Optimizing Vehicle Loading to Improve Operational Safety at KMP. Dharma Ferry VIII

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Abstract.
Sea transportation by Roll-on/Roll-off (Ro-Ro) vessels requires the implementation of vehicle lashing according to standards to prevent cargo shifting and maintain the operational safety of the vessel. Observations at KMP Dharma Ferry VIII showed that there were still problems in the form of cargo density, inadequate lashing equipment conditions, limited loading and unloading time, and inconsistent implementation of procedures. This study aims to analyze the implementation of vehicle load lashing and the factors that influence its effectiveness. The study used a qualitative descriptive approach with a purposive sampling technique. The study population was all crew members involved in loading and lashing activities, while the sample consisted of Chief Officers, Bosuns, Helmsmen, and Classes. Data were collected through observation, semi-structured interviews, and documentation, then analyzed using data reduction, data presentation, conclusion drawing, Fishbone diagrams, and NVivo Project Map visualization. The results showed that the effectiveness of lashing was influenced by the condition of lashing equipment, consistency of procedure implementation, limited loading and unloading time, and human factors in the form of crew fatigue. It was concluded that improving operational safety requires regular maintenance of lashing equipment, consistent implementation of SOPs, more effective supervision, and optimal management of working time and crew adequacy.
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I. INTRODUCTION

Maritime transportation is a crucial means of supporting public mobility and logistics distribution in Indonesia, an archipelagic nation. Roll-on/Roll-off (Ro-Ro) vessels are a widely used mode of transportation, capable of transporting both passengers and vehicles at a relatively affordable cost. Operationally, shipping safety is significantly influenced by the implementation of standard vehicle lashings to prevent cargo shifting that could disrupt vessel stability, particularly during adverse weather conditions (Li et al., 2024; Pérez-Canosa & Orosa, 2024).

The phenomenon of lashing failure remains a cause of numerous Ro-Ro ship accidents. The European Causeway incident in 2018 demonstrated that inadequate cargo lashing caused the vessel to shift during rough weather. In Indonesia, the National Transportation Safety Committee (KNKT) investigation into the sinking of the KMP Tunu Pratama Jaya in 2025 also revealed that improper lashing and overloading were factors contributing to the loss of stability (Marine Accident Investigation Branch, 2020; KNKT, 2025).

Observations on the KMP Dharma Ferry VIII indicate that there are still challenges in implementing vehicle lashing. As the number of vehicles increases, deck space becomes very crowded, making it difficult to install lashings optimally. This situation results in some vehicles not being properly tied down and makes it difficult for the crew to conduct pre-sailing inspections (Siahaan et al., 2025; Li et al., 2024).

In addition to cargo density, the condition of the lashing equipment is also a concern. Several D-rings, lashing points, and ratchets were found to be corroded or damaged, reducing the effectiveness of securing the vessel. If these conditions are not promptly repaired, the risk of cargo shifting will increase and potentially compromise the operational safety of the vessel, particularly during high waves (Pérez-Canosa & Orosa, 2024; Li et al., 2024).

Based on these problems, this study aims to analyze the suitability of vehicle cargo lashing techniques on KMP Dharma Ferry VIII with applicable standard procedures. This research is important to support the improvement of operational safety of Ro-Ro vessels through the evaluation of lashing implementation in the field. The novelty of this research lies in the analysis of the implementation of lashing procedures based on real operational conditions on Indonesian domestic vessels, taking into account aspects of cargo density, crew readiness, and the condition of lashing equipment as the basis for compiling recommendations for improving shipping safety (Siahaan et al., 2025; Li et al., 2024).

II. RESEARCH METHODS

This study uses a qualitative descriptive approach to analyze the implementation of vehicle load shedding techniques on KMP Dharma Ferry VIII. This approach was chosen because it can describe actual conditions in the field through observation, interviews, and documentation, thus gaining an understanding of the suitability of the shedding implementation with applicable procedures. The research was conducted during the author's sea practice from August 2024 to August 2025 to obtain factual and comprehensive data (Sugiyono, 2022; Creswell & Creswell, 2023).

The study population included all crew members involved in vehicle loading and unloading activities on KMP Dharma Ferry VIII. The sample was determined using purposive sampling, selecting informants directly involved in the unloading process, consisting of the Chief Officer, deck officers, and deck crew, so that the information obtained was in accordance with the research objectives (Emzir, 2021; Sugiyono, 2022).

The primary research instrument was the researcher (human instrument), supported by observation guidelines, semi-structured interview guidelines, documentation, and field notes. Data collection was conducted through observations of the vehicle stripping process, interviews with the Chief Officer and crew, and documentation of equipment conditions and operational activities. The use of these three techniques enabled triangulation, thereby increasing the credibility of the research results (Creswell & Creswell, 2023; Sudaryono, 2021).

Data were analyzed using qualitative descriptive techniques through the stages of data reduction, data presentation, and conclusion drawing. Furthermore, the root causes of the problems were identified using a Fishbone (Ishikawa) diagram based on human, method, equipment, material, environmental, and management aspects. Then, alternative solutions were formulated using a problem-solving approach to generate recommendations for improving the effectiveness of vehicle braking (Sugiyono, 2022; Li et al., 2024).

The research began with problem identification, instrument development, and data collection through observation, interviews, and documentation during sea practice. This was followed by analysis using a qualitative approach and Fishbone diagrams. The final stage involved developing recommendations based on the analysis results to improve the implementation of vehicle lashing in accordance with Ro-Ro vessel operational safety standards and the provisions of the IMO CSS Code (IMO, 2021; Pérez-Canosa & Orosa, 2024).

III. RESULTSANDDISCUSSION

Observation results

Fig. 1. Position of the Load that is Too Close

The first case found was the placement of vehicles too close together on the car deck, so that the smoothing process could not be carried out optimally because the crew's movement space was limited. As a result, several vehicles have the potential to rub against each other during the voyage and access to the operational area is hampered. This condition is not in accordance with the Regulation of the Minister of Transportation Number 115 of 2016, which stipulates a minimum distance of 30 cm between vehicles and a minimum distance of 60 cm between vehicles and the ship's wall. Therefore, the arrangement of cargo that is too close together has the potential to increase the risk of shifting cargo and disrupt the safety of ship operations.

Fig. 2 Inclined and Frictional Loads

The second case involved a large truck (TB) that tilted during its voyage from Lembar Port to Padang Bai Port due to the lashing system being unable to support the vehicle's load optimally. This condition is inconsistent with the Minister of Transportation Regulation Number 115 of 2016, which stipulates that vehicles weighing 30–40 tons must be secured using at least four lashing gears with an appropriate safe working load (SWL) on each side of the vehicle. Furthermore, the lack of re-inspection of the lashing tightness during the voyage increases the risk of load shifting, vehicle damage, ship stability disturbances, and endangers navigational safety.

Fig. 3 Motorcycles Fall on Cardeck

The third case involved a motorcycle falling and hitting another vehicle during a voyage from Padangbai Port to Lembar Port during Ramadan. Observations indicated that the incident was triggered by high traffic volume, excessively tight motorcycle traffic, and inadequate safety measures. These conditions caused the motorcycle to lose balance, causing damage to surrounding vehicles, such as cracked hulls and broken brake handles, and increasing the risk to ship operational safety.

Fig. 4 Ratchet Strap Assembly

The fourth case involved the discovery of several lashing devices that were unsuitable for use, such as worn, rusted, and jammed ratchets. Observations revealed that these conditions reduced the effectiveness of the lashing, made the cargo lashing process difficult, and increased the risk of vehicle shifting during shipping. These findings indicate that maintenance and regular inspections of the lashing devices are still suboptimal, potentially compromising the safety of cargo on the car deck.

Interview data

Based on the results of the interview with the Chief Officer, it can be concluded that the vehicle lashing procedure at KMP. Dharma Ferry VIII is in principle in accordance with applicable operational standards, however, under heavy load conditions, its implementation in the field is not always optimal due to space and time limitations.

The success of lashing is influenced by internal factors such as the readiness and condition of the lashing equipment, crew discipline, and officer supervision. External factors include weather conditions, vehicle density, and limited loading and unloading time. Furthermore, the condition of some lashing equipment, which is partially unusable, also reduces the effectiveness of load securing.

Limited loading and unloading time also reduces the accuracy of lashing installation and inspection. Therefore, improvements in the suitability of lashing equipment, disciplined implementation of standard operating procedures (SOPs), and better planning of work schedules are needed to ensure safe, fast, and efficient lashing operations.

Based on the interview with the Bosun, it can be concluded that the success of cargo lashing on a ship does not depend solely on a single factor, but is influenced by a combination of internal and external factors. Internal factors include the condition and readiness of the lashing equipment, the number of available crew, and the level of discipline in implementing SOPs. Meanwhile, external factors include loading and unloading time pressures at the port, weather conditions, and vehicle density on deck, which directly affect the effectiveness and quality of lashing implementation.

Based on the results of interviews with the Driver, it can be concluded that the limited time for loading and unloading significantly affects the quality of vehicle load lashing, because the crew is required to work quickly so that the lashing tightening and checking process is not always carried out thoroughly. Therefore, to improve the safety and efficiency of lashing, it is necessary to have proper conditions and quantity of lashing tools, supervision of the implementation of SOPs, and more realistic loading and unloading time arrangements so that the crew can work safely and optimally.

Based on the results of interviews with Klasi, it can be concluded that increasing lashing activities needs to be focused on the availability and suitability of lashing tools, more adequate loading and unloading time arrangements, and better work supervision, so that the implementation of vehicle load lashing can take place safely, quickly and efficiently.

IV. DISCUSSION

Fig. 5 Fishbone Diagram

1. **Method**
   Lashing procedures on KMP Dharma Ferry VIII are in place and adhere to operational standards, but their implementation is inconsistent. Under heavy load conditions, space and time constraints result in suboptimal lashing installation and re-inspection, increasing the risk of cargo shifting. Therefore, oversight and discipline are required in implementing lashing procedures.
2. **Machine (Lashing Equipment)**
   Observations indicate that some lashing equipment, such as ratchets, chains, and hooks, is experiencing wear, corrosion, or damage, reducing the effectiveness of cargo securing. These conditions, combined with the high volume of loading activities, mean that lashing is not always carried out according to procedures. Improved maintenance and routine inspections of equipment are needed to ensure cargo safety during shipping.
3. **Manpower (Deck Crew)**
   Deck crew members experienced fatigue due to the additional sailing schedule and limited personnel. This reduced concentration and accuracy during the lashing operation, resulting in suboptimal cargo securing procedures. To strengthen the analysis, interview results were processed using NVivo and visualized in Project Maps to demonstrate the relationship between causal factors, the lashing operation, and its impact on operational safety on KMP Dharma Ferry VIII.

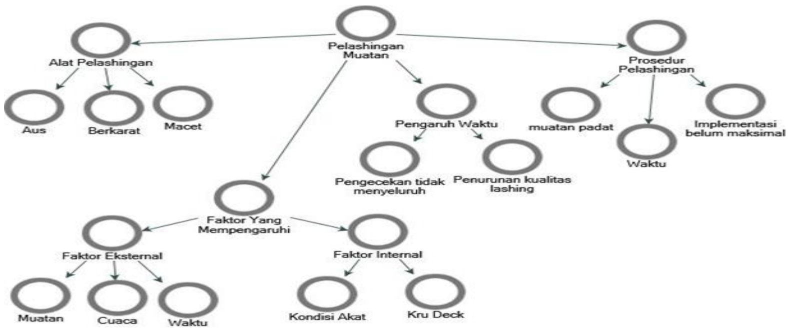

Fig. 6 Maps Project

Based on the results of the interview analysis using NVivo, four main factors were obtained that influenced the effectiveness of cargo lashing on KMP Dharma Ferry VIII, namely the condition of the lashing equipment, the implementation of procedures, time constraints, and internal and external factors. The analysis results showed that some worn, rusty, and jammed lashing equipment reduced the effectiveness of vehicle lashing, while lashing procedures were not consistently applied, especially when the load was dense and loading and unloading time was limited. In addition, time pressures resulted in incomplete lashing inspections, while internal factors such as crew and equipment conditions and external factors such as load density, weather, and operational hours also influenced the quality of lashing. Overall, the NVivo Project Map shows that lashing effectiveness is the result of the interaction of these various factors, not solely dependent on the existence of procedures.

Previous Research

Research by Wardana (2024) entitled "Securing Cargo with Lashing on the Ro-Ro Ship Mv. Sulawesi Leader" This research states that the process of securing cargo with lashing on the Ro-Ro ship MV. Sulawesi Leader has not fully met the standards, especially due to several factors, namely: inconsistent implementation of cargo lashing (lashing), suboptimal condition of lashing tools and equipment, and variations in procedures and supervision during the lashing process.

Table 1. Comparison of research with Case Study 1

No	Main Factors	Impact	Solution
1.	Lashing is not routine and lack of lashing tools well maintained	Moving loads and damage occurs vehicle	Checking and lashing treatment in a way periodically
2.	Lack ofABK's understanding of procedure *lashing*	Use of lashing Noacc ording to standards	Directions and traininglashing procedure
3.	*Lashing* saggydur ing the voyage	Risk of cargo damage Ands hip safety	Re-tightening *lashing*du ring cruise

Research conducted by Yutis (2021) entitled "The Effect of Lashing Errors on Cargo and Balance on the KMP. Athaya Ship" explains that the implementation of lashing on ships has not been optimal due to time constraints during loading and unloading, which results in some vehicles not being tied according to procedures and potentially causing shifting of cargo when the ship is sailing.

Table 2 Comparison of research with Case Study 2

No	Main Factors	Impact	solution
1.	Limited anchor time (±45 minutes) so that binding is not optimal	*Lashing* Noeffe ctively, the vehicle can move or shift	Rechecking the binding after loading
2.	Vehicle binding frequency Still low	Risk changeship stability	The binding is adjusted to condition cargo
3.	Equipment *lashing* not enough treatedro utinely	Potential damage to cargo and ship	Inspection And maintenancelas hing tool
4.	Error inload binding	Accident risk and crew safety and passengers	Increased accuracy when binding Increased accuracy moment binding

According to Muttaqin (2025) entitled "Optimization of Vehicle Lashing in Cardeck to Improve Operational Safety on KMP. Dharma Kencana VII" the results of his research show that there are two main problems in the process of lashing vehicles on Ro-Ro ships, namely the lack of supervision of watch officers and crew on lashing and minimal maintenance of lashing tools such as snatch blocks and wires that are no longer suitable for use. Through SWOT, IFAS, and EFAS analysis, solutions were obtained in the form of increasing the number of watch crews, training ship crews on lashing standards, and regular maintenance of lashing tools to minimize the risk of vehicle accidents during shipping and improve the overall operational safety of the ship.

Table 3 Comparison of research with Case Study 3

No	Main Factors	Impact	Solution
1.	Lack of supervision officerguard and crew guard during the stripping process	Suboptimal lighting, potential for negligence and cargo accident	Compilationmore effective guard schedules and additions number of watch crew
2.	High crew workload and physical fatigue	Decreased alertness and response todangerous conditions	Recruitment crew addition to reduceworkload
3.	Lack of crew concern for the condition of the lashing equipment	Risk of cargo damage and disturbance ship stability	Crew training and upgrades discipline as well asresponsibility

From the explanation of the research results and comparison with several relevant studies, conclusions can be drawn regarding the results and discussion of the problems faced previously.

1. Lack of maintenance on the washing tools

Optimal lashing equipment significantly impacts the smoothness, speed, and safety of the for vehicle cargo on board. Properly functioning lashing equipment ensures that cargo is securely secured and meets standards, preventing movement during shipping and maintaining vessel stability.

Several factors can make lashing equipment difficult to use, including rust, jammed fastening mechanisms, and wear on the wire or chain due to prolonged use without regular maintenance. Furthermore, a lack of regular inspection and maintenance can also prevent lashing equipment from being ready for use when needed, hindering the lashing process and reducing load safety.

2. The load shedding procedure is not implemented optimally. The implementation of the vehicle load shedding procedure is

A crucial aspect in ensuring the safety of the cargo and maintaining the stability of the ship during navigation. Properly performed fastening prevents shifting and movement of the cargo due to the effects of waves, ship maneuvers, and weather conditions.

Therefore, the implementation of vehicle cargo clearance must refer to established provisions, including the Minister of Transportation Regulation Number 115 of 2016 and guidelines from the International Maritime Organization (IMO, 2020), which comprehensively regulates the procedures for loading, arranging, and securing vehicle cargo on ships.

Based on the results of observations and analysis carried out in this research, it is known that the implementation of vehicle load shedding generally refers to applicable regulations and standards. However, in practice various deviations and imperfections are still found, especially at the parking stage and the load shedding process. Some of the main problems found include the following:

a. The distance between vehicles is too close

Vehicle cargo is arranged on the car deck with excessively narrow spacing between vehicles. This situation not only hinders access and movement for crew during the unloading process, but also increases the risk of collisions between vehicles, cargo damage, and jeopardizes crew safety while working.

The irregular arrangement of vehicles also hampers the crew's circulation route to the stern area and other operational areas, thereby reducing work efficiency and increasing the potential risk of accidents. In accordance with the Regulation of the Minister of Transportation Number 115 of 2016 concerning the Safety of Vehicle Transportation on Ships, every vehicle and its cargo must be arranged with adequate distance and secured using a standard lashing system to prevent shifting, friction, and endangering shipping safety.

And the distance between the front and rear of each vehicle is at least 30 cm. For vehicles whose sides are adjacent to the ship's wall, the distance is 60 cm calculated from the inner wall layer or the outer side of the hull.

b. Waiver of lashing on light loads

The lashing of light vehicles, particularly motorcycles, is often not carried out according to regulations. In some cases, motorcycles are not tied down at all, assuming they are relatively light.

This practice has the potential to cause cargo shifting, especially when the ship is undergoing significant maneuvering, which can endanger other cargo and the stability of the ship.

c. The number of lashings on the load is not correct.

For medium to heavy-duty vehicles, the number of lashing devices used is often not commensurate with the weight and characteristics of the load. Furthermore, the lashing techniques employed are often substandard, such as using fastening angles that do not form a 45-degree angle or lashings that do not intersect. This results in suboptimal tensile and tension forces, thus rendering the load securing function ineffective.

According to IMO Resolution MSC. 479(102) (2020), to ensure optimal and safe transmission of the binding force, binding must only be performed at specific binding points directly connected to the vehicle frame (chassis), not on the bumper or axle.

Vehicles with a total weight of between 3.5 (three point five) tons and 20 (twenty) tons must use at least 2 (two) lashing gears with a suitable safe working load on each side of the vehicle.

vehicles whose total weight is between 20 (twenty) tons to 30 (thirty) tons must use at least 3 (three) lashing gears with appropriate safe working loads on each side of the vehicle;

vehicles whose total weight is between 30 (thirty) tonnes to 40 (forty) tonnes must use at least 4 (four) lashing gears with appropriate safe working loads on each side of the vehicle.

d. Human Factor

Factor third Which cause not enough optimal implementation pe*lashing*an cargo vehicle is human factors (*human factor*), especially crew fatigue. Based on interviews conducted by researchers with First Officers, Bosuns, and Classmates, it was discovered that all deck crew members had essentially attended training and safety meetings organized by the company. The training aimed to provide an understanding of procedureLoading and unloading of vehicle cargo complies with applicable operational standards and shipping safety regulations. Therefore, theoretically, all deck crew members have adequate knowledge and competence regarding cargo unloading procedures. However, conditions in the field indicate that unloading procedures are not carried out properly. cargo vehicle no always carried out optimally and in accordance with procedures. One of the factorsmain Which influence condition This is work fatigue experienced by the deck crew.

Based on observations and research conducted by researchers, the crossing route from Padangbai Port (Bali) to Lembar Port (Lombok) is classified as a short route, with a distance of approximately 32 nautical miles and a sailing time of approximately 4–5 hours. This relatively short route characteristic results in high shipping intensity, especially under certain operational conditions.

In certain situations, sailing schedules can be subject to changes, particularly when another vessel is inoperable due to damage and requires repairs. Under these circumstances, a ship that is still operational must often replace another vessel's schedule (nyisip), resulting in the ship making up to two voyages in a single day. This situation directly impacts the workload of deck crews, who must perform watchkeeping, loading and unloading activities, and cargo unloading processes repeatedly without adequate rest time.

The limited number of crew on board further exacerbates this fatigue, as deck crew must perform shifts over long shifts. The physical and mental fatigue experienced by the crew can potentially reduce their concentration, accuracy, and vigilance when carrying out vehicle load shedding.

Consequently, even though the crew understands the correct shedding procedures, in practice, the shedding process is less than optimal and carries the risk of errors that can impact cargo safety, ship stability, and overall navigational safety.

Based on the provisions of the International Convention for the Safety of Life at Sea (SOLAS) Chapter V Regulation 14 which emphasizes that every ship must be sufficiently and efficiently manned, and referring to the guidelines in IMO Resolution A.1047(27) regarding the principle of minimum safe manning, it is necessary to evaluate the adequacy of the number and composition of the ship's crew, especially the deck crew who are directly involved in cargo unloading activities.

This evaluation is important to ensure that operational workloads, especially during heavy load conditions and limited loading and unloading time, can still be carried out optimally without reducing aspects of accuracy and work safety.

Having an adequate crew will support the thorough lashing, tightening, and rechecking of lashings in accordance with established procedures. Thus, the principle of adequate and efficient manning is not only fulfilled administratively through the Minimum Safe Manning document, but also functionally realized in supporting cargo safety and overall shipping security.

e. Relatively Short Docking Time

The berthing time of ships on the Bali-Lombok ferry route is relatively short, with each ship generally only given about two hours, covering all operational activities, from ship maneuvering, vehicle loading and unloading, cargo arrangement, and preparation for departure. Under these conditions, deck crews and ship officers are required to efficiently load vehicles by optimally utilizing the cargo space (cardeck) within a limited time. Loading efficiency is a crucial aspect of ferry operations, as ship carrying capacity must be maximized to meet service needs, especially during periods of high demand.

Limited berthing time requires all operational activities to be completed quickly to ensure the sailing schedule is met. This time pressure often causes the officer on duty and deck crew to prioritize expediting the loading process, resulting in tighter vehicle placement on the cardeck to maximize cargo space. This limits the deck crew's mobility and makes it difficult to properly load the vehicles according to established standards.

This situation creates an operational dilemma in the field, as demands for efficient loading space utilization do not always align with the need for safe and proper lashing. The limited workspace makes it difficult for crews to optimally lash loads, both in terms of the number of lashing tools and their installation techniques. This can lead to lashing being rushed or unevenly applied across all vehicles.

Although loading is required to be carried out quickly and efficiently, cargo safety must remain a top priority. Every vehicle loaded onto a ship must be ensured to be in a safe, stable position and secured according to established procedures. If the demands of loading efficiency and limited berthing time are not balanced with the implementation of proper securing procedures, the risk of cargo shifting, vehicle damage, and disruption to the ship's stability during the voyage will increase.

Thus, limited berthing time, demands for loading efficiency, and efforts to maximize the utilization of cargo space are interrelated factors that have a direct influence on optimizing the loading of vehicle cargo on board ships.

V. CONCLUSION

The results of the study indicate that the implementation of vehicle load lashing on KMP Dharma Ferry VIII has basically referred to the applicable procedures, but the implementation has not been fully optimal. The main findings of the study indicate that the effectiveness of lashing is influenced by several factors, namely the condition of lashing equipment which is partly worn and unsuitable for use, inconsistent application of procedures especially in dense load conditions, limited loading and unloading time, and human factors in the form of crew fatigue due to high operational intensity. These conditions result in vehicle placement that is too close together, the use of a number of lashings that do not meet standards, and less than optimal re-inspections, thereby increasing the risk of load shifting and potentially disrupting the operational safety of the ship.

This study still has limitations because it was only conducted on one vessel with a qualitative descriptive approach, so the results cannot be generalized to all Ro-Ro vessels in Indonesia. Nevertheless, the results of the study provide practical implications for shipping companies to improve maintenance programs and regular inspections of lashing equipment, strengthen supervision of the implementation of operational standards, manage loading and unloading times more effectively, and evaluate the adequacy of the number of crews so that lashing can be carried out optimally. Further research is recommended to involve more vessels, use a quantitative approach or mixed methods, and develop a risk analysis of lashing effectiveness so that it can produce more comprehensive recommendations in supporting the operational safety of Ro-Ro vessels.

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