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Improving Material Handling among PTSS Mechanical Engineering Department Staff using "Stacked Load Securing Trolley"

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Abstract: Material handling is the activity of lifting, loading, and moving goods from one place to another. Load transfer needs to be managed well so that the safety of workers and goods is preserved and energy and time can be saved. This project aims to improve the equipment used by PTSS Mechanical Engineering Department staff to transport loads. The design of this tool was adapted from an existing conventional trolley, which was later developed as a versatile trolley that can be used on elevated floor surfaces. This trolley is built to be compact in size but able to bear stacked loads. The unique feature of this trolley design is the load-securing mechanism that can maintain the stability of the load being carried. Ergonomic aspects are also applied to the trolley for comfort while working and to avoid injuries due to lifting and carrying heavy loads. The trolley named "Stacked Load Securing Trolley" has been placed in the PTSS Mechanical Engineering Department office equipment supply room and is available for use whenever needed.

Keywords: *Material handling, ergonomics, trolley*

1.0 INTRODUCTION

Safety is critical to material handling and should always be a top priority. Many potential hazards are associated with material handling activities, including falls, slips, trips, and injuries from lifting heavy loads (Ahmed Thanveer et al., 2022; del Puerto et al., 2015). Proper safety practices can help prevent accidents and injuries and create a safer working environment for employees. This technical action research aims to enhance the efficiency of material handling processes by optimizing the design of the trolley. Material handling is a critical aspect of various industries, and improving the performance of trolleys can lead to increased productivity, reduced manual effort, and enhanced workplace safety (Sitepu et al., 2020).

Effective material handling is crucial for the smooth operation of any organization. In many workplaces, employees are responsible for handling various materials, such as raw materials, finished products, and tools. However, it is common to find that employee material handling processes are often inefficient and can lead to workplace injuries or materials damage (Kempegowda et al., 2020; Yadav et al., 2022). As a result, employees need to improve material handling practices to increase efficiency, reduce the risk of workplace injuries, and ensure proper handling of materials.

The problem is that employees lack the necessary skills and knowledge to handle materials effectively, leading to inefficient material handling practices that can result in workplace injuries, delays, and damage to materials (Hsu et al., 2023). Many organizations have not provided adequate training on material handling techniques, and employees often resort to incorrect or unsafe handling practices, which can lead to injuries and damage to materials (Chen et al., 2022; Sene-Mir et al., 2020). Additionally, there may be a lack of standard operating procedures for material handling, resulting in inconsistency and inefficiency in material handling practices.

Improving material handling practices among employees is essential for creating a safe and efficient workplace. Therefore, it is necessary to identify ways to improve material handling practices among employees to ensure a safe and efficient workplace. This study will investigate the existing practices and equipment used among PTSS MED staff, identify the limitations and areas of improvement, and propose a new trolley design to improve material handling practices.

1.1 Research Objectives

The objectives of this research are to:

i. Evaluate the existing trolley design and identify its limitations and areas for improvement.
ii. Propose design modifications or enhancements to overcome identified limitations and optimize the trolley's performance.
iii. Validate the effectiveness of the optimized trolley design through practical implementation and comparison with the existing design.
iv. Assess the impact of the optimized trolley design on material handling efficiency, ergonomics, and safety.

2.0 LITERATURE REVIEW

This literature review aims to provide an overview of existing research and studies related to trolley design and its impact on material handling processes. The review explores various aspects of trolley design, including load capacity, maneuverability, ergonomics, and

safety considerations. Load capacity is a critical factor in trolley design as it directly affects the efficiency and safety of material handling operations.

Maneuverability plays a crucial role in optimizing material handling processes. Masepogu et al. (2020) emphasized the importance of trolley maneuverability in reducing operator fatigue and improving overall productivity. They highlighted the significance of wheel size and comfortable handle height of the trolley in achieving efficient and effortless movement.

In another study, Lukmanhakim et al. (2020) developed a material handling device that incorporates a mechanism allowing it to traverse various terrain types, including rough constructional areas and stairs, while minimizing energy consumption and maintaining portability. To ensure the best possible space utilization and portability, a further modification that makes the cart totally collapsible can also be added.

Wilson Kumar et al. (2021) applied a response surface methodology for designing a trolley. Experiments were carried out in a laboratory using five different heights of handle, A 35% of reduction was found in the initial forces after using 1100 mm handle height by the subjects during the pushing activity.

Ergonomics considerations are essential for designing trolleys that minimize physical strain on operators. A study by Milania and Prabaswari (2021) aims to minimize manual material handling and the physical workload by making multifunction trolleys using anthropometrics. The anthropometry is applied to the design of the supporting tools so it fits the workers. The body dimension that is used in the design is high handgrip, shoulder height standing, elbow height standing, and palm width. They found that ergonomic handle designs significantly reduced muscle fatigue and discomfort during material handling tasks.

A trolley intended for the purpose of bulk handling of garments was designed and developed by Rajesh and Naidu (2022). The trolley was designed with two distinct compartments: a top basket intended for the storage of pre-pressed garments, and two bottom racks designated for the placement of stacks of pressed garments. Results showed that the frequency of feeding helper trips decreased from 23 to 11, leading to a notable increase in labour productivity by 109%.

3.0 RESEARCH METHODOLOGY

i. Data collection: Gather information on the current trolley design, including dimensions, weight capacity, maneuverability, and user feedback. Conduct interviews and observations to identify specific challenges faced during material handling tasks.
ii. Design optimization: Based on the collected data and identified limitations, propose design modifications to address the identified challenges. Consider load stability, maneuverability, weight distribution, ergonomics, and safety factors.
iii. Prototype development: Create a prototype of the optimized trolley design using appropriate materials and manufacturing techniques. Ensure that the prototype aligns with the proposed modifications and is feasible for practical implementation.
iv. Testing and validation: Conduct controlled experiments to compare the performance of the existing trolley design with the optimized prototype. Measure parameters such as load capacity, maneuverability, ease of handling, and user satisfaction. Collect feedback from staffs to assess the effectiveness of the new design.
v. Performance evaluation: Analyze the data collected during testing to quantify the improvements achieved by the optimized trolley design. Evaluate factors such as time efficiency, labor requirements, ergonomic benefits, and overall safety enhancements.
vi. Implementation and feedback: Implement the optimized trolley design in real-world material handling scenarios. Seek feedback from staff regarding the usability, practicality, and any additional improvements that can be made.

4.0 DATA COLLECTION AND ANALYSIS

4.1 Evaluating the existing trolley design and identifying its limitations and areas for improvement.

To evaluate an existing trolley design as shown in Figure 1 and identify areas for improvement, researcher follows these steps: First, determine its purpose and assess if it meets the intended requirements. Next, evaluate its functionality, considering factors like load capacity and maneuverability. Analyze the trolley's ergonomics, including handle height and comfort. Assess the durability of materials used and examine safety features. Evaluate maintenance needs and gather user feedback. Compare the design to industry standards.

Finally, generate improvement suggestions and collaborate on redesigning the trolley to address identified limitations effectively.

Figure 1: Existing Trolley

4.2 Proposing design modifications or enhancements to overcome identified limitations and optimize the trolley's performance.

To propose design modifications or enhancements to overcome identified limitations and optimize the trolley's performance, the researcher focus on addressing specific areas for improvement. Consider implementing changes such as increased load capacity, improving maneuverability through better wheel systems and better handles, enhancing ergonomic features for user comfort, incorporating durable materials for longevity, adding safety mechanisms like load securing components, simplifying maintenance with easily replaceable parts, and integrating user feedback to ensure practicality and user satisfaction.

Figure 2: Proposed Trolley Design

4.3 Validating the effectiveness of the optimized trolley design through practical implementation and comparison with the existing design.

To validate the effectiveness of the optimized trolley design through practical implementation and comparison with the existing design, the researcher follows these steps: Build a prototype of the optimized design, conduct performance tests to evaluate factors like load capacity and maneuverability, measure time and efficiency in real tasks, gather user feedback on comfort and ergonomics, assess safety features and compare user satisfaction with the old trolley design.

Figure 4: Existing Trolley Design with Loads

Figure 5: Optimized trolley design with loads

4.4 Assessing the impact of the optimized trolley design on material handling efficiency, ergonomics, and safety.

To assess the impact of the optimized trolley design on material handling efficiency, ergonomics, and safety, consider the following steps: First, measure and compare the time

taken and efficiency achieved in material handling tasks with the optimized trolley design against the existing design. Analyze data such as load capacity, maneuverability, and ease of operation to determine if the optimization has improved efficiency. Secondly, gather user feedback to assess the design modifications' impact on ergonomics. Evaluate factors such as user comfort, handle height, and maneuverability to ensure the optimized design enhances ergonomics and minimizes the risk of injuries or strain. Lastly, evaluate the safety features incorporated into the optimized design, such as braking mechanisms and load-securing mechanisms, to ensure they meet or exceed safety standards. Compare the safety performance of the optimized design with the existing design and identify any improvements made. By considering these factors and conducting a comprehensive assessment, you can evaluate the impact of the optimized trolley design on material handling efficiency, ergonomics, and safety.

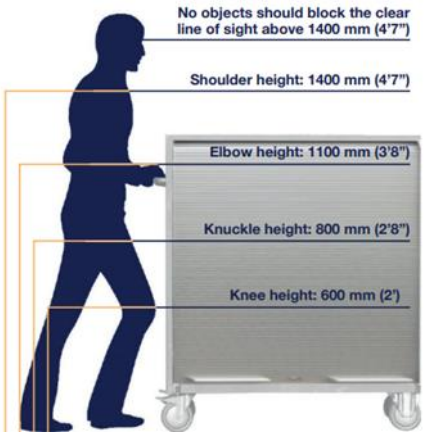

Figure 6: Ergonomics measurement in trolley handling

5.0 DISCUSSION

The assessment results of the optimized trolley design indicate the following: Firstly, it has improved material handling efficiency by reducing time, improving maneuverability, and increasing load capacity. Secondly, user feedback shows enhanced ergonomics with increased comfort, better handle height, and improved maneuverability. Lastly, the optimized design demonstrates improved safety features such as effective braking systems and load securing mechanisms, ensuring user safety during material handling operations. Overall, the design modifications have positively impacted material handling efficiency, ergonomics, and safety. Based on the features found on the trolley, it is named as "Stacked Load Securing Trolley".

6.0 CONCLUSION

In conclusion, the assessment of the Stacked Load Securing Trolley's impact on material handling efficiency, ergonomics, and safety reveals significant improvements. The design modifications have resulted in enhanced material handling efficiency, demonstrated by reduced time, improved maneuverability, and increased load capacity. Users have reported improved ergonomics, including increased comfort, better handle height, and enhanced maneuverability, indicating that the design modifications successfully address user needs. Furthermore, the optimized design incorporates improved safety features such as effective load securing mechanisms, ensuring a higher level of user and goods safety during material handling operations. Overall, the assessment results validate the effectiveness of the design modifications, confirming that the optimized trolley design optimizes material handling efficiency, enhances user ergonomics, and prioritizes safety considerations.

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