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 conducted extensive research and investigations on the practices and standards regarding container stowage and securing methods, and has published “Guidelines for Container Stowage and Securing Arrangements” in October 2009. In the guidelines, the latest ISO standards relating to containers are reflected and diversified container stowage and securing methods as well as detailed evaluation methods are shown and explained.

In the second edition of the guidelines, the evaluation methods have been amended in order to enable the effect of sea routes, which the container ships operate in, to be taken into consideration. Also, procedures related to affixing class notations for the following two types of ships have been added:

- Those with lashing calculation program, which is capable of evaluating container lashing strength in accordance with these guidelines, installed onboard ship; and

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.
Guidelines for Container Stowage and Securing Arrangements

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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>
<thead>
<tr>
<th>Grouping</th>
<th>Cargo</th>
<th>General cargo ships</th>
<th>Special ships</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Packing type, Category</td>
<td>Securing type</td>
<td>Ship type</td>
</tr>
<tr>
<td>Blocks</td>
<td>Ropes, nets, blocks</td>
<td>Container ships</td>
<td>Cargo is loaded into containers, and containers are then secured by using dedicated devices such as stackers, twistlocks, lashing rods and turnbuckles.</td>
</tr>
<tr>
<td>Drums</td>
<td>Same as above</td>
<td>Car carriers</td>
<td>Secured by dedicated securing devices such as textile belts and D-rings.</td>
</tr>
<tr>
<td>Steels</td>
<td>Same as above</td>
<td>Car ferries</td>
<td></td>
</tr>
<tr>
<td>Bags</td>
<td>Nets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Containers</td>
<td>Ropes, blocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cars</td>
<td>Same as above</td>
<td>Heavy cargo carriers</td>
<td>Secured by dedicated wires</td>
</tr>
<tr>
<td>Heavy cargo</td>
<td>Ropes, chains, blocks</td>
<td>Lumber carriers</td>
<td>Secured by dedicated wires</td>
</tr>
<tr>
<td>Logs</td>
<td>Ropes, chains, stanchions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ores</td>
<td>No need to be secured; however, cargo trimming is needed.</td>
<td>Ore carriers</td>
<td>No need to be secured</td>
</tr>
<tr>
<td>Coals</td>
<td>Same as above</td>
<td>Bulk carriers</td>
<td>No need to be secured. However, cargo is to be trimmed as necessary.</td>
</tr>
<tr>
<td>Grains</td>
<td>Same as above</td>
<td>Same as above</td>
<td></td>
</tr>
<tr>
<td>Liquid cargo</td>
<td>No need to be secured</td>
<td>Tankers</td>
<td>No need to be secured</td>
</tr>
</tbody>
</table>
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 (32.3m 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 10,000TEU containers. In general, an over-Panamax ship with a breadth of around 45m is capable of stowing up to 18 rows of containers on exposed decks and up to 16 rows in cargo holds. In addition, in recent years, many major ports started using large cranes capable of stowing 22 rows of containers on ships.

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.
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.
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.

-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.
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.
<table>
<thead>
<tr>
<th>Terms</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Cargo Container</td>
<td>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</td>
</tr>
<tr>
<td>General Purpose Container</td>
<td>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)</td>
</tr>
<tr>
<td>Specific-purpose Container</td>
<td>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</td>
</tr>
<tr>
<td>Open-top container</td>
<td>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</td>
</tr>
<tr>
<td>Platform Container</td>
<td>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</td>
</tr>
<tr>
<td>Platform-based Container with Incomplete Superstructure and Fixed Ends</td>
<td>Platform-based container without any permanently fixed longitudinal load-carrying structure between ends other than at the base.</td>
</tr>
<tr>
<td>Thermal Container</td>
<td>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</td>
</tr>
<tr>
<td>Refrigerated Container</td>
<td>(1) Mechanically Refrigerated Container                                                                                               Thermal container fitted with a refrigeration unit and a heat-producing appliance</td>
</tr>
<tr>
<td></td>
<td>(2) Refrigerated and Heated Container                                                                                               Thermal container fitted with a refrigerating appliance (mechanical or expendable refrigerant) and heat-producing appliance</td>
</tr>
<tr>
<td>Tank Container</td>
<td>Freight container which includes two basic elements, the tank or tanks and the framework</td>
</tr>
</tbody>
</table>
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](image)

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.
### Table 1.3  Overview of Container Securing Devices

<table>
<thead>
<tr>
<th>Description</th>
<th>Overview of Securing Device</th>
<th>Schematic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lashing Rod</td>
<td>Lashing rods secure onto the end walls of containers and are used with securing turnbuckles.</td>
<td><img src="image1.png" alt="Schematic" /></td>
</tr>
<tr>
<td>Turnbuckle</td>
<td>Turnbuckles remove slack from securing devices such as lashing rods and apply tension for securing.</td>
<td><img src="image2.png" alt="Schematic" /></td>
</tr>
<tr>
<td>Twistlock</td>
<td>Twistlocks fix the 4 corners between upper and lower containers and prevents containers from moving vertically and horizontally.</td>
<td><img src="image3.png" alt="Schematic" /></td>
</tr>
<tr>
<td>Eye Plate</td>
<td>Eye plates are fitted on the hull side of lashing devices and are installed on lashing bridges and hatch covers.</td>
<td><img src="image4.png" alt="Schematic" /></td>
</tr>
<tr>
<td>Lashing Bridge</td>
<td>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.</td>
<td><img src="image5.png" alt="Schematic" /></td>
</tr>
<tr>
<td>Hatch Cover</td>
<td>Hatch covers act as platforms for receiving container loads, and securing devices such as container sockets and eye plates are installed on hatch covers.</td>
<td><img src="image6.png" alt="Schematic" /></td>
</tr>
<tr>
<td>Deck Socket</td>
<td>Deck sockets are installed on exposed decks and hatch covers and secure bottom containers stowed on exposed decks by using twistlocks.</td>
<td><img src="image7.png" alt="Schematic" /></td>
</tr>
</tbody>
</table>
Fig. 1.8  Cross Lashing (Single)

Fig. 1.9  Cross Lashing (Parallel)
-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.1.10  External Lashing
(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.

(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.

-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

<table>
<thead>
<tr>
<th>Description</th>
<th>Overview of Securing Device</th>
<th>Schematic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Guide</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Entry Guide</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Positioning Cone</td>
<td>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.</td>
<td><img src="image" alt="Positioning Cone" /></td>
</tr>
<tr>
<td>Container Guide</td>
<td>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.</td>
<td><img src="image" alt="Container Guide" /></td>
</tr>
<tr>
<td>Stacker</td>
<td>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.</td>
<td><img src="image" alt="Stacker" /></td>
</tr>
</tbody>
</table>
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.
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)

<table>
<thead>
<tr>
<th>Freight container designation</th>
<th>Length, $L$</th>
<th>Width, $W$</th>
<th>Height, $H$</th>
<th>Max. container weight, $R$</th>
<th>Tolerance on diagonal line (See Fig.2.1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dim.</td>
<td>tol.</td>
<td>dim.</td>
<td>tol.</td>
<td>dim.</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>1EEE</td>
<td>13,716</td>
<td>0</td>
<td>2,438</td>
<td>0</td>
<td>2,896</td>
</tr>
<tr>
<td>1EE</td>
<td>12,192</td>
<td>0</td>
<td>2,438</td>
<td>0</td>
<td>2,896</td>
</tr>
<tr>
<td>1AAA</td>
<td>9,125</td>
<td>0</td>
<td>2,438</td>
<td>0</td>
<td>2,591</td>
</tr>
<tr>
<td>1AA</td>
<td>6,058</td>
<td>0</td>
<td>2,438</td>
<td>0</td>
<td>2,591</td>
</tr>
<tr>
<td>1A</td>
<td>2,991</td>
<td>0</td>
<td>2,438</td>
<td>0</td>
<td>2,438</td>
</tr>
<tr>
<td>1AX</td>
<td>&lt;2,438</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1BBB</td>
<td>9,125</td>
<td>0</td>
<td>2,438</td>
<td>0</td>
<td>2,591</td>
</tr>
<tr>
<td>1BB</td>
<td>6,058</td>
<td>0</td>
<td>2,438</td>
<td>0</td>
<td>2,591</td>
</tr>
<tr>
<td>1BX</td>
<td>&lt;2,438</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1C</td>
<td>2,991</td>
<td>0</td>
<td>2,438</td>
<td>0</td>
<td>2,438</td>
</tr>
<tr>
<td>1DX</td>
<td>&lt;2,438</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Notes)
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’ Containers
   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)
Guidelines for Container Stowage and Securing Arrangements

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 3,392 kN. 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.

\[
24 \times 8 \times 1.8 \times 9 = 3,392 kN
\]

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 3,767 kN. 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 –)

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

(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 –)

<table>
<thead>
<tr>
<th>1</th>
<th>Stacking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>942KN (848KN)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2</th>
<th>Top Lift</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3</th>
<th>Top Lift</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>End Elevations</td>
<td>Side Elevations</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>4 Bottom Lift</td>
<td></td>
</tr>
</tbody>
</table>

![Diagram](image)

<table>
<thead>
<tr>
<th>5 Restraint (Longitudinal)</th>
<th></th>
</tr>
</thead>
</table>

![Diagram](image)

<table>
<thead>
<tr>
<th>6 Restraint (Longitudinal)</th>
<th></th>
</tr>
</thead>
</table>

![Diagram](image)

<table>
<thead>
<tr>
<th>7 Rigidity (Transverse)</th>
<th></th>
</tr>
</thead>
</table>

![Diagram](image)

<table>
<thead>
<tr>
<th>8 Rigidity (Transverse)</th>
<th></th>
</tr>
</thead>
</table>

![Diagram](image)

<table>
<thead>
<tr>
<th>9 Rigidity (Longitudinal)</th>
<th></th>
</tr>
</thead>
</table>

![Diagram](image)

<table>
<thead>
<tr>
<th>10 Rigidity (Longitudinal)</th>
<th></th>
</tr>
</thead>
</table>

![Diagram](image)

(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.
-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

<table>
<thead>
<tr>
<th>No</th>
<th>Description</th>
<th>Load Direction</th>
<th>Working Load (kN)</th>
<th>Breaking Load (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deck Socket (Pedestal Type)</td>
<td><img src="image1.png" alt="Diagram" /></td>
<td>250</td>
<td>500</td>
</tr>
<tr>
<td>2</td>
<td>Deck Socket (Flush Type)</td>
<td><img src="image2.png" alt="Diagram" /></td>
<td>250</td>
<td>500</td>
</tr>
<tr>
<td>3</td>
<td>Sliding Base</td>
<td><img src="image3.png" alt="Diagram" /></td>
<td>245</td>
<td>490</td>
</tr>
<tr>
<td>4</td>
<td>Eye Plate (Fixed Type)</td>
<td><img src="image4.png" alt="Diagram" /></td>
<td>245</td>
<td>490</td>
</tr>
<tr>
<td>5</td>
<td>Eye Plate (Collapsible Type)</td>
<td><img src="image5.png" alt="Diagram" /></td>
<td>100</td>
<td>400</td>
</tr>
<tr>
<td>6</td>
<td>Positioning Cone</td>
<td><img src="image6.png" alt="Diagram" /></td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>7</td>
<td>Container Guide</td>
<td><img src="image7.png" alt="Diagram" /></td>
<td>420</td>
<td>840</td>
</tr>
</tbody>
</table>
## Table 2.5  Typical Loose Securing Devices

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Load Direction</th>
<th>Working Load (kN)</th>
<th>Breaking Load (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Manual Twistlock</td>
<td></td>
<td>250</td>
<td>500</td>
</tr>
<tr>
<td>2</td>
<td>Semi-automatic Twistlock</td>
<td></td>
<td>250</td>
<td>500</td>
</tr>
<tr>
<td>3</td>
<td>Sliding Twistlock</td>
<td></td>
<td>245</td>
<td>490</td>
</tr>
<tr>
<td>4</td>
<td>Twistlock</td>
<td></td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>5</td>
<td>Lashing Rod (Short Type)</td>
<td></td>
<td>225</td>
<td>450</td>
</tr>
<tr>
<td>6</td>
<td>Lashing Rod (Long Type)</td>
<td></td>
<td>178</td>
<td>352</td>
</tr>
<tr>
<td>7</td>
<td>Turnbuckle</td>
<td></td>
<td>225</td>
<td>450</td>
</tr>
<tr>
<td>8</td>
<td>Adjusting Hook</td>
<td></td>
<td>225</td>
<td>450</td>
</tr>
<tr>
<td>9</td>
<td>Vertical Stacker (Single type)</td>
<td></td>
<td>150</td>
<td>300</td>
</tr>
<tr>
<td>10</td>
<td>Twist Stacker (Drop off type)</td>
<td></td>
<td>150</td>
<td>300</td>
</tr>
</tbody>
</table>
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.
In cases where the limiting value of the stacking load is 80t.
Stack A is “OK” but stack B is “Not OK”.

Fig. 3.1 Stacking Load on Deck

In cases where the loads due to ship rolling shown in the figure may act as a moment on the panel face at Point A.

Fig. 3.2 Moment Acting on Hatch Covers
3.3 Precautions for Container Stowage in Hold

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.
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 CONTAINER 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) $m$
$B$ : Breadth of ship $m$
$D$ : Depth for strength computation $m$
$d_f$ : Design draught of ship $m$
$d_i$ : Draught amidships for relevant loading condition $m$
$C_b$ : Block coefficient corresponding to design draught and $L_{pp}$ -
$V$ : 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 $m$
$T_{Pitch}$ : Natural period of pitch motion $sec.$
$T_{Roll}$ : Natural period of roll motion $sec.$
$\theta$ : Pitch angle $rad$
$\phi$ : 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 $m/s^2$
$S_{\theta}$ : Sea route correction factor (pitch angle) -
$S_{\phi}$ : Sea route correction factor (roll angle) -
$S_P$ : Sea route correction factor (pitch acceleration) -
$S_R$ : Sea route correction factor (roll acceleration) -
$S_H$ : Sea route correction factor (heave acceleration) -
$F_l$ : 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 effects from parametric rolling are not considered in this chapter, since parametric rolling is expected to be avoided by the captain’s appropriate judgments and good seamanship.

5.2 Ship Motions and Ship Accelerations

-1. The calculation of the dynamic loads acting on each container is important for calculating the
loads used for the strength evaluations of container stowage and securing arrangements. Dynamic loads acting on each container are calculated based on conditions at which ship motions and ship accelerations corresponding to pitch, roll, and heave directions are at their maximum.

2. Table 5.1 shows the formulae of ship motions and ship accelerations.

<table>
<thead>
<tr>
<th>Natural periods (sec)</th>
<th>Angle (rad)</th>
<th>Ship accelerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch $T_{Pitch} = \frac{\pi L_{pp}}{g} \left(1 + \frac{d_f}{d_f'}\right)$</td>
<td>$\theta = 3.66C \frac{(V+5)^{\alpha_2}}{L_{pp}^{1.2} \sqrt{C_b}}$</td>
<td>$a_{pitch} = \theta \left(\frac{2\pi}{T_{Pitch}}\right)^2$ (rad/s²)</td>
</tr>
<tr>
<td>Roll $T_{Roll} = 1.1 \frac{2K_{xx}}{\sqrt{GM}}$</td>
<td>$\phi = \frac{2.81C}{T_E \sqrt{B}} \frac{L_0}{L_{pp}} \left(1 + \frac{gT_E^2}{2\pi L_{pp} L_{pp}} \frac{125}{2d_f L_{pp}}\right)$</td>
<td>$a_{roll} = \phi \left(\frac{2\pi}{T_{Roll}}\right)^2$ (rad/s²)</td>
</tr>
<tr>
<td>Heave</td>
<td>$a_{heave} = 3.07C \frac{g(V+5)^{\alpha_2}}{B \cdot L_{pp}^{0.5} \sqrt{C_b}} \left(\frac{0.2 + \frac{L_0}{L_{pp}}}{1 + 0.15 \frac{d_f}{d_f'} \frac{125}{L_{pp}}}\right)$ (m/s²)</td>
<td></td>
</tr>
</tbody>
</table>

$L_0$: Length of ship taken as the distance on the designed maximum load line from the fore side of the stem to the center of the rudder stock (m). If the length $L_0$ is less than 110 m, $L_0$ is taken as 110 m.

$C$: Coefficient related to assumed wave height, and its value is according to following equations:

- $C = 10.75 - \left(\frac{300 - L_{pp}}{100}\right)^{1.5}$ if $L_{pp} \leq 300$ m
- $C = 10.75$ if $300$ m < $L_{pp} \leq 350$ m
- $C = 10.75 - \left(\frac{L_{pp} - 350}{150}\right)^{1.5}$ if $350$ m < $L_{pp}$

$K_{xx}$: Roll radius of gyration (m), and if $K_{xx}$ is not available, $K_{xx}$ is taken as 0.35B.

$T_E$: According to the following equations depending on the value of $T_{Roll}$:

In cases where $T_{Roll} > \frac{2\pi V}{g}$: $T_E = 0.5 \left(\frac{2\pi V}{g} + \sqrt{T_{Roll}^2 - \frac{2\pi V^2}{g} T_{Roll}}\right)$

In cases where $T_{Roll} \leq \frac{2\pi V}{g}$: $T_E = T_{Roll}$
5.3 Correction of Ship Motions and Ship Accelerations According to Sea Route

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. Fig.5.1 shows the specific sea routes, and Table 5.2 shows the sea route correction factors corresponding to the operation in each specific sea route. The sea route correction factors for each specific sea route are derived based on the ratio of ship motions and ship accelerations determined by long-term prediction using wave data for the North Atlantic Ocean as described in 5.2 and for each representative specific sea route. The formulae are derived assuming that a ship operates for about 25 years in the North Atlantic Ocean and each specific sea route respectively.
- 2. Sea route correction factors for sea routes not shown in Table 5.2 are at the Society’s discretion.

5.3.3 Correction of Ship Motions and Ship Accelerations According to Sea Route
When a ship is planned to operate in the specific routes shown in Fig.5.1, ship motions and ship accelerations in Table 5.1 may be corrected as follows using the sea route correction factors shown in Table 5.2.

- Pitch Angle: $S_\theta \times \theta$
- Roll Angle: $S_\phi \times \phi$
- Pitch Acceleration: $S_p \times a_{pitch}$
- Roll Acceleration: $S_R \times a_{roll}$
- Heave Acceleration: $S_H \times a_{heave}$

![Figure 5.1 Representative Specific Sea Routes](image-url)
### Table 5.2 Correction Factors for Representative Specific Sea Routes

<table>
<thead>
<tr>
<th>Representative Specific Sea Route</th>
<th>East Asia - Europe</th>
<th>North America - Europe</th>
<th>East Asia - Australia</th>
<th>Japan - Hong Kong</th>
<th>East Asia - North America</th>
<th>South America - Europe</th>
<th>South Africa - Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_\theta$</td>
<td>$0.944 - 3L_{pp} \cdot 10^{-4}$</td>
<td>1.00</td>
<td>$0.929 - 6L_{pp} \cdot 10^{-4}$</td>
<td>$0.985 - 8L_{pp} \cdot 10^{-4}$</td>
<td>$1.020 - 2L_{pp} \cdot 10^{-4}$</td>
<td>$0.964 - L_{pp} \cdot 10^{-4}$</td>
<td>$0.954 - L_{pp} \cdot 10^{-4}$</td>
</tr>
<tr>
<td>$S_\phi$</td>
<td>$0.956 - 2B \cdot 10^{-3}$</td>
<td>1.00</td>
<td>$(1.05 - 0.11f_T) - 4B \cdot 10^{-3}$</td>
<td>$(1.12 - 0.16f_T) - 4B \cdot 10^{-3}$</td>
<td>$1.018 - 13B \cdot 10^{-4}$</td>
<td>$0.967 - 8B \cdot 10^{-4}$</td>
<td>$0.958 - 9B \cdot 10^{-4}$</td>
</tr>
<tr>
<td>$S_p$</td>
<td>$1.022 - 5L_{pp} \cdot 10^{-4}$</td>
<td>1.00</td>
<td>$1.020 - 7L_{pp} \cdot 10^{-4}$</td>
<td>$1.075 - 8L_{pp} \cdot 10^{-4}$</td>
<td>$1.036 - 2L_{pp} \cdot 10^{-4}$</td>
<td>$0.992 - 2L_{pp} \cdot 10^{-4}$</td>
<td>$0.977 - L_{pp} \cdot 10^{-4}$</td>
</tr>
<tr>
<td>$S_R$</td>
<td>$0.940 - 6B \cdot 10^{-4}$</td>
<td>1.00</td>
<td>$(1.14 - 0.23f_T) - (8.25 - 6.75f_T)B \cdot 10^{-3}$</td>
<td>$(1.21 - 0.27f_T) - (8.80 - 7.30f_T)B \cdot 10^{-3}$</td>
<td>$1.010 - 6B \cdot 10^{-4}$</td>
<td>$0.962 - 3B \cdot 10^{-4}$</td>
<td>$0.950 - 3B \cdot 10^{-4}$</td>
</tr>
<tr>
<td>$S_H$</td>
<td>$(1.05 - 0.05f_T) - 3L_{pp} \cdot 10^{-4}$</td>
<td>1.00</td>
<td>$(1.01 - 0.05f_T) - 3L_{pp} \cdot 10^{-4}$</td>
<td>$(1.02 - 0.01f_T) - 3L_{pp} \cdot 10^{-4}$</td>
<td>$1.020 - L_{pp} \cdot 10^{-4}$</td>
<td>$0.985 - L_{pp} \cdot 10^{-4}$</td>
<td>$0.976 - 2L_{pp} \cdot 10^{-4}$</td>
</tr>
</tbody>
</table>

(Note) $f_T$: Ratio Between draught amidships for relevant loading condition and design draught, taken as $d_i/d_f$. 

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5.4 Loads Acting on Each Container

-1. Loads acting on containers are calculated from the combination of ship motions including pitch, roll, heave, etc. based on the ship motions and ship accelerations. Considering the simultaneity of ship motions, since pitch and roll cannot be simultaneously at their maximums, the following two conditions are taken as design conditions in the Guideline:
   
   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.

![Diagram](image_url)

Fig.5.2  Design Condition i and Design Condition ii
Table 5.3 Loads Acting on Each Container

<table>
<thead>
<tr>
<th>Design Condition i (kN)</th>
<th>Design Condition ii (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_v = M \left[ g \cos \theta + a_{\text{heave}} + x_i - x_{pc} \right] a_{pitch} )</td>
<td>( F_v = M \left[ g \cos \phi + 0.1 a_{\text{heave}} + y_i \right] a_{roll} )</td>
</tr>
<tr>
<td>( F_i = M \left[ g \sin \theta + (z_i - z_{rc}) a_{pitch} \right] )</td>
<td>( F_i = C_y M \left[ g \sin \phi + (z_i - z_{rc}) a_{roll} \right] )</td>
</tr>
<tr>
<td>( F_v = M \left[ g \cos \theta - a_{\text{heave}} - x_i - x_{pc} \right] a_{pitch} )</td>
<td>( F_v = M \left[ g \cos \phi - 0.1 a_{\text{heave}} - y_i \right] a_{roll} )</td>
</tr>
<tr>
<td>( F_i = M \left[ g \sin \theta + (z_i - z_{rc}) a_{pitch} \right] )</td>
<td>( F_i = C_y M \left[ g \sin \phi + (z_i - z_{rc}) a_{roll} \right] )</td>
</tr>
<tr>
<td>( F_v = M \left[ g \cos \theta - a_{\text{heave}} - x_i - x_{pc} \right] a_{pitch} )</td>
<td>( F_v = M \left[ g \cos \phi - 0.1 a_{\text{heave}} - y_i \right] a_{roll} )</td>
</tr>
<tr>
<td>( F_i = M \left[ g \sin \theta + (z_i - z_{rc}) a_{pitch} \right] )</td>
<td>( F_i = C_y M \left[ g \sin \phi + (z_i - z_{rc}) a_{roll} \right] )</td>
</tr>
</tbody>
</table>

(Notes)

- \( x_{pc} \): Longitudinal Distance from AP to the center of rotation of the pitch motion of the ship (center of flotation), and its value is 0.45\( L_{pp} \) (m).
- \( x_i \): Longitudinal Distance from AP to the considered center of gravity of the container (m)
- \( y_i \): Transverse distance from the centerline of the hull to the considered center of gravity (m)
- \( z_{rc} \): Vertical distance from the ship bottom to the center of rotation of the roll motion of the ship, and its value is 0.5(\( D/2+d \)) or \( D/2 \), whichever is greater (m)
- \( z_i \): Vertical distance from the ship bottom to the considered center of gravity of the container (m)
- \( C_y \): Coefficient that takes into consideration the increase in acceleration of the bow according to yaw motion, which is taken as follows:
  - \( C_y = 1 + \left( x_i - 0.75L_{pp} \right) / L_{pp} \) when \( x_i \geq 0.75L_{pp} \)
  - \( C_y = 1 \) when \( x_i < 0.75L_{pp} \)
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, taken as greater than 36 m/sec, in principle.

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

<table>
<thead>
<tr>
<th>Exposed wall surfaces</th>
<th>$C_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windward side (Positive pressure)</td>
<td>1.0</td>
</tr>
<tr>
<td>Leeward side (Negative pressure)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

(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:

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

$A$: 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  \( i \)th tier  \( kN \)
\[ F_{tbi} \]: Transverse load acting on bottom corner of the end walls of container in  \( i \)th tier  \( kN \)
\[ F_{vi} \]: Vertical load acting on one corner post of container in  \( i \)th tier  \( kN \)
\[ h_i \]: Ratio of the height of the center of gravity of container in  \( i \)th 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  \( i \)th tier  \( kN \)
\[ W \]: Breadth of containers  \( m \)
\[ H_i \]: Height of container in  \( i \)th tier  \( m \)
\[ Z_i \]: Height from bottom of container stack to top of container in  \( i \)th tier  \( m \)
\[ k_C \]: Stiffness constant for containers against racking  \( kN/mm \)
\[ k_L \]: Stiffness constant for lashing rods  \( kN/mm \)
\[ T_{sti} \]: Tension acting on lashing rod that lashes top corner of container in  \( i \)th tier (cross lashing)  \( kN \)
\[ T_{xbi} \]: Tension acting on lashing rod that lashes bottom corner of container in  \( i \)th tier (cross lashing)  \( kN \)
\[ T_{eti} \]: Tension acting on lashing rod that lashes top corner of container in  \( i \)th tier (external lashing)  \( kN \)
\[ T_{ebi} \]: Tension acting on lashing rod that lashes bottom corner of container in  \( i \)th tier (external lashing)  \( kN \)
\[ \theta_{sti} \]: Angle of lashing rod that lashes top corner of container in  \( i \)th tier (cross lashing)  \( rad \)
\[ \theta_{xbi} \]: Angle of lashing rod that lashes bottom corner of container in  \( i \)th tier (cross lashing)  \( rad \)
\[ \theta_{eti} \]: Angle of lashing rod that lashes top corner of container in  \( i \)th tier (external lashing)  \( rad \)
\[ \theta_{ebi} \]: Angle of lashing rod that lashes bottom corner of container in  \( i \)th 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. 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

-4. Special consideration needs to be given when containers are stowed or secured by methods different from those mentioned above.

-5. 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>
<thead>
<tr>
<th>Stiffness Constant $k_C$ against Container Racking ($kN/mm$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container End Wall (Door Ends)</td>
</tr>
<tr>
<td>Container End Wall (Closed Ends)</td>
</tr>
<tr>
<td>3.7</td>
</tr>
<tr>
<td>15.7</td>
</tr>
</tbody>
</table>

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 $102 kN/mm^2$ may be used.

### 6.3 Allowable Loads Used in Strength Evaluation

1. **Allowable Loads for Containers**
The allowable loads on each part of a container based on 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>
<thead>
<tr>
<th>Allowable load (kN)</th>
<th>Allowable load (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Racking load acting on containers</td>
<td>ISO1496-1:1990</td>
</tr>
<tr>
<td>Transverse direction</td>
<td>150</td>
</tr>
<tr>
<td>Longitudinal direction</td>
<td>150</td>
</tr>
<tr>
<td>Compressive load acting on one corner post of containers</td>
<td>848</td>
</tr>
<tr>
<td>Lifting load acting on one corner post of containers</td>
<td>250</td>
</tr>
<tr>
<td>Lashing load acting on container corner fittings</td>
<td>Vertical direction</td>
</tr>
<tr>
<td>Horizontal direction</td>
<td>150</td>
</tr>
</tbody>
</table>

-2. Allowable Loads of Securing Devices
The allowable loads of securing devices such as lashing rods are, in principle, the safe working loads (S.W.L) stated on the certificates of securing devices. For the typical safe working loads of standard devices, refer to Table 2.4 and Table 2.5 of “Chapter 2 STRENGTH OF CONTAINERS AND SECURING DEVICES”.

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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 loads act 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.

6.4.2 Distribution of Loads Acting on Each Container Stowed on Deck
- 1. Transverse loads $F_{ti}$ acting on top corner and $F_{bi}$ acting on bottom corner of the end wall are calculated according to the procedure in (1) to (4) using transverse load $F_l$ 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:
  
  $$F_{ti} = \frac{F_l}{2} \quad (kN)$$

  (2) In case of an outermost container stack, wind load $P$ acting on the side wall of a container in $i$th tier is equally distributed to the door end and closed end of the container as follows:
  
  $$P_i = \frac{P}{2}$$

  (3) In case of an outermost container stack, the wind load $P_i$ acting on one side of the end walls of container in $i$th tier calculated in (2) is equally distributed to the upper side and lower side of the container as follows:
  
  $$P_i = \frac{P}{2} \quad (kN)$$

  (4) Transverse load $F_{ti}$ distributed to the end walls of the container is further distributed to transverse loads $F_{ti}$ acting on top corner and $F_{bi}$ 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 \(i\)th tier: \(F_{iti} = h_i F_{it} + \frac{P_i}{2}\)

Transverse load acting on the bottom corner on one side of the end walls of container in \(i\)th tier: \(F_{itb} = (1 - h_i) F_{it} + \frac{P_i}{2}\)

Vertical load \(F_{vi}\) acting on the bottom of four corner posts of container in \(i\)th 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 \(i\)th tier: \(F_{vi} = \frac{F_v}{4}\)
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:
Guidelines for Container Stowage and Securing Arrangements

Racking load: \[ \sum_{i=j}^{n} F_{\text{iti}} + \sum_{i=j+1}^{n} F_{\text{ibj}} \]

(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: \[ 0.5 \sum_{i=j}^{n} (F_{\text{iti}} + F_{\text{ibj}}) \]

(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: \[ \sum_{i=j}^{n} F_{\text{vi}} + \sum_{i=j}^{n} \left( F_{\text{iti}} \frac{Z_i - Z_{j-1}}{W} \right) + \sum_{i=j}^{n-1} \left( F_{\text{ib}(i+1)} \frac{Z_i - Z_{j-1}}{W} \right) \]

(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: \[ \sum_{i=j}^{n} F_{\text{vi}} + \sum_{i=j}^{n} \left( F_{\text{iti}} \frac{Z_i - Z_{j-1}}{W} \right) + \sum_{i=j}^{n-1} \left( F_{\text{ib}(i+1)} \frac{Z_i - Z_{j-1}}{W} \right) \]

(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: \[ - \sum_{i=j}^{n} F_{\text{vi}} + \sum_{i=j}^{n} \left( F_{\text{iti}} \frac{Z_i - Z_{j-1}}{W} \right) + \sum_{i=j}^{n-1} \left( F_{\text{ib}(i+1)} \frac{Z_i - Z_{j-1}}{W} \right) \]

(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: \[ - \sum_{i=j}^{n} F_{\text{vi}} + \sum_{i=j}^{n} \left( F_{\text{iti}} \frac{Z_i - Z_{j-1}}{W} \right) + \sum_{i=j}^{n-1} \left( F_{\text{ib}(i+1)} \frac{Z_i - Z_{j-1}}{W} \right) \]

6.4.3.2 Strength Evaluation of Lashed Container Stacks

-1. In cases where containers are stowed and lashed on deck, the loads in (1) to (9) 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. However; if loads other than those calculated in (1) to (9) are considered to affect the strength of container stowage and lashing, loads calculated as strength evaluation criteria are to be separately examined.

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

-2. When containers are lashed, transverse loads \( F_{\text{iti}} \) and \( F_{\text{ibj}} \) acting at lashing points on the
container in \(i\)th tier in 6.4.2 are affected by tension \(T_{xti}, T_{xbi}, T_{eti}\) and \(T_{ebi}\) acting on lashing rods. Thus, transverse component of tension \(T_{xti}, T_{xbi}, T_{eti}\) and \(T_{ebi}\) acting on lashing rods are taken into consideration with regard to \(F_{tti}\) and \(F_{tbi}\) at lashing points as shown below (see Fig.6.3). \(F_{tti}'\) and \(F_{tbi}'\) for all tiers are calculated, while the value of respective tension is taken as 0 at locations where tension acting on lashing rods has no effect.

\[
F_{tti}' = F_{tti} - T_{xti} \cos \theta_{xti} - T_{eti} \cos \theta_{eti}
\]

\[
F_{tbi}' = F_{tbi} - T_{xbi} \cos \theta_{xbi} - T_{ebi} \cos \theta_{ebi}
\]

![Fig.6.3 Transverse loads \(F_{tti}'\) and \(F_{tbi}'\) acting on one side of end walls of container in \(i\)th tier considering lashing effect](image)

- 3. Tension \(T_{xti}, T_{xbi}, T_{eti}\) and \(T_{ebi}\) acting on lashing rod in -2 are derived by simultaneously solving the equations that express displacement \(\delta_{i}\) of the end wall of each container and the equations that express the relationship between tension \(T_{xti}, T_{xbi}, T_{eti}\) and \(T_{ebi}\) and displacement \(\delta_{j}\) (see Fig.6.4). When lashing methods shown in 6.4.3.3 are used, the equations of tension acting on lashing rods may be in accordance with those in 6.4.3.3.

(1) Derivation of Equations that Express Displacement of End Wall of Each Container by Taking Stiffness of Containers into Consideration

Displacement \(\delta_{j}\) of the end wall of container in \(j\)th tier in \(n\)-tier container stack is as follows:

\[
\delta_{j} = \sum_{i=1}^{j} \frac{R_{j}}{k_{Cj}} \quad (mm)
\]

\(R_{j}\): Racking load acting on container in \(j\)th tier considering lashing effect, taken as follows:

\[
R_{j} = \sum_{i=j}^{n} F_{tti} + \sum_{i=j+1}^{n} F_{tbi}' \quad (kN)
\]

\(k_{Cj}\): Stiffness of container in \(j\)th tier against racking \((kN/mm)\)

(2) Derivation of Equations that Express the Relationship between Tension Acting on Lashing Rods and Displacement of End Wall of Each Container by Taking Stiffness of Lashing Rods into Consideration

When the stiffness constants of lashing rods receiving tension \(T_{xti}, T_{xbi}, T_{eti}\) and \(T_{ebi}\) are taken as \(k_{xti}, k_{xbi}, k_{eti}\) and \(k_{ebi}\) respectively, the equations expressing relationship between tension \(T_{xti}, T_{xbi}, T_{eti}\) and \(T_{ebi}\) acting on each lashing rod and displacement \(\delta_{j}\) of containers at the lashing points are as follows:

\[
\delta_{j} = \frac{T_{xti}}{k_{xti} \cos \theta_{xti}}
\]

![Diagram](image)
Guidelines for Container Stowage and Securing Arrangements

\[ \delta_i = \frac{T_{xb(i+1)}}{k_{xb(i+1)} \cos \theta_{xb(i+1)}} \]

\[ \delta_i = \frac{T_{eti}}{k_{eti} \cos \theta_{eti}} \]

\[ \delta_i = \frac{T_{eb(i+1)}}{k_{eb(i+1)} \cos \theta_{eb(i+1)}} \]

-4. The loads shown in -1(1) to (9) for n-tier container stack are calculated using the tension determined in -3 as in (1) to (9).

(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: \( 0.5 \sum_{i=j}^{n} (F_{iti} + F_{tbh}) \)

(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:

Fig.6.4 Example of Load-Displacement Diagram (3-Tier Container Stack)
Compressive load:
\[
\sum_{i=j+1}^{n} F_{vi} + \sum_{i=j}^{n} \left( F_{ti} \frac{Z_i - Z_{j-1}}{W} \right) + \sum_{i=j}^{n-1} \left( F_{tb(i+1)} \frac{Z_i - Z_{j-1}}{W} \right) + \sum_{i=j}^{n} T_{xli} \sin \theta_{xli} + \sum_{i=j+1}^{n} T_{xbi} \sin \theta_{xbi}
\]

(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:
\[
\sum_{i=j}^{n} F_{vi} + \sum_{i=j}^{n} \left( F_{ti} \frac{Z_i - Z_{j-1}}{W} \right) + \sum_{i=j}^{n-1} \left( F_{tb(i+1)} \frac{Z_i - Z_{j-1}}{W} \right) + \sum_{i=j}^{n} T_{xli} \sin \theta_{xli} + \sum_{i=j+1}^{n} T_{xbi} \sin \theta_{xbi}
\]

(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:
\[
-\sum_{i=j+1}^{n} F_{vi} + \sum_{i=j}^{n} \left( F_{ti} \frac{Z_i - Z_{j-1}}{W} \right) + \sum_{i=j}^{n-1} \left( F_{tb(i+1)} \frac{Z_i - Z_{j-1}}{W} \right) - \sum_{i=j}^{n} T_{eli} \sin \theta_{eli} - \sum_{i=j+1}^{n} T_{ebi} \sin \theta_{ebi}
\]

(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:
\[
-\sum_{i=j}^{n} F_{vi} + \sum_{i=j}^{n} \left( F_{ti} \frac{Z_i - Z_{j-1}}{W} \right) + \sum_{i=j}^{n-1} \left( F_{tb(i+1)} \frac{Z_i - Z_{j-1}}{W} \right) - \sum_{i=j}^{n} T_{eli} \sin \theta_{eli} + \sum_{i=j+1}^{n} T_{ebi} \sin \theta_{ebi}
\]

(7) 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: \( T_{xli}, T_{xbi}, T_{eti} \) and \( T_{ebi} \)

(8) 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:
\( T_{xli} \cos \theta_{xli}, T_{xbi} \cos \theta_{xbi}, T_{eti} \cos \theta_{eti} \) and \( T_{ebi} \cos \theta_{ebi} \)
(9) 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:

\[ T_{xtj} \sin \theta_{xtj}, \ T_{xbj} \sin \theta_{xbj}, \ T_{etj} \sin \theta_{etj} \text{ and } T_{ebj} \sin \theta_{ebj} \]

6.4.3.3 Tension in Lashing Rods
For reference, the tension in the lashing rods of various securing methods which are generally used is as given below. The tension equations are derived based on pre-condition that all containers have the same value of stiffness \( k_C \) against racking. A “short” lashing rod is used for lashing containers stowed above on the first tier; a “long” lashing rod is used for lashing containers stowed above on the second tier.

(1) Cross Lashing (Single)
   (a) Without Lashing Bridges

<table>
<thead>
<tr>
<th>Illustrated Position</th>
<th>Lashing Rod</th>
<th>Tension in Lashing Rod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outboard Stack</td>
<td>Short</td>
<td>( T_{sh2} = \frac{k_c + k_{ab2} \cos^2 \theta_{ab2}}{k_c + k_{ab2} \cos^2 \theta_{ab2} + k_{ab2} \cos \theta_{ab2}} )</td>
</tr>
<tr>
<td></td>
<td>Long</td>
<td>( T_{sl3} = \frac{k_c (Q_j + Q_1) + k_{ab2} \cos \theta_{ab2}}{k_c + k_{ab2} \cos^2 \theta_{ab2} + k_{ab2} \cos \theta_{ab2}} )</td>
</tr>
<tr>
<td>Inboard Stack</td>
<td>Short</td>
<td>( T_{sh2} = \frac{Q_j}{k_c + k_{ab2} \cos^2 \theta_{ab2}} )</td>
</tr>
</tbody>
</table>

\( Q_j \): Racking load acting on container in \( j \)th tier in \( n \)-tier container stack without considering lashing effect, taken as follows:

\[ Q_j = \sum_{i=j}^{n} F_{iti} + \sum_{i=j+1}^{n} F_{ithi} \ (kN) \]
(b) 1-Tier Lashing Bridges

<table>
<thead>
<tr>
<th>Illustrated Position</th>
<th>Lashing Rod</th>
<th>Tension in Lashing Rod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outboard Stack</td>
<td>Short</td>
<td>( T_{sh3} = \frac{k_i + k_{sh4}\cos^2\theta_{sh4}}{k_i + 2k_{sh4}\cos^2\theta_{sh4}} (Q_1 + Q_2) - \frac{k_{sh5}Q_1\cos^2\theta_{sh5}}{k_i + 2k_{sh5}\cos^2\theta_{sh5}} k_{sh4}\cos\theta_{sh4} )</td>
</tr>
<tr>
<td></td>
<td>Long</td>
<td>( T_{sh4} = \frac{k_i (Q_1 + Q_2 + Q_3) + 2k_{sh4}Q_1\cos^2\theta_{sh4}}{k_i + 2k_{sh4}\cos^2\theta_{sh4}} )</td>
</tr>
<tr>
<td>Inboard Stack</td>
<td>Short</td>
<td>( T_{sh3} = \frac{Q_1 + Q_2}{k_i + 2k_{sh3}\cos^2\theta_{sh3}} )</td>
</tr>
</tbody>
</table>

(c) 2-Tier Lashing Bridges

<table>
<thead>
<tr>
<th>Illustrated Position</th>
<th>Lashing Rod</th>
<th>Tension in Lashing Rod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outboard Stack</td>
<td>Short</td>
<td>( T_{sh4} = \frac{k_i + k_{sh4}\cos^2\theta_{sh4}}{k_i + 3k_{sh4}\cos^2\theta_{sh4}} (Q_1 + Q_2 + Q_3) - \frac{3k_{sh5}Q_1\cos^2\theta_{sh5}}{k_i + 3k_{sh5}\cos^2\theta_{sh5}} k_{sh4}\cos\theta_{sh4} )</td>
</tr>
<tr>
<td></td>
<td>Long</td>
<td>( T_{sh5} = \frac{k_i (Q_1 + Q_2 + Q_3) + 3k_{sh4}Q_1\cos^2\theta_{sh4}}{k_i + 3k_{sh4}\cos^2\theta_{sh4}} )</td>
</tr>
<tr>
<td>Inboard Stack</td>
<td>Short</td>
<td>( T_{sh4} = \frac{Q_1 + Q_3}{k_i + 3k_{sh4}\cos^2\theta_{sh4}} )</td>
</tr>
</tbody>
</table>
Guidelines for Container Stowage and Securing Arrangements

(2) Cross Lashing (Parallel)
(a) Without Lashing Bridges

<table>
<thead>
<tr>
<th>Illustrated Position</th>
<th>Lashing Rod</th>
<th>Tension in Lashing Rod</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outboard Stack</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$T_{a1} = \frac{(k_i + k_{a1} \cos^2 \theta_{a1}) Q_1 - k_{a1} Q_2 \cos \theta_{a1}}{(k_i + k_{a1} \cos^2 \theta_{a1} + k_{a2} \cos^2 \theta_{a2}) k_i \cos \theta_{a1} + k_{a2} \cos \theta_{a2}}$</td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>$T_{a2} = \frac{(k_i + k_{a1} \cos^2 \theta_{a1} + k_{a2} \cos^2 \theta_{a2}) Q_1 - k_{a1} Q_2 \cos \theta_{a1}}{(k_i + k_{a1} \cos^2 \theta_{a1} + k_{a2} \cos^2 \theta_{a2}) k_i \cos \theta_{a1} + k_{a2} \cos \theta_{a2}}$</td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td>$T_{a3} = \frac{k_i (Q_1 + Q_2) + (k_i + k_{a1} \cos^2 \theta_{a1} + k_{a2} \cos^2 \theta_{a2}) Q_1}{(k_i + k_{a1} \cos^2 \theta_{a1} + k_{a2} \cos^2 \theta_{a2}) k_i \cos \theta_{a1} + k_{a2} \cos \theta_{a2}}$</td>
<td></td>
</tr>
<tr>
<td><strong>Inboard Stack</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>$T_{a1} = \frac{Q_1 k_i \cos \theta_{a1}}{k_i + k_{a1} \cos^2 \theta_{a1} + k_{a2} \cos^2 \theta_{a2}}$</td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>$T_{a2} = \frac{Q_1 k_i \cos \theta_{a1}}{k_i + k_{a1} \cos^2 \theta_{a1} + k_{a2} \cos^2 \theta_{a2}}$</td>
<td></td>
</tr>
</tbody>
</table>

(b) 1-Tier Lashing Bridges

<table>
<thead>
<tr>
<th>Illustrated Position</th>
<th>Lashing Rod</th>
<th>Tension in Lashing Rod</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outboard Stack</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>$T_{a1} = \frac{(k_i + k_{a1} \cos^2 \theta_{a1}) (Q_1 + Q_2) - 2 k_{a1} Q_2 \cos \theta_{a1}}{(k_i + k_{a1} \cos^2 \theta_{a1} + 2 k_{a1} \cos \theta_{a1}) k_i \cos \theta_{a1} + 2 k_{a1} \cos \theta_{a1}}$</td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>$T_{a2} = \frac{(k_i + k_{a1} \cos^2 \theta_{a1} + 2 k_{a1} \cos \theta_{a1}) (Q_1 + Q_2) - 2 k_{a1} Q_2 \cos \theta_{a1}}{(k_i + k_{a1} \cos^2 \theta_{a1} + 2 k_{a1} \cos \theta_{a1}) k_i \cos \theta_{a1} + 2 k_{a1} \cos \theta_{a1}}$</td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td>$T_{a3} = \frac{k_i (Q_1 + Q_2) + 2 (k_i + k_{a1} \cos^2 \theta_{a1} + 2 k_{a1} \cos \theta_{a1}) Q_1}{(k_i + k_{a1} \cos^2 \theta_{a1} + 2 k_{a1} \cos \theta_{a1}) k_i \cos \theta_{a1} + 2 k_{a1} \cos \theta_{a1}}$</td>
<td></td>
</tr>
<tr>
<td><strong>Inboard Stack</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>$T_{a1} = \frac{Q_1 Q_2}{k_i + k_{a1} \cos^2 \theta_{a1} + 2 k_{a1} \cos \theta_{a1}}$</td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>$T_{a2} = \frac{Q_1 Q_2}{k_i + k_{a1} \cos^2 \theta_{a1} + 2 k_{a1} \cos \theta_{a1}}$</td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>$T_{a3} = \frac{Q_1 Q_2}{k_i + k_{a1} \cos^2 \theta_{a1} + 2 k_{a1} \cos \theta_{a1}}$</td>
<td></td>
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</tbody>
</table>
### 2-Tier Lashing Bridges

<table>
<thead>
<tr>
<th>Illustrated Position</th>
<th>Lashing Rod</th>
<th>Tension in Lashing Rod</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outboard Stack</strong></td>
<td>Short</td>
<td>$T_{s13} = \frac{k_y + k_{s20} \cos^2 \theta_{s32}}{k_y + k_{s20} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32}} Q_s + Q_3 - 3k_{s45} \cos^2 \theta_{s32} k_{s20} \cos \theta_{s23}$</td>
</tr>
<tr>
<td></td>
<td>Short</td>
<td>$T_{s44} = \frac{k_y + k_{s20} \cos^2 \theta_{s32}}{k_y + k_{s20} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32}} Q_s + Q_3 - 3k_{s45} \cos^2 \theta_{s32} k_{s20} \cos \theta_{s34}$</td>
</tr>
<tr>
<td></td>
<td>Long</td>
<td>$T_{s55} = \frac{k_y (Q_s + Q_3) + k_{s20} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32} k_{s20} \cos \theta_{s35}}{k_y (Q_s + Q_3) + k_{s20} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32} k_{s20} \cos \theta_{s35}} Q_s + Q_3$</td>
</tr>
<tr>
<td><strong>Inboard Stack</strong></td>
<td>Short</td>
<td>$T_{b13} = \frac{k_y + k_{s20} \cos^2 \theta_{s32}}{k_y + k_{s20} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32}} Q_s + Q_3 - 3k_{s45} \cos^2 \theta_{s32} k_{s20} \cos \theta_{s23}$</td>
</tr>
<tr>
<td></td>
<td>Short</td>
<td>$T_{b44} = \frac{k_y + k_{s20} \cos^2 \theta_{s32}}{k_y + k_{s20} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32}} Q_s + Q_3 - 3k_{s45} \cos^2 \theta_{s32} k_{s20} \cos \theta_{s34}$</td>
</tr>
</tbody>
</table>

### External Lashing

#### (a) Without Lashing Bridges

<table>
<thead>
<tr>
<th>Illustrated Position</th>
<th>Lashing Rod</th>
<th>Tension in Lashing Rod</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outboard Stack</strong></td>
<td>Short</td>
<td>$T_{o2} = \frac{k_y + k_{s20} \cos^2 \theta_{s32}}{k_y + k_{s20} \cos^2 \theta_{s32} + k_{s35} \cos^2 \theta_{s35}} Q_s + Q_3 - k_{s35} \cos^2 \theta_{s35} k_{s20} \cos \theta_{s22}$</td>
</tr>
<tr>
<td></td>
<td>Long</td>
<td>$T_{o3} = \frac{k_y (Q_s + Q_3) + k_{s20} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32} k_{s20} \cos \theta_{s32}}{k_y (Q_s + Q_3) + k_{s20} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32} + 3k_{s45} \cos^2 \theta_{s32} k_{s20} \cos \theta_{s32}} Q_s + Q_3$</td>
</tr>
<tr>
<td><strong>Inboard Stack</strong></td>
<td>Short</td>
<td>$T_{b2} = \frac{k_y + k_{s20} \cos^2 \theta_{s32}}{k_y + k_{s20} \cos^2 \theta_{s32} + k_{s35} \cos^2 \theta_{s35}} Q_s + Q_3 - k_{s35} \cos^2 \theta_{s35} k_{s20} \cos \theta_{s22}$</td>
</tr>
</tbody>
</table>
Guidelines for Container Stowage and Securing Arrangements

(b) 1-Tier Lashing Bridges

<table>
<thead>
<tr>
<th>Illustrated Position</th>
<th>Lashing Rod</th>
<th>Tension in Lashing Rod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outboard Stack</td>
<td>Short</td>
<td>( T_{a,b3} = \frac{(k_e + k_{a,b3} \cos^2 \theta_{a,b3}) (Q_e + Q_3) - 2k_{a,b3} Q_3 \cos^2 \theta_{a,b3}}{(k_e + 2k_{a,b3} \cos^2 \theta_{a,b3}) (k_e + k_{a,b3} \cos^2 \theta_{a,b4}) + 2k_{a,b4} k_{a,b3} \cos^2 \theta_{a,b4}} k_{a,b3} \cos \theta_{a,b3} )</td>
</tr>
<tr>
<td>Outboard Stack</td>
<td>Long</td>
<td>( T_{a,b4} = \frac{k_e (Q_e + Q_4) + 2k_{a,b3} Q_3 \cos^2 \theta_{a,b3}}{(k_e + 2k_{a,b3} \cos^2 \theta_{a,b3}) (k_e + k_{a,b3} \cos^2 \theta_{a,b4}) + 2k_{a,b4} k_{a,b3} \cos^2 \theta_{a,b4}} k_{a,b3} \cos \theta_{a,b4} )</td>
</tr>
<tr>
<td>Inboard Stack</td>
<td>Short</td>
<td>( T_{a,b3} = \frac{Q_e + Q_1}{k_e + 2k_{a,b3} \cos^2 \theta_{a,b3}} k_{a,b3} \cos \theta_{a,b3} )</td>
</tr>
</tbody>
</table>

(c) 2-Tier Lashing Bridges

<table>
<thead>
<tr>
<th>Illustrated Position</th>
<th>Lashing Rod</th>
<th>Tension in Lashing Rod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outboard Stack</td>
<td>Short</td>
<td>( T_{a,b4} = \frac{(k_e + k_{a,b4} \cos^2 \theta_{a,b4}) (Q_e + Q_2 + Q_3) - 3k_{a,b4} Q_3 \cos^2 \theta_{a,b4}}{(k_e + 3k_{a,b4} \cos^2 \theta_{a,b4}) (k_e + k_{a,b4} \cos^2 \theta_{a,b5}) + 3k_{a,b5} k_{a,b4} \cos^2 \theta_{a,b5}} - k_{a,b4} \cos \theta_{a,b4} )</td>
</tr>
<tr>
<td>Outboard Stack</td>
<td>Long</td>
<td>( T_{a,b5} = \frac{k_e (Q_e + Q_2 + Q_4) + 3k_{a,b4} Q_3 \cos^2 \theta_{a,b4}}{(k_e + 3k_{a,b4} \cos^2 \theta_{a,b4}) (k_e + k_{a,b4} \cos^2 \theta_{a,b5}) + 3k_{a,b5} k_{a,b4} \cos^2 \theta_{a,b5}} k_{a,b5} \cos \theta_{a,b5} )</td>
</tr>
<tr>
<td>Inboard Stack</td>
<td>Short</td>
<td>( T_{a,b4} = \frac{Q_e + Q_2 + Q_3}{k_e + 3k_{a,b4} \cos^2 \theta_{a,b4}} - k_{a,b4} \cos \theta_{a,b4} )</td>
</tr>
</tbody>
</table>

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

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

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/sec²) | 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 | 24.0 | 24.0 | 23.8 | 19.2 | 16.0 | 13.7 | 11.8 | 9.9 |
| 3.6 | 24.0 | 24.0 | 23.2 | 18.7 | 15.6 | 13.4 | 11.5 | 9.6 |
| 3.7 | 24.0 | 24.0 | 22.7 | 18.3 | 15.2 | 13.0 | 11.2 | 9.4 |
| 3.8 | 24.0 | 24.0 | 22.1 | 17.8 | 14.8 | 12.6 | 10.9 | 9.2 |
| 3.9 | 24.0 | 24.0 | 21.5 | 17.3 | 14.4 | 12.3 | 10.6 | 8.9 |
| 4.0 | 24.0 | 24.0 | 20.9 | 16.8 | 14.0 | 11.9 | 10.3 | 8.7 |
| 4.1 | 24.0 | 24.0 | 20.3 | 16.3 | 13.6 | 11.6 | 10.0 | 8.5 |
| 4.2 | 24.0 | 24.0 | 19.7 | 15.8 | 13.1 | 11.2 | 9.7 | 8.2 |
| 4.3 | 24.0 | 24.0 | 19.1 | 15.3 | 12.7 | 10.8 | 9.4 | 8.0 |
| 4.4 | 24.0 | 24.0 | 18.5 | 14.9 | 12.3 | 10.5 | 9.1 | 7.8 |
| 4.5 | 24.0 | 23.7 | 17.9 | 14.4 | 11.9 | 10.1 | 8.8 | 7.5 |
| 4.6 | 24.0 | 22.9 | 17.3 | 13.9 | 11.5 | 9.8 | 8.5 | 7.3 |
| 4.7 | 24.0 | 22.1 | 16.7 | 13.4 | 11.1 | 9.4 | 8.2 | 7.2 |
| 4.8 | 24.0 | 21.4 | 16.1 | 12.9 | 10.7 | 9.1 | 7.9 | 6.9 |
| 4.9 | 24.0 | 20.6 | 15.5 | 12.4 | 10.3 | 8.7 | 7.6 | 6.6 |
| 5.0 | 24.0 | 19.9 | 14.9 | 11.9 | 9.8 | 8.3 | 7.3 | 6.3 |
| 5.1 | 24.0 | 19.1 | 14.4 | 11.5 | 9.4 | 8.0 | 7.0 | 6.0 |
| 5.2 | 24.0 | 18.3 | 13.8 | 11.0 | 9.0 | 7.6 | 6.8 | 5.8 |
| 5.3 | 24.0 | 17.6 | 13.2 | 10.5 | 8.6 | 7.3 | 6.5 | 5.5 |
| 5.4 | 24.0 | 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 |
### 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/sec²) | Maximum Allowable Weight of 20° Containers (ton) |
|---|---|---|---|---|---|---|---|---|
| 3.5 | 24.0 | 24.0 | 24.0 | 23.0 | 19.3 | 16.5 | 14.4 |
| 3.6 | 24.0 | 24.0 | 24.0 | 22.4 | 18.8 | 16.1 | 14.0 |
| 3.7 | 24.0 | 24.0 | 24.0 | 21.9 | 18.3 | 15.7 | 13.6 |
| 3.8 | 24.0 | 24.0 | 24.0 | 21.3 | 17.8 | 15.3 | 13.3 |
| 3.9 | 24.0 | 24.0 | 24.0 | 20.7 | 17.3 | 14.9 | 12.9 |
| 4.0 | 24.0 | 24.0 | 24.0 | 20.1 | 16.8 | 14.4 | 12.5 |
| 4.1 | 24.0 | 24.0 | 24.0 | 19.6 | 16.4 | 14.0 | 12.1 |
| 4.2 | 24.0 | 24.0 | 24.0 | 19.0 | 15.9 | 13.6 | 11.8 |
| 4.3 | 24.0 | 24.0 | 23.1 | 18.4 | 15.4 | 13.2 | 11.4 |
| 4.4 | 24.0 | 24.0 | 22.4 | 17.9 | 14.9 | 12.7 | 11.0 |
| 4.5 | 24.0 | 24.0 | 21.7 | 17.3 | 14.4 | 12.3 | 10.6 |
| 4.6 | 24.0 | 24.0 | 21.0 | 16.7 | 13.9 | 11.9 | 10.3 |
| 4.7 | 24.0 | 24.0 | 20.3 | 16.1 | 13.4 | 11.5 | 9.9 |
| 4.8 | 24.0 | 24.0 | 19.6 | 15.6 | 13.0 | 11.0 | 9.5 |
| 4.9 | 24.0 | 24.0 | 18.9 | 15.0 | 12.5 | 10.6 | 9.1 |
| 5.0 | 24.0 | 24.0 | 18.2 | 14.4 | 12.0 | 10.2 | 8.8 |
| 5.1 | 24.0 | 23.2 | 17.5 | 13.9 | 11.5 | 9.8 | 8.4 |
| 5.2 | 24.0 | 22.3 | 16.8 | 13.3 | 11.0 | 9.4 | 8.0 |
| 5.3 | 24.0 | 21.4 | 16.1 | 12.7 | 10.5 | 8.9 | 7.7 |
| 5.4 | 24.0 | 20.5 | 15.4 | 12.1 | 10.0 | 8.5 | 7.3 |
| 5.5 | 24.0 | 19.6 | 14.7 | 11.6 | 9.6 | 8.1 | 6.9 |
| 5.6 | 24.0 | 18.7 | 14.0 | 11.0 | 9.1 | 7.7 | 6.5 |
| 5.7 | 24.0 | 17.8 | 13.3 | 10.4 | 8.6 | 7.2 | 6.2 |
| 5.8 | 24.0 | 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 |
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
-1. 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.
-2. For ships which keep onboard a lashing calculation program, capable of carrying out strength evaluation of container stowage and securing arrangements taking specific sea routes into consideration, “Container Stowage and Securing Arrangements with Service on Specific Sea Routes” (abbreviated to CSSA-R) 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.

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

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.

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, 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

2. Guidelines for Container Carrier Structures, ClassNK, November 2003
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
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

Excerpt from CSS Code Annex 14

CSS Code

(Code of Safe Practice for Cargo Stowage and Securing)

2011 Consolidated Version

Annex 14

Guidance on providing safe working conditions for securing of containers on deck
Note on annex 14

Member Governments are invited to bring the amendments to the CSS Code (annex 14) to the attention of shipowners, ship operators, shipmasters and crews and all other parties concerned and, in particular, encourage shipowners and terminal operators to:

.1 apply the amendments in their entirety for containerships, the keels of which were laid or which are at a similar stage of construction on or after 1 January 2015;

.2 apply sections 4.4, 7.1, 7.3 and 8 to existing containerships, the keels of which were laid or which are at a similar stage of construction before 1 January 2015; and

.3 apply the principles of this guidance contained in sections 6 and 7.2 to existing containerships as far as practical by the flag State Administration with the understanding that existing ships would not be required to be enlarged or undergo other major structural modifications as determined.
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 Fencing is a generic term for guardrails, safety rails, safety barriers and similar structures that provide protection against the falls of persons.

3.3 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.

3.4 SATLs are semi-automatic twistlocks.

3.5 Securing includes lashing and unlashing.

3.6 Stringers are the uprights or sides of a ladder.

3.7 Turnbuckles and lashing rods* include similar cargo securing devices.

* 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:

- slips, trips and falls;
- falls from height;
- injuries whilst manually handling lashing gear;
- being struck by falling lashing gear or other objects;
- 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;
- adjacent electrical risks (temperature controlled unit cable connections, etc.);
- the adequacy of the access to all areas that is necessary to safely perform container securing operations;
- ergonomics (e.g., size and weight of equipment) of handling lashing equipment; and
- 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:

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

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;

.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.

6.2.2.3 The width of permanent lashing bridges should be:

.1 750 mm between top rails of fencing; and

.2 a clear minimum of 600 mm between storage racks, lashing cleats and any other obstruction.

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;
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.

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

* Refer to Safety and Health in Ports, ILO Code of Practice, section 7.1.5.
.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

.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.

* Refer to Safety and Health in Ports, ILO Code of Practice, section 7.1.5.
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 can not be avoided, safe means of access should be provided by the container cargo operation terminal, unless the ship has appropriate means of access in 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 unlash 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


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)."