: Stiffness constant for lashing rods	*kN/mm*
T_{xti}	: Tension acting on lashing rod that lashes top corner of container in ith tier (cross lashing)	*kN*
T_{xbi}	: Tension acting on lashing rod that lashes bottom corner of container in ith tier (cross lashing)	*kN*
T_{eti}	: Tension acting on lashing rod that lashes top corner of container in ith tier (external lashing)	*kN*
T_{ebi}	: Tension acting on lashing rod that lashes bottom corner of container in ith tier (external lashing)	*kN*
θ_{xti}	: Angle of lashing rod that lashes top corner of container in ith tier (cross lashing)	*rad*
θ_{xbi}	: Angle of lashing rod that lashes bottom corner of container in ith tier (cross lashing)	*rad*
θ_{eti}	: Angle of lashing rod that lashes top corner of container in ith tier (external lashing)	*rad*
θ_{ebi}	: Angle of lashing rod that lashes bottom corner of container in ith tier (external lashing)	*rad*
m_i	: Weight of each 20' container	*ton*
M_i	: Weight of each 40' container	*ton*

6.1 General

-1. This chapter describes strength evaluation methods for container stowage arrangements with a presumption that the containers could experience the following basic failure modes in **(1)** to **(4)**:

(1) Racking in one side of container end walls due to horizontal loads acting on containers

(2) Shearing between two vertically adjacent containers at their corner fittings due to horizontal loads acting on containers

(3) Compression in one corner post due to vertical loads and overturning moments acting on containers

(4) Lifting in one corner post due to vertical loads and overturning moments acting on containers

-2. In addition to the basic failure modes in **-1**, this chapter describes strength evaluation methods for container stowage and securing arrangements taking into consideration the tension acting on lashing rods that lash containers on deck.

-3. In strength evaluations of container stowage and securing arrangements, it is necessary to confirm that the loads on the containers and the container stowage and securing arrangements do not exceed the allowable loads. The allowable loads for container stowage and securing arrangements are to be the values specified by their designers.

-4. Strength evaluation methods for container stowage and securing arrangements in this chapter are based on the following pre-conditions:

(1) Containers are stowed so that the longitudinal edge of the container is along the longitudinal direction of the ship, and both the door end and closed end of a container are similarly secured.

(2) The loads acting on each container are transmitted through the frames of the container.

(3) Only racking deformation is considered as deformation of the container.

(4) Containers in strength evaluation of container stowage and securing arrangements are manufactured based on the following ISO standards.

ISO 668 Series 1: Freight Containers, Classification Dimensions and Ratings
ISO 1161 Series 1: Freight Containers, Corner Fittings, Specification
ISO 1496 Series 1: Freight Containers, Specification and Testing

-5. Special consideration needs to be given when containers are stowed or secured by methods different from those mentioned above.

-6. This chapter describes the strength evaluation of container securing arrangements in the transverse direction; however, evaluation in the case of the longitudinal direction is also to be evaluated similar to that of the transverse direction.

6.2 Stiffness Constants Used in Strength Evaluation

-1. Stiffness Constant for Containers

Stiffness against racking deformation varies according to the type and material used for the container. If the stiffness constant of a container is not available, the standard values of steel containers given in **Table 6.1** may be used.

Table 6.1 Stiffness Constant against Container Racking

Stiffness Constant k_C against Container Racking (kN/mm)	
Container End Wall (Door Ends)	Container End Wall (Closed Ends)
3.7	15.7

-2. Stiffness Constants of Lashing Rods

The stiffness constant of lashing rods used to secure containers is as follows:

$$k_L = \frac{EA}{l} \quad (kN/mm)$$

E: Elastic modulus of lashing rod (kN/mm^2)
A: Cross sectional area of lashing rod (mm^2)
l: Overall length of lashing rod (mm)

When the elastic modulus of a lashing rod is not available, the standard value of 140 kN/mm^2 may be used.

-3. Stiffness Constants of Lashing Bridges

The stiffness used for lashing bridges to which lashing rods are connected is to be the value specified by the designer. The designer may calculate the stiffness of lashing bridges considering the average deformation of the lashing bridge for the unit tension force of the lashing rods. Lashing bridges need to be designed in a way that will not to hinder the securing effect of the lashing rods.

6.3 Allowable Loads Used in Strength Evaluation

-1. Allowable Loads for Containers

The allowable loads on each part of a container should be determined considering its structure, material and so on. The allowable loads on each part of a container shown in ISO standards are as given in **Table 6.2**. Upon setting the allowable loads used in container strength evaluation, it should be noted that the containers planned to be stowed and secured may actually include those manufactured based on different allowable loads. Therefore, the allowable loads based on ISO1496-1:1990 are desirable to be used for strength evaluation when allowable loads for containers to be stowed cannot be confirmed. Further, the allowable loads shown in **Table 6.2** do not take into account corrosion, deformation or damage of containers due to aging, which would affect the container strength.

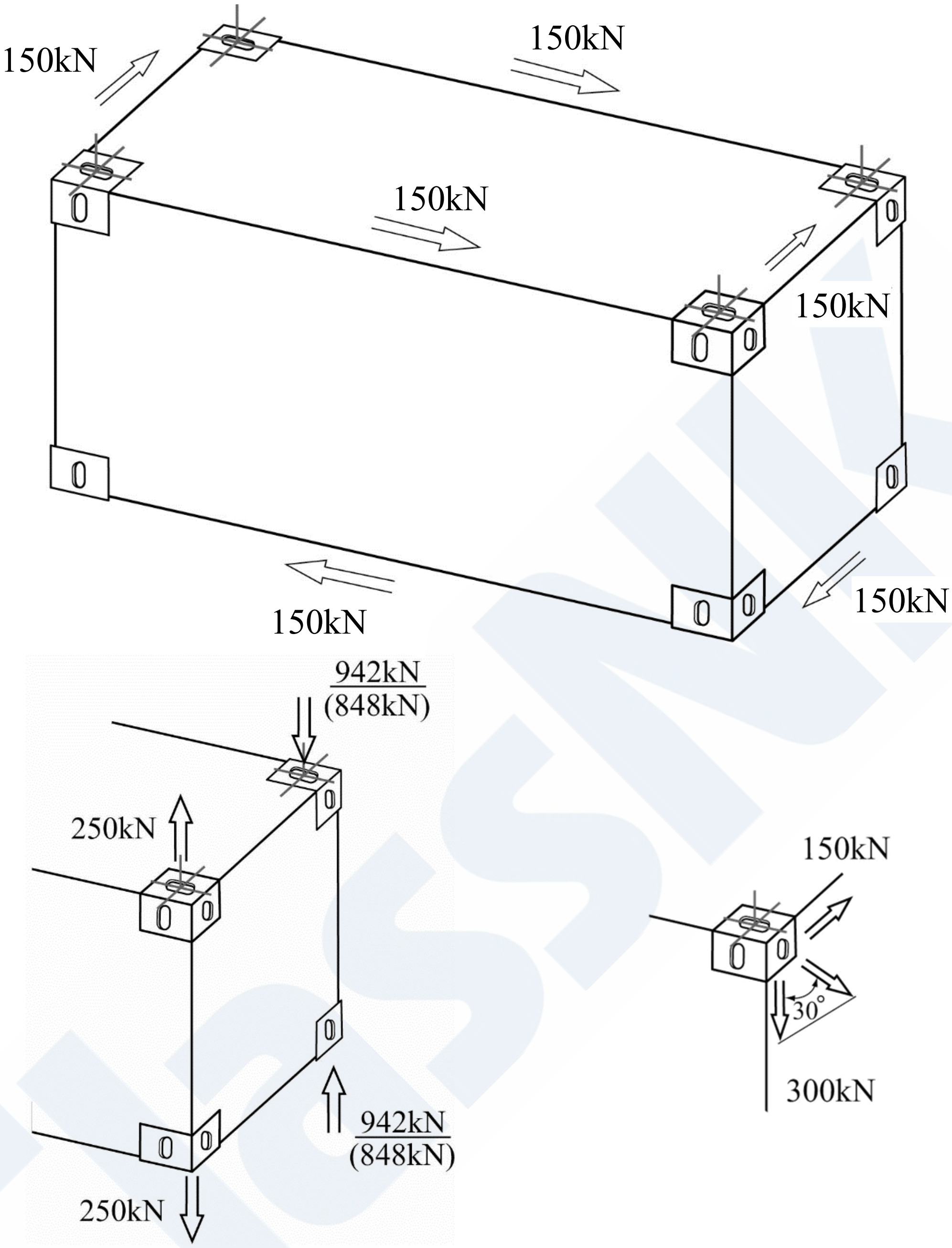
Table 6.2 Allowable Loads on Each Part of Containers

<table>
<tr><th colspan="2" rowspan="2"></th><th>ISO1496-1:1990</th><th>ISO1496-1 (including amendments up to 2014)</th></tr>
<tr><th>Allowable load (kN)</th><th>Allowable load (kN)</th></tr>
<tr><td rowspan="2">Racking load acting on containers</td><td>Transverse direction</td><td>150</td><td>150</td></tr>
<tr><td>Longitudinal direction</td><td>150</td><td>150</td></tr>
<tr><td colspan="2">Compressive load acting on one corner post of containers</td><td>848</td><td>942</td></tr>
<tr><td colspan="2">Lifting load acting on one corner post of containers</td><td>250</td><td>250</td></tr>
<tr><td rowspan="2">Lashing load acting on container corner fittings</td><td>Vertical direction</td><td>300</td><td>300</td></tr>
<tr><td>Horizontal direction</td><td>150</td><td>150</td></tr>
</table>

-2. Allowable Loads of Securing Devices

The allowable loads on securing devices such as lashing rods etc. are, in principle, to be the values specified by the designer of each device. When evaluating the vertical compressive load acting on the corner castings of the containers in the first (bottommost) tier, the allowable load may be taken as the sum of allowable load for compressive loading acting on the corner post and 1.8 $Rg/4$ (kN), where R is the rated value of the maximum allowable superimposed load and g is acceleration of gravity. In this case, attention is to be given to the strength of the members with which the containers are in contact.

Depending on the structure and contact angle of the lashing rods and corner castings, a large load may be generated by the corner casting. It is recommended that the allowable load be set considering this fact.



(Notes)

The underlined parts show changes that have been made by amendments up to 2014. Values shown in parentheses are allowable loads based on ISO1496-1:1990 before the amendments.

Fig.6.1 Allowable Loads on Each Part of Containers

6.4 Strength Evaluation of Container Stowage and Securing Arrangements on Deck

6.4.1 General

-1. This section is based on the following pre-conditions:

(1) Containers are, basically, lashed by using short or long lashing rods and the lower parts of containers stowed above on the first tier or the second tier are lashed.

(2) Only forces in tensile direction act on lashing rods. Forces in compressive direction do not act on them.

(3) Pre-tension is not applied to lashing rods.

(4) Wind loads uniformly act only on exposed containers stowed in outboard stacks.

(5) Upper and lower containers are fixed in place by using twistlocks.

(6) Containers are stowed within the allowable range of hatch cover stacking loads.

-2. Static loads, dynamic loads and wind loads are considered as loads acting on containers stowed on deck. Dynamic loads due to ship motions and wind loads acting on containers are according to **"Chapter 5 DESIGN LOADS FOR STRENGTH EVALUATION OF CONTAINER STOWAGE AND SECURING ARRANGEMENTS"**.

-3. Dynamic loads due to ship motions act at the center of gravity of each container, and wind load acts uniformly on the side wall of each container. Dynamic loads and wind loads are distributed to the top/bottom corners and corner post of each container through the side/end walls and the upper/lower sides of each container according to the procedure in **6.4.2**.

-4. The loads used for strength evaluation of container stowage and securing arrangements on deck are calculated as loads acting on each part of containers in a container stack by combining the loads determined according to the procedure in **6.4.2**. The methods of strength evaluation of container stowage and securing arrangements are specified in **6.4.3.1** or **6.4.3.2** for unlashed or lashed containers, respectively.

-5. In cases where lashing rods are connected to a lashing bridge and the deformation of the lashing bridge is not negligible, the stiffness of the lashing bridge is to be considered when calculating the stiffness of the lashing rods.

6.4.2 Distribution of Loads Acting on Each Container Stowed on Deck

-1. Transverse loads F_{tti} acting on top corner and F_{tbi} acting on bottom corner of the end wall are calculated according to the procedure in **(1)** to **(4)** using transverse load F_t acting on each container and wind load P acting on containers (see **Fig.6.2**).

(1) Transverse loads due to ship motions are equally distributed to the door end and closed end of the container as follows:

Transverse load acting on one end wall of the container in ith tier: $F_{ti} = \dfrac{F_t}{2}$ (kN)

(2) In case of an outermost container stack, wind load P acting on the side wall of a container in ith tier is equally distributed to the door end and closed end of the container as follows:

Wind load acting on one side of the end walls of container in ith tier: $P_i = \dfrac{P}{2}$

(3) In case of an outermost container stack, the wind load P_i acting on one side of the end walls of container in ith tier calculated in **(2)** is equally distributed to the upper side and lower side of the container as follows:

Wind load acting on upper and lower sides
on one side of the end walls of container in ith tier: $\dfrac{P_i}{2}$ (kN)

(4) Transverse load F_{ti} distributed to the end walls of the container is further distributed to transverse loads F_{tti} acting on top corner and F_{tbi} acting on bottom corner on one side of the end walls of the container, according to the position of the center of gravity of each container, as shown below. In case of an outermost stack, the wind loads acting on upper and lower sides on one side of the end walls of container in **(3)** are also taken into consideration.

Transverse load acting on the top corner
on one side of the end walls of container in ith tier: $F_{tti} = h_i F_{ti} + \frac{P_i}{2}$

Transverse load acting on the bottom corner
on one side of the end walls of container in ith tier: $F_{tbi} = (1 - h_i) F_{ti} + \frac{P_i}{2}$

-2. Vertical load F_{vi} acting on the bottom of four corner posts of container in ith tier is calculated as follows using vertical load F_v acting on each container:

Transverse load acting on one end wall of the container in ith tier: $F_{vi} = \frac{F_v}{4}$

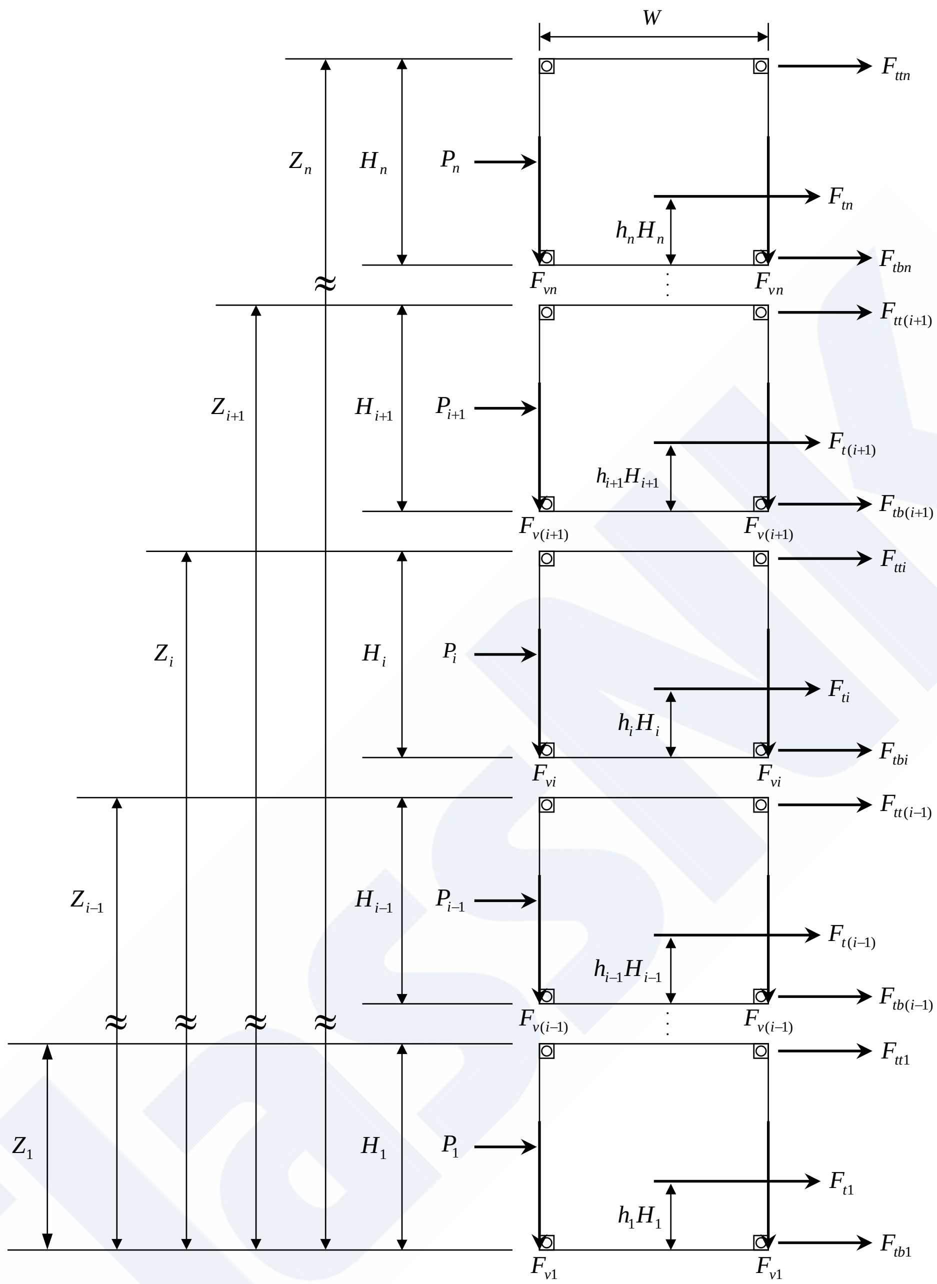


Fig.6.2 Loads Acting on Exposed n-Tier Container Stack

6.4.3 Strength Evaluation of Container Stowage and Securing Arrangements on Deck

6.4.3.1 Strength Evaluation of Unlashed Container Stacks

In cases where containers are stowed on deck without being lashed, the loads in **(1)** to **(6)** are calculated as strength evaluation criteria. Containers are to be stowed so that the calculated loads do not exceed the allowable load of containers and securing devices in **6.3**. The formulae below express the loads acting on each part of the container in jth tier in n-tier container stack.

(1) Transverse Racking Load Acting on Containers (per End Wall)

Racking load acting on the top corner on one side of the end walls of container in jth tier due to transverse loads acting on containers is as follows:

Racking load: $\sum_{i=j}^{n} F_{tti} + \sum_{i=j+1}^{n} F_{tbi}$

(2) Shear Load Acting on Twistlocks (per Corner Post of Container)

Shear load acting on a twistlock at the bottom corner of container in *j*th tier due to horizontal loads acting on containers is as follows:

Shear load: $0.5\sum_{i=j}^{n}\left(F_{tti} + F_{tbi}\right)$

(3) Compressive Load Acting on Corner Posts (per Corner Post of Container)

Compressive load acting on one corner post of container in *j*th tier due to vertical loads and overturning moments acting on containers is as follows:

Compressive load: $\sum_{i=j+1}^{n} F_{vi} + \sum_{i=j}^{n}\left(F_{tti}\frac{Z_i - Z_{j-1}}{W}\right) + \sum_{i=j}^{n-1}\left(F_{tb(i+1)}\frac{Z_i - Z_{j-1}}{W}\right)$

(4) Compressive Load Acting on Twistlocks (per Corner Post of Container)

Compressive load acting on a twistlock at the bottom corner of container in *j*th tier due to vertical loads and overturning moments acting on containers is as follows:

Compressive load: $\sum_{i=j}^{n} F_{vi} + \sum_{i=j}^{n}\left(F_{tti}\frac{Z_i - Z_{j-1}}{W}\right) + \sum_{i=j}^{n-1}\left(F_{tb(i+1)}\frac{Z_i - Z_{j-1}}{W}\right)$

(5) Lifting Load Acting on Corner Posts (per Corner Post of Container)

Lifting load acting on one corner post of container in *j*th tier due to vertical loads and overturning moments acting on containers is as follows:

Lifting load: $-\sum_{i=j+1}^{n} F_{vi} + \sum_{i=j}^{n}\left(F_{tti}\frac{Z_i - Z_{j-1}}{W}\right) + \sum_{i=j}^{n-1}\left(F_{tb(i+1)}\frac{Z_i - Z_{j-1}}{W}\right)$

(6) Lifting Load Acting on Twistlocks (per Corner Post of Container)

Lifting load acting on a twistlock at the bottom corner of container in *j*th tier due to vertical loads and overturning moments acting on containers is as follows:

Lifting load: $-\sum_{i=j}^{n} F_{vi} + \sum_{i=j}^{n}\left(F_{tti}\frac{Z_i - Z_{j-1}}{W}\right) + \sum_{i=j}^{n-1}\left(F_{tb(i+1)}\frac{Z_i - Z_{j-1}}{W}\right)$

6.4.3.2 Strength Evaluation of Lashed Container Stacks

-1. In cases where containers are stowed on deck, and the containers are lashed, the loads shown in the following **(1)** to **(8)** are to be calculated, and stowing is to be performed in a way that does not exceed the allowable loads of the containers and securing devices shown in **6.3**. However, if loads other than those indicated in **(1)** to **(8)** are considered to affect the strength of container stowage and lashing, the loads that should be taken into account are to be examined separately.

(1) Transverse racking load acting on containers
(2) Shear load acting on twistlocks
(3) Compressive load acting on container corner posts
(4) Compressive load acting on corner castings
(5) Tensile load acting on twistlocks
(6) Tension acting on lashing rods
(7) Tensile load acting on securing devices due to **(6)** above
(8) Horizontal and vertical lashing loads acting on container corner fittings due to **(6)** above

-2. When containers are lashed using fully automatic twistlocks, a strength evaluation of the container stowage and securing arrangements considering separation of the twistlocks needs to be conducted. The gap displacement u_{gap} of twistlocks accompanying vertical separation of the twistlocks and the twistlock load F_{TL} acting on the twistlocks must satisfy any one of the following conditions. Note that u_{max} is the maximum displacement when the twistlock concerned separates in the vertical direction, and is the value specified by the designer of that twistlock.

(1) $F_{TL} > 0$ and $u_{gap} = u_{max}$

(2) $F_{TL} = 0$ and $0 < u_{gap} < u_{max}$

(3) $F_{TL} < 0$ and $u_{gap} = 0$

Here, (1) is a condition in which tensile loading occurs even while vertical separation of the twistlock causes the maximum displacement, (2) is a condition in which the loads acting on the corner castings of the upper container are in balance, and (3) is a condition is which vertical separation of the twistlock does not occur.

-3. When containers are lashed, among the transverse loads F_{tti} and F_{tbi} acting on the container in ith tier specified in **6.4.2**, tensions T_{xti}, T_{xbi}, T_{eti} and T_{ebi}, which act on the lashing rods due to racking deformation of the containers, affect the positions where lashing is performed. If fully automatic twistlocks are used, the tensions T_{xit_gap}, T_{eti_gap}, T_{xbi_gap}, and T_{ebi_gap} of the lashing rods accompanying vertical separation of the twistlocks also need to be considered. Thus, the transverse component of tension T_{xti}, T_{xbi}, T_{eti}, T_{ebi}, T_{xit_gap}, T_{eti_gap}, T_{xbi_gap}, and T_{ebi_gap} due to the lashing rods for F_{tti} and F_{tbi} at the said positions are considered as shown below (see **Fig.6.3**). If there is no effect of this tension by the lashing rods, F'_{tti} and F'_{tbi} are calculated assuming this tension is 0.

$$F'_{tti} = F_{tti} - T_{xti}\cos\theta_{xti} - T_{eti}\cos\theta_{eti} - T_{xti\_gap}\cos\theta_{xti} - T_{eti\_gap}\cos\theta_{eti}$$

$$F'_{tbi} = F_{tbi} - T_{xbi}\cos\theta_{xbi} - T_{ebi}\cos\theta_{ebi} - T_{xbi\_gap}\cos\theta_{xbi} - T_{ebi\_gap}\cos\theta_{ebi}$$

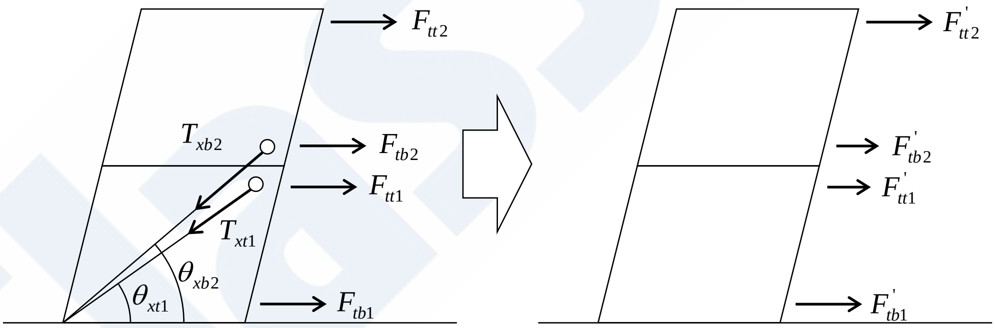


Fig.6.3 Transverse loads F'_{tti} and F'_{tbi} acting on one side of end walls of container in ith tier considering lashing effect

-4. The tension acting on a lashing rod caused by vertical separation in a fully automatic twistlock is calculated as follows:

$$T_{xti\_gap} = \sum_{1}^{i} k_{xti} u_{hgap\_j} \cos\theta_{xti}$$

$$T_{eti\_gap} = \sum_{1}^{i} k_{eti} u_{gap\_j} \sin\theta_{eti} + \sum_{1}^{i} k_{eti} u_{hgap\_j} \cos\theta_{eti}$$

$$T_{xbi\_gap} = \sum_{1}^{i-1} k_{xbi} u_{hgap\_j} \cos\theta_{xti}$$

$$T_{ebi\_gap} = \sum_{1}^{i} k_{ebi} u_{gap\_j} \sin\theta_{ebi} + \sum_{1}^{i-1} k_{ebi} u_{hgap\_j} \cos\theta_{eti}$$

Here, u_{gap_j} is the vertical displacement of a twistlock in the jth tier, and u_{hgap_j} is the horizontal displacement of a lashing rod that occurs accompanying separation of the twistlock in the jth tier.

-5. In calculations of the strength of container stowage and securing arrangements, the racking displacement of the containers in each tier needs to be obtained by the following equation of equilibrium.

$$\boldsymbol{\delta} = \boldsymbol{K}^{-1}(\boldsymbol{R} - \boldsymbol{T}_{gap})$$

Here, $\boldsymbol{R}$, $\boldsymbol{K}$, $\boldsymbol{\sigma}$, and $\boldsymbol{T}_{gap}$ are, respectively, the racking force vector of a container stack, the stiffness matrix of a container stack consisting of containers and lashing rods, the racking displacement matrix of the container stack, and the horizontal tensile force acting on the lashing rods due to the vertical separation of twistlocks. Because $\boldsymbol{T}_{gap}$ depends on the gap displacement of the twistlock, it is necessary to perform a nonlinear calculation so the twistlock load and gap displacement will take values that satisfy the conditions shown in **-2**.

-6. The racking load acting on the containers in the jth tier, which comprises the racking force vector $\boldsymbol{R}$, is calculated by the following formula:

$$R_j = \sum_{i=j}^{n} F'_{tti} + \sum_{i=j+1}^{n} F'_{tbi} \quad (kN)$$

-7. The stiffness matrix of a container stack is calculated considering both the stiffness of the containers and the stiffness of the lashing rods. For example, in the case of **Fig.6.4**, the stiffness matrix shown below is obtained. The stiffness of the lashing rods is obtained considering the stiffness of the lashing bridge when necessary.

$$\boldsymbol{K} = \begin{bmatrix} k_{C3} & -k_{C3} & 0 \\ 0 & k_{C2} + k_{xb3}\cos^2\theta_{xb3} & -k_{C2} \\ 0 & -k_{xb3}\cos^2\theta_{xb3} & k_{C1} + k_{xb2}\cos^2\theta_{xb2} \end{bmatrix}$$

-8. In calculating the lashing displacement that satisfies the equation of equilibrium shown in **-4**, an appropriate assumption for improving convergence may be posited for the occurrence of vertical separation of twistlocks. It may also be considered that loading does not occur in lashing rods that are connected to the corner castings on the tension side due to cross lashing.

-9. In obtaining the lashing displacement that satisfies the equation of equilibrium in **-4** by nonlinear calculation, a sufficiently small convergence error should be set in F_{TL} and U_{gap} in order to improve convergence.

-10. When vertical lashing is to be performed, the lashing is treated as an external lashing in which the angle of the lashing rods is 90°.

-11. Where a horizontal clearance exists between the corner castings for reasons related to the twistlock design, the tension of the lashing rods is to be calculated assuming an increase in tension due to that clearance. In this calculation, it may be assumed that the lashing rods receive additional tension equivalent to the sum of the horizontal clearances that exist at positions lower than the corner castings to which they are connected.

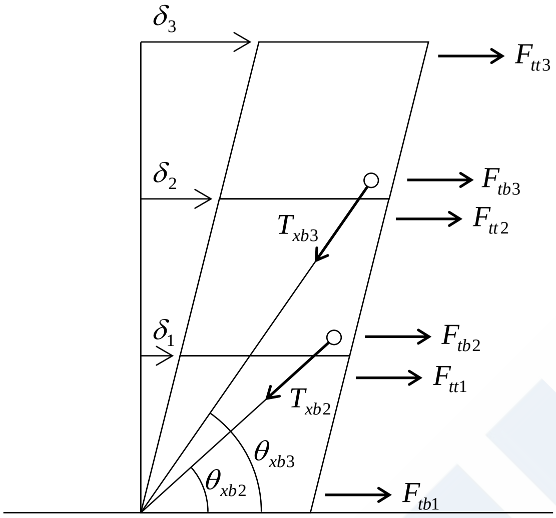


Fig.6.4 Example of Load-Displacement Diagram (3-Tier Container Stack)

-12. The loads shown in **-1(1)** to **(8)** for n-tier container stack are calculated using the tension determined in **-3** as in **(1)** to **(8)**.

(1) Transverse Racking Load Acting on Containers (per End Wall)
Racking load acting on the top corner on one side of the end walls of container in jth tier due to transverse loads acting on containers is as follows:

Racking load: R_j

(2) Shear Load Acting on Twistlocks (per Corner Post of Container)
Shear load acting on a twistlock at the bottom corner of container in jth tier due to horizontal loads acting on containers is as follows:

Shear load: $0.5\sum_{i=j}^{n}\left(F_{tti}+F_{tbi}\right)$

(3) Compressive Load Acting on Corner Posts (per Corner Post of Container)
Compressive load acting on one corner post of container in jth tier due to vertical loads and overturning moments acting on containers is as follows:

Compressive load:

$$\sum_{i=j+1}^{n} F_{vi} + \sum_{i=j}^{n}\left(F'_{tti}\frac{Z_i - Z_{j-1}}{W}\right) + \sum_{i=j}^{n-1}\left(F'_{tb(i+1)}\frac{Z_i - Z_{j-1}}{W}\right) + \sum_{i=j}^{n} T_{xti}\sin\theta_{xti} + \sum_{i=j+1}^{n} T_{xbi}\sin\theta_{xbi} + \sum_{i=j}^{n} T_{xti\_gap}\sin\theta_{xti} + \sum_{i=j+1}^{n} T_{xbi\_gap}\sin\theta_{xbi}$$

(4) Compressive Load Acting on Corner Casting (per Corner Post of Container)
Compressive load acting on a twistlock at the bottom corner of container in *j*th tier due to vertical loads and overturning moments acting on containers is as follows:

Compressive load:

$$\sum_{i=j}^{n} F_{vi} + \sum_{i=j}^{n}\left(F'_{tti}\frac{Z_i - Z_{j-1}}{W}\right) + \sum_{i=j}^{n-1}\left(F'_{tb(i+1)}\frac{Z_i - Z_{j-1}}{W}\right) + \sum_{i=j}^{n}\left(T_{xti}\sin\theta_{xti} + T_{xti\_gap}\sin\theta_{xti} + T_{xbi\_gap}\sin\theta_{xbi} + T_{xbi}\sin\theta_{xbi}\right)$$

(5) Lifting Load Acting on Twistlocks (per Corner Post of Container)
Lifting load acting on a twistlock at the bottom corner of container in *j*th tier due to vertical loads and overturning moments acting on containers is as follows:

Lifting load:

$$-\sum_{i=j}^{n} F_{vi} + \sum_{i=j}^{n}\left(F'_{tti}\frac{Z_i - Z_{j-1}}{W}\right) + \sum_{i=j}^{n-1}\left(F'_{tb(i+1)}\frac{Z_i - Z_{j-1}}{W}\right) - \sum_{i=j}^{n}\left(T_{eti}\sin\theta_{eti} + T_{eti\_gap}\sin\theta_{ebi} + T_{ebi}\sin\theta_{ebi} + T_{ebi\_gap}\sin\theta_{ebi}\right)$$

(6) Tension Acting on Lashing Rods and Lifting Load Acting on Securing Devices (Eye Plates etc.) (per Lashing Rod)
Tension acting on lashing rods that lash the container in *j*th tier and lifting load acting on securing devices due to such tension are as follows:

Tension acting on each lashing rod:

$T_{xtj}+T_{xtj\_gap}$, $T_{xbj}+T_{xbj\_gap}$, $T_{etj}+T_{etj\_gap}$ and $T_{ebj}+T_{ebj\_gap}$

(7) Horizontal Lashing Load Acting on Container Corner Fittings due to **(7)** (per Lashing Rod)
Horizontal lashing load acting on container fittings due to tension acting on lashing rods that lash the container in *j*th tier are as follows:

Horizontal component of tension acting on each lashing rod:

$$\left(T_{xtj} + T_{xtj\_}gap\right)\cos\theta_{xbj}, \left(T_{xtj} + T_{xtj\_}gap\right)\cos\theta_{xbj}, \left(T_{etj} + T_{etj\_}gap\right)\cos\theta_{etj}, \left(T_{ebj} + T_{ebj\_}gap\right)\cos\theta_{ebj}$$

(8) Vertical Lashing Load Acting on Container Corner Fittings due to **(7)** (per Lashing Rod)
Vertical lashing load acting on container fittings due to tension acting on lashing rods that lash the container in *j*th tier are as follows:

Vertical component of tension acting on each lashing rod:

$$\left(T_{xtj} + T_{xtj\_}gap\right)\sin\theta_{xtj}, \left(T_{xbj} + T_{xbj\_}gap\right)\sin\theta_{xbj}, \left(T_{etj} + T_{etj\_}gap\right)\sin\theta_{etj}, \left(T_{ebj} + T_{ebj\_}gap\right)\sin\theta_{ebj}$$

6.5 Strength Evaluation of Container Stowage Arrangements in Hold

6.5.1 General

This section is based on the following pre-conditions:

(1) In cases where a container is supported at its four corners by cell guides with small gaps, the load acting on the container in a transverse direction is supported by the cell guides.

(2) In cases where 20' containers are stowed in a 40' container bay, the container shifting is appropriately prevented by use of container guides and stackers since one end wall of the 20' container would not be supported by the cell guides.

(3) In cases where 20' containers are stowed in a 40' container bay, the 20' containers are prevented from shifting and racking deformation in the longitudinal direction of the ship by cell guides and other 20' containers.

(4) Containers are stowed within the allowable range of double bottom stacking loads.

6.5.2 Loads Acting on Each Container Stowed in Hold

-1. Static loads and dynamic loads are considered as loads acting on each container stowed in holds. Dynamic loads due to ship motions are according to **"Chapter 5 DESIGN LOADS FOR STRENGTH EVALUATION OF CONTAINER STOWAGE AND SECURING ARRANGEMENTS"**.

-2. Loads acting on each container stowed in holds are calculated similar to loads acting on the container stowed on deck given in **6.4.2** (see **Fig.6.2)**.

-3. If two 20' containers are stowed in the longitudinal direction of the ship in a 40' container bay, the transverse load on the container is divided into three-fifths on the end wall supported by cell guides and two-fifths on the end wall not supported by cell guides.

-4. If two 20' containers are stowed in the longitudinal direction of the ship in a 40' container bay, and if one or more 40' containers are stowed on top of those 20' containers, then the transverse load on the container is divided into two-thirds on the end wall supported by cell guides and one-third on the end wall not supported by cell guides since the deformation of the 20' containers are prevented by the 40' containers.

6.5.3 Strength Evaluation of Container Stowage and Securing Arrangements in Hold

6.5.3.1 Strength Evaluation of Container Stowage in Holds Exclusive for 20' Containers, 40' Containers, etc.

When containers are stowed in holds exclusive for 20'containers, 40'containers, etc., the loads below are calculated as strength criteria. Containers are to be stowed so that the calculated loads do not exceed the allowable load of containers in **6.3**.

(1) Compressive Load Acting on Corner Posts (per Corner Post of Container)

Containers are supported by cell guides at their four corners in cases where they are stowed in exclusive holds. Therefore, transverse loads and overturning moments acting on the container are supported by the cell guides. However, compressive load act on corner posts of containers due to vertical loads.

The following equation expresses the compressive load acting on one corner post of container in jth tier in n-tier container stack.

Compressive load: $\sum_{i=j+1}^{n} F_{vi}$

6.5.3.2 Strength Evaluation of 20' Containers Stowed in 40' Container Bays

-1. When 20' containers are stowed in a 40' container bay, the loads in **(1)** and **(2)** are calculated as strength criteria. Containers are to be stowed so that the calculated loads do not exceed the allowable load of containers in **6.3**.

(1) Transverse Racking Load Acting on Containers

Since a container stowed in exclusive holds is supported at its four corners by cell guides, special considerations for the racking of containers need not to be given. However, if 20' containers are stowed in the longitudinal direction of the ship in a 40' container bay, the central part of the container bay is not supported by cell guides; therefore, transverse racking loads act in the end walls of such 20'containers at the middle of the container bay.

The following calculation expresses the racking load acting on container in jth tier in n-tier container stack of 20' containers.

Racking Force: $\sum_{i=j}^{n} F_{tti} + \sum_{i=j+1}^{n} F_{tbi}$

(2) Compressive Load Acting on Corner Posts (per Corner Post of Container)

Compressive loads act on corner posts of containers due to vertical loads and overturning moments. However, overturning moments are supported by cell guides on the end wall of containers in cases where the end wall is supported by cell guides with small gaps in between.

The following equations express the compressive loads acting on one corner post of container in jth tier in n-tier container stack.

Compressive load (20' containers only, the side supported by cell guides): $\sum_{i=j+1}^{n} F_{vi}$

Compressive load (20' containers only, the side not supported by cell guides):

$$\sum_{i=j+1}^{n} F_{vi} + \sum_{i=j}^{n}\left(F_{tti}\frac{Z_i - Z_{j-1}}{W}\right) + \sum_{i=j}^{n-1}\left(F_{tb(i+1)}\frac{Z_i - Z_{j-1}}{W}\right)$$

Compressive load (20' containers with one or more 40' containers stowed on top): $\sum_{i=j+1}^{n} F_{vi}$

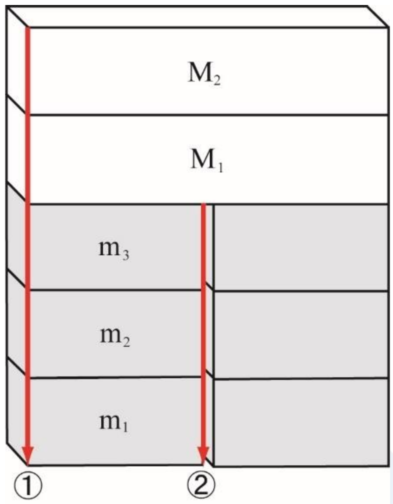


Fig.6.5 Stacking Load Acting on Double Bottom

-3. For reference, **Tables 6.3** and **6.4** show the allowable container weights of 20' containers which have been calculated based on **-1**, according to full loading conditions where a 40'container is stowed on top of the 20' container stack or not stowed on top of the 20' container stack, respectively.
The calculations of **Tables 6.3** and **6.4** are based on the conditions below.
(1) The allowable load of containers according to ISO1496-1: 1990 is used (refer to **6.3**).
(2) Same container weight is assumed to be stowed in each tier of containers.
(3) **Table 6.4** is for those cases where one tier of 40' containers laden with the same weight is stowed on top of the 20' container stack. The number of stowage tiers in **Table 6.4** indicates the number of stowage tiers of 20' containers.

Table 6.3 40’ Container is Not Stowed on Top of the 20’ Container Stack

Transverse acceleration at the lowest container in the container stack (*m*/*sec*^{2})	Maximum Allowable Weight of 20’ Containers (*ton*)							
	3-tiers	4-tiers	5-tiers	6-tiers	7-tiers	8-tiers	9-tiers	10-tiers
3.5	30.5	30.5	23.8	19.2	16.0	13.7	11.8	9.9
3.6	30.5	30.5	23.2	18.7	15.6	13.4	11.5	9.6
3.7	30.5	29.7	22.7	18.3	15.2	13.0	11.2	9.4
3.8	30.5	29.0	22.1	17.8	14.8	12.6	10.9	9.2
3.9	30.5	28.2	21.5	17.3	14.4	12.3	10.6	8.9
4.0	30.5	27.5	20.9	16.8	14.0	11.9	10.3	8.7
4.1	30.5	26.7	20.3	16.3	13.6	11.6	10.0	8.5
4.2	30.5	25.9	19.7	15.8	13.1	11.2	9.7	8.2
4.3	30.5	25.2	19.1	15.3	12.7	10.8	9.4	8.0
4.4	30.5	24.4	18.5	14.9	12.3	10.5	9.1	7.8
4.5	30.5	23.7	17.9	14.4	11.9	10.1	8.8	7.5
4.6	30.5	22.9	17.3	13.9	11.5	9.8	8.5	7.3
4.7	30.5	22.1	16.7	13.4	11.1	9.4	8.2	7.2
4.8	30.5	21.4	16.1	12.9	10.7	9.1	7.9	6.9
4.9	30.0	20.6	15.5	12.4	10.3	8.7	7.6	6.6
5.0	28.9	19.9	14.9	11.9	9.8	8.3	7.3	6.3
5.1	27.8	19.1	14.4	11.5	9.4	8.0	7.0	6.0
5.2	26.8	18.3	13.8	11.0	9.0	7.6	6.8	5.8
5.3	25.7	17.6	13.2	10.5	8.6	7.3	6.5	5.5
5.4	24.6	16.8	12.6	10.0	8.2	6.9	6.2	5.2
5.5	23.5	16.1	12.0	9.5	7.8	6.5	5.9	4.9
5.6	22.4	15.3	11.4	9.0	7.4	6.2	5.6	4.6
5.7	21.4	14.6	10.8	8.5	7.0	5.8	5.3	4.3
5.8	20.3	13.8	10.2	8.1	6.5	5.5	5.0	4.0
5.9	19.2	13.0	9.6	7.6	6.1	5.1	4.7	3.8
6.0	18.1	12.3	9.0	7.1	5.7	4.8	4.4	3.5

(Notes)
(1) In the above table, a container with a maximum weight of 30.5 ton is considered.
(2) When a container with a maximum weight of 24.0 ton is used, values that exceed 24.0 ton in the above table are to be replaced with 24.0 ton.

Table 6.4 One 40' Container is Stowed on Top of the 20' Container Stack

Transverse acceleration at the lowest container in the container stack (m/sec^2)	Maximum Allowable Weight of 20' Containers (*ton*)						
	3-tiers	4-tiers	5-tiers	6-tiers	7-tiers	8-tiers	9-tiers
3.5	30.5	30.5	28.7	23.0	19.3	16.5	14.4
3.6	30.5	30.5	28.0	22.4	18.8	16.1	14.0
3.7	30.5	30.5	27.3	21.9	18.3	15.7	13.6
3.8	30.5	30.5	26.6	21.3	17.8	15.3	13.3
3.9	30.5	30.5	25.9	20.7	17.3	14.9	12.9
4.0	30.5	30.5	25.2	20.1	16.8	14.4	12.5
4.1	30.5	30.5	24.5	19.6	16.4	14.0	12.1
4.2	30.5	30.5	23.8	19.0	15.9	13.6	11.8
4.3	30.5	30.4	23.1	18.4	15.4	13.2	11.4
4.4	30.5	29.5	22.4	17.9	14.9	12.7	11.0
4.5	30.5	28.6	21.7	17.3	14.4	12.3	10.6
4.6	30.5	27.7	21.0	16.7	13.9	11.9	10.3
4.7	30.5	26.8	20.3	16.1	13.4	11.5	9.9
4.8	30.5	25.9	19.6	15.6	13.0	11.0	9.5
4.9	30.5	25.0	18.9	15.0	12.5	10.6	9.1
5.0	30.5	24.1	18.2	14.4	12.0	10.2	8.8
5.1	30.5	23.2	17.5	13.9	11.5	9.8	8.4
5.2	30.5	22.3	16.8	13.3	11.0	9.4	8.0
5.3	30.5	21.4	16.1	12.7	10.5	8.9	7.7
5.4	30.0	20.5	15.4	12.1	10.0	8.5	7.3
5.5	28.7	19.6	14.7	11.6	9.6	8.1	6.9
5.6	27.4	18.7	14.0	11.0	9.1	7.7	6.5
5.7	26.2	17.8	13.3	10.4	8.6	7.2	6.2
5.8	24.9	16.9	12.6	9.9	8.1	6.8	5.8
5.9	23.6	16.0	11.9	9.3	7.6	6.4	5.4
6.0	22.3	15.1	11.2	8.7	7.1	6.0	5.0

(Notes)

(1) In the above table, a container with a maximum weight of 30.5 ton is considered.

(2) When a container with a maximum weight of 24.0 ton is used, values that exceed 24.0 ton in the above table are to be replaced with 24.0 ton.

Chapter 7 LASHING CALCULATION PROGRAM

7.1 General

A lashing calculation program is a software program which is capable of carrying out strength evaluation of container stowage and securing arrangements based on the flowchart of strength evaluation shown in **Fig.4.1,** and relevant standards in Chapters 5 and 6.

7.2 Application

This chapter applies to ships classed with NIPPON KAIJI KYOKAI (hereinafter referred to as “the Society”), installed with lashing calculation program onboard ship, and submitted with an application to affix an appropriate notation to their Classification Characters.

7.3 Class Notations

For ships which keep onboard a lashing calculation program, capable of carrying out strength evaluation based on the method of container stowage and securing arrangements in accordance with Chapters 5 and 6 in the Guideline without taking specific sea routes into consideration, “Container Stowage and Securing Arrangements” (abbreviated to CSSA) is to be affixed to the Classification Characters in accordance with the provisions of **Chapter 2 of the Regulation for the Classification and Registry of Ships**.

In addition, for ships which keep onboard a lashing calculation program with a function for performing strength evaluations of container stowage and securing arrangements considering the effects of specific sea routes or the effects of specific seasons, the following class notations are to be affixed, based on **Chapter 2 of the Regulation for the Classification and Registry of Ships**.

• In case the effects of specific sea routes are considered: Container Stowage and Securing Arrangements with Service on Specific Sea Routes (abbreviation: CSSA-R)

• In case the effects of specific sea routes and seasons are considered: Container Stowage and Securing Arrangements with Service on Specific Sea Routes and Seasons (abbreviation: CSSA-RS)

7.4 Termination of Class Notation

The Society will withdraw the class notation specified in 7.3 in cases where the Society determines that the onboard installation of lashing calculation program, capable of carrying out strength evaluation of container stowage and securing arrangements in accordance with the Guideline, is not being maintained. Requirements based on this chapter are not conditions for class maintenance.

7.5 Lashing Calculation Program

-1. Lashing calculation program should be capable of producing the specified performance and functions on installation.

-2. The operation manual and the output of the lashing calculation program should be prepared in a language understood by the ship master. Where this language is not English, a translation into English should be included.

-3. Input and output of the lashing calculation program should be in compliance with the following:

(1) Input data required for calculating ship motions in accordance with Chapter 5 can be inputted via manual operation or output from a loading computer.

(2) Container weights and lashing patterns of containers stowed on deck and in hold can, in principle, be inputted individually.

(3) Input data can be verified.

(4) At least the following items can be outputted.

(a) Metacentric Height (GM)
(b) Natural Period of Roll Motion
(c) Roll Angle
(d) Position of Each Container
(e) Longitudinal, Transverse, and Vertical Accelerations of Each Container
(f) Stiffness Constant of Each Container against Racking
(g) Stiffness Constant of Each Lashing Rod
(h) Weight of Each Container
(i) Stacking load of Each Container Stack
(j) Lashing Pattern
(k) Racking Load Acting on End Walls of Each Container
(l) Lashing Load Acting on Corner Fittings of Each Container
(m) Compressive Load Acting on Corner Posts of Each Container
(n) Lifting Load Acting on Corner Posts of Each Container
(o) Allowable Load of Each Container Corresponding to Loads in **(k)** to **(n)** Above
(p) Tension of Each Lashing Rod
(q) Allowable Load of Each Securing Device

-4. The lashing calculation program should be capable of outputting evaluation results regardless of the outcome of the strength evaluation of container stowage and securing arrangements. A clear warning should be given in any of the following cases where strength requirements are not satisfied.
(1) When racking load has exceeded the allowable load of the container
(2) When compressive load acting on a corner post has exceeded the allowable load of the container
(3) When lifting load acting on a corner post has exceeded the allowable load of the container
(4) When lashing load has exceeded the allowable load of the container corner fitting or the securing device
(5) When the stacking load of the hatch cover or double bottom has exceeded

7.6 Kinds of Audits

The kinds of audits are specified in the following **(1)** to **(3)**:
(1) Initial Audit
(2) Periodical Audit
(3) Occasional Audit

7.7 Timing of Audits

The timing of audits is specified in the following **1** to **3**:
-1. Initial Audits are to be carried out at the time the application for the audit is made.
-2. Periodical audits are to be carried out at the times of Periodical Surveys for Classification specified in **1.1.3-1(1)** to **(3)**, **Part B of the Rules for the Survey and Construction of Steel Ships**.
-3. Occasional Audits are to be carried out on the following occasions at times other than Initial Audits or Periodical Audits.
(1) In cases where the lashing calculation program is modified
(2) In cases where the method of container stowage and securing arrangements is fundamentally altered
(3) In cases where any applications for audits are submitted by owners
(4) Other occasions when Occasional Audits are considered to be necessary

7.8 Periodical Audits Carried Out in Advance or Postponement

The requirements for Periodical Audits carried out in advance and in postponement are to be in accordance with provisions in **1.1.4** or **1.1.5**, **Part B of the Rules for the Survey and Construction of Steel Ships**, relevant to Periodical Surveys for Classification.

7.9 Ships Laid-up

Ships laid-up are not subject to those Periodical Audits specified in **7.6(2)**.

7.10 Preparation for Audits and Other Related Issues

-1. In cases where ships are to be audited in accordance with this chapter, it is the responsibility of the Owners to notify the Surveyors of the locations where they wish to undergo such audits. Surveyors are to be advised of audits a reasonable time in advance so that such audits can be carried out at proper times.
-2. All such preparations required for initial, periodical and other audits specified in this chapter as well as those which may be required by the Surveyors in accordance with the provisions given in this chapter are the responsibility of the Owners or their representatives.
-3. Applicants for audits are to arrange supervisors who are well conversant with all of the audit items required for the preparation of such audits and who are able to provide all necessary assistance to the Surveyor according to their requests during such audits.
-4. Audits may be suspended in case where necessary preparations have not been made, any appropriate supervisor is not present, or the Surveyor considers that the safety needed for the execution of the audit is not ensured.
-5. In cases where repairs are considered to be necessary as a result of audits, the Surveyor is to notify the audit applicants of his or her findings. Applicants, upon receiving such notification, are to obtain Surveyor verification after carrying out any necessary repairs.

7.11 Equivalency

Class notation in **7.3** may be affixed to Classification Characters of ships which keep onboard a lashing calculation program based on the method of strength evaluation of container stowage and securing arrangements different from the method specified in the Guideline provided that, having verified the accuracy of such program, they are deemed by the Society to be equivalent to the method specified in the Guideline.

7.12 Initial Audits

7.12.1 General
During Initial Audits, accuracy verification and performance test of the lashing calculation program are to be carried out.

7.12.2 Submission of Plans and Documents
Prior to Initial Audits, loading manual, cargo securing manual, and output of lashing calculation program are to be submitted to and approved by the Society beforehand. The operation manual for the lashing calculation program is also to be submitted for reference. Submission of additional plans and documents may be required in cases where deemed necessary by the Society.

7.12.3 Output of Lashing Calculation Program
-1. When affixing "CSSA" to the Classification Characters, the output of lashing calculation program which is to be submitted in **7.12.2** should include the following evaluation results without taking specific sea routes into consideration:
(1) The container stacks subject to evaluation on deck are to be at least one outermost stack and the next stack inward per bow area and midship area. The container stacks subject to evaluation in

hold are to be at least one outermost stack per bow area and midship area.

(2) The GM values are to be the maximum and minimum GM values of loading conditions specified in the loading manual and their intermediate value.

-2. When affixing "CSSA-R" to the Classification Characters, the output of lashing calculation program should, in addition to the output specified in **-1**, include the evaluation results carried out in accordance with **-1(1)** and **(2)** taking at least one specific sea route shown in **Table 5.2** (except for North America – Europe route) into consideration.

-3. When affixing "CSSA-RS" to the Classification Characters, the output of lashing calculation program should, in addition to the output specified in **-1**, include the evaluation results carried out in accordance with **-1(1)** and **(2)** taking at least one combination of specific sea route and season into consideration.

7.12.4 Items of Initial Audit

-1. The following plans and documents are to be confirmed that they are kept onboard.

(1) Loading Manual

(2) Cargo Securing Manual

(3) Output of Lashing Calculation Program at its Approval

(4) Operation Manual for Lashing Calculation Program

-2. The computer on which the approved lashing calculation program is installed is to be confirmed that it is kept onboard.

-3. The performance test of lashing calculation program is to be carried out in the presence of the Surveyor according to the procedures specified in **(1) to (3)**, so as to ensure that the lashing calculation program is working correctly.

(1) Retrieve at least one of the test loading conditions which were used for the approval of lashing calculation program, carry out a strength evaluation of container stowage and securing arrangements, an and compare the evaluation results with those at the approval of lashing calculation program.

(2) Change the value of GM to the maximum and minimum values specified in the loading manual. The results are to be reviewed to ensure that they differ in logical way from those of the test condition as mentioned in **(1)**.

(3) Revise the modified loading condition mentioned in **(2)** to restore the initial test condition mentioned in **(1)** and compare the results.

7.13 Periodical Audits

At Periodical Audits, the performance test of lashing calculation program is to be carried out in the presence of the Surveyor according to the procedures specified in **7.12.4-3**, so as to ensure that the lashing calculation program is working correctly.

7.14 Occasional Audits

Items to be examined at Occasional Audits are to be at the discretion of the Society.

Chapter 8 SAFE DESIGN FOR CONTAINER LASHING

8.1 General

-1. **CSS Code (Code of Safe Practice for Cargo Stowage and Securing) Annex 14** was developed at IMO with primary aim to ensure that persons engaged in carrying out container securing operations on deck have safe working conditions, and in particular safe access, appropriate securing equipment and safe places of work.
-2. Although **CSS Code Annex 14** is a non-mandatory code, a number of states have been requiring that ships, which are specifically designed and fitted for the purpose of carrying containers on deck, calling at their ports should comply with **CSS Code Annex 14**. In addition, some flag administrations have been requiring that their flag ships, which are specifically designed and fitted for the purpose of carrying containers on deck, should comply with the **CSS Code Annex 14**.

8.2 Application

This chapter applies to ships classed with NIPPON KAIJI KYOKAI (hereinafter referred to as "the Society"), intended to comply with **CSS Code Annex 14**, and submitted with an application to affix an appropriate notation to their Classification Characters.

8.3 Class Notations

-1. "Safe Design for Container Lashing" (abbreviated to SDCL) is to be affixed to the Classification Characters of ships, the keels of which were laid or which are at a similar stage of construction on or after 1 January 2015, whose construction and equipment are complying with the **CSS Code Annex 14** in its entirety.
-2. "Safe Design for Container Lashing to Existing Containership" (abbreviated to SDCL-E) is to be affixed to the classification characters of existing ships, the keels of which were laid or which are at a similar stage of construction before 1 January 2015, whose construction and equipment are; complying with **Section 4.4 (Training and familiarization)**, **7.1 (Introduction)**, **7.3 (Maintenance)** and **Section 8 (Specialized container safety design)**;and complying with the principles of the **CSS Code Annex 14** contained in **Section 6 (Design)** and **7.2 (Operational procedure)** as far as practical by the flag States Administration with the understanding that existing ships would not be required to be enlarged or undergo other major structural modification as determined.

8.4 Termination of Class Notation

The Society will withdraw the class notation specified in **8.3** in cases where the Society determines that the construction and equipment required by the **CSS Code Annex 14** are not being maintained. Requirements based on this chapter are not conditions for class maintenance.

8.5 Kinds of Audits

The kinds of audits are specified in the following **(1)** to **(3)**:
(1) Initial Audit
(2) Periodical Audit
(3) Occasional Audit

8.6 Timing of Audits

The timing of audits is specified in the following **1** to **3**:
-1. Initial Audits are to be carried out at the time the application for the audit is made.
-2. Periodical audits are to be carried out at the times of Periodical Surveys for Classification

specified in **1.1.3-1(1)** to **(3)**, **Part B of the Rules for the Survey and Construction of Steel Ships**.
-3. Occasional Audits are to be carried out on the following occasions at times other than Initial Audits or Periodical Audits.
(1) In cases where the construction and equipment, required by the **CSS Code Annex 14**, are changed or replaced
(2) In cases where any applications for audits are submitted by owners
(3) Other occasions when Occasional Audits are considered to be necessary

8.7 Periodical Audits Carried Out in Advance and Postponement

The requirements for Periodical Audits carried out in advance and in postponement are to be in accordance with provisions in **1.1.4** or **1.1.5**, **Part B of the Rules for the Survey and Construction of Steel Ships**, relevant to Periodical Surveys for Classification.

8.8 Ships Laid-up

Ships laid-up are not subject to those Periodical Audits specified in **8.5(2)**.

8.9 Preparation for Audits and Other Related Issues

-1. In cases where ships are to be audited in accordance with this chapter, it is the responsibility of the Owners to notify the Surveyors of the locations where they wish to undergo such audits. Surveyors are to be advised of audits a reasonable time in advance so that such audits can be carried out at proper times.
-2. All such preparations required for initial, periodical and other audits specified in this chapter as well as those which may be required by the Surveyors in accordance with the provisions given in this chapter are the responsibility of the Owners or their representatives.
-3. Applicants for audits are to arrange supervisors who are well conversant with all of the audit items required for the preparation of such audits and who are able to provide all necessary assistance to the Surveyor according to their requests during such audits.
-4. Audits may be suspended in case where necessary preparations have not been made, any appropriate supervisor is not present, or the Surveyor considers that the safety needed for the execution of the audit is not ensured.
-5. In cases where repairs are considered to be necessary as a result of audits, the Surveyor is to notify the audit applicants of his or her findings. Applicants, upon receiving such notification, are to obtain Surveyor verification after carrying out any necessary repairs.

8.10 Initial Audits

8.10.1 General

During Initial Audits, the construction and equipment for container securing operations on deck are to be examined in order to ascertain that they comply with the **CSS Code Annex 14**.

8.10.2 Submission of Plans and Documents

Prior to Initial Audits, Cargo Safe Access Plan (CSAP) is to be submitted to and approved by the Society beforehand. This plan should detail arrangements necessary for conducting cargo stowage and securing in a safe manner. Cargo Safe Access Plan should include the following for all working areas:
(1) Hand Rails
(2) Platforms
(3) Walkways

(4) Ladders
(5) Access Covers
(6) Location of Equipment Storage Facilities
(7) Lighting Fixtures
(8) Container Alignment on Hatch Covers/Pedestals
(9) Fittings for Specialized Containers, such as Reefer Plugs/Receptacles
(10) First Aid Stations and Emergency Access/Egress
(11) Gangways
(12) Any Other Arrangements Necessary for the Provisions of Safe Access

Submission of additional plans and documents may be required in cases where deemed necessary by the Society.

8.10.3 Items of Audit

At Initial Audits, the items specified in the following are to be examined:

-1. Confirmation that following plans and documents are kept onboard.
(1) Approved Cargo Securing Manual
(2) Approved Cargo Safe Access Plan

-2. Confirmation that the construction and equipment contained in Cargo Safe Access Plan are arranged properly.

8.11 Periodical Audits

At Periodical Audits, the items specified in the following are to be examined:

-1. Confirmation that the following plans and documents are kept onboard.
(1) Approved Cargo Securing Manual
(2) Approved Cargo Safe Access Plan

-2. Confirmation that the construction and equipment contained in Cargo Safe Access Plan are in good order.

8.12 Occasional Audits

8.12.1 General

In case where the construction and equipment contained in the Cargo Safe Access Plan are changed, the construction and equipment are to be confirmed as complying with the **CSS Code Annex 14** through Occasional Audits.

8.12.2 Submission of Plans and Documents

In case where the construction and equipment contained in the Cargo Safe Access Plan are changed, the modified Cargo Safe Access Plan is to be approved by the Society beforehand.

8.12.3 Items of Audit

In case where construction and equipment, required by the **CSS Code Annex 14**, are changed or replaced, the items specified in the following are to be examined:

-1. Confirmation that the following plans and documents are modified appropriately.
(1) Approved Cargo Securing Manual
(2) Approved Cargo Safe Access Plan

-2. Confirmation that the construction and equipment contained in the approved Cargo Safe Access Plan are arranged properly.

References

1. Guide to Cargo Stowage and Securing Arrangements (Japanese only), ClassNK 1988
2. Guidelines for Container Carrier Structures, ClassNK, November 2003
3. Yoshiyuki Inoue and Kazutaka Ayada, "A study on motion responses of a mega container ship in seaways" 10th International Marine Design Conference (IMDC), 26-29 May, Trondheim, Norway
4. P87 Design Guidelines for Container Ship Equipment (Japanese only), The Society of Naval Architecture of Japan, Ship Design and Technical Research Committee, Ship Design Group
5. Research on Ship Cargo Securing Systems, 1999 Report (General Report) (Japanese only) Shipbuilding Research Association of Japan
6. International Container Handbook (Japanese only), Japan Container Association
7. About Container Ships (Japanese only), Author: Itsuro Watanabe; publisher Seizando Shoten, 2006
8. ISO 668:1995 Series 1 freight containers – Classification, dimensions and ratings
9. ISO 1161:984 Series 1 freight containers – Corner fittings – Specification
10. ISO 1496-1:1990 Series 1 freight containers – Specification and testing – Part 1: General cargo containers for general purposes
11. JIS Z1613 Freight containers for international trade - terminology
12. JIS Z1614 Freight containers for international trade - external dimensions and ratings
13. JIS Z1616 Freight containers for international trade - corner fittings
14. JIS Z1618 General cargo containers for international trade

Appendix

CSS Code Annex 14
(Excerpt from MSC.1/Circ.1352/Rev.1)

CSS Code

(Code of Safe Practice for Cargo Stowage and Securing)

Annex 14

Guidance on providing safe working conditions for securing of containers on deck

Annex 14

GUIDANCE ON PROVIDING SAFE WORKING CONDITIONS FOR SECURING OF CONTAINERS ON DECK

1 AIM

To ensure that persons engaged in carrying out container securing operations on deck have safe working conditions and, in particular safe access, appropriate securing equipment and safe places of work. These guidelines should be taken into account at the design stage when securing systems are devised. These guidelines provide shipowners, ship builders, classification societies, Administrations and ship designers with guidance on producing or authorizing a Cargo Safe Access Plan (CSAP).

2 SCOPE

Ships which are specifically designed and fitted for the purpose of carrying containers on deck.

3 DEFINITIONS

3.1 *Administration* means the Government of the State whose flag the ship is entitled to fly.

3.2 *Containership* means dedicated containerships and those parts of other ships for which arrangements are specifically designed and fitted for the purpose of carrying containers on deck.

3.3 *Fencing* is a generic term for guardrails, safety rails, safety barriers and similar structures that provide protection against the falls of persons.

3.4 *Lashing positions* include positions:

.1 in between container stows on hatch covers;

.2 at the end of hatches;

.3 on outboard lashing stanchions/pedestals;

.4 outboard lashing positions on hatch covers; and

.5 any other position where people work with container securing.

3.5 *SATLs* are semi-automatic twistlocks.

3.6 *Securing* includes lashing and unlashing.

3.7 *Stringers* are the uprights or sides of a ladder.

3.8 *Turnbuckles and lashing rods*[*] include similar cargo securing devices.

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[*] Refer to standard ISO 3874, Annex D Lashing rod systems and tensioning devices.

4 GENERAL

4.1 Introduction

4.1.1 Injuries to dockworkers on board visiting ships account for the majority of accidents that occur within container ports, with the most common activity that involves such injuries being the lashing/unlashing of deck containers. Ships' crew engaged in securing operations face similar dangers.

4.1.2 During the design and construction of containerships the provision of a safe place of work for lashing personnel is essential.

4.1.3 Container shipowners and designers are reminded of the dangers associated with container securing operations and urged to develop and use container securing systems which are safe by design. The aim should be to eliminate or at least minimize the need for:

- **.1** container top work;
- **.2** work in other equally hazardous locations; and
- **.3** the use of heavy and difficult to handle securing equipment.

4.1.4 It should be borne in mind that providing safe working conditions for securing containers deals with matters relating to design, operation, and maintenance, and that the problems on large containerships are not the same as on smaller ones.

4.2 Revised recommendations on safety of personnel during container securing operations (MSC.1/Circ.1263)

Shipowners, ship designers and Administrations should take into account the recommendations on safe design of securing arrangements contained in these guidelines, and in the Recommendations on safety of personnel during container securing operations (MSC.1/Circ.1263).

4.3 Cargo Safe Access Plan (CSAP)

4.3.1 The *Guidelines for the preparation of the Cargo Securing Manual* (MSC/Circ.745) requires ships which are specifically designed and fitted for the purpose of carrying containers to have an approved Cargo Safe Access Plan (CSAP) on board, for all areas where containers are secured.

4.3.2 Stakeholders, including, but not limited to shipowners, ship designers, ship builders, administrations, classification societies and lashing equipment manufacturers, should be involved at an early stage in the design of securing arrangements on containerships and in the development of the CSAP.

4.3.3 The CSAP should be developed at the design stage in accordance with chapter 5 of the annex to MSC.1/Circ.1353.

4.3.4 Designers should incorporate the recommendations of this annex into the CSAP so that safe working conditions can be maintained during all anticipated configurations of container stowage.

4.4 Training and familiarization

4.4.1 Personnel engaged in cargo securing operations should be trained in the lashing and unlashing of containers as necessary to carry out their duties in a safe manner. This should include the different types of lashing equipment that are expected to be used.

4.4.2 Personnel engaged in cargo securing operations should be trained in the identification and handling of bad order or defective securing gear in accordance with each ship's procedures to ensure damaged gear is segregated for repair and maintenance or disposal.

4.4.3 Personnel engaged in cargo securing operations should be trained to develop the knowledge and mental and physical manual handling skills that they require to do their job safely and efficiently, and to develop general safety awareness to recognize and avoid potential dangers.

4.4.4 Personnel should be trained in safe systems of work. Where personnel are involved in working at heights, they should be trained in the use of relevant equipment. Where practical, the use of fall protection equipment should take precedence over fall arrest systems.

4.4.5 Personnel who are required to handle thermal cables and/or connect and disconnect temperature control units should be given training in recognizing defective cables, receptacles and plugs.

4.4.6 Personnel engaged in containership cargo operations should be familiarized with the ship's unique characteristics and potential hazards arising from such operations necessary to carry out their duties.

5 RESPONSIBILITIES OF INVOLVED PARTIES

5.1 Administrations should ensure that:

.1 lashing plans contained within the approved Cargo Securing Manual are compatible with the current design of the ship and the intended container securing method is both safe and physically possible;

.2 the Cargo Securing Manual, lashing plans and the CSAP are kept up to date; and

.3 lashing plans and the CSAP are compatible with the design of the vessel and the equipment available.

5.2 Shipowners and operators should ensure that:

.1 portable cargo securing devices are certified and assigned with a maximum securing load (MSL). The MSL should be documented in the cargo securing manual as required by the CSS Code;

.2 the operational recommendations of this annex are complied with;

.3 correction, changes or amendments of the Cargo Securing Manual, lashing plans and the Cargo Safe Access Plan (CSAP) should be promptly sent to the competent authority for approval; and

.4 only compatible and certified equipment in safe condition is used.

5.3 Designers should follow design recommendations of these guidelines.

5.4 Shipbuilders should follow design recommendations of these guidelines.

5.5 Containership terminal operators should ensure that the recommendations of relevant parts of this annex are complied with.

6 DESIGN

6.1 General design considerations

6.1.1 *Risk assessment*

6.1.1.1 Risk assessments should be performed at the design stage taking into account the recommendations of this annex to ensure that securing operations can be safely carried out in all anticipated container configurations. This assessment should be conducted with a view toward developing the Cargo Safe Access Plan (CSAP). Hazards to be assessed should include but not be limited to:

.1 slips, trips and falls;

.2 falls from height;

.3 injuries whilst manually handling lashing gear;

.4 being struck by falling lashing gear or other objects;

.5 potential damage due to container operations. High-risk areas should be identified in order to develop appropriate protection or other methods of preventing significant damage;

.6 adjacent electrical risks (temperature controlled unit cable connections, etc.);

.7 the adequacy of the access to all areas that is necessary to safely perform container securing operations;

.8 ergonomics (e.g. size and weight of equipment) of handling lashing equipment; and

.9 implications of lashing 9'6" high, or higher, containers and mixed stows of 40' and 45' containers.

6.1.1.2 Shipbuilders should collaborate with designers of securing equipment in conducting risk assessments and ensure that the following basic criteria are adhered to when building containerships.

6.1.2 Ship designers should ensure that container securing operations performed in outer positions can be accomplished safely. As a minimum, a platform should be provided on which to work safely. This platform should have fencing to prevent workers falling off it.

6.1.3 The space provided between the containers stows for workers to carry out lashing operations should provide:

.1 a firm and level working surface;

.2 a working area, excluding lashings in place, to provide a clear sight of twist lock handles and allow for the manipulation of lashing gear;

.3 sufficient spaces to permit the lashing gear and other equipment to be stowed without causing a tripping hazard;

.4 sufficient spaces between the fixing points of the lashing bars on deck, or on the hatch covers, to tighten the turnbuckles;

.5 access in the form of ladders on hatch coamings;

.6 safe access to lashing platforms;

.7 protective fencing on lashing platforms; and

.8 adequate lighting in line with these guidelines.

6.1.4 Ship designers should aim to eliminate the need to access and work on the tops of deck stows.

6.1.5 Platforms should be designed to provide a clear work area, unencumbered by deck piping and other obstructions and take into consideration:

.1 containers must be capable of being stowed within safe reach of the workers using the platform; and

.2 the work area size and the size of the securing components used.

6.2 Provisions for safe access

6.2.1 *General provisions*

6.2.1.1 The minimum clearance for transit areas should be at least 2 m high and 600 mm wide (see table in supplement, dimensions B, J, K1).

6.2.1.2 All relevant deck surfaces used for movement about the ship and all passageways and stairs should have non-slip surfaces.

6.2.1.3 Where necessary for safety, walkways on deck should be delineated by painted lines or otherwise marked by pictorial signs.

6.2.1.4 All protrusions in access ways, such as cleats, ribs and brackets that may give rise to a trip hazard should be highlighted in a contrasting colour.

6.2.2 *Lashing position design (platforms, bridges and other lashing positions)*

6.2.2.1 Lashing positions should be designed to eliminate the use of three high lashing bars and be positioned in close proximity to lashing equipment stowage areas. Lashing positions should be designed to provide a clear work area which is unencumbered by deck piping and other obstructions and take into consideration:

.1 the need for containers to be stowed within safe reach of the personnel using the lashing position so that the horizontal operating distance from the securing point to the container does not exceed 1,100 mm and not less than 220 mm for lashing bridges and 130 mm for other positions (see table in supplement, dimensions C1, C2, C3);

.2 the size of the working area and the movement of lashing personnel; and

.3 the length and weight of lashing gear and securing components used.

6.2.2.2 The width of the lashing positions should preferably be 1,000 mm, but not less than 750 mm (see table in supplement, dimensions A, GL, GT, I, K).

6.2.2.3 The width of permanent lashing bridges should be:

.1 750 mm between top rails of fencing (see table in supplement, dimension F); and

.2 a clear minimum of 600 mm between storage racks, lashing cleats and any other obstruction (see table in supplement, dimension F1).

6.2.2.4 Platforms on the end of hatches and outboard lashing stations should preferably be at the same level as the top of the hatch covers.

6.2.2.5 Toe boards (or kick plates) should be provided around the sides of elevated lashing bridges and platforms to prevent securing equipment from falling and injuring people. Toe boards should preferably be 150 mm high, however, where this is not possible they should be at least 100 mm high.

6.2.2.6 Any openings in the lashing positions through which people can fall should be possible to be closed.

6.2.2.7 Lashing positions should not contain obstructions, such as storage bins or guides to reposition hatch covers.

6.2.2.8 Lashing positions which contain removable sections should be capable of being temporarily secured.

6.2.3 ***Fencing design***

6.2.3.1 Bridges and platforms, where appropriate, should be fenced. As a minimum, fencing design should take into consideration:

.1 the strength and height of the rails should be designed to prevent workers from falling;

.2 flexibility in positioning the fencing of gaps. A horizontal unfenced gap should not be greater than 300 mm;

.3 provisions for locking and removal of fencing as operational situations change based on stowage anticipated for that area;

.4 damage to fencing and how to prevent failure due to that damage; and

.5 adequate strength of any temporary fittings. These should be capable of being safely and securely installed.

6.2.3.2 The top rail of fencing should be 1 m high from the base, with two intermediate rails. The opening below the lowest course of the guard rails should not exceed 230 mm. The other courses should be not more than 380 mm apart.

6.2.3.3 Where possible fences and handrails should be highlighted with a contrasting colour to the background.

6.2.3.4 Athwartships cargo securing walkways should be protected by adequate fencing if an unguarded edge exists when the hatch cover is removed.

6.2.4 ***Ladder and manhole design***

6.2.4.1 Where a fixed ladder gives access to the outside of a lashing position, the stringers should be connected at their extremities to the guardrails of the lashing position, irrespective of whether the ladder is sloping or vertical.

6.2.4.2 Where a fixed ladder gives access to a lashing position through an opening in the platform, the opening shall be protected with either a fixed grate with a lock back mechanism, which can be closed after access, or fencing. Grabrails should be provided to ensure safe access through the opening.

6.2.4.3 Where a fixed ladder gives access to a lashing position from the outside of the platform, the stringers of the ladder should be opened above the platform level to give a clear width of 700 to 750 mm to enable a person to pass through the stringers.

6.2.4.4 A fixed ladder should not slope at an angle greater than 25° from the vertical. Where the slope of a ladder exceeds 15° from the vertical, the ladder should be provided with suitable handrails not less than 540 mm apart, measured horizontally.

6.2.4.5 A fixed vertical ladder of a height exceeding 3 m, and any fixed vertical ladder, from which a person may fall into a hold, should be fitted with guard hoops, which should be constructed in accordance with paragraphs 6.2.4.6 and 6.2.4.7.

6.2.4.6 The ladder hoops should be uniformly spaced at intervals not exceeding 900 mm and should have a clearance of 750 mm from the rung to the back of the hoop and be connected by longitudinal strips secured to the inside of the hoops, each equally spaced round the circumference of the hoop.

6.2.4.7 The stringers should be carried above the floor level of the platform by at least 1 m and the ends of the stringers should be given lateral support and the top step or rung should be level with the floor of the platform unless the steps or rungs are fitted to the ends of the stringers.

6.2.4.8 As far as practicable, access ladders and walkways, and work platforms should be designed so that workers do not have to climb over piping or work in areas with permanent obstructions.

6.2.4.9 There should be no unprotected openings in any part of the workplace. Access opening must be protected with handrails or access covers that can be locked back during access.

6.2.4.10 As far as practicable, manholes should not be situated in transit areas, however, if they are, proper fencing should protect them.

6.2.4.11 Access ladders and manholes should be large enough for persons to safely enter and leave.

6.2.4.12 A foothold at least 150 mm deep should be provided.

6.2.4.13 Handholds should be provided at the top of the ladder to enable safe access to the platform to be gained.

6.2.4.14 Manhole openings that may present a fall hazard should be highlighted in contrasting colour around the rim of the opening.

6.2.4.15 Manhole openings at different levels of the lashing bridge should not be located directly below one another, as far as practicable.

6.3 Lashing systems

6.3.1 *General provisions*

Lashing systems, including tensioning devices, should:

.1 conform to international standards*, where applicable;

* Refer to standard ISO 3874 - The Handling and Securing of Type 1 Freight Containers, annex A-D.

.2 be compatible with the planned container stowages;

.3 be compatible with the physical ability of persons to safely hold, deploy and use such equipment;

.4 be uniform and compatible, e.g. twistlocks and lashing rod heads should not interfere with each other;

.5 be subject to a periodic inspection and maintenance regime. Non-conforming items should be segregated for repair or disposal; and

.6 be according to the CSM.

6.3.2 *Twistlock design*

6.3.2.1 Shipowners should ensure that the number of different types of twistlocks provided for cargo securing is kept to a minimum and clear instructions are provided for their operation. The use of too many different types of twistlocks may lead to confusion as to whether the twistlocks are locked.

6.3.2.2 The design of twistlocks should ensure the following:

.1 positive locking with easy up and down side identification;

.2 dislodging from corner fitting is not possible even when grazing a surface;

.3 access and visibility of the unlocking device is effective in operational situations;

.4 unlocked positions are easily identifiable and do not relock inadvertently due to jolting or vibration; and

.5 unlocking poles are as light as possible, of a simple design for ease of use.

6.3.2.3 Where it is not feasible to entirely eliminate working on the tops of container stows, the twistlock designs used should minimize the need for such working, e.g. use of SATLs, fully automatic twistlocks or similar design.

6.3.3 *Lashing rod design*

6.3.3.1 The design of containership securing systems should take into account the practical abilities of the workers to lift, reach, hold, control and connect the components called for in all situations anticipated in the cargo securing plan.

6.3.3.2 The maximum length of a lashing rod should be sufficient to reach the bottom corner fitting of a container on top of two high cube containers and be used in accordance with the instructions provided by the manufacturers.

6.3.3.3 The weight of lashing rods should be minimized as low as possible consistent with the necessary mechanical strength.

6.3.3.4 The head of the lashing rod that is inserted in the corner fitting should be designed with a pivot/hinge or other appropriate device so that the rod does not come out of the corner fitting accidentally.

6.3.3.5 The rod's length in conjunction with the length and design of the turnbuckle should be such that the need of extensions is eliminated when lashing high cube (9'6") containers.

6.3.3.6 Lightweight rods should be provided where special tools are needed to lash high cube containers.

6.3.4 *Turnbuckle design*

6.3.4.1 Turnbuckle end fittings should be designed to harmonize with the design of lashing rods.

6.3.4.2 Turnbuckles should be designed to minimize the work in operating them.

6.3.4.3 Anchor points for turnbuckles should be positioned to provide safe handling and to prevent the bending of rods.

6.3.4.4 To prevent hand injury during tightening or loosening motions, there should be a minimum distance of 70 mm between turnbuckles.

6.3.4.5 The turnbuckle should incorporate a locking mechanism which will ensure that the lashing does not work loose during the voyage.

6.3.4.6 The weight of turnbuckles should be minimized as low as possible consistent with the necessary mechanical strength.

6.3.5 *Storage bins and lashing equipment stowage design*

6.3.5.1 Bins or stowage places for lashing materials should be provided.

6.3.5.2 All lashing gear should be stowed as close to its intended place of use as possible.

6.3.5.3 The stowage of securing devices should be arranged so they can easily be retrieved from their stowage location.

6.3.5.4 Bins for faulty or damaged gear should also be provided and appropriately marked.

6.3.5.5 Bins should be of sufficient strength.

6.3.5.6 Bins and their carriers should be designed to be lifted off the vessel and restowed.

6.4 Lighting design

A lighting plan should be developed to provide for:

.1 the proper illumination[†] of access ways, not less than 10 lux (1 foot candle)[*], taking into account the shadows created by containers that may be stowed in the area to be lit, for example different length containers in or over the work area;

.2 a separate fixed or temporary (where necessary) lighting system for each working space between the container bays, which is bright enough, not less than 50 lux (5 foot candle)[*], for the work to be done, but minimizes glare to the deck workers;

.3 such illumination should, where possible, be designed as a permanent installation and adequately guarded against breakage; and

† For the upper tier of a lashing bridge, lights at the port and starboard extremities are generally adequate.
* Refer to Safety and Health in Ports, ILO Code of Practice, section 7.1.5.
* Refer to Safety and Health in Ports, ILO Code of Practice, section 7.1.5.

.4 the illumination† intensity should take into consideration the distance to the uppermost reaches where cargo securing equipment is utilized.

7 OPERATIONAL AND MAINTENANCE PROCEDURES

7.1 Introduction

7.1.1 Procedures for safe lashing and securing operations should be included in the ship's Safety Management System as part of the ISM Code documentation.

7.1.2 Upon arrival of the ship, a safety assessment of the lashing positions and the access to those positions should be made before securing work commences.

7.2 Operational procedures

7.2.1 Container deck working

7.2.1.1 Transit areas should be safe and clear of cargo and all equipment.

7.2.1.2 Openings that are necessary for the operation of the ship, which are not protected by fencing, should be closed during cargo securing work. Any necessarily unprotected openings in work platforms (i.e. those with a potential fall of less than 2 m), and gaps and apertures on deck should be properly highlighted.

7.2.1.3 The use of fencing is essential to prevent falls. When openings in safety barriers are necessary to allow container crane movements, particularly with derricking cranes, removable fencing should be used whenever possible.

7.2.1.4 It should be taken into account that, when lifting lashing bars that can weigh between 11 and 21 kg and turnbuckles between 16 and 23 kg, there may be a risk of injury and severe illness as a result of physical strain if handled above shoulder height with the arms extended. It is therefore recommended that personnel work in pairs to reduce the individual workload in securing the lashing gear.

7.2.1.5 The company involved with cargo operation should anticipate, identify, evaluate and control hazards and take appropriate measures to eliminate or minimize potential hazards to prevent in particular with harmful lumbar spinal damage and severe illness as a result of physical strain.

7.2.1.6 Personnel engaged in containership cargo operations should wear appropriate Personnel Protective Equipment (PPE) whilst carrying out lashing operations. The PPE should be provided by the company.

7.2.1.7 Manual twistlocks should only be used where safe access is provided.

7.2.1.8 Containers should not be stowed in spaces configured for larger sized containers unless they can be secured under safe working conditions.

7.2.2 ***Container top working***

7.2.2.1 When work on container tops cannot be avoided, safe means of access should be provided by the container cargo operation terminal, unless the ship has appropriate means of access in

† For the upper tier of a lashing bridge, lights at the port and starboard extremities are generally adequate.

accordance with the CSAP.

7.2.2.2 Recommended practice involves the use of a safety cage lifted by a spreader to minimize the risk to personnel.

7.2.2.3 A safe method of work should be developed and implemented to ensure the safety of lashers when on the top of container stows on deck. Where practical, the use of fall prevention equipment should take precedence over fall arrest equipment.

7.2.3 *Failure to provide safe lashing stations on board/carry out lashing by port workers*

7.2.3.1 Where there are lashing and unlashing locations on board ship where no fall protection, such as adequate handrails are provided, and no other safe method can be found, the containers should not be lashed or unlashed and the situation should be reported to shoreside supervisor and the master or deck officer immediately.

7.2.3.2 If protective systems cannot be designed to provide safe protected access and lashing work positions, in all cargo configurations then cargo should not be stowed in that location. Neither crew nor shore workers should be subjected to hazardous working conditions in the normal course of securing cargo.

7.3 Maintenance

7.3.1 In line with section 2.3 (Inspection and maintenance schemes) of the *Revised guidelines for the preparation of the cargo securing manual* (MSC.1/Circ.1353) all ships should maintain a record book, which should contain the procedures for accepting, maintaining and repairing or rejecting of cargo securing devices. The record book should also contain a record of inspections.

7.3.2 Lighting should be properly maintained.

7.3.3 Walkways, ladders, stairways and fencings should be subject to a periodic maintenance programme which will reduce/prevent corrosion and prevent subsequent collapse.

7.3.4 Corroded walkways, ladders, stairways and fencings should be repaired or replaced as soon as practicable. The repairs should be effected immediately if the corrosion could prevent safe operations.

7.3.5 It should be borne in mind that turnbuckles covered with grease are difficult to handle when tightening.

7.3.6 Storage bins and their carriers should be maintained in a safe condition.

8 SPECIALIZED CONTAINER SAFETY DESIGN

8.1 Temperature controlled unit power outlets should provide a safe, watertight electrical connection.

8.2 Temperature controlled unit power outlets should feature a heavy duty, interlocked and circuit breaker protected electrical power outlet. This should ensure the outlet can not be switched "live" until a plug is fully engaged and the actuator rod is pushed to the "On" position. Pulling the actuator rod to the "Off" position should manually de-energize the circuit.

8.3 The temperature controlled unit power circuit should de-energize automatically if the plug is accidentally withdrawn while in the "On" position. Also, the interlock mechanism should break the circuit while the pin and sleeve contacts are still engaged. This provides total operator safety and protection against shock hazard while eliminating arcing damage to the plug and receptacle.

8.4 Temperature controlled unit power outlets should be designed to ensure that the worker is not standing directly in front of the socket when switching takes place.

8.5 The positioning of the temperature controlled unit feed outlets should not be such that the flexible cabling needs to be laid out in such a way as to cause a tripping hazard.

8.6 Stevedores or ship's crew who are required to handle temperature controlled unit cables and/or connect and disconnect reefer units should be given training in recognizing defective wires and plugs.

8.7 Means or provisions should be provided to lay the temperature controlled unit cables in and protect them from lashing equipment falling on them during lashing operations.

8.8 Defective or inoperative temperature controlled unit plugs/electrical banks should be identified and confirmed as "locked out/tagged out" by the vessel.

9 REFERENCES

ILO Code of Practice – Safety and Health in Ports

ILO Convention 152 – Occupational Safety and Health in Dock Work

ISO Standard 3874 – The Handling and Securing of Type 1 Freight Containers

International Convention on Load Lines, 1966, as modified by the 1988 LL Protocol

Revised Recommendation on safety of personnel during container securing operations (MSC.1/Circ.1263)

Revised Guidelines for the preparation of the Cargo Securing Manual (MSC.1/Circ.1353/Rev.1).

SUPPLEMENT

CONTAINER SECURING DIMENSIONS

Dimension (*see* Figures)	**Description**	**Requirement (mm)**
A	Width of work area between container stacks (see figure 1)	750 minimum
B	Distance between lashing plates on deck or on hatch covers (see figure 1)	600 minimum
C1	Distance from lashing bridge fencing to container stack (see figure 2)	1100 maximum
C2	Distance from lashing plate to container stack (lashing bridge) (see figure 2)	220 minimum
C3	Distance from lashing plate to container stack (elsewhere) (see figures 1 and 4)	130 minimum
F	Width of lashing bridge between top rails of fencing (see figure 2)	750 minimum
F1	Width of lashing bridge between storage racks, lashing cleats and any other obstruction (see figure 2)	600 minimum
GL	Width of working platform for outboard lashing – fore/aft (see figure 3)	750 minimum
GT	Width of working platform for outboard lashing – transverse (see figure 3)	750 minimum
I	Width of work platform at end of hatch cover or adjacent to superstructure (see figure 4)	750 minimum
J	Distance from edge of hatch cover to fencing (see figure 4)	600 minimum
K	Width of lashing bridge between top rails of fencing (see figure 2)	750 minimum
K1	Width of lashing bridge between the pillars of the lashing bridge (see figure 2)	600 minimum

NOTES

B	- Measured between the centres of the lashing plates.
C1	- Measured from inside of fencing.
C2, C3	- Measured from centre of lashing plate to end of container.
F, K	- Measured to inside of fencing.
GL	- Measured from end of container to inside of fencing.
GT	- Measured to inside of fencing.
I	- Measured to inside of fencing.
J	- Measured to inside of fencing.

Figure 1

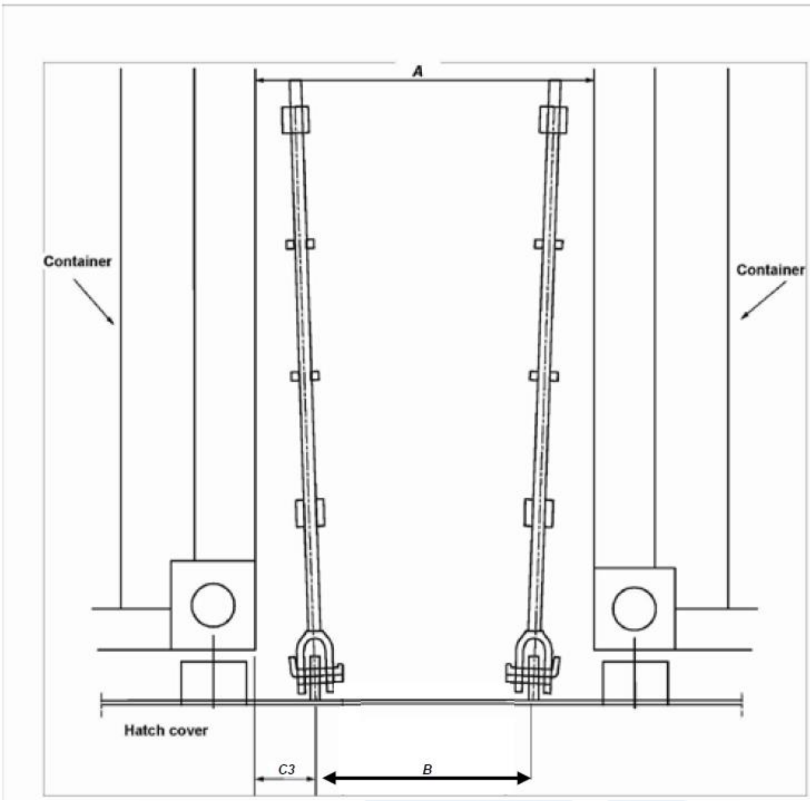


Figure 2

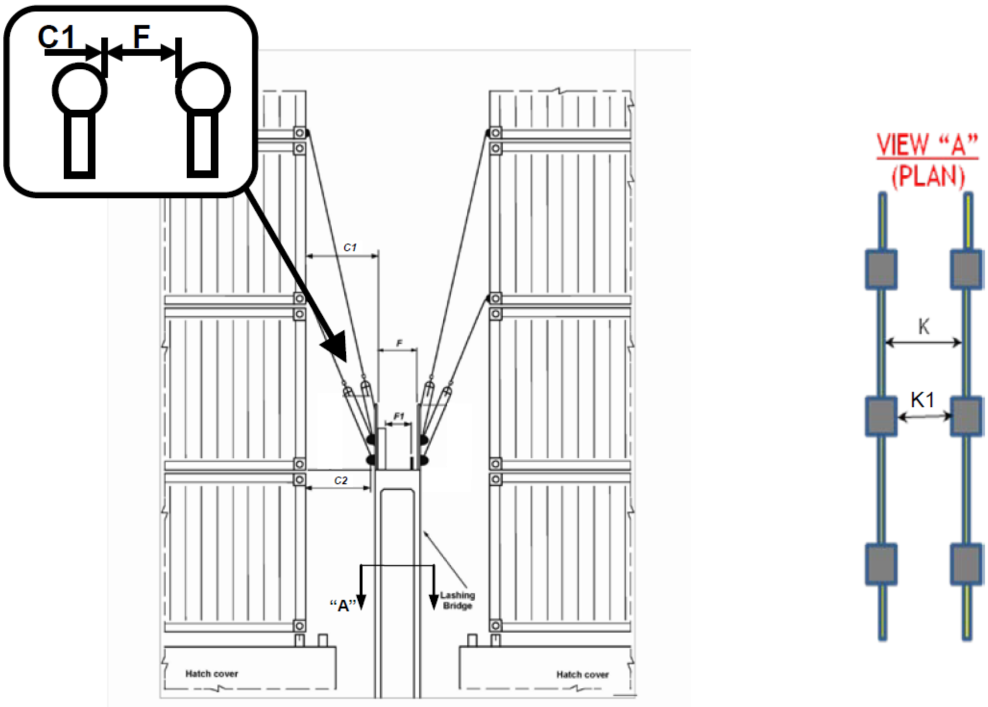


Figure 3

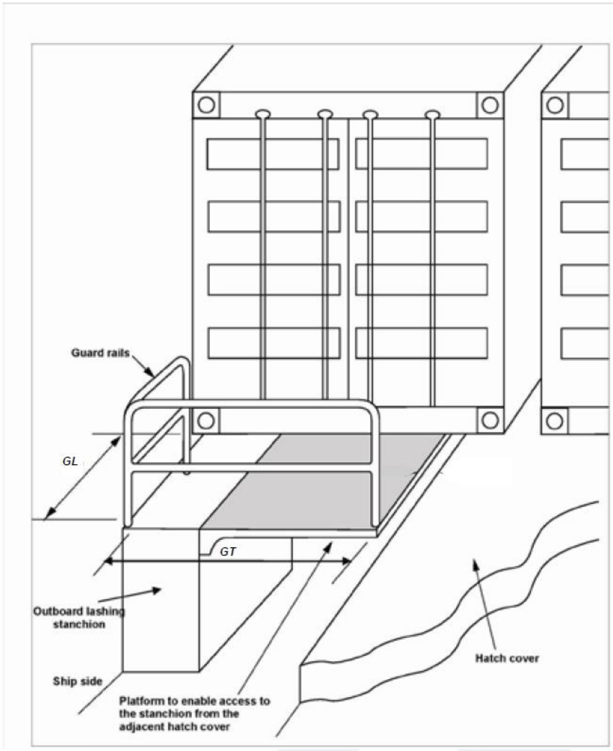
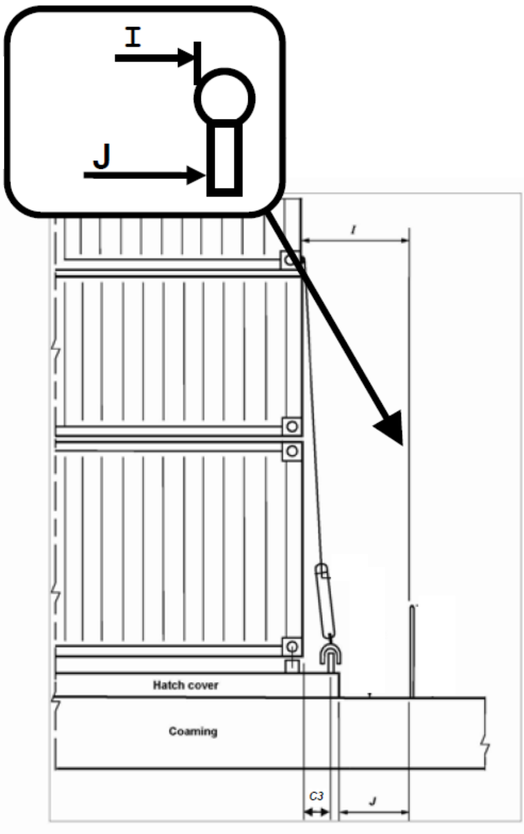


Figure 4



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Guidelines for Container Stowage
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[English]

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