Analysis of Factors and Development of a Storage Model: A Case Study of Ceramic Tile Warehouse

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Abstract

This research aims to develop a model for storing ceramic tiles categorized as overstock items within a warehouse. These tiles are kept in storage to be sold to customers who require older tile designs for various purposes, such as home repairs. From the warehouse study, it was found that the primary issue lies in the complexity and redundancy of the operational processes. In the process of locating ceramic tiles stored on pallets, the procedure must be divided into two sub-steps. Specifically, if employees need to retrieve ceramic tiles located on the bottom-most pallet for customer sales, they must first remove the tiles stacked on top before accessing the bottom layer. This challenge arises because the warehouse stores overstock ceramic tiles, necessitating the stacking of different tile types in two layers to maximize the use of the five available storage shelves. To address these issues, the researcher applied can be achieved through the application of Space Optimization principle to reduce waste. After the improvement, one redundant step in the workflow was eliminated. Additionally, the storage capacity on the shelves was increased from 5 to 9 layers, enabling more efficient use of storage space. This adjustment not only allowed for greater storage capacity but also enhanced the convenience of warehouse operations for employees.

Keywords: Warehouse, Location Management, Order Picking Process

1. Introduction

A warehouse is a crucial component of logistics and supply chain systems, playing a key role in storing, managing, and distributing goods efficiently and safely from one point to another. It serves as a space that enhances the ability to manage inventory, ensuring timely responses to market demands while reducing operational costs. Moreover, warehouse design and location selection are vital to operational efficiency. Choosing the right location can reduce transportation costs and enable effective management of diverse goods, which are critical factors influencing an organization's competitiveness in the global market. The study of warehouses not only focuses on the storage of goods but also encompasses the management of all related processes to meet customer demands effectively and achieve long-term business advantages. A case study involves a company that sells ceramic tiles, storing products on shelves. Different colors and patterns of tiles are stacked together as they are slow-moving inventory, held in stock for customers needing home repairs.

Regarding the challenges in storing ceramic tiles, warehouse management for such items is particularly complex and demanding due to their fragile nature, which makes them prone to damage if not handled properly. These challenges include preventing breakage, organizing the warehouse, maintaining product quality, and ensuring accurate stock control. Ceramic tiles are delicate and can easily break if subjected to impact or improper storage. This issue often arises from inadequate storage support or overcrowded spaces, increasing the risk of damage during handling or transportation. Ceramic tiles come in various sizes and shapes, requiring well-organized storage for easy access and minimized risk of damage. Proper stacking, either vertically or horizontally, and using shelves that can support their weight are essential considerations.

Storing tiles in limited warehouse space presents significant challenges, as careful placement is required to prevent collisions or overlapping that could damage the products. Warehouse design must ensure adequate storage space for each type of tile while facilitating safe and convenient movement. Addressing these challenges involves streamlining work processes, reducing handling steps, and managing storage areas efficiently. This can be achieved through the application of Space Optimization and ECRS (Eliminate, Combine, Rearrange, Simplify) principles to enhance warehouse efficiency.

1.1 Research Objective

1. To Design the storage space for ceramic tiles.
2. To Study the workflow within the warehouse.

2. Literature Review

conducted a study on the application of ECRS to improve warehouse and logistics management processes. By utilizing the ECRS approach, the processes of inventory storage and transportation were enhanced, resulting in reduced operation time and increased efficiency in inventory management Liu et al. (2021) :

Eliminate: Removing unnecessary steps, such as redundant inventory checks.

Combine: Integrating packing and storage processes to be carried out simultaneously.

Rearrange: Improving the arrangement of goods within the warehouse to expedite searching and transportation.

Simplify: Streamlining inventory management, such as using RFID technology to enable instant inventory checks.

Slotting Optimization or arranging goods in optimal positions based on their movement patterns, is a widely adopted technique in warehouses. Placing high-demand items in easily accessible areas helps reduce search time and enhance operational efficiency.

A study highlighted that Slotting Optimization is a crucial process for improving warehouse storage. This involves considering the importance or movement frequency of items over specific periods. High-selling or fast-moving items should be stored in locations that are convenient for retrieval, such as near entry points or at accessible heights. Slotting algorithms, which analyze item movement data, are employed to minimize the time required for picking goods. Zhao et al. (2021)

Vertical Space Utilization The utilization of vertical space is one of the strategies that effectively enhances storage capacity. Employing adjustable racking systems and automated storage systems allows for increased vertical storage and maximizes the use of available space. the use of Vertical Storage Solutions, which involve repositioning goods on vertical racks to expand storage capacity. This approach enables the use of higher areas for storing items that are infrequently moved or lightweight. Managing vertical space not only increases the overall storage capacity of warehouses but also improves the speed of storing and retrieving items from the racks. Wang et al. (2020)

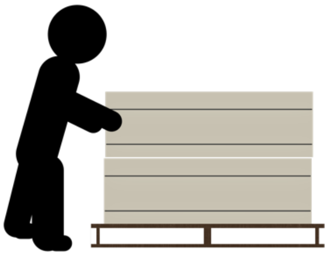
Product Clustering and the Use of Clustering Algorithms Grouping products with similar movement patterns or categories plays a critical role in optimizing warehouse space utilization. Organizing products into clusters based on similar movement characteristics helps reduce the time required for searching or transporting items.

Research by Chen et al. (2 0 2 2) found that clustering algorithms, such as K-means and hierarchical clustering, can be employed to group products in warehouses to enhance space management efficiency. By arranging products according to demand and turnover rates, these methods can reduce the travel distances of warehouse staff and improve overall space utilization.

3. Methods

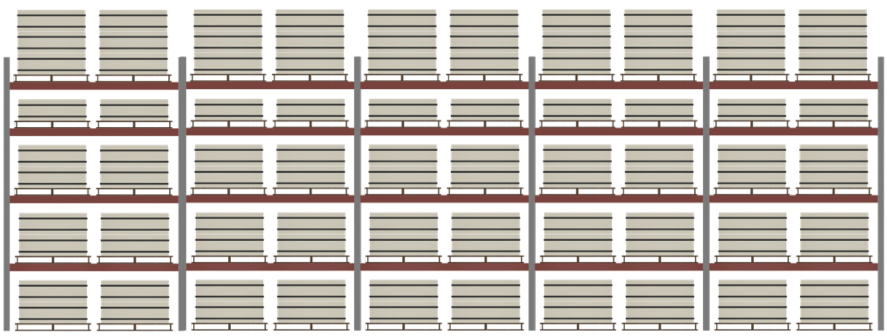
In this study, the researchers examined the workflow, starting with employees removing items from the top to retrieve the products located at the bottom.

Figure 3.1: The process of picking products from a pallet



From Figure 3.1, warehouse employees must first remove the items on top before accessing the products located at the bottom. The researcher studied the storage data on the racks and found that the racks are organized into five levels, as shown in Figure 3.2

Figure 3.2: The process of picking products from a pallet 5 Layers



From Figure 3.2, ceramic tiles sized 12x24 inches, with varying quantities per design, are stacked in two layers to maximize the use of the rack space. The quantity of ceramic tiles in the area shown in Figure 3.2 is presented in Table 3.1

Table 3.1: Quantity of 12x24 Ceramic Tiles on the Rack

Level	Quantity (Boxes) 10 pallet/Level	Weight(kg.)/ 10 pallet
1	320	10,996.4
2	320	10,996.4
3	320	10,996.4
4	160	5,483.2
5	480	16,449.6

From Table 1, it can be seen that the heaviest ceramic tiles on the rack are on Level 5, with a weight of 16,449.6 kg. The researcher studied the weight-bearing capacity of the rack to assess the feasibility of adding more shelving levels to accommodate improvements in the layout of products on the pallets. The data is presented in Table 3.2 amd Table 3.3

Table 3.2: The table shows the weight capacity of the shelves (TRUSS) at each level.

Height Rack (m.)	Level	Max Load / Level (Kg./Level)
4	3	2,400
4.5	4	2,500
5	4	2,500
5.5	4	2,500
6	5	2,500

Table 3.3: Weight of Equipment Installed on the Rack

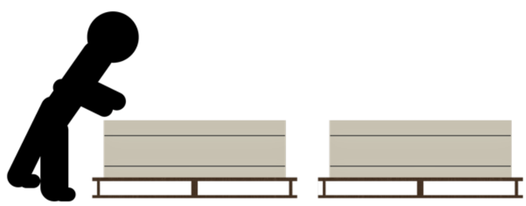
Equipment	Weight(kg.)/Piece	Level (Piece)	Piece	Quantity Used	Total/level	Piece/Rack	Weight(kg.)
BEAM	320	6	5	2	12	60	672
Sub BEAM	320	6	5	4	24	120	120
Piller	320	-	-	-	-	6	270
screw	160	6	5	16	96	480	528
Total							1,590

According to Table 3.2 and Table 3.3, it can be seen that within the warehouse, the shelf size with a height of 4.5 meters can support a maximum weight of 10,000 Kg.

4. Results and Discussion

Based on the study, the researcher has designed and developed a system to reduce the steps involved for employees who need to remove items from the top. This will involve separating the items into two categories to reduce redundant steps in the process and minimize errors. This design is based on the principles of ECRS (Eliminate, Combine, Rearrange, Simplify) and Vertical Space Utilization, as shown in Figure 4.1

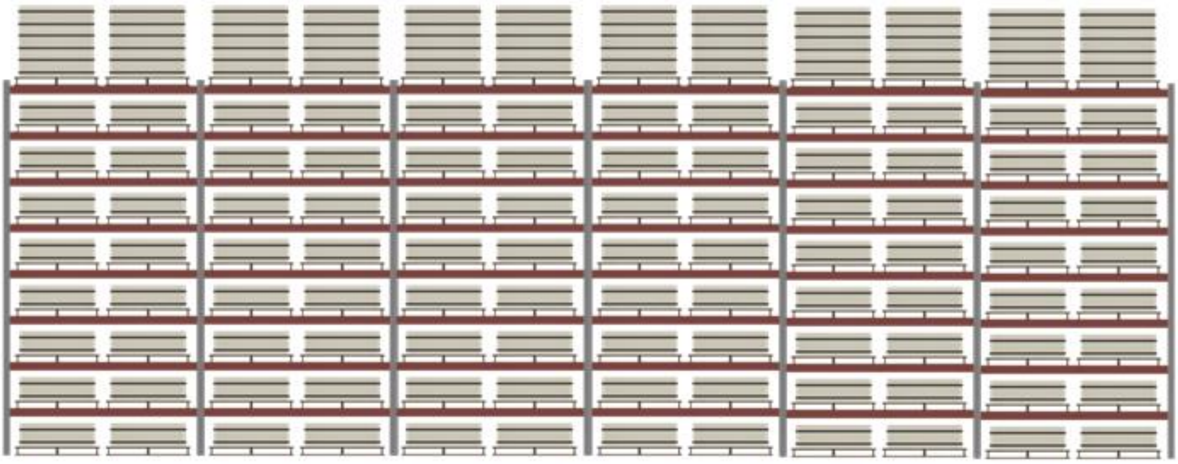
Figure 4.1: Picking items from the Pallet.



From Figure 4.1, the improvement in the arrangement of items on the pallet will impact the storage space on the shelves, as the original setup had items stacked in two layers.

Therefore, the researcher has designed a new shelving system to accommodate the arrangement of items, as shown in Figure 4.2

Figure 4.2: The process of picking products from a pallet 9 Layers



From Figure 4.2, after adjusting the pallet arrangement to a single layer, the researcher has improved the shelving system to 9 levels for organizing 12x24 inch ceramic tiles. This change has resulted in a greater storage capacity on the shelves. The comparison of the product quantity on the rack before and after the improvement is shown in Table 4.1

Table 4.1: Quantity of 12x24 Ceramic Tiles on the Rack

Before		After	
Level	Quantity (Boxes) 10 pallet /Level	Level	Quantity (Boxes) 10 pallet /Level
1	320	1	160
2	320	2	160
3	320	3	160
4	160	4	160
5	480	5	160
-	-	6	160
-	-	7	160
-	-	8	160
-	-	9	480
Total	1,600	Total	1,760

From Table 4.1, the researcher analyzed and compared the weight on each shelf level after the improvements. The analysis results are shown in Table 4.2

Table 4.1: The weight of 12x24 inch ceramic tiles on the Rack

Level	Quantity (Boxes) 10 pallet /Level	Weight(kg.)/ 10 pallet
1	160	5,483.2
2	160	5,483.2
3	160	5,483.2
4	160	5,483.2
5	160	5,483.2

Level	Quantity (Boxes) 10 pallet /Level	Weight(kg.)/ 10 pallet
4	160	5,483.2
5	160	5,483.2
6	160	5,483.2
7	160	5,483.2
8	160	5,483.2
9	480	16,449.6

5. Conclusion

This research focuses on developing a storage model to optimize the storage and retrieval processes for ceramic tiles in a warehouse. The primary challenges identified were the inefficiencies caused by redundant handling processes and the risk of product damage due to inadequate space utilization. The improved shelving system increased the total storage capacity for 12x24 inch ceramic tiles from 1,600 to 1,760 boxes. Employee efficiency improved by reducing redundant handling steps, leading to lower operational errors.

6. Discussion

The findings of this study highlight the significant impact of applying principles such as ECRS and Vertical Space Utilization to optimize warehouse storage and operations. These findings are consistent with the research of Setthachotsombut et al. (2024), which emphasized the critical role of adopting smart logistics systems to enhance operational efficiency, reduce costs, and minimize errors in logistics management.

By redesigning the shelving systems and optimizing pallet arrangements, this study demonstrates how increasing storage capacity from 5 to 9 levels improves warehouse operations. Such structural modifications align with the smart logistics strategies highlighted in the Setthachotsombut et al. (2024) study, which found that space management.

Additionally, the integration of clustering techniques for inventory arrangement supports findings by Liu et al. (2021), which emphasized the benefits of grouping items by demand or movement patterns to improve warehouse efficiency. These clustering methods complement the automated inventory systems described by Setthachotsombut et al., where smart technologies enable real-time tracking, reducing the complexity of inventory searches.

This study also underscores the importance of reducing redundant handling steps, as described in previous findings by Wang et al. (2020), which illustrated how automation and vertical space utilization can streamline warehouse workflows. The integration of these systems into the Thai logistics sector, as proposed by Setthachotsombut et al., could significantly enhance efficiency and competitiveness in international supply chain management

7. Acknowledgment

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