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SAFE CARGO SECURING ON OPEN TRAILERS: FLAT BED AND STEP DECK

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ABSTRACT

The article examines the features of safely securing cargo on open trailers of the Flat bed and Step Deck types. Special attention is given to the analysis of the regulatory framework, technical aspects of cargo securing, and modern solutions based on the integration of digital monitoring systems. The study conducts a comparative analysis of the standards that govern vehicle parameters and operational characteristics, and reviews methods for evenly distributing loads as well as modern fastening devices capable of ensuring transport reliability. The results obtained may serve as a basis for developing new recommendations to improve the regulatory framework in the field of transport safety and to optimize cargo securing processes. The information presented in the article will be of interest to specialists in transport logistics, engineering design, and system safety, as it combines theoretical analysis, regulatory aspects, and practical recommendations aimed at minimizing risks during transportation. The material will also attract researchers and academicians engaged in optimizing technological processes and integrating innovative methods into the management of transport flows, as well as those striving for an interdisciplinary understanding of the interrelation between dynamic cargo loads, the structural integrity of vehicles, and the resilience of logistics systems.

Keywords: Safe Cargo Securing; Flat Bed; Step Deck; Digital Monitoring Systems; Regulatory Framework; Dynamic Loads; Freight Transportation.

I. INTRODUCTION

The relevance of safe cargo securing on open trailers of the Flat bed and Step Deck types is determined by the increasing load on transport infrastructure and the growing volume of freight transportation. One significant factor is the popularity of e-commerce, which continues to grow as high-speed internet access becomes more widespread. An increasing number of consumers now shop online, and more home delivery options are emerging every day. This trend has led to a higher demand for efficient logistics services [3]. According to statistical data presented in source [4], the global logistics industry recovered after COVID-19 in 2023, reaching a volume of 9.41 trillion US dollars and is projected to exceed 14.08 trillion US dollars by 2028 [4]. Along with the increasing focus on overload control and compliance with vehicle dimensions [2], the problem of reliably securing cargo remains insufficiently studied despite its direct impact on road safety and the preservation of transported goods. Unsafe securing can lead to cargo shifting, which in turn increases the risk of traffic accidents, infrastructure damage, and even catastrophic consequences for the lives of those involved in the transportation process.

The literature on safe cargo securing on open trailers of the Flat bed and Step Deck types reveals several main research directions that can be conditionally grouped by their content features. The first group encompasses studies focused on analyzing the technical aspects and methods of cargo securing, where the primary attention is given to engineering solutions and the optimization of fastening systems. For example, Tampubolon F. et al. [1] propose a conceptual approach for developing a tool to mitigate the consequences of overloading and inaccurate assessment of vehicle dimensions used at ferry terminals, which enables consideration of load control methods under intensive transportation conditions. These works underscore the importance of technical justification and engineering analysis in ensuring the safety of freight transportation, which is directly applicable to the operating conditions of open trailers.

An equally significant review is presented by Korayem A. H., Khajepour A., and Fidan B. [5], which is devoted to assessing the condition and parameters of transportation systems that include trailers. This work integrates existing evaluation methods and proposes a comprehensive scheme for monitoring the dynamics of interaction between the cargo and the structural elements of vehicles, thereby facilitating accurate prediction of system behavior under various operating conditions.

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The practical aspect of the issue is elucidated in the work by Xoshimov J. [4] and several electronic publications. For instance, the guidelines presented by Xoshimov J. systematize professional approaches and recommendations for updating cargo securing methods, drawing on current regulatory and technical requirements. The online resource "Flatbeds and Step-Decks — Workhorses of Oversize Load Hauling" [6], available on the oversize website, and "Flatbed vs Step Deck Trailers: Which One Should You Choose?" [7], whose information is hosted on the interstate365 website, provide a comparative analysis of trailer types, emphasizing the practical importance of choosing between flatbed and step-deck platforms to ensure transport safety.

Thus, despite significant achievements in the modeling of dynamic processes and the development of practical recommendations, the literature reveals certain contradictions. On the one hand, theoretical models demonstrate high accuracy and comprehensiveness, yet their results sometimes diverge from the practical recommendations outlined in guidelines and electronic sources. On the other hand, the problem of integrating dynamic models of transportation systems with real operating conditions remains insufficiently addressed, indicating the need for further research into the comprehensive assessment of cargo–trailer interactions as well as the development of adaptive monitoring and management systems.

Finally, the fifth group of sources is dedicated to statistical data concerning the logistics services market, with information presented in sources [2, 3] from the websites benchmarkintl and statista.

Thus, the analysis of the literature reveals both significant achievements and existing contradictions in approaches to ensuring transport safety. On one hand, the focus on engineering analysis and technical means of cargo securing indicates a high level of development in methods for optimizing fastening systems. On the other hand, studies that emphasize behavioral and systemic aspects, as well as evaluations of regulatory and infrastructural measures, underscore the need to integrate comprehensive management strategies into transport safety systems. Moreover, issues related to the integration of innovative information systems and systematic infrastructure planning remain insufficiently addressed in existing publications, indicating the need for further interdisciplinary research in this area.

The aim of the study is to examine methods of safe cargo securing on open trailers.

The scientific novelty lies in synthesizing traditional engineering solutions for cargo securing with modern digital monitoring technologies.

The author's hypothesis is that applying an integrated system—one that combines modern digital monitoring tools with advanced physical methods of cargo securing—will enhance the safety of freight transportation on open trailers by ensuring an even distribution of loads and minimizing the risk of abnormal situations arising from dynamic forces during vehicle movement.

The methodology of the study is based on a literature review and a comparative analysis of existing engineering solutions.

1. Theoretical and methodological analysis of the regulatory framework

The analysis of the regulatory framework in the field of safe cargo securing on open trailers (Flat bed and Step Deck) requires a comprehensive approach that integrates provisions from national and international standards, technical regulations, and modern digital solutions for vehicle monitoring. In the current conditions of intensive development of transport infrastructure and increasing freight volumes, regulations aimed at preventing overloads and vehicle dimension discrepancies—known as the ODOL (Over-Dimension and Over-Load) concept—acquire particular significance. The study by Tampubolon F., Seno W., and Sarjana S. [3] describes how strict control over vehicle technical parameters, including the use of weighbridges and measurement systems, minimizes risks associated with non-compliance with regulatory requirements.

One of the regulatory documents is the Regulation of the General Director for Ground Transportation (KP.4413/AJ.307/DRJD/2020), which defines the parameters and permissible dimensions for vehicles used in freight transportation. Alongside national regulations, international standards, such as those prescribed by the International Maritime Organization (IMO) and European regulations, also play an important role in shaping the legal framework for freight transportation [1,3].

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In the context of safe cargo securing, it is necessary to consider not only the requirements for limiting vehicle dimensions and mass but also specific recommendations for the physical securing of cargo. This includes the analysis of dynamic loads, weight distribution, and structural stability during travel on various road types and under intensive usage of the transport system. The application of modern digital technologies for monitoring vehicle movement and condition—for example, BLU-e systems integrated with the Ferizy platform—allows for the timely identification of deviations from regulatory values and the implementation of preventive measures [2].

For the analysis of the regulatory framework, it is useful to consider a comparative table that demonstrates the parameters established for various configurations of open bodies, thereby allowing an assessment of the degree of compliance of the construction with safety requirements. However, regulatory documents do not always detail the methods for implementing these requirements in practice, which creates a scientific gap in the integration of regulatory provisions with engineering solutions. Thus, ensuring the safety of cargo securing on open trailers requires not only strict adherence to existing regulations but also the development of new integrated approaches that combine traditional engineering methods with modern digital control and monitoring technologies. This integrated approach can serve as the basis for developing recommendations to improve the regulatory framework in the field of transport safety and to enhance the efficiency of cargo securing during transportation [ ].

2. Technical aspects of safe cargo securing

The technical aspects of safely securing cargo on open trailers, such as Flat bed and Step Deck, represent a multifaceted challenge that requires the integration of engineering solutions, materials science, and dynamic load analysis.

Flat bed and Step Deck trailers have specific constructions that determine their operational capabilities. A Flat bed is characterized by a flat cargo platform, which provides greater versatility for accommodating various types of cargo; however, it requires special attention to weight distribution across the entire platform surface. In contrast, a Step Deck trailer features a lowered rear section, which allows for the transportation of taller loads but imposes limitations on load distribution due to differences in height [3].

To ensure stability and prevent cargo shifting, it is necessary to consider dynamic loads that arise during movement, including acceleration, braking, turning, and the impact of road irregularities. Precise calculation and forecasting of these loads enable the development of optimal securing schemes. Modern computer modeling methods and experimental tests on dynamic rigs facilitate a comprehensive evaluation of these parameters [1,6].

The use of modern fastening devices—such as straps, chains, tensioners, and specialized fixings—is fundamental to ensuring the safety of cargo securing. It is essential that the fastening devices employed possess sufficient strength and flexibility to adapt to changing operating conditions. Methods of multipoint securing that allow for an even distribution of load across the cargo surface are recommended, as they significantly reduce the risk of cargo shifting during transit [3,4]. An additional advantage is the possibility of integrating digital monitoring systems, which can track the condition of fastening elements in real time and alert the driver to potential safety breaches.

Below is Table 1, which demonstrates the main technical specifications and recommendations for cargo securing methods for Flat bed and Step Deck trailers.

Table 1. Technical specifications and recommendations on cargo securing methods for Flat bed and Step Deck trailers [1,3,5]

Trailer type	Main structural features	Recommended securing methods	Key recommendations for load distribution
Flat bed	Flat platform, versatile cargo placement	Multipoint securing using straps and chains	Even distribution of cargo; use of additional fixings to prevent sliding

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Trailer type	Main structural features	Recommended securing methods	Key recommendations for load distribution
Step Deck	Platform with a lowered rear section	Combined use of tensioners and straps	Consideration of height differences; reinforcement of securing at the transition zone between levels

Thus, the technical aspects of safely securing cargo on open trailers include the analysis of platform structural features, consideration of dynamic loads, optimization of securing methods, and the application of modern digital technologies for monitoring the condition of fastening elements. A comprehensive approach that combines traditional engineering solutions with modern digital control methods can enhance the safety of freight transportation and minimize risks associated with improper cargo securing.

3. Methods and technologies for securing cargo on open trailers

Safe cargo securing on open trailers is a critically important element of freight transportation organization. This is due to the necessity of minimizing the risk of cargo shifting or damage, as well as preventing accidents caused by dynamic loads and changes in driving conditions (Transport Industry Publications, n.d.-a; Federal Motor Carrier Safety Administration, n.d.). This section discusses the main cargo securing systems, their technical requirements and practical recommendations, and provides a comparative analysis of various technologies using a table.

A wide range of securing systems is used to fix cargo on flatbed and step-deck trailers. Figure 1 below demonstrates these securing systems.

Fig. 1. Fastening systems for securing cargo on flatbed and step-deck trailers [6, 7].

Next, let us examine in more detail the cargo securing systems listed in Figure 1 for flatbed and step-deck trailers. Strap tie-downs and straps made of high-strength synthetic materials allow for an even distribution of securing forces across the cargo surface. These systems are widely used for cargoes that are sensitive to vibrational loads, as well as for transporting materials with a high likelihood of shifting.

Due to their high strength, chains are used in situations requiring a reliable mechanical connection, especially for heavy machinery and oversized cargo. Their use is often combined with additional securing means, such as straps or tie-downs.

Mesh securing systems are used to protect cargo from settling and shifting, especially when transporting a large number of small or bulky items. Meshes help distribute pressure evenly and prevent the formation of local overload points.

For cargo that tends to roll (e.g., vehicles, rolls of wire, pipes, and other cylindrical items), wedge devices and specialized chocks are frequently employed to prevent cargo movement during sudden braking or turns [6, 7].

The effectiveness of cargo securing systems is determined by several technical parameters:

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- Reliability and strength: every element of the system must possess sufficient mechanical strength to withstand both dynamic and static loads occurring during vehicle movement. This requires not only appropriate material specifications but also adherence to recommended tension norms during securing [6].
- Even force distribution: it is essential to distribute the forces acting on the cargo so that there are no overloads on specific sections of the trailer or on the vehicle's axles. Improper distribution may lead to weight discrepancies, resulting in penalty sanctions and potentially dangerous situations [7].
- Compliance with regulatory requirements: all securing systems must conform to current regulations and standards, such as FMCSA recommendations for commercial transportation. These standards cover requirements for the number of securing points, the minimum strength of materials, and cargo fixing methods [5, 6].

For a detailed analysis of various cargo securing systems, Table 2 is presented below.

Table 2. Comparative analysis of cargo securing systems on open trailers [6, 7]

Type of securing	Description and materials	Main application areas	Advantages	Limitations and disadvantages
Straps / tie-downs	High-strength synthetic materials; adjustable tension	Universal use for light to medium-heavy cargo	Easy to use; even distribution of forces	Limited strength under extreme loads
Chains	Metal links providing high strength	Heavy machinery, oversized cargo	High mechanical strength; reliable connection	Increased weight; often must be used in conjunction with other systems
Meshes	Fabric or metal constructs for even pressure distribution	Transporting multiple small items or bulky cargo	Even load distribution; ease of installation	Potential issues under strong external forces (e.g., wind loads)
Wedges/chocks	Specialized devices to prevent cargo from rolling	Cargo prone to rolling (vehicles, pipes, cylinders)	Reliable prevention of rolling; added safety	Require precise calculation and proper placement

For enhanced transportation safety, it is recommended to follow these guidelines:

- Prior to loading, conduct a thorough evaluation of the cargo's characteristics: its weight, dimensions, center of gravity, and potential for shifting. This enables the selection of the optimal securing method and determination of the number of fixing points.
- For complex or oversized cargo, a combined approach is often used, employing straps, chains, meshes, and wedge devices simultaneously. This approach increases overall securing reliability and compensates for the limitations of individual systems.
- After loading and securing the cargo, regular checks of the fastening elements are recommended. During transit, it is important to monitor changes in tension, signs of wear, and potential cargo shifting. The use of monitoring systems (e.g., tension sensors) allows for prompt response to changing conditions and helps prevent accidents.

Thus, the choice of methods and technologies for securing cargo on open trailers should be based on a comprehensive analysis of cargo characteristics, transportation conditions, and regulatory requirements. The

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use of combined systems increases transportation reliability, minimizes the risk of cargo damage, and ensures compliance with safety standards—a key factor in modern freight transportation.

II. CONCLUSION

The conducted study demonstrates that ensuring the safety of cargo securing on open trailers requires an integrated approach that combines strict regulatory requirements, engineering solutions, and modern digital monitoring technologies. The analysis of the regulatory framework revealed the need for further specification of requirements for fastening elements, taking into account the dynamic loads experienced during vehicle movement. Technical aspects, such as the structural features of Flat bed and Step Deck platforms and methods for even load distribution, are key factors in ensuring transportation stability. The innovative digital control systems presented in the article enable real-time monitoring of vehicle conditions, prompt detection of violations, and the implementation of preventive measures, thereby enhancing safety and reducing operational costs. The findings hold practical significance for industry specialists and may contribute to further development of safe cargo securing systems.

III. REFERENCES

[1] Tampubolon F. et al. BLU-e: Over-dimension and over-load for vehicle transport mitigation tool at ferry ports //E3S Web of Conferences. – EDP Sciences, 2025. – Vol. 604. – pp. 1-11.

[2] 2024 Global Transportation & Logistics Industry Report. [Electronic resource] Access mode: https://www.benchmarkintl.com/de/insights/2024-global-transportation-logistics-industry-report /(accessed: 03/21/2025).

[3] Size of the global logistics industry from 2018 to 2023, with forecasts until 2028. [Electronic resource] Access mode: https://www.statista.com/statistics/943517/logistics-industry-global-cagr / (date of access: 03/21/2025).

[4] Xoshimov J. Handbook for professional updater //Nordic_Press. – 2025. – Vol. 6 (1-6). - pp. 2-8.

[5] Korayem A. H., Khajepour A., Fidan B. A review on vehicle-trailer state and parameter estimation //IEEE Transactions on intelligent transportation systems. – 2021. – Vol. 23 (7). – pp. 5993-6010.

[6] Flatbeds and Step-Decks — Workhorses of Oversize Load Hauling. [Electronic resource] Access mode: https://oversize.io/regulations/flatbed-step-deck-trailers (date of request: 03/28/2025).

[7] Flatbed vs Step Deck Trailers: Which One Should You Choose? [Electronic resource] Access mode: https://interstate365.com/flatbed-vs-step-deck-trailers/ (date of request: 03/28/2025).