



MODULAR AND FLEXIBLE CATTLE CAGE DESIGN FOR ENHANCED SAFETY AND ADAPTABILITY IN LOCAL GOODS CARRIER VEHICLES

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ABSTRACT

In India, the transportation of cattle is predominantly conducted using local goods carrier vehicles, which lack specialized design features to ensure safety and efficiency. This study proposes a modular and flexible cattle cage design, emphasizing adaptability to diverse vehicle sizes and addressing critical safety concerns. The cage features telescopic adjustments for length, top linkages for width, and a cross-link base for stability. With dimensions adjustable from 7 to 10 feet in length, 4 to 7 feet in width, and a fixed height of 6.5 feet, the structure ensures compatibility with a wide range of vehicles. Constructed using structural steel (S275N), the design incorporates square steel pipes (40 mm x 40 mm) for durability and a cross-link base mounted on roller wheels for enhanced stability and ease of installation. The methodology integrates design calculations for static and dynamic stiffness, load distribution, and safety factor analysis to validate the structural integrity under real-world conditions. The modular cage is removable, enabling multipurpose use of vehicles, and is specifically tailored to meet the economic and practical needs of Indian farmers. Comparative analysis of three design models highlights the superior performance of the proposed modular cage, demonstrating its potential to revolutionize cattle transportation practices in India.

Keywords: Cattle Transportation Design, Modular Cattle Cage, Flexible Vehicle Adaptation, Transportation Safety Standards

I. Introduction

Cattle transportation plays a crucial role in India's agricultural and dairy sectors[1]. Farmers and dairy owners often need to transport cattle for purposes such as market sales, medical treatment, or relocation. Despite the importance of cattle transportation, the infrastructure and vehicles used are largely unregulated and unsafe. According to the 2022 Road Transport Report of India, traditional goods carrier vehicles, frequently used for cattle transport, lack essential design considerations, leading to accidental injuries and unsanitary conditions[3].

Cattle transportation is a significant issue in India, and this research area offers considerable scope for further exploration and development [7]. In India, cattle transportation is important for farmers and dairy owners. Over 60% of farmers own 3 to 5 cattle, mainly for farming. They need to transport cattle occasionally for purposes like selling at markets, getting medical treatment, or shifting to another location. Most farmers use local goods carrier vehicles to transport cattle. These vehicles are not designed for cattle safety and often lead to accidents or injuries, as noted in the 2022 Road Transport Report of India. Special vehicles for cattle transport are expensive and not affordable for most farmers. To solve these problems, there is a need for a simple, low-cost, and safe design that can fit into local vehicles. This study focuses on creating a modular and flexible cattle cage that meets the needs of farmers and transporters in India.

This study aims to address these issues by proposing a modular and flexible cattle cage design that integrates with existing local goods carrier vehicles. The proposed solution prioritizes safety, modularity, and ease of use, aligning with the unique requirements of Indian cattle transporters.

II. Cattle transportation in Indian

Survey and Data Collection: A comprehensive survey was conducted with farmers, dairy owners, transporters, and veterinarians to understand the current practices, challenges, and needs in cattle

transportation. Key parameters included the frequency of transportation, number of cattle transported, and the preferred mode of transport. To address the challenges of cattle transportation in India, a systematic methodology was adopted. First, a comprehensive survey was conducted involving 38 farmers, 18 dairy owners, 13 transporters, and 4 veterinary professionals. The survey aimed to identify current practices, challenges, and requirements for cattle transportation. Key findings included infrequent transportation (less than five times annually for most users), the use of local goods carrier vehicles, and the absence of safety features and design standards. Graphical representation of the survey results is shown in Figure 1 with stakeholder preferences for local transportation modes.

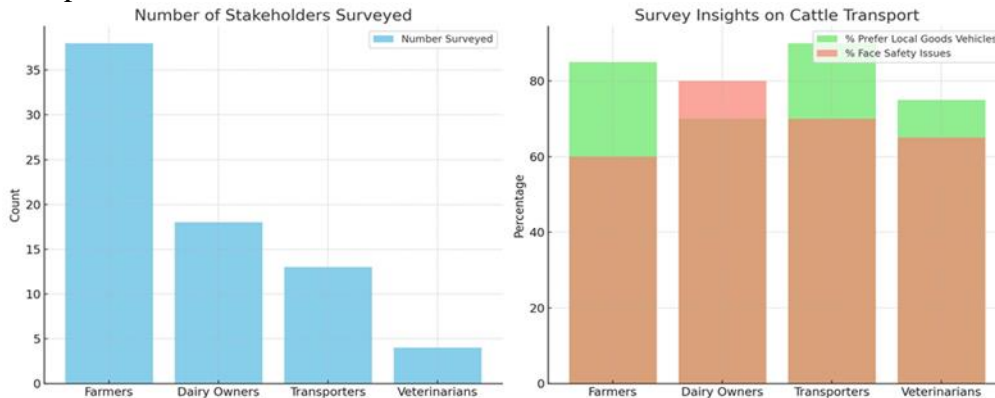


Figure 1: Graphical representation of survey and preference for local transportation

The survey highlights key insights into the transportation patterns and challenges faced by stakeholders in India. Over 60% of farmers transport 3 to 5 cattle infrequently, while only 1% of firms manage larger herds exceeding 100 cattle. These findings underscore the need for a cost-effective and adaptable solution for local cattle transportation. Given the low frequency of transportation, typically less than five occurrences annually, purchasing dedicated cattle transport vehicles is economically unfeasible for most users.

III. Design Solution

As per the guidelines and the carriage of the average size of the carriage 8ft x 6ft the design models is developed [9]. Figure 2. shows the three suggested different design models for the cattle cage. Based on the survey insights, three cattle cage designs were developed for comparison: (a) a trolley with a fixed structure, (d) a trolley with a fixed structure and partitions, and (c) a trolley with a flexible structure and adjustable partitions. Among these, the flexible and modular design was prioritized due to its adaptability and alignment with user requirements.

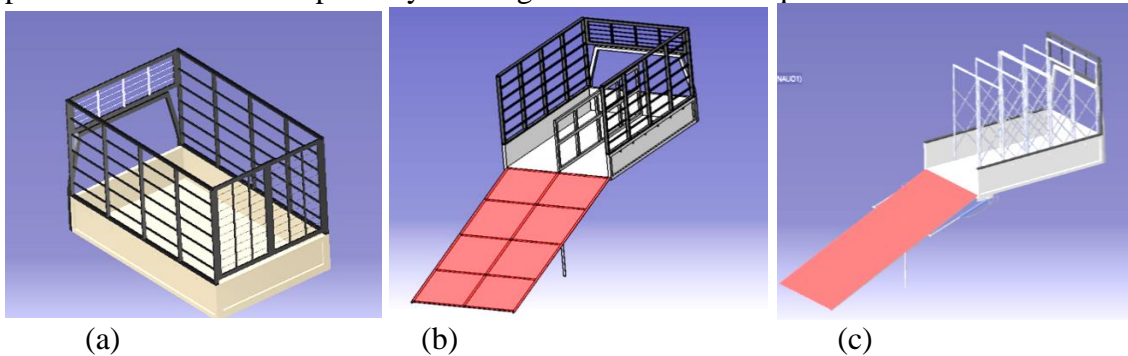


Figure 2: Different cattle design models (a) a trolley with a fixed structure, (d) a trolley with a fixed structure and partitions, and (c) a trolley with a flexible structure and adjustable partitions.



IV. Design considerations and comparison

Design calculations were conducted to ensure the structural integrity and practical feasibility of the proposed modular cage. Static stiffness analysis evaluated the ability of the structural steel (S275N) frame to withstand a total load of 1000 kg (two cattle) with an additional safety factor of 1.5. Dynamic stiffness calculations considered impact forces at a vehicle speed of 40 km/h to minimize vibrations and fatigue. Load distribution across the cross-link base and roller wheels was analyzed to ensure uniform stress on the vehicle chassis. Finally, safety factor analysis validated the strength of telescopic adjustments, cross-link bars, and mounting mechanisms under various stress conditions. The proposed modular cage design features telescopic adjustments for length (7 to 10 feet), top linkages for width (4 to 7 feet), and a fixed height of 6.5 feet. The cross-link base, constructed using 4-inch square bars, enhances stability and integrates seamlessly with local goods carrier vehicles. The removable nature of the cage facilitates multipurpose use of the vehicle, addressing cost concerns for users.

V. Results and discussion

The survey results highlighted the pressing need for a modular and flexible cattle cage design. Most farmers and transporters emphasized the importance of safety, adaptability, and compatibility with existing vehicles. Comparative analysis of the three design models revealed significant advantages of the proposed modular design over fixed structures as shown in figure 3. The modular design's telescopic and adjustable features accommodated varying vehicle sizes, while the cross-link base provided superior stability during transportation.

Structural analysis confirmed that the modular cage could safely support the weight of two cattle (1000 kg) with minimal deflection. Dynamic stiffness calculations demonstrated the cage's ability to withstand vibrations and impact forces at speeds up to 40 km/h. Load distribution analysis verified uniform stress on the vehicle chassis, reducing the risk of structural damage during transit. The safety factor analysis indicated that all critical components, including telescopic adjustments and mounting mechanisms, performed well under expected stress conditions.

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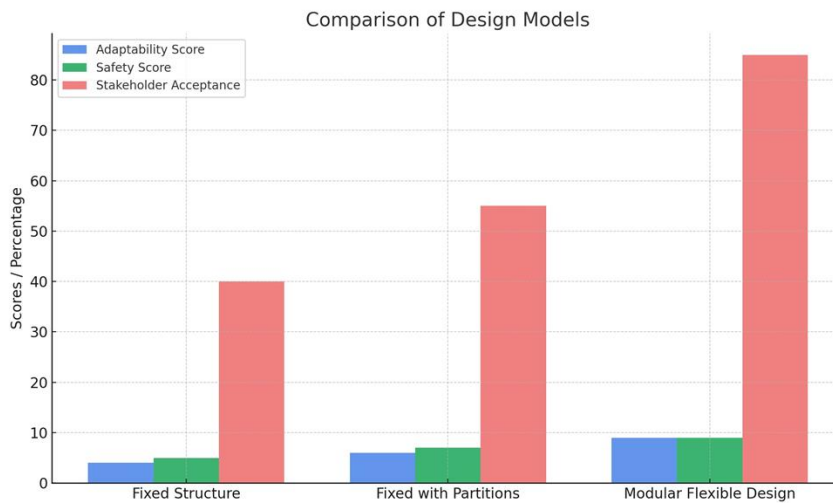


Figure 3: Comparison of Design models

The proposed design addresses critical shortcomings in existing transportation practices. Its modularity allows it to accommodate varying vehicle sizes, while its telescopic adjustments and cross-link support ensure stability and safety. Furthermore, the removable nature of the cage facilitates multipurpose use of the goods carrier vehicle, addressing economic concerns.

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VI. Conclusion

This study presents a modular and flexible cattle cage design tailored to the needs of Indian farmers and transporters. By addressing safety, adaptability, and cost concerns, the proposed solution offers a practical alternative to traditional transportation methods. The design's compatibility with local goods carrier vehicles ensures widespread applicability, promoting safer and more efficient cattle transportation practices. Future work includes performance validation through computational fluid dynamics (CFD) analysis, focusing on ventilation efficiency and structural stability. The findings will further refine the design and establish standards for cattle transportation infrastructure in India.

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