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Safety analysis of OOG cargo stowage and securing on flat rack

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SAFETY ANALYSIS OF OOG CARGO STOWAGE AND SECURING ON FLAT RACK

By

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The People's Republic of China

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views and are not necessarily endorsed by the University.

(Signature): ……

(Date): ……

Supervised by: Professor BAO Junzhong

Supervisor's affiliation: Dalian Maritime University

Assessor: ……

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ABSTRACT

Title of Research paper: **Safety Analysis of OOG Cargo Stowage and Securing on Flat Rack**

Degree: **MSC**

With unique structural design and combined advantages of containers and bulk transportation, flat rack container (FR, hereafter referred to as flat rack) has excellent extendibility and compatibility as the main transportation for oversize cargo. The OOG cargo leads to a high risk of transportation, and the cargo is prone to damages. So, safety stowage and effective securing must be performed on the cargo to withstand the impact of wind and waves. There is no uniform standard in the current international and regional relevant laws and regulations. Because the shapes and the weights of awkward and lengthy cargo vary, it is difficult to apply these checking methods into engineering practice.

This paper researches the safety stowage, securing of OOG cargo for marine Container transportation. It focuses on analyzing and exploring the main characteristics of various reasonable securing methods of OOG cargo on the flat rack and the key points and precautions of safe and reasonable stowage. By explaining the characteristics and functions of different securing methods, considering the particularity of OOG cargo established safe and reasonable stowage plans. According to these procedures, a set of checking procedures using Visual Basic computer language should be established, which integrates safety check list and cargo stowage, securing fast checking procedures to implement effective safety supervision to OOG cargo.

The operation methods put forward in this paper have improved the theoretical knowledge of OOG cargo operation personnel and provided a significant reference for the safe transportation of OOG cargo transportation.

KEYWORDS: Container transportation, Out of gauge, Flat rack, Container stowage, Cargo securing

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LIST OF ABBREVIATIONS

BBK	Break Bulk Cargo
BS	Breaking Strength
CIC	Concentrated Inspection Campaign
CS	Calculated Strength
CSC Code	International Convention for Safe Containers
CSM	Cargo Securing Manual
CSS Code	Code of Safe Practice for Cargo Stowage and Securing
CTU Code	Code of Practice for Packing of Cargo Transport Units
DMU	Dalian Maritime University
EDI	Electronic Data Interchange
FR	flat rack Container
HQ	High Cube Container
IG	In Gauge
IMO	International Maritime Organization
ISO	International Standardization Organization
LOA	Length Overall
LOI	Letter of Indemnity
MoU	Memoranda of Understanding
MSL	Maximum Securing Load
OOG	Out of gauge
O/H	Over Height
O/L	Over length
OT	Open top container
O/W	Over Width
PF	Platform container
PSCO	Port State Control and Inspection Officer
SOLAS	International Convention for Safety of Life at Sea
STCW	International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers
SWL	Safe working load
TEU	Twenty feet Equivalent Unit
VB	Visual Basic
VGM	Verified Gross Mass
WLL	Working Load Limit
WMU	World maritime University
WUT	Wuhan University of Technology
U/C	Un-containerized Cargo

CHAPTER 1 INTRODUCTION

1.1 Background

1.1.1 Need for Efficient Shipping

The vigorous development of a significant container shipping trade has put forward higher requirements for the efficiency of cargo transportation. Due to the low efficiency in cargo handling and transportation, serious cargo damage and shortage, and complicated transportation handling procedures, general cargo transportation have an extremely negative impact on the economic benefits of cargo owners, shipping companies, and ports (Li, 2016).

Container shipping has realized fast, low-cost, high-efficiency, and high-benefit cargo transportation; therefore, it represents the modern shipping industry. Container ships can deliver awkward and lengthy cargo anywhere globally and strong cargo loading and unloading capabilities at the ports they call. Thanks to the high efficiency of container shipping, flat rack transportation of OOG cargo plays a critical role in leveraging international shipping.

1.1.2 Accidents Frequently Occur

Although the container shipping industry is under good supervision and with high importance, the accidents of container collapse happened frequently (UNCTAD, 2018). According to a report published by World Shipping Council in July 2020, between 2018 and 2019, an average of 1,382 containers fell into the sea every year (Ion, 2021). This has aroused the widespread concern of researchers at home and abroad. The safety of container transportation has also been questioned and discussed by the industry.

The large-scale collapse of container stacks often starts from a certain “accident source” (The first container to be displaced and overturned), and the top container is most likely to fall. The accident investigation report from the relevant investigation agency pointed out that in addition to the extremely bad weather encountered by the ship during the voyage, the poor stacking of containers and the defects of securing are also important reasons for such accidents (Zhou et al., 2011). Container stacking generally follows the principle of “Upper lighter cargo, Lower heavier cargo", and the standard container stowed at the top is often relatively light (Wang, 2020). To avoid cargo congestion, this leads to unnecessary unloading containers before arriving at the destination port. For the convenience of operation, the cargo may be required to be stacked separately between the two ports instead of being adjusted or stacked according to the weight of the cargo, which cannot meet the requirements of the “Upper lighter cargo, Lower heavier cargo” principle. The special dimensions of OOG cargo led to the situations that they are often “forced” to be bestowed on the top of standard containers. Compared with standard containers, the securing process of OOG cargo is more complicated, but there is a lack of effective evaluation and professional risk assessment (Zhu, 2018). The occurrence of accidents of OOG cargo

during shipping is much more frequent than that of standard container transportation. They are more likely to become the “source of accidents causing the “Domino effect", ranging from cargo damage caused by container stacking collisions to the most serious container stacking collapse in large quantities or even loss of falling cargo and pollution to the marine environment.

1.1.3 General Lack of Knowledge about OOG Cargo Operations

The stowage of OOG cargo requires the relevant operators to master the knowledge of maritime container transportation and early inland transportation, securing, customs declaration and clearance, and even machinery, mechanics, materials, and other knowledge. In practice, the knowledge of the operation of OOG cargo generally lacks. Very few people can grasp reasonable knowledge regarding the configuration of OOG cargo stowage and securing checking (IRU, 2015).

1.1.4 Insufficient Preliminary Work of OOG Cargo Stowage

There are certain risks of the stowage, securing mode of OOG cargo. The Center Planner and Local Planner, responsible for the early receipt and pre-loading of the cargo, almost no on-site inspections are conducted on the handling and dimension of OOG cargo. The relevant personnel on board should carry out many preliminary preparations, such as measuring the actual over-limit dimensions and checking the securing method and strength to implement an effective safety stowage evaluation. Any problem in any link incurs the interruption of the entire transportation. It takes a lot of time and energy. The current operation level is subject to multiple constraints and is not convenient for modern container shipping. This has also become a “stumbling block” for the safe transportation of OOG cargo.

1.2 Relevant Regulations about OOG Cargo

The legislative bodies, industry associations, and other organizations in many countries and regions have successively issued relevant regulatory documents for the transportation of awkward and lengthy cargo by sea, including but not limited to, as illustrated in Table 1.

Table 1 - Relevant Provisions of Various Bibliographies

Bibliography	Relevant regulations
SOLAS Convention	International Convention for Safety of Life at Sea contains relevant standards and safety rules for cargo transportation in ships and relevant operations (IMO, 2014a).
STCW Convention	International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers prescribes the competency requirements on seafarers. Ensuring the understanding of international regulations, rules, and standards regarding safe loading, stowage, securing, and transportation of cargo units and the ability to apply the relevant knowledge (IMO, 2012).
CSS Code	The Code of Safe Practice for Cargo Stowage and Securing is containing the methods for calculating the external force and the securing force of non-standard cargo (Kaps & Andersson, 2017). Includes guidance and suggestions on non-standard cargo and provides operational requirements for safe stowage, securing non-standard cargo with potential risks (IMO, 2011; Jerzy & Bogusz, 2009).
CTU Code	The Code of Practice for Packing of Cargo Transport Units provides basic safety requirements and recommendations for stowage and securing OOG cargo on the flat rack. It mainly concerns securing container cargo and containers that need to be secured separately and awkward and lengthy cargo that cannot be loaded into containers (Annexes, 2013).
CSC Code	The International Convention for Safe Containers applies to newly built and existing containers and specifies the testing, inspection, approval, and maintenance of containers, including flat rack.
CSM Manual	The Cargo Securing Manual for container ships shall be in line with the requirements of Chapter VI Section 5 of the SOLAS

	Convention and its amendments, and Chapter VII Section 5 “Cargo Securing Manual” of CSS. The compilation of the Cargo Securing Manual shall also comply with the requirements of MSC/Circ.745, Circ.1352, Circ.1353, and other relevant regulations (Cargo Securing Manuals, 2016). The most important is the diagram of the securing styles of containers in a specific loading state (IMO, 2014b; Wang, 2020).
SQE Manual	SQE Manual is the system document formulated by shipping companies for ship operations. Due to the particularity of the OOG cargo, which does not have a securing size or structure, it is impossible to guide and explain the safety stowage, securing the OOG cargo through specific documents.

Source: Compiled by author.

Based on the above-mentioned relevant regulations, we deeply realize that these contents are stowage suggestions and securing principles for awkward and lengthy cargo handling under general or specific conditions, standard models under typical and/or ideal conditions with limited practical guidance and explanation.

1.3 Status of the OOG Cargo Stowage

There are many technical problems in the use of flat rack to carry OOG cargo. Transportation is often carried out only based on the experience of relevant personnel, resulting in many economic losses and even casualties (Wang, 2017a). At present, there is no unified solution to this problem. It has always been the focus of the authorities of major container shipping companies. The main reasons are as follows, including but not limited to:

1.3.1 Limitations of Stowage Software

In the process of formulating the stowage plan for modern container ships, stowage software is widely used to check the gross longitudinal strength, local strength, ship

stability, standard container securing plan, and lashing force for each ship and also the isolation and stowage of special containers, etc. Timely and effective communications about the container stowage plans are carried out through Electronic Data Interchange (EDI). For awkward and lengthy cargo, there is no effective stowage plan. Only simple checks can be made based on the weight and the estimated stowage position, and the OOG cargo units are checked as a whole module for the securing forces. It has not fully considered the oversize size of OOG cargo and the methods of securing the cargo. For the cargo that exceeds the proportions and capabilities of a single standard container, a safe and reasonable stowage position can only be arranged based on field measurements and related documents (Cargo manifest). Based on avoiding “Dead space", OOG cargo should be guaranteed not to touch other nearby containers and not affect the loading and unloading of cargo of different ports. In addition, due consideration should be given to arranging the stowage of standard containers on the left and right sides to “protect” the OOG cargo from being affected by wind and waves and falling into the sea when they are displaced and/or capsized.

1.3.2 Lack of Special Securing Devices

Standard containers are equipped with standard fixed and movable fasteners, while OOG cargo is a non-standard cargo and does not have securing devices. Wire ropes, fiber ropes, lashing straps, turnbuckles, lashing steel band and chains, shackles, dunnage, chocking, etc. They are usually used separately or in combination to securing the OOG cargo. Various securing devices have different sizes and strengths, which means that they have different Safe Working Load (SWL) and Maximum Securing Load (MSL). Because of the different ways and methods of securing, different effectiveness is obtained.

1.3.3 Lack of Early Securing

Before arrives at the dock, the shippers need to effectively securing the OOG cargo to the flat rack according to relevant standards and specifications. However, shippers often lack the foresight of potential risks for marine shipments and/or professional securing skills, so they often only follow the common inland transportation mode. Generally, securing marine transportation requirements is stricter than inland transportation, which leads to the improper use of securing devices with insufficient securing strength. Therefore, before OOG cargo is loaded, a strict check is required to ensure port lifting and maritime transportation safety.

1.3.4 Indefinite Guidance Documents

Some international or regional cargo transportation-related regulations, conventions, and guidance documents prescribe force calculation methods for some general cargo, which can be the basis for checking OOG cargo securing. However, the particularity of OOG cargo transportation must be considered, and the specifications cannot be simply applied. On this basis, the particularity of each OOG cargo should be fully considered to meet the actual needs of the project.

It is unclear what rules should be used to design the scheme for OOG cargo stowed on the flat rack for the current maritime transportation. It is generally believed that the process should be carried out under the “CSS Code”, but the rules of the Code are mainly applicable to the direct stowage of non-standard cargo in the hull, rather than the stowage of OOG cargo on the flat rack (Jerzy & Bogusz, 2009). Some believe that this process should be carried out under the “CTU Code”. However, these codes mainly apply to the stowage of cargo in a transportation component. For OOG cargo, it often needs to be stowed in several transportation components of the flat rack that are not rigidly connected.

1.3.5 Lack of securing Experience

For OOG cargo, there is a wide range of securing types, and almost all the securing is “Case by Case". Securing is usually carried out by dock workers or packers of cargo production enterprises based on experience. So, various potential hazards often exist, such as unscientific securing schemes and non-standard operation and implementation. Generally, the chief officer of each ship conducts an on-site inspection on the actual securing of the cargo to determine whether the relevant stowage requirements are met. And the captain will decide whether to approve the shipment based on the ship's characteristics and the sea conditions encountered. All of these require corresponding professional knowledge, experience, and skills. But in actual work, the captain, chief officer, and the supervisor often have not received training or guidance on the OOG cargo transportation system and lack scientific analysis and guiding theories. They usually predict the transportation safety of OOG cargo based on subjective feelings and the sea conditions that may be encountered in the future and fail to conduct effective risk identification through systematic analysis, which incurs the lingering danger throughout the entire transportation process.

1.3.6 Improper Stowage Operations

If the flat rack is stowed on the deck, they will inevitably be attacked by large or small wind and waves during marine transportation, which will easily cause OOG cargo damage. If the flat rack is stowed in the cargo hold, there must be enough standard containers for dunnage. If the stowage is improper, it will cause an unreasonable re-stow of containers, which will passively increase the handling time of the ship and increase unnecessary operating costs.

1.3.7 Insufficient securing Check

In the actual loading process, trailers are often used to carry OOG cargo directly to the ship's side to wait to check its Dimensions and securing. However, the poor communication between the cargo owners and the ports and/or the ship owners often causes information lag, resulting in the late arrival of the trailers. The loading operations are forced to stall to wait for checks. Therefore, the checks are often not sufficient enough. Or the cargo is rejected because of the tight shipping schedule (Zhang, 2017).

1.3.8 Lack of Research Practicability

The relevant rules of international organizations such as the International Standardization Organization (ISO) and the International Maritime Organization (IMO) stipulate the technical indicators that the flat rack should have or should achieve. Still, none of them have given the basic principles for stowing OOG cargo on the flat rack. No classification societies have considered the safety impact of using the flat rack to load OOG cargo when determining the stowage plan for container ships at the international level. The academic writings and textbooks used by maritime colleges and maritime training institutions to train seafarers do not contain introductions. Research reports and related papers proposed by relevant research institutions are limited to theoretical discussions and are not of applicable meaning to the practice of seafarers.

1.4 Main Research Content

Based on the analysis and theoretical research of OOG cargo stowage, this paper conducted specific research and discussion on the securing strength of OOG cargo and concisely summarized various effective securing techniques. After the check of

securing plan is completed, a safe and reasonable stowage position should be selected, and at the same time, unnecessary “Dead Spaces” should be avoided. And on this basis, a set of calculation auxiliary software tools was developed with Visual Basic (VB) computer language to ensure the safety of OOG cargo transportation.

Due to the open-top container stowage is relatively simple, this paper will not discuss it. This paper focuses on the discussion and research of more complicated securing OOG cargo on the flat rack. Among them, because the Athwartships Stow is rare in actual container cargo transportation practice, and the stowage needs to be carefully calculated by a professional team, it will not be discussed in this paper, either.

1.5 Research Implications and Objectives

With the acceleration of modern logistics, and under the leadership of IMO, modern scientific and technological navigation has gradually become a new technical means and environment, which promotes the realization of the goal of “Safer navigation and Cleaner Ocean". It is imperative to use the computer programming language to design and develop software as an automatic evaluation tool for stowage and securing OOG cargo. It can meet the requirements of relevant conventions and help advance modern science and technology navigation strategy and better stowage of OOG cargo.

The purpose of this paper is to guide quickly and effectively confirm the stowage and securing OOG cargo in engineering practice, ensure the safety of container ships and OOG cargo during loading/unloading at ports and maritime transportation, avoid the disturbance and threats caused by external environmental factors (Sea wind, swells, bumps, etc.) to the greatest extent, prevent the slipping and/or overturning of containers and effectively curb the “source of the accident". At the same time, the

safety of relevant operators can be guaranteed, and the loading and unloading efficiency can be increased. Therefore, this is a subject of certain practical significance which is worthy of in-depth study.

1.6 Research Status and Trend in China and Abroad

As OOG cargo transportation activities become more and more frequent, in China and abroad scholars, maritime universities, and scientific research institutions have done a lot of related research on this.

1.6.1 Research Status and Trend in China

Professor Cui Hehuai of Dalian Maritime University (DMU) and others published a paper entitled “Study on binding and checking system for the major cargo of ships” in 2019 and systematically evaluated major cargo securing plans and designed the lashing, securing, and checking the system for awkward and lengthy cargo based on “C++” technology to realize the visual operation and real-time check of the securing plans (Cui, Cheng & Liu, 2019); Professor Yang Shouwei of Wuhan University of Technology (WUT) published a paper entitled “Research on securing methods of loading awkward” in 2010. He studied the methods of cargo securing for the transportation of awkward and lengthy cargo, proposed using the method of calculating lanyard tension to determine securing plans or conduct safety evaluation of the determined securing plan to ensure the safety of ships and cargo during the transportation (Yang, 2010). The theories mentioned above still need to establish corresponding data models for complex oversized cargo and carry out theoretical calculations and analysis, which means that the actual operability is not good enough. The front-line personnel of ships cannot use this as a basis to evaluate OOG cargo stowage and securing and safety stowage effectively and conveniently.

1.6.2 Research Status and Trend Abroad

On September 1, 2016, the member states of Tokyo Memoranda of Understanding (MOU) organized a three-month Concentrated Inspection Campaign (CIC) with the theme of "Cargo securing arrangement". The port state control and inspection officer (PSCO) mainly inspected the effectiveness of the "Cargo Securing Manual" for container ships. Still, they did not focus on securing oversized cargo containers (INSB Class, 2016); In recent years, Regulation 2 of Chapter VI of the SOLAS Convention has put forward new regulations on Verified Gross Mass (VGM), which effectively controls the inconsistency between the declared weight of containers and the actual weight and reduces the risk of casualties at sea and cargo damage caused by unreasonable stowage. The safety coefficient of maritime transportation has been increased; Det Norske Veritas (2002) provided shipowners and ship management companies with a set of non-standard cargo securing and checking procedures (LASHCON^{TM}), further amended in 2004. This program provided computer support for non-standard cargo securing and checking that can be used by crew members. However, it requires more values for calculation and can only provide the final check result but cannot show the correctness of the calculation process or formulate a securing plan or realize the supporting function of the lanyard. To sum up, People in the shipping industry have gradually realized that although these foreign studies and initiatives have played a significant role in increasing the safety of container shipping, they cannot completely guarantee the safety of OOG cargo.

1.7 Research Methodologies

This paper uses various combined research methods to comprehensively and effectively analyze and summarize the most reasonable operation mode of OOG

cargo.

1.7.1 Literature Review

Through a large number of literature reviews, the focus of this paper is OOG cargo stowage and securing, the latest regulations were grasped.

1.7.2 Field Investigation

Through field investigation, the actual operation modes of container shipping companies were understood, the supervision mechanisms for OOG cargo were comprehended. The field visits were performed to understand the check and supervision methods of OOG cargo stowage, securing plans used by the front-line operators of container ships, which help understand the current situation of using computer stowage software and explore the disadvantages the software for OOG cargo stowage.

1.7.3 Experience Summary

Combined with relevant theoretical research, specific analysis of the research object of OOG cargo is conducted, the rules were summarized from a large amount of research information, and key information about OOG cargo is extracted.

1.8 Main Research Innovations

By summarizing and analyzing the first-hand data collected from previous field visits, the effects of different types of securing are summarized with the container shipping practice experience. A set of effective OOG cargo stowage and securing checking procedures is established. Uses the Visual Basic computer language to develop a safety check list to check the stowage and securing the OOG cargo. Combined with

the checking program, the list can be used to analyze the securing effectiveness. Only a few necessary parameters are needed to be input by the user to complete the automatic calculation of a single effective lashing force and the check of overall securing safety. It assists and guides the check of stowage plans.

CHAPTER 2 SAFETY STOWAGE OF OOG CARGO

2.1 Overview of OOG Cargo

2.1.1 Definition of OOG Cargo

According to the definition, OOG cargo refers to the oversized cargo that cannot be loaded into the standard container. Any one or more of its length, width, and height dimensions exceed the standard oversize dimensions of the stowage tool that carries the cargo. However, it is still possible to transport in the form of container cargo units using container loading tools with top openings and side openings, called Out of Gauge (OOG), commonly known as “Trilateral over-dimension cargo”; Conversely, known as In Gauge (IG). It is a containerization transport method (Det Norske Veritas, 2002).

2.1.2 OOG Cargo Dimension Scope

As securing devices are used for securing OOG cargo, the oversize of the cargo increases, which is also included in the oversize of OOG cargo, i.e., The total length, total width, and total height of OOG cargo measured after securing. OOG dimensions are generally marked in cm, and the maximum limit of their dimensions is specified, as illustrated in Table 2.

Table 2 - OOG Dimension Limit

Types	Abbreviation	Flat rack dimension (cm)		Max. Limit (cm)
Over Length	O/L(F) O/L(A)	563 (20')	1165 (40')	200 (F or A)
Over Width	O/W(L) O/W(R)	243		-
Over Height	O/H	223 (20')	195 (40')	4
Over Weight	O/Weight	-		45T

Source: Compiled by author.

2.2 Types of Cargo Stowage Tools

Container ships not only transport container cargo of standard size (20' GP, 40' GP, 40' HQ) but also often carry various OOG cargo. The loading tools specially made for this kind of cargo have different shape designs from standard closed containers and allow cargo that is slightly taller and/or slightly wider or even longer than the standard containers. This kind of loading tool has a higher payload rating. According to their structure, OOG cargo-carrying tools are divided into Open Top container (OT), flat rack, Platform container (PF) (IMO, ILO & UNECE, 2013).

Unlike the standard container, the flat rack compared to the standard container reduces the container top and sidewalls, more special two ends of the rack set into four corner columns, according to the shape of the flat rack respectively for the plate flat rack and columns flat rack (Gross, 2013); The flat rack retains the basic characteristics of the standard container standard size its size, convenient flat rack in the container ship handing, with “Container” the significant characteristics of the flat rack have a high load-bearing capacity and hard-wood parquet flooring, according to the different types of flat rack, the rack on both sides can be divided into collapsible type or non-collapsible type, as illustrated in Figure 1 and 2.

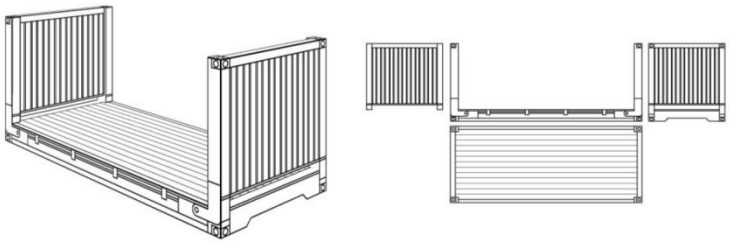


Figure 1 - Schematic Diagram of the Flat Rack (Collapsible)

Source: Compiled by author.

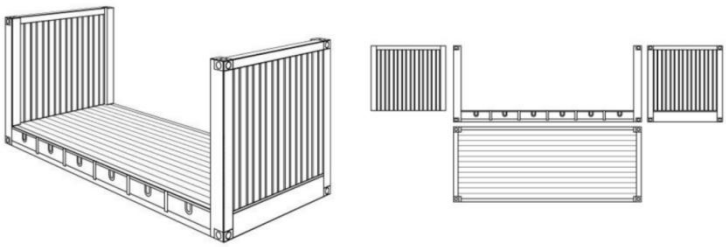


Figure 2 - Schematic Diagram of the Flat Rack (Non-collapsible)

Source: Compiled by author.

2.3 Standard Dimensions of Flat Rack

The Flat Rack with a length of 20'and 40', as illustrated in Table 3 (More Than Shipping, 2018).

Table 3 - Standard Dimensions of Flat Rack

Type	20′ Flat Rack	40′ Flat Rack
Length between end headers (cm)	592	1205
Length between corner posts (cm)	563	1165
Width between end sides (cm)	243	243
Width of floor (cm)	223	195
Max. gross weight (kg)	34, 000	45, 000
Average tare (kg)	2, 750	4, 900
Max. payload (kg)	31, 250	40, 000
Securing/Lashing Rings (Each side)	12	32

Source: Compiled by author.

2.4 Usage of the Flat Rack

2.4.1 Principle of Classification of Usage

The flat rack mainly determines the stowage mode according to the cargo dimensions, divided into OOG and BBK, as illustrated in Table 4 (Log freight, 2021).

Table 4 - Delimitation Standard of Stowage Mode

Determination criteria (Including package size)	OOG (Containerization Cargo)	BBK (Un-containerized Cargo)
L	Within 1165cm	More than 1165cm
W	More than 243cm	More than 400cm
H	Over 223cm (20' FR) Over 195cm (40' FR)	Over 400cm
Weight	Within 34t (20' FR) Within 45t (40' FR)	More than 45t

Source: OOCL. (n.d.).

2.4.2 Usage Mode

Using a single FR to carry OOG cargo is called Containerization Cargo, employed

“securing in advance”, as illustrated in Figure 3.

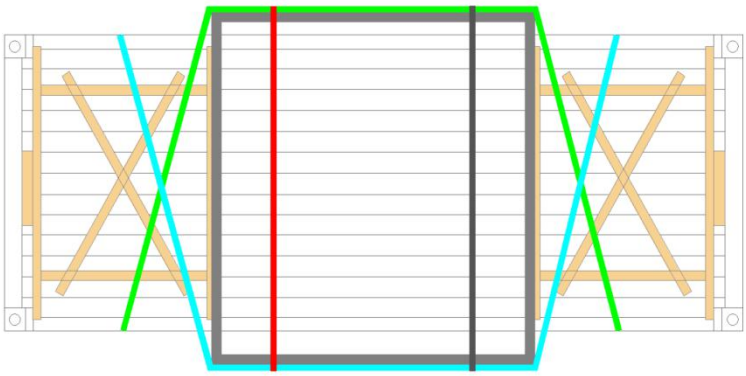


Figure 3 - Single FR stowage OOG cargo

Source: Compiled by author.

Using multiple FR to carry OOG cargo together is called Un-containerized Cargo (U/C). Generally speaking, the specifications of OOG cargo carried by containers are strictly controlled within the scope described in the containerization Cargo above. For the shipping mode by container liner, if the weight or external size of the cargo exceeds the payload of a single flat rack or its size affects the cargo used at the lifting point, the OOG cargo transported by multiple flat rack will be loaded in a non-containerized form. And the operation mode of “Break Bulk Cargo (BBK)” and the operation mode of “Separation of container and cargo” will be respectively adopted to lifting the cargo onto the ship. The shipping company will provide two or more FR as a bed, which will be combined into a large “Bedding” for stowage, and then the lashing and unlashing will be completed onboard (Wang, 2017b). The specific stowage mode is divided according to the stowage orientation of OOG cargo and usually adopts athwartships stow or longitudinally stow, as illustrated in Figure 4 and Figure 5. Under the guidance of the notary appointed by the shipping company, the consignor, and the ship, the cargo is usually reinforced after being lifted onto the

ship, which is generally stowed on the top tier of the cargo hold. And no other containers can be stacked in the upper space.

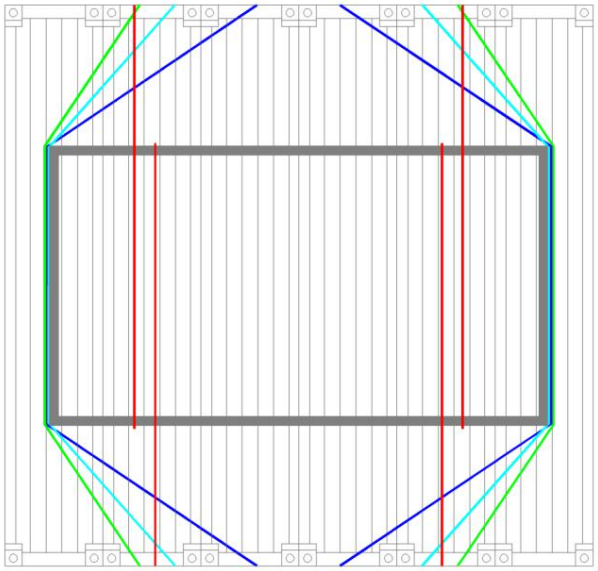


Figure 4 - Multiple FR Carrying OOG Cargo Stowage Mode (Athwartships Stow)

Source: Compiled by author.

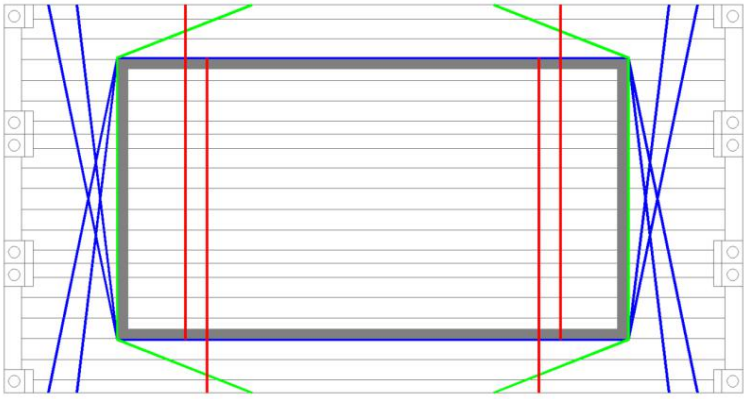


Figure 5 - Multiple FR Carrying OOG Cargo Stowage Mode (Longitudinally Stow)

Source: Compiled by author.

2.5 Transport Characters of Flat Rack

2.5.1 Superiority

Flat rack ship freight transport breaks through the boundary between the standard container and bulk cargo transportation. It integrates the advantages of (F. Wang, 2018), which has the characteristics of “Safety, high efficiency, and simplicity", and realizes “Door to Door” transportation of cargo through multimodal transport, covering more than 95% of ports in the world (Annexes, 2013); The threshold of the number of transportation pieces is low, even a single object can be booked for transportation, which has strong market competitiveness; The shift schedule is relatively fixed, with fixed calling port and high timeliness; Generally stowed in the cargo hold. Even if it is stowed on the deck, ordinary containers are set up on the left and right sides as “protective walls” as far as possible, which reduces the possible damage to other cargo and has high transportation safety and good cargo suitability. Only the door can be opened for loading and unloading compared with traditional containers, the ductility of the flat rack is excellent, which can meet the transportation needs of OOG cargo; Multi-angle loading and unloading can be realized, which is convenient for securing operation; The bottom plate is thick with strong load-bearing capacity, which meets the transportation needs of OOG cargo (Chen, 2019).

2.5.2 Limitations

The specifications of OOG cargo transported by flat rack ship freight transport are limited; It is difficult to supervise cargo due to the limitation of stowage position; Shipping companies and/or port parties generally consider that the upstream ship has been safely transported and that downstream vessels are equally suitable, direct loading is not considered for a risk assessment, resulting in inadequate regulation of

“transshipment cargo”; The available single voyage space is limited with a high price of a single position, which is not suitable for mass transportation; Open structure, unable to stow wet cargo.

2.6 General Principles of Stowage

2.6.1 Stowage Preferences

The principle of container ship stowage location selection should determine the overall container loading area for this voyage, prioritize the special stowage container, and finally stowage the general container (including the empty container) (Zoran, 2004).

The following stowage principles are summarized: Do not stow in the bow as much as possible; Do not stow on the seaside of the deck as much as possible; Stow on the lower stacking tier as much as possible; Do not stow on the bottom deck as much as possible (So as not to affect the stowage of the whole Bay of container cargo); Do not stowage at the bottom of the hold as much as possible; Ensure stowage in the cargo hold as much as possible (Unless specially required by the shipper or stowed on the deck with the consent); Minimize the dead spaces as far as possible. Through the reasonable stowage of OOG cargo to ensure the transportation safety of OOG cargo, as illustrated in Figure 6.

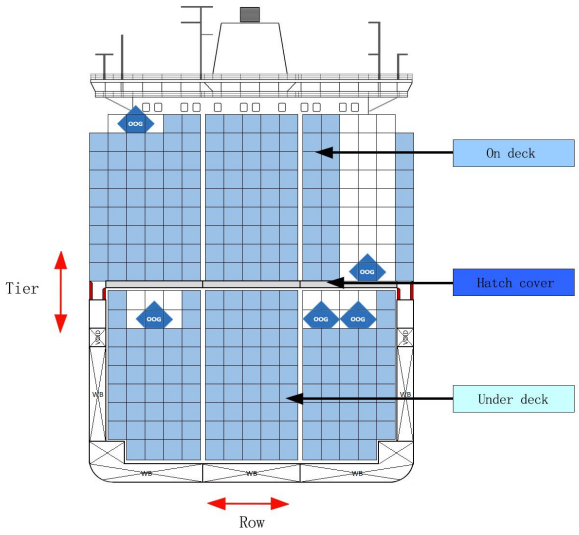


Figure 6 - OOG Cargo Stowage Cross Section Diagram

Source: Compiled by author.

Consideration should be given to selecting the reasonable location for special containers, and priority should be given as far as possible to facilitate the crew to enter the stowage location for daily inspection and securing when necessary. It is easy to take effective emergency measures for this kind of container even in an accident(Burnson, 2014). Special cargo sensitive to acceleration should be as close as possible to the center of motion of the ship (The center of gravity of the ship).

2.6.2 Accurate Measurement of OOG Cargo

When the OOG cargo stowage on the flat rack for transportation, it must be positioned accurately. For deck cargo, the size of the protruding flat rack should be measured accurately (The data stowed in the manifest may be inaccurate). The containers in the nearby Bay location should be integrated to confirm whether there is the phenomenon of “Overstock a harbour” or the influence of securing OOG cargo.

2.6.3 Dead Spaces Location of OOG Cargo

It will inevitably lead to Dead Spaces because the size of OOG cargo exceeds the limit, which will lead to the adjacent space of the cargo stowage position being partially “occupied” by the loaded cargo (Space is not fully utilized). Other cargo cannot be stowed, which objectively causes the waste of container ship space, as illustrated in Figure 7. When calculating the cost, container ships usually take the quantity occupied by Twenty feet Equivalent Unit (TEU) as the basis for freight collection, as illustrated in Table 5. The stowage of OOG cargo must be carefully and fully consider reducing the dead spaces caused by the stowage of OOG cargo as much as possible.

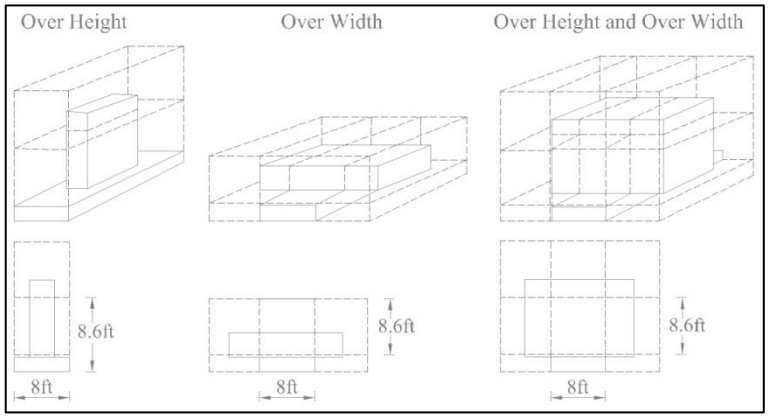


Figure 7 - Schematic Diagram of OOG Cargo Dead Spaces

Source: Compiled by author.

Table 5 - Dead Spaces due to OOG Cargo

Type	Total space occupied (TEU_S)	
	20' FR	40' FR
Over height	2	4
Over-width	3	6
Over-width and Over height	6	12

Source: Compiled by author.

2.7 Specific Countermeasures for Stowage

There are many kinds of OOG cargo, sizes of which are inevitably different. This kind of non-standard cargo is stowed by a flat rack with a standard structure, and reasonable stowage positions must be arranged according to their specific oversize.

2.7.1 Over Length

2.7.1.1 Deck Stowage for O/L

It should be considered whether its loading will affect the loading of containers in the forward, after, and near Bay adjacent to it when stowage on deck. For 40ft over length OOG cargo, i.e., L > D, and the length of one-side over length container is greater than the safety gap (Width of lashing bridge) of the fixed stowage position of the container, it must be stowed on the top tier of the stack, as illustrated in Figure 8.

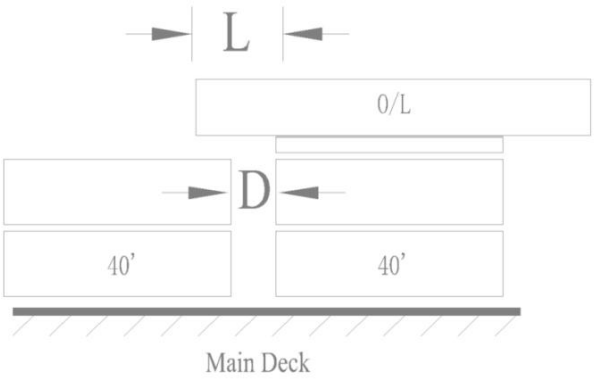


Figure 8 - Deck Loading Limits for Over Length Container

Source: Compiled by author.

2.7.1.2 Cargo Hold Stowage for O/L

The 20ft OOG cargo with only one end over length can also be selected on the cargo hold; The 40ft over length containers are provided with a fixed cell guide on the cargo hold wall due to the barrier of the bulkhead or to facilitate the rapid loading and

unloading of cargo. Cargo that cannot be stowage beyond the bulkhead length limit or the length of the fore and aft symmetrical cell guide can only stowage on the deck or loaded in the cargo hold in a U/C manner (R. Q. Wang, 2018).

2.7.2 Over Width

2.7.2.1 Deck Stowage for O/W

Container ship cargo is closely arranged horizontally. For stowage of over-width cargo, it is often necessary to leave the Row on the over width side vacant for stowage of over width OOG cargo. Or stowage it “independently” at the top of the whole Row container. But it often causes no occlusion on both sides, which is a great challenge to securing OOG cargo, this kind of stowage position is generally not desirable.

When lifting over width OOG cargo, the rack at the front and rear ends of the over-width cargo shall keep a gap of at least 30 cm (12') from the front and rear sides of the crate at both ends (including attached blocking and supporting materials). Otherwise, it is easy to block the four top corner casting of the flat rack, making the wharf machinery unable to lift OOG cargo (Zhang, 2018). Therefore, top corner casting must be kept unshielded (Keep the top corner castings clear). To ensure the smooth operation of OOG cargo loading and unloading, as illustrated in Figure 9.

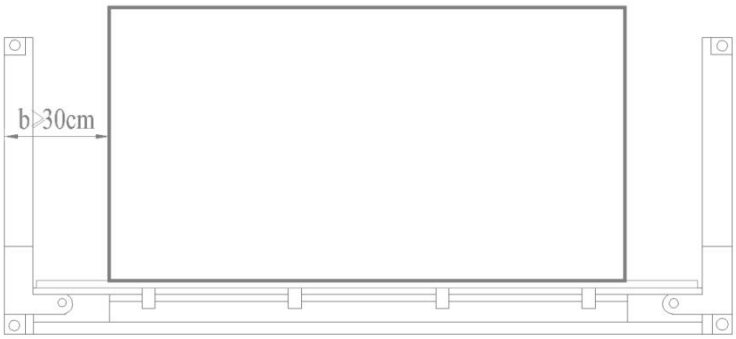


Figure 9 - Length Limit for Over Width OOG Cargo Stowage on FR

Source: Compiled by author.

2.7.2.2 Cargo hold stowage for O/W

Containers can be easily guided into the slot by cell guides in the cargo hold, extending about 50 cm (19.6') from the inside of the cargo hold wall, as illustrated in Figure 10.

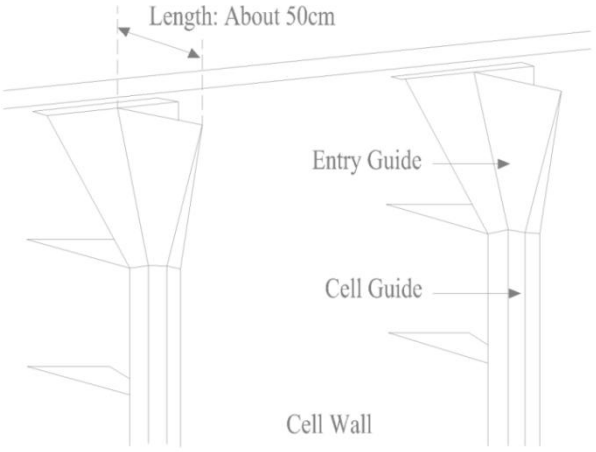


Figure 10 - Schematic Diagram of Structure and Dimensions of Cell Guide

Source: Compiled by author.

It is necessary to ensure that the front and rear ends of the crate are at least 50cm (19.6') away from the cell guide when over width OOG cargo is stowed in the cargo

hold (Fan, 2004). If the over-width cargo is stowed too close to the corner post in the flat rack, the cargo may touch the cell guide and cause damage to components and cargo (He, et al, 2019), as illustrated in Figure 11.

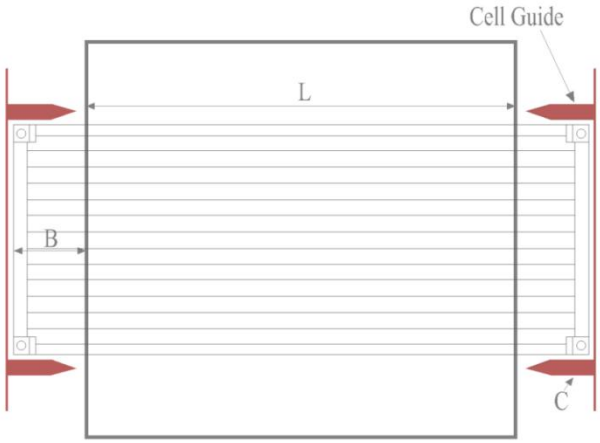


Figure 11 - Schematic Diagram of Allowable Stowage Dimensions of Over Width OOG Cargo in the Cargo Hold (Top View)

Source: Compiled by author.

To sum up, the stowage limit dimensions of over width OOG cargo are summarized, as illustrated in Table 6.

Table 6 - Stowage Limit Dimensions for Over Width OOG Cargo

No.	Explanation	20' FR (cm)	40' FR (cm)
L	Max. allowed length for over width cargo	532	1145
B	Min. distance to flat rack outer end (Stowage on Main deck) 30 cm clearance from the corner posts	30	30
	Min. distance to flat rack outer end (Stowage on Cargo hold)	50	50
C	Cell guides of the vessel under deck		

Source: Compiled by author.

2.7.2.3 Other Considerations for O/W

Consideration should be given not to loading the unloading channel of the first unloading port of the adjacent row. The over width of cargo protruding from the side of the flat rack is less than the gap between the row and its adjacent row, that is, when the over width of cargo (Including the thickness occupied by securing devices) is within 10cm (3.9'), the over width container does not occupy the adjacent row. When stowing in the cargo hold, due to the tight arrangement of the cargo in the cargo hold and the limitation of the ship unit structure, there is only the thickness of the cell guides between the two rows of containers in the hold, which leads to the over width part extending to the adjacent stowage position when stowing the over width cargo. must be set aside for stowage over width OOG cargo. When the over wide container is loaded in the cargo hold, it should also be considered that the left-over wide container / right-over wide container should not be loaded on the lowest tier with only one container located in the compartment structure; The left/right over wide container shall not be carried in the corresponding leftmost/rightmost location of the cargo hold, as illustrated in Figure 12.

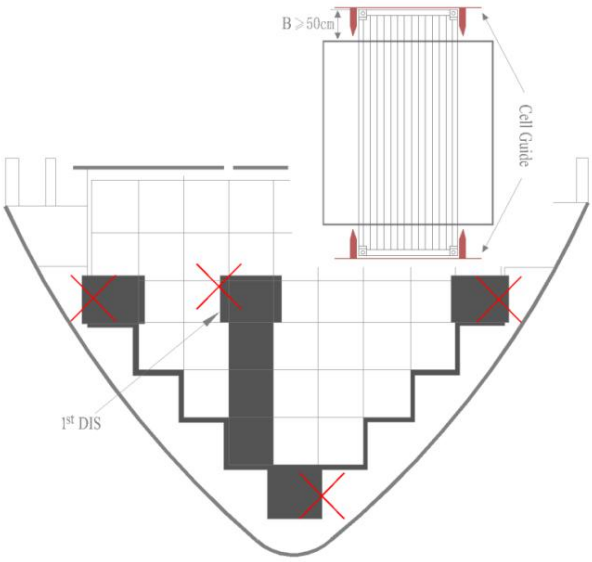


Figure 12 - Schematic Diagram of Stowage Restrictions for Over Width OOG Cargo (Cargo Hold)

Source: Compiled by author.

2.7.3 Over Height

2.7.3.1 Deck Stowage for O/H

For over height OOG cargo, it is not suitable to stack any other containers on top of the containers. The top of other cargo stowed in the front area of the bridge house will lead to the increase of the blind area of the ship, which has a great influence on the visual observation of the ship during navigation and the visual impact of the captain when navigating the ship when inbound, outbound and berthing, unberthing. According to the requirements of the SOLAS Convention on the visual range of bridge house, the sea surface visual range seen from the driving position should not be shielded by corresponding distance (Twice the hull Length Overall (LOA) or 500m, whichever is smaller) from the front of the bow to the range of 10 degrees on either side under any possible draught, trim and deck loading within the normal allowable range (Pan, 2006). Over height containers are often stowed on the top tier

of general containers on deck. The stowage software can only identify the stowage of the High Cube container (HQ) but cannot judge the actual excess dimensions of OOG cargo. Therefore, the blind area of bridge house caused by improper OOG cargo stowage is easily ignored in the stowage process, which exceeds the limit value of the blind area required by the normal navigation of the ship, resulting in potential danger to the ship; If it is on the first deck, the upper deck of the row cannot stow other cargo, resulting in a large area of dead space, which is not desirable when the cargo quantity is sufficient.

2.7.3.2 Cargo Hold Stowage for O/H

When stowed in the cargo hold, it is often loaded on the top tier of the hold. The effective height of cargo hold of container ships is usually designed according to the integral multiple of the container height of 8.5 ft (The top 2 ~ 3 tiers of large container ships tend to be designed according to 9.5ft), and then the surplus is reserved. When selecting over height containers in the cargo hold, it should be checked whether the overall height of the stack is less than the effective height of the cargo hold. Otherwise, the cargo in the hold will be damaged by the hatch cover. On the contrary, the corresponding stacking tiers should be reduced.

2.7.4 Over Weight

2.7.4.1 Deck Stowage for O/Weight

For stowage of Over weight OOG cargo, the securing strength of stowage on the flat rack and the local strength limit of the hull at bearing position should be considered. To ensure the reliability of securing between OOG cargo and flat rack, it should be selected near the drift center of the ship as much as possible (Burnson, 2014).

2.7.4.2 Cargo Hold Stowage for O/Weight

If the Over Weight OOG cargo is loaded in the cargo hold, the slots should be determined after a comprehensive trade-off. If it is loaded on the top tier of the cargo hold, it may be damaged due to Overweight, which makes the bottom containers exceed its design load; If it is loaded on the lower tier, it may lose more space on the upper tier, because other containers are not allowed to be loaded on the upper tier.

2.8 Stowage and Handling Precautions

2.8.1 Stowage Points

The load-bearing strength of the flat rack depends on the H-Beam Girders on both sides of the stowage surface. When loading OOG cargo such as steel products, iron castings, or heavy machinery, shall not be bestowed on hardwood panels alone but shall be evenly distributed on the bottom plate stowage surface of the flat rack as far as possible longitudinally and transversely, the overall stress shall not be borne by hardwood panels and the bearing beams below them (TIS-GDV, 2006). must be jointly participated by the main bearing steel beams, as illustrated in Figure 13.

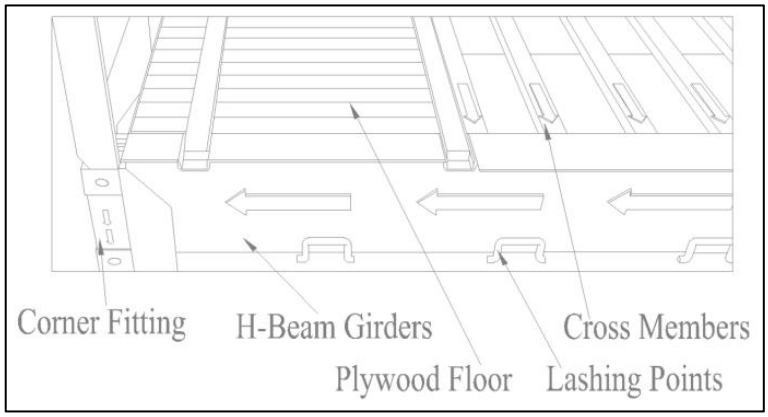


Figure 13 - Schematic Diagram of flat rack H-Beam Girders and Other Load-bearing Components

Source: Compiled by author.

Sleepers of the same width as the flat rack or H-Beam Girders (equipped with anti-slipping bedding) must be provided to support the base, which must pass through the hardwood paneling area to the H-Beam girder around the stowage surface and transfer the weight to the H-Beam girder so that the weight of the OOG cargo is evenly distributed over the entire length. The weight of the cargo is dispersed by using dunnage with a large contact surface to reduce the load-bearing of stowage surface per unit area. Such supporting beams are called “Bedding". The Bedding should be paid for adequately. Short wood chips and wooden pallets should not replace the sleepers selected for base support. Softwood such as pine should not be used. Hardwood with a tight texture and without serious cracks, decay, or moth-eaten defects, should be used as much as possible, as illustrated in Figure 14.

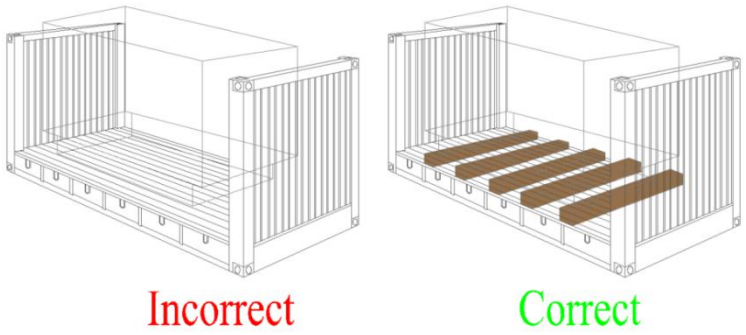


Figure 14 - Schematic Diagram of Over Weight Cargo Stowage and “Bedding” Laying

Source: Compiled by author.

2.8.2 Key Points of Loading & Unloading

When loading OOG cargo, attention should be paid to adjusting the cable to prevent the hull swimming from affecting safe operation, minimize the draft difference of the

ship, and keep the ship as free from heeling as possible to ensure that the flat rack base can contact the stowage surface at the same time when OOG cargo is stowed, and prevent the deformation of the stowage deck surface or cargo hold bottom and the flat rack base. In addition, it may cause the lower side of the cell guide in the hold to be squeezed and impacted by the flat rack column, which will affect the safety of cargo lifting (Aqua Air Enterprises, 2021).

CHAPTER 3 SECURING OF OOG CARGO

3.1 Main Attributes

The common securing methods can be divided into flexible securing (Lashing belt or Lashing rope) and rigid securing (Rigid securing such as welding or Baffle plate) for OOG cargo. The surface of the cargo cannot be damaged, so flexible securing is mainly adopted. The cargo loaded on the ship is bound by chains, wire ropes, lashing strap, shackle, turnbuckle, and other devices so that OOG cargo can be stowage to the flat rack (Hu, 2020). Ensure that OOG cargo will not slipping and/or overturning due to the influence of ship movement during navigation, avoid causing cargo damage, and even endanger the safety of the whole ship and the crew on board (Wu, 2012).

3.2 Types and Methods of Effective Securing

The securing of OOG cargo adopts different methods, which can be used alone or in combination as appropriate. The factors that determine the lashing effect are the quality of lashing materials and fixing points, and the lashing method. Considering the stress characteristics of OOG cargo, the length of most OOG cargo is much larger than the width and height, which is arranged longitudinally. It is unlikely to turn over lengthways for this kind of cargo, but it is necessary to set chocking to stop moving. They can be divided into a square (mostly crate) and cylindrical (mostly tank) based

on the shape of OOG cargo.

3.2.1 Square Crates

3.2.1.1 Own Lashing Eyes

For square crates with special lashing eyes, generally, there is detailed design securing schemes according to the lashing eyes. Only reasonable securing is needed, according to the lashing eyes. It is worth noting that the upper tie-up point shall not be lower than the center of gravity.

3.2.1.1.1 Cross Lashing

Cross Lashing applies to cargo units with lashing eyes against sliding and tipping. Refers to the lashing method in which one end of the rope is directly securing to the lashing eyes of the cargo and the other end is securing to the lashing eyes of the flat rack base. Adopt the way of cross-cable tension of the same side securing rope, as illustrated in Figure 15.

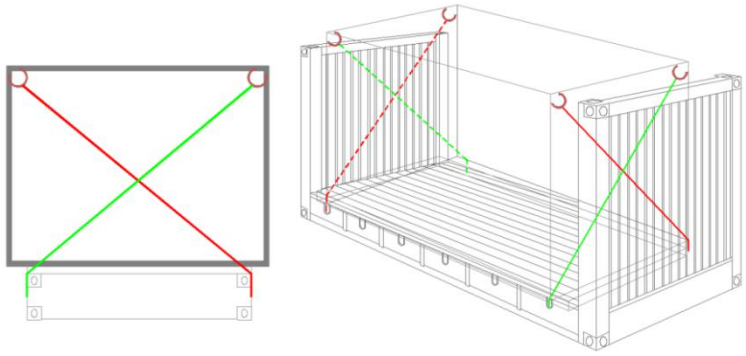


Figure 15 - Schematic Diagram of Cross Lashing for Square Crates

Source: Compiled by author.

3.2.1.1.2 Vertical Lashing

Vertical Lashing is suitable for cargo with lashing eyes, which can protect against tipping. However, against sliding is not good, which is often applied to the lashing

with insufficient intermediate space that can't realize Cross Lashing. Refers to the lashing method in which one end of the rope is directly securing to the lashing eyes of the cargo and the other end is securing to the lashing eyes of the flat rack base. Adopt the principle of nearest lashing, as illustrated in Figure 16.

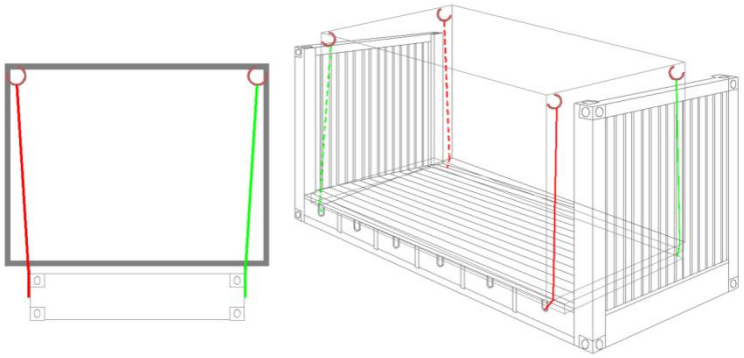


Figure 16 - Schematic Diagram of Vertical Lashing for Square Crates

Source: Compiled by author.

3.2.1.2 No Lashing Eyes

In addition to supporting or packing, the following methods can be adopted for cargo without lashing eyes:

3.2.1.2.1 Top Over Lashing

Top Over Lashing is wound around the top of the cargo by Straight Lashing. And both ends of the rope are securing to the lashing eyes of the flat rack H-Beam Girders, as illustrated in Figure 17.

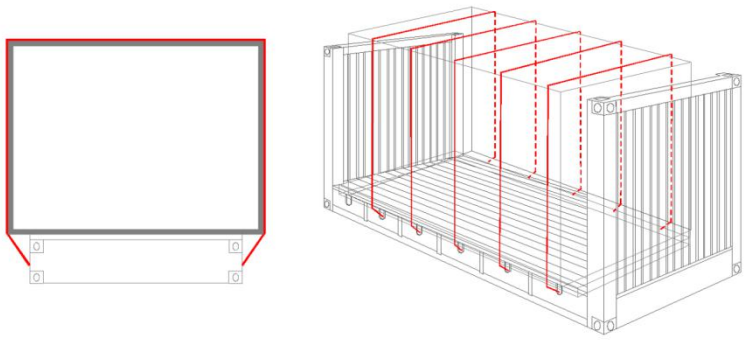


Figure 17 - Schematic Diagram of Top Over Lashing for Square Crates

Source: Compiled by author.

The lashing method increases the horizontal friction between the bottom surface of the cargo and the flat rack by applying downward pressure along the vertical direction, so it is also called Friction loop Lashing or Tie-down Lashing. Although the static friction between the cargo and the bearing surface can prevent the cargo from moving to a certain extent, the vibration and impact generated during the transportation of the cargo cannot completely prevent the cargo from slipping in the loop, strictly speaking, it is not included in the calculation of lashing force to prevent cargo from slipping and/or overturning. It should be combined with other securing methods, which are commonly used in combination with Horizontal half-loop lashing, which can prevent cargo from sliding laterally. But it is not recommended to use it in combination with Vertical half-loop lashing, which can prevent cargo from sliding longitudinally (Jagelčák. & Sanigal, 2013).

3.2.1.2.2 Vertikal Loop Lashing

Vertikal Loop Lashing wraps the lashing cable around the cargo to form a ring sleeve, which is securing on one side of the cargo. This securing method can effectively prevent the cargo from sliding to the opposite side and be used in pairs symmetrically left and right, also known as the Clashing System. There should be at

least one group before and after if the OOG cargo is long (one piece at the left and right of each group). This method can only restrain the lateral movement of cargo. It is necessary to cooperate with a chocking to prevent the cargo from sliding longitudinally preferred for OOG cargo without lashing eyes, as illustrated in Figure 18.

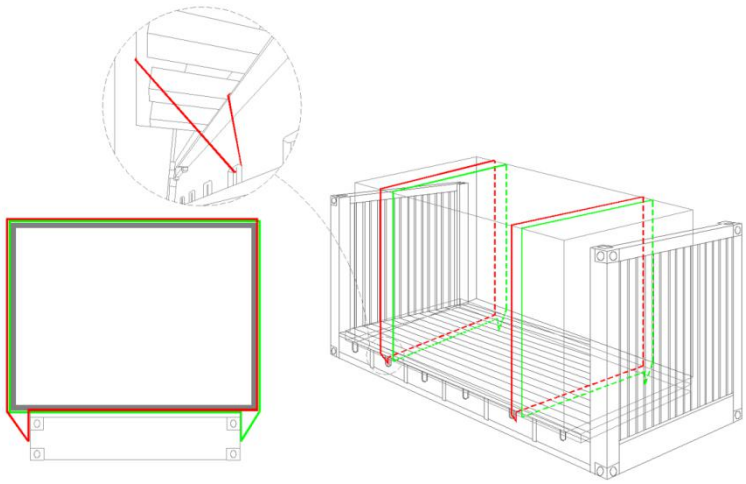


Figure 18 - Schematic Diagram of Vertikal Loop Lashing for Square Crates

Source: Compiled by author.

3.2.1.2.3 Horizontal Half Loop Lashing

Horizontal Half Loop Lashing (Side Direction) is a lateral securing of OOG cargo, which can effectively prevent lateral sliding. The securing position should be as low as possible. Generally, Timber Planks are nailed into the transverse surface of the crate to resist the rope so as not to slide down (Charles Bliault and North of England P&I Association, 2007). However, it can't effectively prevent the cargo from overturning and is generally used in conjunction with Top Over Lashing, as illustrated in Figure 19.

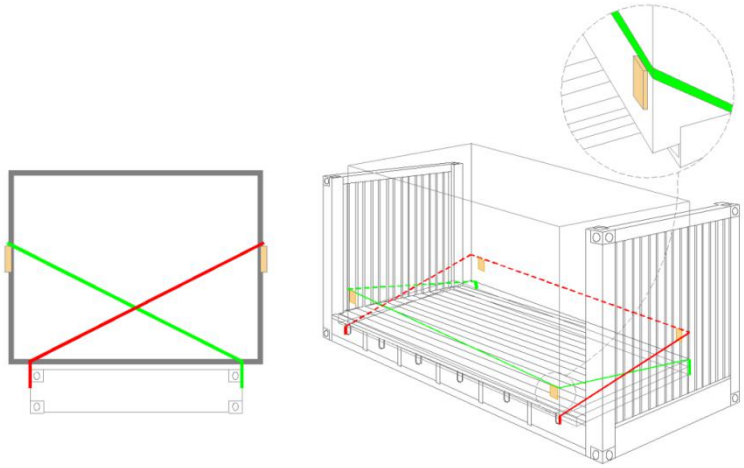


Figure 19 - Schematic Diagram of Horizontal Half Loop Lashing (Side direction) for Square Crates

Source: Compiled by author.

3.2.1.2.4 Horizontal Half Loop Lashing (Length Direction)

Horizontal Half Loop Lashing (Length Direction) is a longitudinal securing of OOG cargo, which can effectively prevent longitudinal sliding. The securing position should be as low as possible. Generally, Timber Planks are nailed into the longitudinal surface of a crate to resist the rope to not slide down. It can replace chocking as longitudinal support, as illustrated in Figure 20.

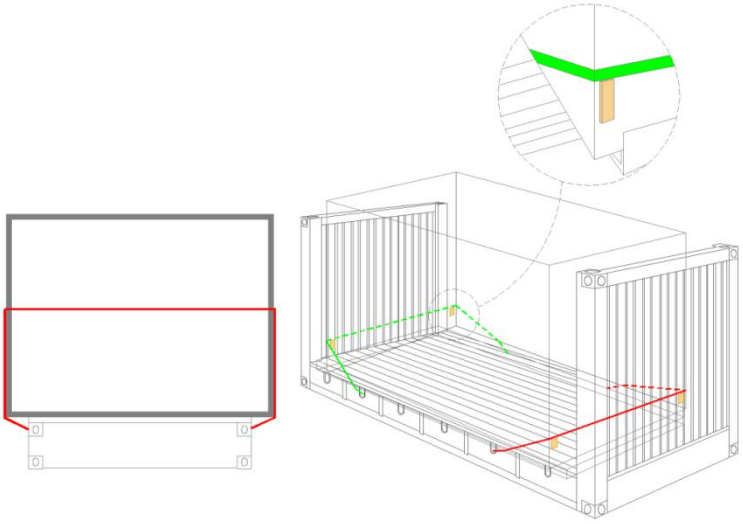


Figure 20 - Schematic Diagram of Horizontal Half Loop Lashing (Length Direction) for Square Crates

Source: Compiled by author.

3.2.1.2.5 Cross Head Lashing (Spring Lashing)

Cross Head Lashing (Spring Lashing) is similar “Ring lashing” can be made to create lashing eyes for OOG cargo without lashing eyes, so it is also called Head loop Lashing. The crate is stressed transversely as a whole, which is a good securing way against sliding and tipping, as illustrated in Figure 21.

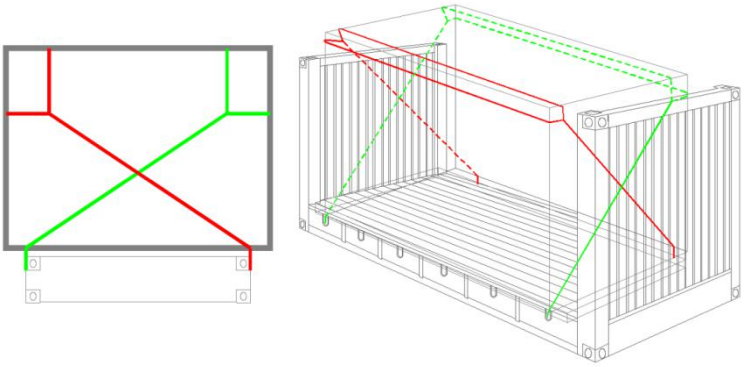


Figure 21 - Schematic Diagram of Cross Head Lashing for Square Crates

Source: Compiled by author.

3.2.2 Cylindrical Tank

3.2.2.1 Own Lashing Eyes

For a cylindrical tank with special lashing eyes, generally, there is detailed design securing schemes according to the lashing eyes. Only reasonable securing is needed, according to the lashing eyes. It is worth noting that the upper tie-up point shall not be lower than the center of gravity.

3.2.2.1.1 Cross Lashing

Cross Lashing is suitable for cargo units with lashing eyes against sliding. Refers to the securing method in which one end of the rope is directly securing to the lashing eyes of the cargo and the other end is securing to the lashing eyes of the flat rack H-Beam Girders. Adopt the way of cross-cable tension of the same side lashing rope, as illustrated in Figure 22.

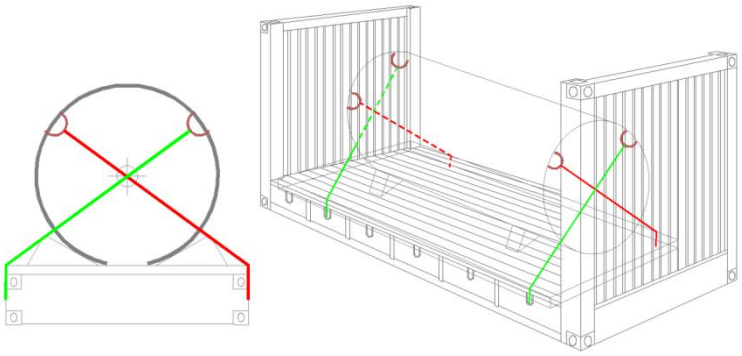


Figure 22 - Schematic Diagram of Cross Lashing for Cylindrical Tank

Source: Compiled by author.

However, this securing method is an invalid securing method against tipping. When the cargo moves in parallel due to the ship's inertia, the cargo may slip in reverse with the lashing eyes as the center point.

3.2.2.1.2 Vertical Lashing

Vertical Lashing is suitable for cargo with lashing eyes, which is effective against tipping. But the against sliding effect is not good. So, it is often used for securing with insufficient intermediate space and unable to realize Cross Lashing. Refers to the lashing method in which one end of the rope is directly securing to the lashing eyes of the cargo and the other end is securing to the lashing eyes of the flat rack base. Adopt the principle of nearest lashing, as illustrated in Figure 23.

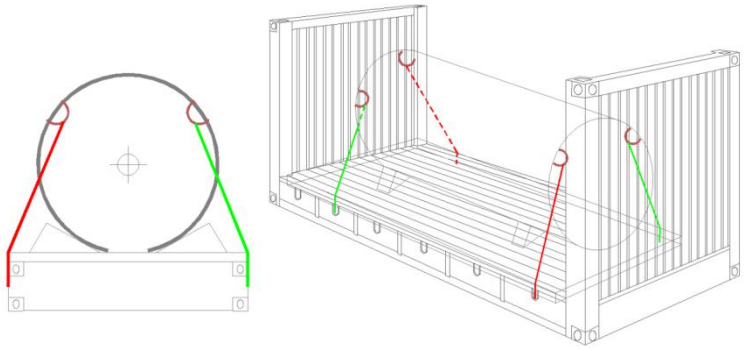


Figure 23 - Schematic Diagram of Vertical Lashing for Cylindrical Tank

Source: Compiled by author.

3.2.2.2 No Lashing Eyes

In addition to supporting or packing, the following methods can be adopted for cargo without lashing eyes:

3.2.2.2.1 Top Over Lashing

(1) With cradle

A “Cradle” suitable for the cargo is usually used under the cargo to limit the lateral rotation of the cargo during the transportation of cylindrical cargo. Usually, it needs to be customized according to the overall dimensions of cylindrical cargo. Rubber

pads are usually arranged between the inner side of the Cradle and the cargo to prevent sliding, as illustrated in Figure 24. In addition, Top Over Lashing, a good securing method, is used to prevent OOG cargo from moving up and down when the ship is pitching and/or heaving (Jagelčák. & Sanigal, 2013).

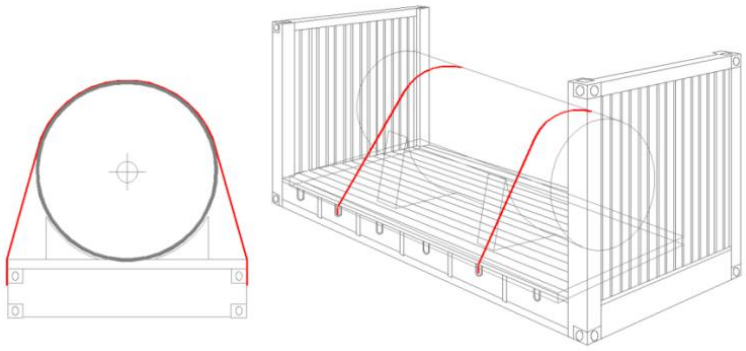


Figure 24 - Schematic Diagram of Top Over Lashing for Cylindrical Tank (With cradle)

Source: Compiled by author.

(2) No Cradle

For cylindrical tank cargo without a cradle, Top Over Lashing must be forced. The key is to nail triangular wedging into the hardwood layer on the front and back sides of the cylindrical tank. At the same time to prevent the column from moving on the flat rack. However, the triangular wedging will destroy the strength of the wooden strip at the base of the flat rack. It is a good practice to cushion the whole wooden gasket plate at the bottom of the flat rack and nail the triangular wedging on the gasket, which can increase the effective friction force and avoid the damage of the bearing surface of the flat rack. The height of the wedging should be at least R/3 (One-third of the cylinder tank), as illustrated in Figure 25.

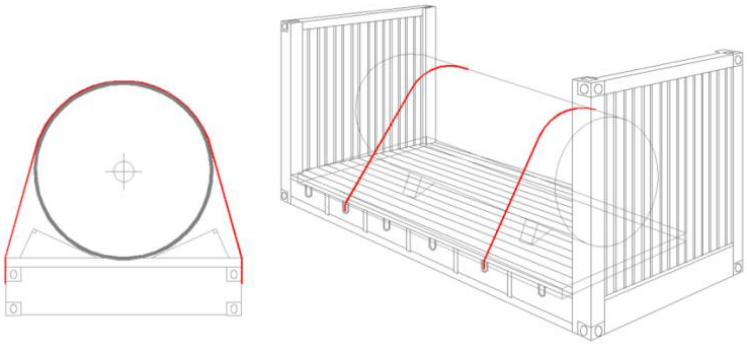


Figure 25 - Schematic Diagram of Top Over Lashing for Cylindrical Tank (No cradle)

Source: Compiled by author.

3.2.2.2.2 Vertikal Loop Lashing

If there is no special bracket or triangular wedging, it is recommended to use Vertikal Loop Lashing, which must be used in pairs and wedged as much as possible, as illustrated in Figure 26.

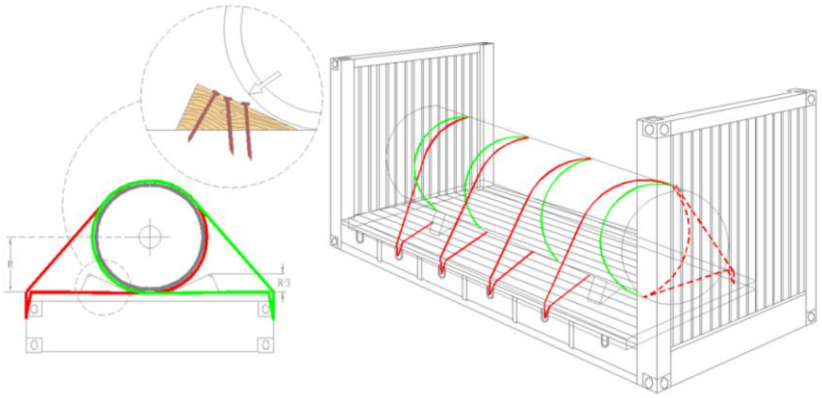


Figure 26 - Schematic Diagram of Top Over Lashing for Cylindrical Tank

Source: Compiled by author.

Vertikal Loop Lashing is also recommended for securing cylindrical tanks with special brackets or diagonal braces mentioned above.

3.2.3 Wheeled Cargo (Ro-ro Cargo)

When stowage, securing Wheeled cargo (Ro-ro cargo) (such as forklifts, excavators), the wheelbase size of wheeled cargo must be considered to determine whether the cargo exceeds the limit. For example, the two sides of the caterpillar of large excavators often exceed the width of the flat rack. The Ro-ro cargo is stowed on sleepers as a whole, securing with proper ropes, and the wheels are securing with wooden blocks. The wooden jacking is reasonably set to support the axle and lift the Ro-ro cargo. The height of wooden blocks must be the same as that of tires to reduce the tire pressure. The safety of cargo is ensured by the cooperation of jacking, blocking, and lashing (Tang, 2012).

3.3 Principles and Precautions for Securing

OOG cargo securing shall be carried out under IMO MSC/Circ.745 *Cargo Securing Manual* and *Good Seamanship Practice* shall be operated regarding the securing methods and requirements in *Cargo Securing Manual.* The effectiveness of the securing scheme shall be calculated. With the OOG cargo stress analysis, the lashing scheme is determined to effectively improve the lashing effect.

3.3.1 Planning and Preparation Before Loading

OOG cargo shall be securing effectively by the consignor before arriving at the loading port according to relevant international specifications. The securing effect must be approved by the carrier before shipment (Yang, 2010). Generally, the captain and chief officer of the shipping company check the securing scheme of OOG cargo to judge whether the cargo can keep relatively static with the ship under the action of securing force, that is, to determine the effectiveness of securing. After determining

the relevant requirements of securing the load, the port party shall apply professional lifting apparatus (Over height Frame) and ship according to the pre-prepared stowage drawing.

3.3.1.1 Inspection of OOG Cargo

It is important to collect necessary information and check necessary equipment in time before OOG cargo is loaded. Obtain manifest of OOG cargo for details such as the port of destination, weight, oversize, type, existing packaging form, and special requirements of the cargo owner (if any) (Liu, 2016). 60% of the cargo's total mass loaded in 50% of the freight container's length is based on experience (Li, 2020). So, it is important to determine the Center of Gravity of OOG cargo. The weight of cargo should be concentrated on the flat rack. When carrying OOG cargo packed in crates, it is necessary to confirm the marking position of the outer center of gravity of the crate (Marked by circle and cross) and the lifting point position (Marked by chain) in time to serve as an important reference for securing and keep the safety of OOG cargo and operators, as illustrated in Figure 27 (Jiang & Wang, 2012).

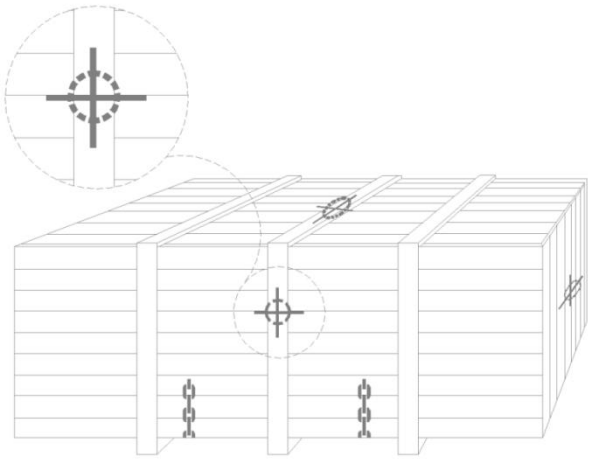


Figure 27 - OOG Cargo Gravity Center and Lifting Point Position Diagram

Source: Compiled by author.

3.3.1.2 Inspection of Flat Rack

3.3.1.2.1 Effective Mark Check

Check the flat rack's front and rear base positions to confirm the maximum load (the difference between Maximum gross weight and tire weight, Net weight (Permissible payload)), and compare the weight of OOG cargo. Those exceeding the maximum load that the flat rack can carry will be rejected, as illustrated in Figure 28.

Figure 28 - Schematic Diagram of Flat Rack Permissible Payload (Examples)

Source: Compiled by author.

3.3.1.2.2 Confirm the Height of the Flat Rack Bottom

The flat rack height of a 20' flat rack is (223cm / 87.80'). The 40' flat rack is used to stow more OOG cargo, so its bottom is properly thickened, and the rack height is (195cm / 76.77'). Therefore, for a 20'flat rack, the cargo may not be super high, but it will Over height for a 40' flat rack, as illustrated in Figure 29.

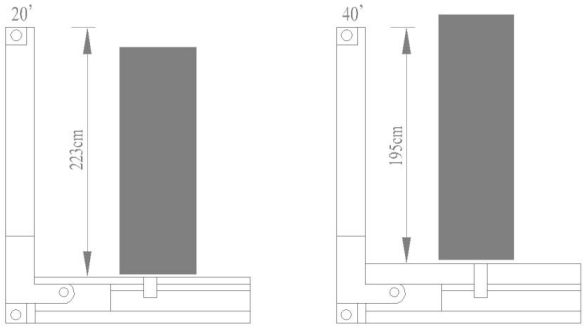


Figure 29 - FR with Different Height of flat rack Bottom

Source: Compiled by author.

3.3.1.2.3 Synchronization Setting of Folding Racks

The racks at both ends of the flat rack must be erected or laid down simultaneously. It is forbidden to erect one end and lay down the other end, and make sure that it has been locked using a bolt.

3.3.1.2.4 Confirmation of Lashing eyes and Precautions for Use

When tying OOG cargo by the flat rack with specially designed lashing eyes, and shall not use any other eyes on the flat rack except the specified eyes. “Stake pockets closing bars” means that when the flat rack is loaded with steel pipes, vehicle tires, and other cargo, plugs (Square timber columns) should be placed around it to prevent the cargo from sliding sideways. In addition, when the flat rack is transversely securing by using the triangular wedge, due to the “reaction” of the triangular wedge, the insufficient supporting force of the transverse triangular wedge is prevented, and the reliability of the transverse securing device is increased, as illustrated in Figure 30.

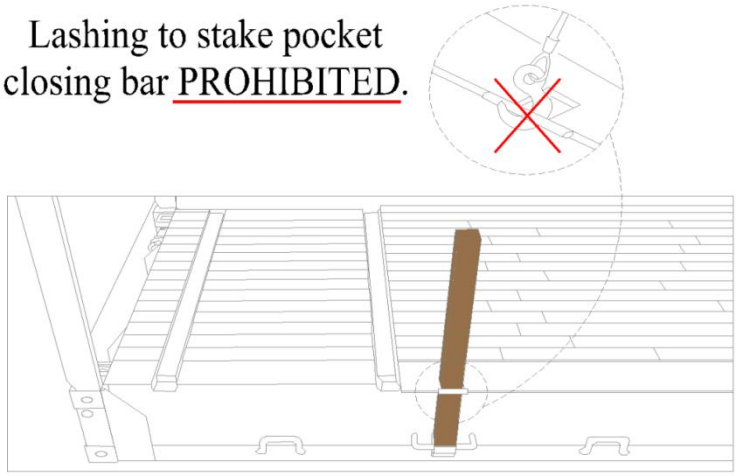


Figure 30 - Design and Use of “Stake pockets closing bars”

Source: Compiled by author.

The lashing eyes welded to the outside of the H-Beam Girders at the base of the flat rack for securing OOG cargo are divided into strong lashing eyes (Charles Bliault and North of England P&I Association, 2007). Strength limit warnings for flat rack lashing eyes should be strictly observed to prevent lashing from concentrating on a certain reinforcement point, as illustrated in Figure 31.

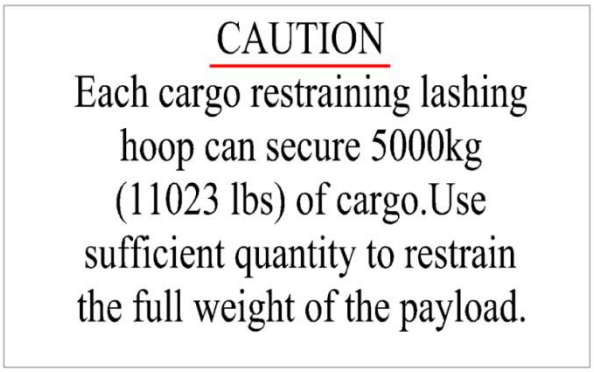


Figure 31 - Warning Board of the Limit Strength for the Lashing Eyes

Source: Compiled by author.

3.3.1.2.5 Chocking Correct Settings

When OOG cargo in a crate is placed on the flat rack, there must be a certain gap between it and the racks at both ends. So, it is necessary to use chocking to bring effective longitudinal support to avoid horizontal movement. It is unscientific to use only wooden wedges for direct fixation. The wooden wedge cannot be fixed to the stowage surface of the flat rack with nails when the OOG cargo is long, and the crate blocks the hardwood panel in the middle of the stowage surface. Moreover, the usage of nails on hardwood panels is generally undesirable, which destroys the overall strength of the flat rack. In addition, the strength of several nails is insufficient, as illustrated in Figure 32.

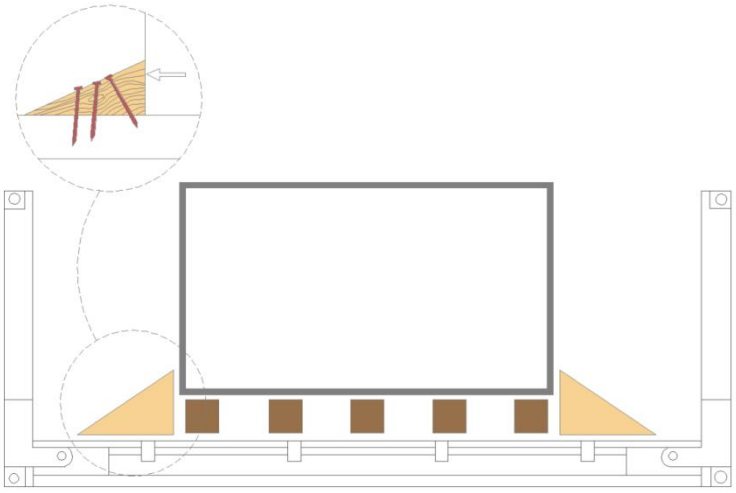


Figure 32 - Schematic Diagram of Using Triangle Wedge to Make Choking Setting for Crates (Incorrect)

Source: Compiled by author.

Use thick crossbeam overlap to longitudinally resist the gap between the upright post of the baffle and the crate to achieve “wall to wall". Use small square timber of appropriate size to embed the gap between the upright post near the baffle end and the iron plate of the baffle. Properly connect the square timber with nails to build and fix the whole wooden bracing. When the cargo is short, and a long support frame is needed, it is necessary to use wooden oblique “X-shaped” fixed diagonal braces to prevent the wooden support frame from being deformed by force. Moreover, a lashing strap is needed to prevent the wooden support frame from shifting during transportation (Charles Bliault and North of England P&I Association, 2007). Wooden dunnage is used on the underside of OOG cargo to transfer the weight of the cargo to the H-Beam Girders on both sides and increase the friction force between the rough surfaces, as illustrated in Figures 33.

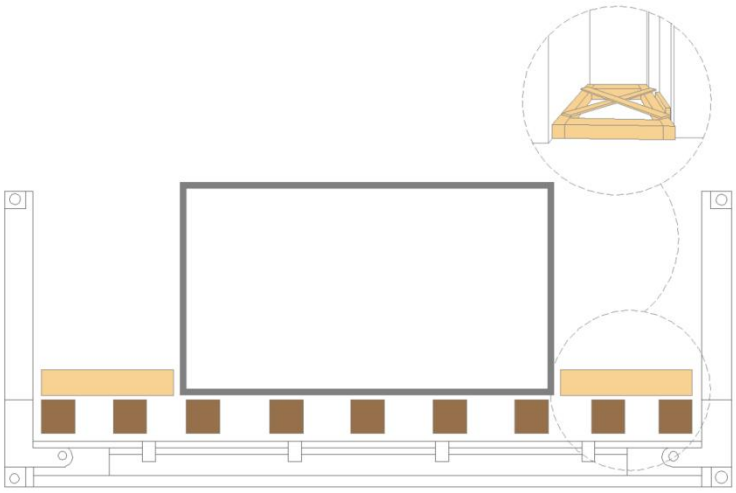


Figure 33 - Schematic Diagram of Wood Bracing (Choking) for Crates (Correct)

Source: Compiled by author.

It can be found, comparing the left/right Chocking setting schematics in the following figure, that in the left diagram, the crossbeam overlap is set in the middle of the columns on both sides of the racks. The rack's iron plate is used as the support, which is easy to cause the deformation of the racks. Strictly follow the correct setting on the right side, as illustrated in Figure 34.

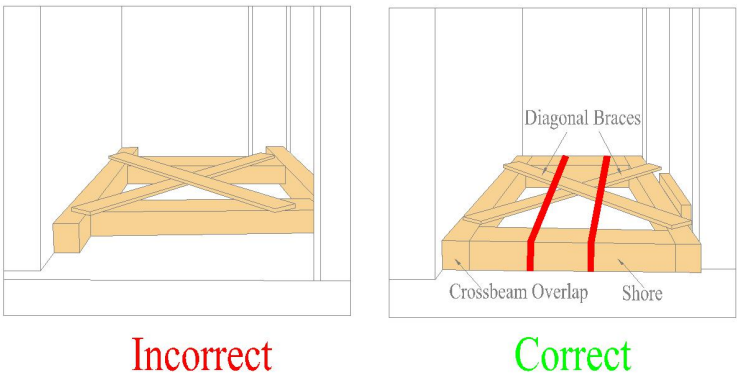


Figure 34 - Schematic Diagram of Simple Chocking Setting (Comparison)

Source: Compiled by author.

If complex holders are used, the support contact surface is close to or exceeds the height of the center of gravity of the cargo, which can effectively prevent the cargo from overturning under the condition of effectively ensuring the longitudinal displacement of the cargo, as illustrated in Figure 35.

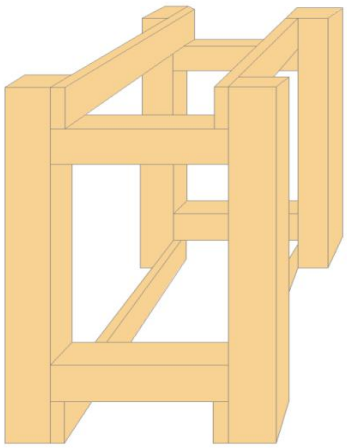


Figure 35 - Schematic Diagram of Complex Chocking Setting

Source: Compiled by author.

3.3.2 Work While Onboard (During Voyage)

The securing materials of OOG cargo will be loose to a certain extent due to the vibration of the main engine and/or the action of wind and waves. Therefore, it is necessary to check and confirm the securing of OOG cargo during the voyage, which contributes to correct the problems in time and prevent accidents. However, it is often difficult to check and reinforce effectively after loading, in the actual cargo stowage process, due to the limitation of storage location. Therefore, higher requirements are put forward for OOG securing. Ensure that the securing is durable and effective before shipment, and ensure that the securing is still effective when the ship moves forward in wind and waves. The actual sea conditions should be

monitored well during the voyage. The captain should correct navigation countermeasures when the ship swings rough when encountering wind and waves, such as adjusting the course properly to slow down the swaying and slow down the impact appropriately. Avoid long-term navigation in sea areas with bad weather or high surge conditions, which can minimize the possibility of accidents of OOG cargo. The assignment of the crew to check will effectively detect the problem of lashing and obtaining more significant results when the ship has a small rolling. The firmness of OOG lashing should be carefully checked based on ensuring safety. At least two ship's crew should go at the same time to take care of each other. It should be handled in time once looseness is found (DNV, 2006).

3.3.3 Work When Unloading

Before the ship arrives at the destination port of OOG cargo for unloading, the OOG cargo shall be inspected and photographed as fully as possible to keep evidence for possible cargo damage complaints in the future. If the port side thinks that the OOG cargo can't be unloaded by "pre-lashing", it needs to be operated by U/C mode. It should be reported to the company in time, and photos should be taken for retention, and the port side should be required to provide relevant certification.

CHAPTER 4 STRENGTH OF SECURING OOG CARGO

4.1 Strength of Securing Devices

In production, OOG cargo stowage on the flat rack must be securing in various ways. The stowage must be reliably connected to the lashing eyes and will not fall off during the voyage. The specific application is comprehensive, so as to effectively prevent OOG cargo from slipping and/or overturning during maritime transportation. The corresponding measures of lashing force include “Breaking Strength” (BS), Maximum Securing Load (MSL) Calculated Strength (CS), and Safety Factor (FS) (Kim, 2015). Select the correct securing devices, such as Lashing strap, Wire rope, and Chain, and them in conjunction with turnbuckles and shackles, etc. Needs to be considered for the securing devices and the strength of the lashing eyes. There is no international standard for securing devices for non-standard cargo, whenever possible, the manufacturer's instructions should be consulted when making strength estimates.

4.2 Determination of the Securing Load

4.2.1 Calculation of the MSL for A Single Group

In the lashing of OOG cargo, multiple devices should be used in tandem for the same strand of securing devices, e.g., wire rope connected to a shackle and then to lashing eyes. For the strand as a whole, the “weakest” part of the strand needs to be taken into account when calculating the MSL of the strand (Charles Bliault and North of

England P&I Association, 2007). This means that the maximum safe load that can be applied to the group is the minimum of the MSL applied to the individual securing devices (He et al., 2019). If the strength of the lashing eyes is less than the strength of the securing devices, then the strength of the lashing eyes should prevail. On the lashing eyes, each lashing eye should not be connected by more than three straps, and the direction should not be the same as each other (He et al., 2019).

4.2.2 Accounting for the Effectiveness of the Overall securing

When a ship is underway, it is subject to bumps, etc. Thus, acceleration generates inertial forces. The empirical method is used to determine whether the MSL provided by the material to which the load is secured the lashing requirements for that OOG cargo. As a general rule of thumb, the combined breaking strength of the lashings to be used must be at least 1.8 times the weight of cargo to be secured (Aqua Air Enterprises, 2021).

4.3 Principles and General Considerations for the Use of Securing Devices

To ensure the safe transportation of OOG cargo, the following points need to be focused on, which include but are not limited to the following matters (Marine & Offshore., 2020):

OOG cargo should be securing according to the prescribed parts. If necessary, dunnage should be added to the tied parts to avoid direct contact of the tied ropes with the surface of the cargo. It should be ensured that the cargo will not be subjected to pressure, moisture, corrosion, and abrasion. For cargo with wooden outer packaging, use high-strength flexible securing as far as possible. When lashing OOG cargo, with reasonable lashing angles, and the lashing of the same side of the cargo to ensure that the force on each lashing is balanced and kept at the same tightness

and not easily loosened. The mix of lashings and securing used needs to be similar in elastic properties. Each component of the securing system must have a similar MSL. Otherwise, only the weakest can be counted. Try to ensure that the length of the lashing device is as short as possible and as close to the OOG cargo as possible to reduce the uneven distribution of tension in the different securing devices, securing in the same lashing direction and that the direction of the lashing should be as close as possible to the direction of the intended inhibiting effect. It should be ensured that there is no friction between the ropes during navigation to ensure that the OOG cargo is easy to unfasten in time when in an emergency. It is strictly forbidden to cut corners and ensure that an authorized body produces the strapping material. A valid certificate of conformity accompanies it. The weight of the cargo to be secured is fully taken into account. First-hand and second-hand materials, with different securing loads. Turnbuckle is used for securing, not directly with a hook, but in conjunction with shackles, wire rope clips, etc. Avoid small radius edge corners or sharp edges where possible without reducing the strength of the lashing. In any contact areas that cannot be avoided, install suitable “chafing gear” and/or “softeners”. Shafts and coils of steel should be protected by plastic tubes at the contact points between the perforated ropes and the cargo edges to prevent excessive wear rope, which may affect the strength of the lashing. Avoid knotting of securing devices. The securing should be rechecked in good time after the ship has been exposed to heavy weather. The lashing strap used for friction lashing should maintain effective pre-tension for a long period and should not slacken due to slight settling or shrinkage of the cargo. It is necessary to use certain methods to limit the looseness of the fasteners, often in the form of wire wrapping, to ensure that they do not become slack during sea transport due to the rocking of the ship and the cargo (Annexes, 2013).

CHAPTER 5 CONVENIENT DESIGN OF CHECKING SOFTWARE

5.1 Safety Stowage and Cargo Securing Checking Procedures

Through the investigation and understanding of OOG cargo transportation technology and daily operation, combined with domestic and international norms applicable to OOG cargo transportation, a set of safety assessment methods have been established for OOG cargo stowage and securing checking procedures. This safety check list is used to manage the OOG cargo stowage process risks, confirm whether the securing strength of OOG cargo is sufficient, and provide necessary basis support for the relevant parties who cannot load OOG cargo due to unqualified bundling. OOG cargo freight operators must follow this process, as illustrated in Figure 36.

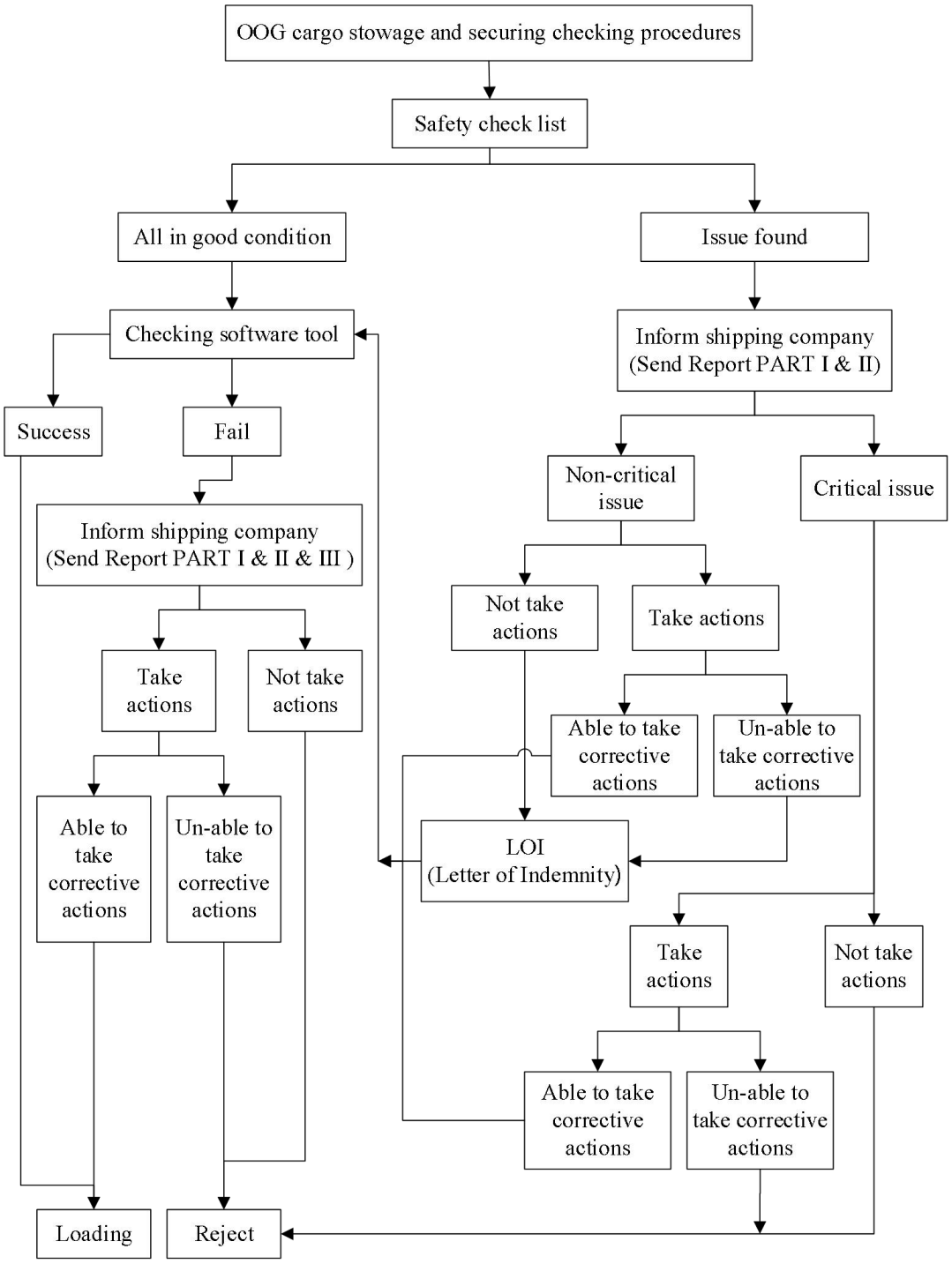


Figure 36 - OOG Cargo Stowage and Securing Checking Procedures

Source: Compiled by author.

5.2 Safety Check List

To facilitate the application of the above checking procedures in engineering practice, a safety check list used to assist the stowage and securing OOG cargo is developed and designed using Visual Basic computer language, which is concretely implemented to complete the quick assessment. As the carrier of the OOG cargo, the shipping company reserves the right to inspect before loading. When OOG cargo does not meet the requirements of the SOLAS Convention or is considered unsafe, the shipping company could refuse to load. Should always adhere to the concept of "Details determine success or failure", try to find out all the unsafe factors that may cause damage to the cargo, and grasp an effective judgment basis. OOG cargo must be confirmed by the chief officer at the wharf yard before stowage. At the same time, the securing conditions shall be checked in advance, and the captain finally decides whether loading is allowed.

For the OOG cargo stowed in the uppermost tier of the cargo hold, necessary to wait until the hatch cover is closed before loading the deck cargo. Whether it is loaded on the top of the deck cargo or on the deck where no other deck cargo is stacked, it is usually the last time before cargo handing is completed. Long-term check of OOG cargo is not allowed in the above situations, which will affect the overall operation progress of cargo handling. To ensure that the shipment time of OOG cargo will not be delayed due to tedious inspection and confirmation, and the necessary inspection items will not be missed and shipped blindly, it is very urgent and necessary to improve the effect and efficiency of OOG cargo inspection and confirmation. To make the captain and chief officer make a reasonable judgment quickly and effectively, a relatively comprehensive safety check list is prepared, which is also a risk assessment table, as illustrated in Table 7.

Table 7 - Safety Check List

NO.	Type	Item
1	Mandatory	Are the binding ropes/belts intact, free from wear, no broken strands, no knotting, and no corrosiveness?
2	Mandatory	securing devices without signs of deformation or fracture?
3	Mandatory	Is the OOG cargo strap tight enough?
4	Mandatory	Are the number of lashing straps on each side of OOG cargo consistent?
5	Mandatory	Is the storage surface clean, dry, and oil-free?
6	Mandatory	Are anti-slip pads properly laid? (Metal to Metal stowage is not allowed)
7	Mandatory	Is the dunnage installed correctly?
8	Mandatory	Is the cargo packed in good condition, without leakage, and are they placed in the suitable flat rack?
9	Mandatory	Is the center of gravity and lifting position marked, and are the positions reasonable?
10	Mandatory	Are the OOG cargo pre-stowage according to the size, and is the corresponding loading space reserved?
11	Mandatory	OOG cargo freight transportation has not blocked the adjacent unloading port channel due to over length and/or over width?
12	Non-mandatory	Chocking wooden support was used to fix the Wall to Wall longitudinally, and the transverse was securing with the lashing strap?
13	Non-mandatory	Have all documents been prepared for OOG cargo stowage? Manifest / Letter of Indemnity (LOI)
14	Non-mandatory	OOG cargo that does not require special lifting equipment or cranes?
15	Non-mandatory	OOG cargo is not provided with designated lashing eyes?
16	Non-mandatory	Are the direction of the wire rope clips set with the wire rope correct? Is the amount used enough?
17	Non-mandatory	Is the flat rack posted with a valid CSC Placard?
18	Non-mandatory	Securing Angle of bow shackle?
19	Non-mandatory	Are the assembly supervisor on duty? How many people?
20	Non-mandatory	Are there any special OOG cargo requirements?

Source: Compiled by author.

According to the actual field evaluation in the safety check list, any item of “Mandatory” (Item 1 to Item 11) in the critical judgment column cannot be selected as “NO". If selected “NO", then it needs to be improved. After completion, you can continue to check the next step.

According to the feasibility of actual operation, the safety check list is combined with the software to conduct a more comprehensive inspection of the binding of OOG cargo, providing a gist for the OOG cargo. According to the safety check list, the relevant defects found shall be reported in writing, and the unqualified cargo shall be guided for stowage and securing, providing strong evidence for the OOG cargo which cannot be corrected in time and cannot be loaded (Cui, Cheng, & Liu, 2019).

5.3 Development of the Software

5.3.1 Research Significance

In OOG cargo transportation, stowage and securing are important factors to ensure the ship's safety. After the stowage and securing plan is made, how to evaluate the securing effect correctly is the key. Its main significance is as follows:

(1) Improve the OOG cargo securing accounting model to make the accounting more scientific;

(2) It is convenient for crew members of container ships to calculate the cargo securing. It can also be used by the staff of logistics departments of shipping companies, shipping agencies, ports and docks, and the staff of classification societies. The paperless securing calculation is realized, which is convenient, fast, and practical;

(3) This can be used for students in training institutions and maritime universities.

The system provides the function of designing the securing plan. Students first design their plans and then complete the securing inspection to fully understand their lack of knowledge in securing OOG cargo. At the same time, it is also convenient for teachers to explain the knowledge of non-standard cargo;

(4) The software's stowage function and calculation method can provide support for improving the function of the ship stowage system. Ensure the safety of OOG cargo transportation and avoid major accidents at sea.

5.3.2 Software Development Prospects

At present, shipping companies and their fleets specialized in carrying awkward and lengthy cargo have designed and calculated special schemes for stowage. Suppose this kind of special design and calculation is used to check the securing scheme of OOG cargo. In that case, the workload is heavy and error-prone, the accuracy of calculation and verification is not clear, and the completion cost is high. Container ship cargo handling efficiency is high. Often a container ship in a docking port handling operation needs to stow a few or dozens of OOG cargo. There is no sufficient time and staffing for accurate calculation and check of OOG cargo binding. Therefore, it is imperative to develop this software (Shu, 2015).

5.3.3 Software Development and Application

The development and application of this software are based on practical application. Based on fully investigating the demand of the container shipping industry, through the research of OOG cargo stowage and securing effectiveness accounting process, the automatic evaluation system of OOG cargo unit binding accounting is developed by using language.

5.3.3.1 System Language Development Tools

The computer language used by the software, called Visual Basic, is a general object-based programming language developed by Microsoft. It is a visual programming language with a structured, modular, object-oriented, and event-driven mechanism that helps the development environment (Jiang & Liu, 2010). It uses a structured programming language, a visual design platform, an event-driven programming mechanism, a powerful database processing function, and other application programs to provide functions (Wang, Yang & Gao, 2020).

5.3.3.2 Software operation program

The software named “OOG Checker” is simple and easy to remember, showing OOG cargo as the main object. A checker is a person who is especially responsible for coordinating the stowage of containers in modern container terminals. Full consideration of the concept of modern shipping development, using computer programs to replace manual checking, that is, to achieve “Artificial intelligence.”

The specific process of the software system is that after the software is activated, the user needs to input the Vessel and Voyage information, flat rack information, and OOG cargo information. After the above data are saved, the safety check list is used for critical judgment. If the inspection items requiring mandatory compliance fail to meet the relevant standards, they will be directly rejected. Relevant reports will be issued to explain the relevant problems. The inspection will be completed; On the contrary, the verification can continue smoothly. The effective MSL of each group (The smallest MSL in series) can be obtained, and then the total MSL of one side can be summarized (Generally transverse). The software automatically calculates whether the result is qualified or not, which means whether the shipment can be carried out smoothly or whether the corresponding binding reinforcement is needed

before the final verification is completed, as illustrated in Figure 37.

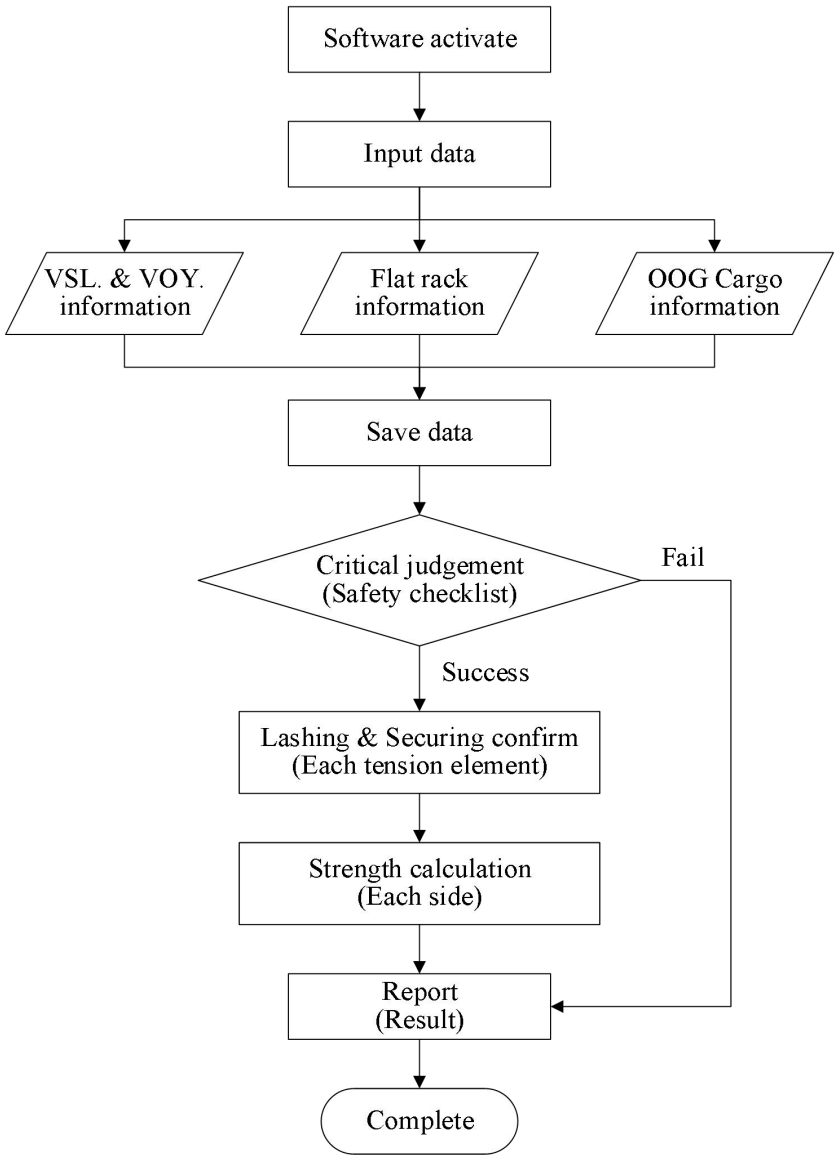


Figure 37 - Software Systems Use Flow Charts

Source: Compiled by author.

5.4 Application Examples of OOG Cargo Check Software

A specific example verifies the effectiveness of the software, and the realization

effect of the software function is also demonstrated.

5.4.1 Target Cargo

This application example takes the OOG cargo to be shipped by a shipping company container ship as an example to verify the security of the binding scheme and the practicability and reliability of the software tool. The actual product photos, as illustrated in Figure 38.

Figure 38 - Example Photo of OOG Cargo

Source: Compiled by author.

5.4.2 Screenshot of the Interface of the Software Check Process

5.4.2.1 Software Activate

To ensure the security of the system, the system designed a login interface for software activation. When the system is turned on, the login interface is first displayed. The software pre-set username and password to be used by authorized users, need to enter your username and password to enter the main window, click Login to make Software activate, and enter the main program interface as illustrated in Figure 39.

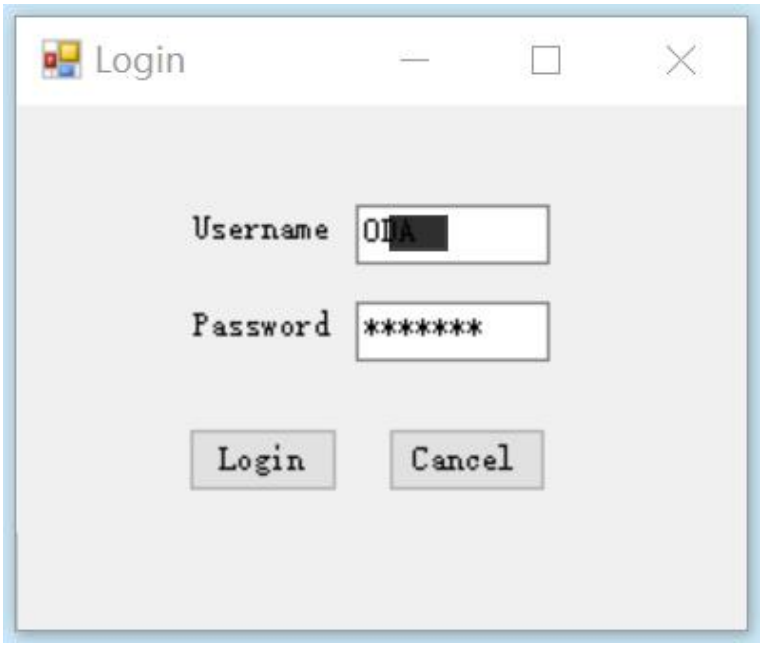


Figure 39 - Login

Source: Compiled by author.

There are six modules in total. The information is entered in the interface from 1 to 5 in the order from left to right, allowing the data of any interface to be modified later so that the entry of various information can be completed efficiently. The check procedure is carried out according to the “OOG Cargo Stowage and Securing

Checking Procedures.”

5.4.2.2 Vessel and Voyage Information

The interface includes the information of the vessel information and the voyage information. It can be known that the container vessel from the port of Kobe, Japan to delivers OOG cargo to Hong Kong, China. POL and POD using the common nautical “Port code” by selecting the standard name so that its expression has universal readability, as illustrated in Figure 40.

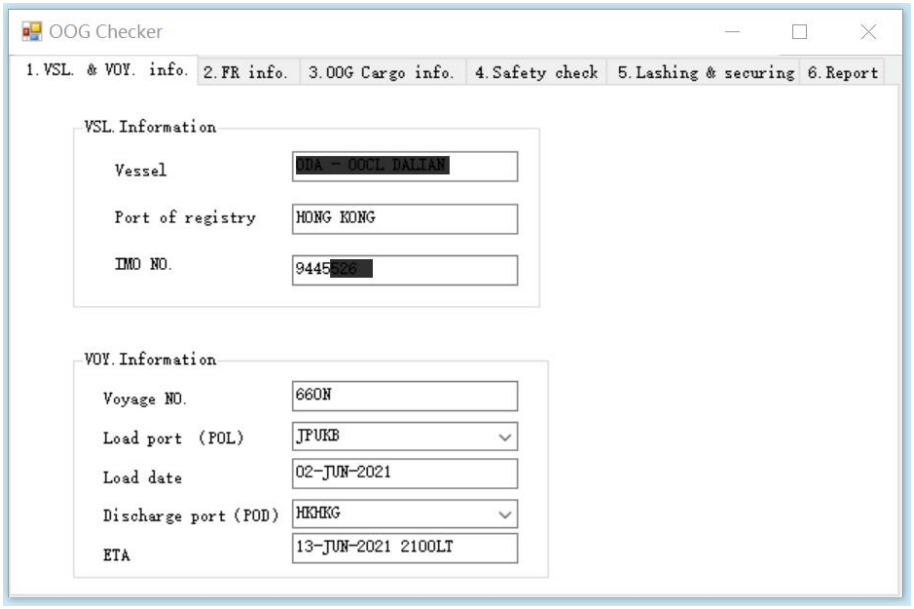


Figure 40 - Vessel and Voyage Information

Source: Compiled by author.

5.4.2.3 Flat Rack Information

After obtaining the flat rack number of the OOG cargo, the verification procedure of the flat rack number can avoid the final report error caused by the wrong entry of the flat rack number information and confirm the flat rack size. Subsequently, the NET weight is entered into the program by checking the information mark on the

longitudinal side of the flat rack base on-site, i.e., Permissible payload, as illustrated in Figure 41.

Figure 41 - Flat Rack Information

Source: Compiled by author.

5.4.2.4 OOG Cargo Information

The weight of the OOG shipment is confirmed and entered by comparing the manifest form with the label information on the outside of the cargo package to see if the Permissible payload of the frame container is exceeded. If the maximum allowable payload is exceeded, a warning dialog box “Warning! Overload!” By entering the six-digit code (Bay / Row / Tier) of the container's accumulation position, the accumulation area is displayed to remind the operator of the key monitoring of the accumulation area and support subsequent logical judgments. Using the OOG cargo size stated in the manifest as a reference, confirming the size of the excess cargo by actual measurement. According to different flat rack types, the corresponding oversize is automatically calculated and set based on different base

heights of different sizes of the flat rack. If the system judges that the over width of OOG cargo stowed on the main deck is less than 10cm, it will prompt “Other containers can be stowed on the Left and/or Right side", thus reminding the stowage staff to avoid unnecessary “Dead space.”

Regarding the software O/L line, the value of the Oversize cell is positive or negative to determine whether the extra-long OOG cargo is allowed to be stowed on the flat rack. Otherwise, it needs to be carried out in the way of “Un-containerized Cargo (U/C)". For oversize OOG cargo, the “OOG to FR distance” calculated by itself is used to determine whether stowage is allowed or not according to the theory described in section 2.7.2 above, combined with the stowage location (Region), and the corresponding prompt and alert dialog box will pop up automatically, as illustrated in Figure 42.

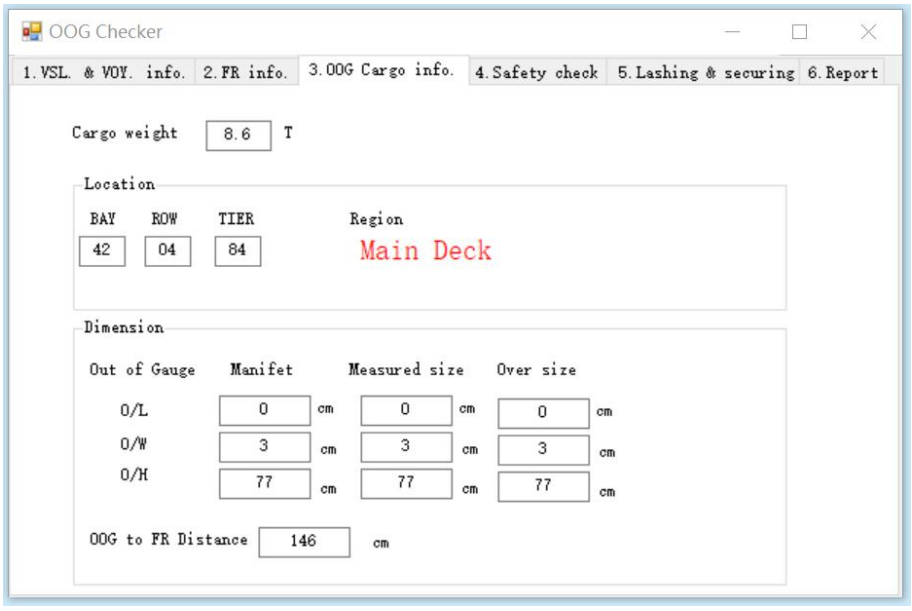
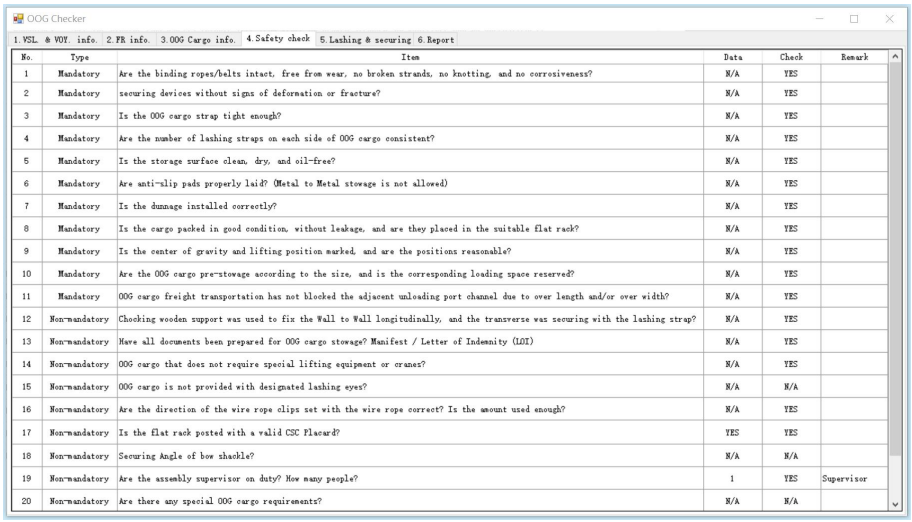


Figure 42 - OOG Cargo Information

Source: Compiled by author.

5.4.2.5 Safety Check List

The items mentioned above mainly focus on the safe loading of OOG cargo, but this item checks the items of Critical judgment by “Safety check list” for the lashing of OOG cargo. This includes the setting of “Mandatory” and “Non-mandatory” and the execution of the relevant settings of the program, as illustrated in Figure 43.



No.	Type	Item	Data	Check	Remark
1	Mandatory	Are the binding ropes/belts intact, free from wear, no broken strands, no knotting, and no corrosiveness?	N/A	YES	
2	Mandatory	securing devices without signs of deformation or fracture?	N/A	YES	
3	Mandatory	Is the OOG cargo strap tight enough?	N/A	YES	
4	Mandatory	Are the number of lashing straps on each side of OOG cargo consistent?	N/A	YES	
5	Mandatory	Is the storage surface clean, dry, and oil-free?	N/A	YES	
6	Mandatory	Are anti-slip pads properly laid? (Metal to Metal stowage is not allowed)	N/A	YES	
7	Mandatory	Is the dunnage installed correctly?	N/A	YES	
8	Mandatory	Is the cargo packed in good condition, without leakage, and are they placed in the suitable flat rack?	N/A	YES	
9	Mandatory	Is the center of gravity and lifting position marked, and are the positions reasonable?	N/A	YES	
10	Mandatory	Are the OOG cargo pre-stowage according to the size, and is the corresponding loading space reserved?	N/A	YES	
11	Mandatory	OOG cargo freight transportation has not blocked the adjacent unloading port channel due to over length and/or over width?	N/A	YES	
12	Non-mandatory	Chocking wooden support was used to fix the Wall to Wall longitudinally, and the transverse was securing with the lashing strap?	N/A	YES	
13	Non-mandatory	Have all documents been prepared for OOG cargo stowage? Manifest / Letter of Indemnity (LOI)	N/A	YES	
14	Non-mandatory	OOG cargo that does not require special lifting equipment or cranes?	N/A	YES	
15	Non-mandatory	OOG cargo is not provided with designated lashing eyes?	N/A	N/A	
16	Non-mandatory	Are the direction of the wire rope clips set with the wire rope correct? Is the amount used enough?	N/A	YES	
17	Non-mandatory	Is the flat rack posted with a valid CSC Placard?	YES	YES	
18	Non-mandatory	Securing Angle of bow shackle?	N/A	N/A	
19	Non-mandatory	Are the assembly supervisor on duty? How many people?	1	YES	Supervisor
20	Non-mandatory	Are there any special OOG cargo requirements?	N/A	N/A	

Figure 43 - Safety Check List

Source: Compiled by author.

5.4.2.6 Securing Confirm

This is done mainly by “finding” the “weakest” single group of ligatures and confirming their effective ligature strength. Subsequently, the effective values of their unilateral joint action are summed up, and a judgment is made as to whether the accumulation of load is allowed according to the requirements of the empirical formula, as illustrated in Figure 44.

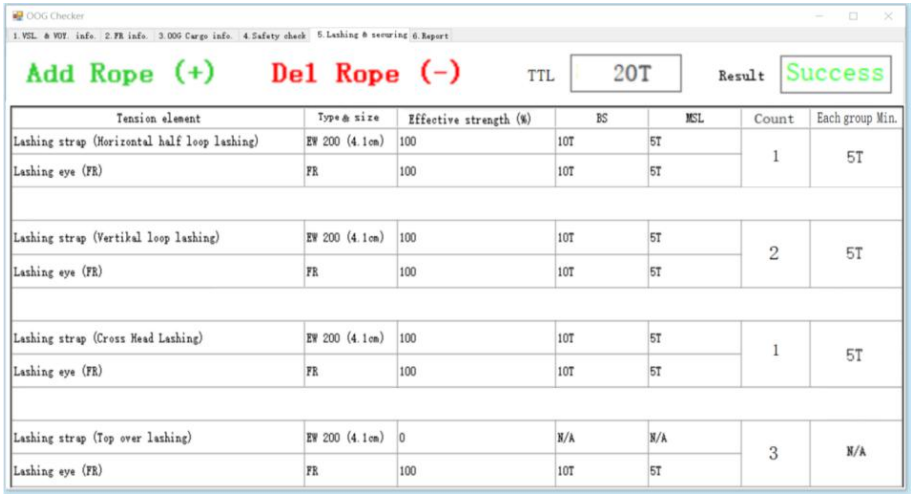


Figure 44 - Securing Confirm

Source: Compiled by author.

5.4.2.7 Report

Finally, it is possible to print a report on whether the target OOG cargo is allowed to be loaded or not based on the above judgment, which is highly practical, as illustrated in Figure 45.

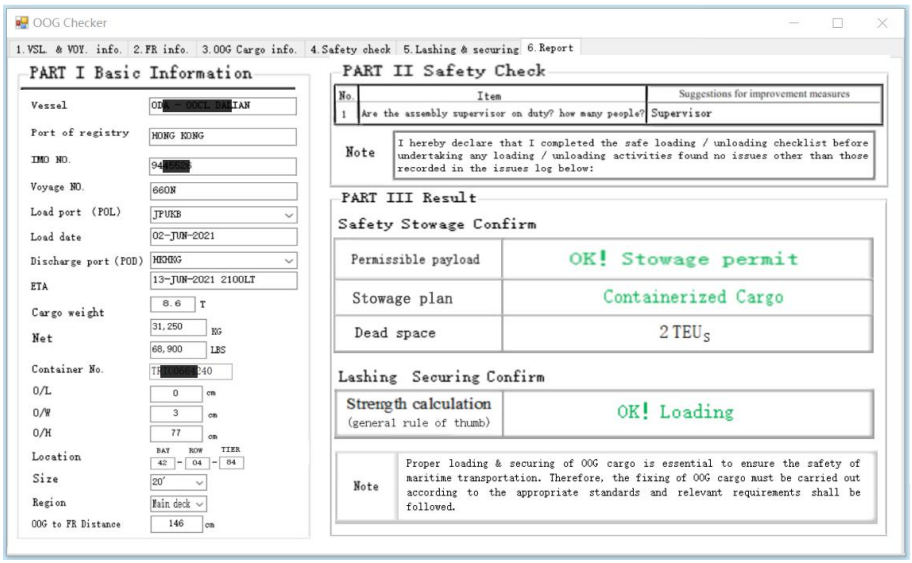


Figure 45 - Report

Source: Compiled by author.

In the above verification process, if there is no indication or alarm during the data input process, the OOG cargo of that size and weight is shown to meet the relevant requirements of the pre-stowage.

5.4.3 Software Verification Conclusion

According to the description of “Safety stowage and cargo securing checking procedures", OOG cargo is verified through the above six programs. The results show that this OOG cargo meets the requirements of safety stowage, securing confirm, can be loading.

5.5 The Practicability and Convenience of the Software

Through the effective implementation of safety check list and the integration with OOG cargo stowage, securing scheme inspection software, the complex calculation and inspection methods are conveniently applied to the project, which ensures the effective identification and evaluation of OOG cargo shipping reasonable binding scheme, greatly improves the efficiency of OOG cargo securing an inspection, and ensure the accuracy of inspection. The report of inspection results can be printed to facilitate other binding personnel to understand the securing scheme and safety and help and guide the safe transportation of OOG cargo.

The calculation method is standardized and simplified through programming to reduce the potential danger of OOG cargo confirmed only by experience and subjective consciousness as far as possible and assist the effective implementation of inspection procedures in increasing the actual operability. In this way, the theoretical model can be applied to engineering practice, providing a more reliable guarantee for

OOG maritime transportation, guiding the frontline personnel of ships to effectively supervise OOG cargo, ensuring the effective identification and evaluation of reasonable securing scheme for OOG maritime transportation, effectively ensuring the transportation safety of container ships and cargo, and ensuring the safety of port loading supervisors and daily ship supervisors (Tian, 2015).

It can realize the automation of securing scheme audit, which reduces the complexity of securing scheme design and ensures the security of the scheme. It is easy to operate and greatly reduces manpower, material resources, and financial resources. It is suitable for the front-line personnel of ships. It can effectively solve the problem that the shipping enterprises and the captain/chief officer / Duty officer do not systematically and professionally learn the relevant operations and standards of OOG cargo binding. It provides convenience for the duty personnel, solves the problem that the existing standard algorithm is too complex. The duty personnel can’t master and use it effectively. The effectiveness of OOG cargo shore binding can't be evaluated quickly because of too complex, improves the theoretical and practical operation ability of relevant personnel, and has important practical significance for the safe transportation of non-standard cargo units at sea.

CHAPTER 6 CONCLUSION AND PROSPECT

6.1 Conclusion

Based on the research and study of relevant knowledge and related literature on OOG cargo securing, this paper integrates the IMO, container shipping companies, classification societies, etc. Combined with ship transportation, the practice of OOG cargo, discussed in detail the types and methods of OOG cargo, flat rack and cargo securing, the safe stowage of OOG cargo, and the reasonable and practical securing system inherently have a more comprehensive understanding. Through systematic analysis, the working principles and methods are given, and the verification method for OOG cargo is put forward, which is verified by a calculation example of actual shipping. This research is necessary from the perspectives of ship safety, cargo integrity, and transportation economy to deeply study the methods of securing OOG cargo on the flat rack, safe and reasonable stowage, and effectiveness verification. For the front line of the ship, Reference, and application by staff in maritime container transportation.

Due to the limitation of personal research level, research time, knowledge, and data, the research content of this paper still has many shortcomings, which need to be improved in future research. At present, by checking the stowage, securing of OOG cargo with software, we can quickly and scientifically judge whether OOG cargo is allowed to be loaded and is suitable for the use of front-line ship personnel. However,

there are still some functions that cannot be realized, and the functions of the system need to be further improved, including but not limited to:

(1) The related information of OOG cargo can be displayed in the ship stowage system, but it cannot be imported into the developed software and needs to be manually input. In the future, the software can be matched with the ship's stowage system, Use the EDI data to realize the automatic import of information;

(2) The software has not checked the local strength of the stowage OOG cargo, cannot propose a whole dunnage usage plan;

(3) To reasonably and effectively ensure the safety of OOG cargo, the system simplifies the verification method. It is estimated under the assumption that each securing device is under the condition of uniform force. For the complex securing of OOG cargo, the influence of the load elasticity, geometric parameters, pre-tensioning, and other factors of each lanyard on the securing effect should be considered. Due to the uncertainty of some parameters, it is difficult to accurately calculate and evaluate the securing scheme of OOG cargo.

6.2 Prospect

The containerization of all kinds of groceries, that is, stowage OOG cargo on the flat rack, has become a new trend in the development of maritime container transportation. Some large-scale equipment used for general cargo ship transportation also has the trend of container ship transportation. It is bound to face a more complicated and dangerous stowage inspection procedure. From the point of view of container shipping companies, although OOG cargo can obtain huge profits, OOG cargo has great risks and responsibilities in shipping. Every link of safety stowage, securing is related to the safety of the ship and cargo. Lashing men or seafarers must

consider and conscientiously bind OOG cargo carefully, strictly control all links of the inspection, select binding material, calculate binding strength, keep a safety margin and ensure safety factors to ensure the safety of OOG cargo and ship. The only prudent and reasonable operation can effectively reduce the risk and cost, make OOG cargo operation institutionalized, standardized, normalized, and form a win-win situation for ship and cargo.

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