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# New Improvement For Existing Warehouse By Implementing Technology 3D

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## ABSTRACT

Warehousing plays a critical role in supporting manufacturing and supply chain operations by ensuring efficient storage, accessibility, and distribution of materials and finished goods. An effective warehouse layout directly influences operational performance, reducing handling time and optimizing space utilization. This study focuses on designing an optimized warehouse layout for PT. ABC. The research employs a combination of interviews and direct observations as primary data collection methods, complemented by secondary data obtained through literature review. The improvement approach integrates the Dedicated Storage system and the 5S methodology to enhance organization, reduce waste, and maintain workplace discipline. Additionally, FlexSim software was utilized to develop two- and three-dimensional models, allowing for visualization and simulation of the proposed layout. Results indicate that the new design improves efficiency by positioning high-turnover items closer to input/output points, reducing travel distance, and increasing throughput. Furthermore, recommendations for material handling equipment and inventory management strategies, such as Reorder Point (ROP), Economic Order Quantity (EOQ), and Safety Stock (SS), are provided to support sustainable operations. This study highlights the importance of systematic warehouse design as a key driver for operational excellence in the manufacturing sector.

**Keywords**:

warehouse, 5s, improvement

## Introduction

Warehousing plays a fundamental role in the operational framework of any manufacturing company, regardless of its scale be it large, medium, or small. As noted by A.M. James (1990), every manufacturing enterprise inevitably requires storage facilities to accommodate raw materials, semi-finished goods, and finished products. A warehouse, often referred to as the backbone of supply chain operations, serves not merely as a storage space but as a dynamic node that supports the smooth flow of goods across the production and distribution network. In the context of logistics, a warehouse is defined as a critical component that not only stores inventory but also provides timely and accurate information regarding stock availability, a factor essential for planning and decision-making. According to Zaroni (2017), a warehouse should ensure that information related to inventory is constantly updated and easily accessible to all stakeholders within the organization. This dual function physical storage and information accessibility positions the warehouse as a strategic element in achieving operational efficiency.

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In modern supply chain management, warehousing has evolved from a passive storage role to a proactive function that drives cost efficiency and customer satisfaction. The increasing complexity of global trade, customer expectations for faster delivery, and the growth of e-commerce have transformed warehouses into high-performance hubs requiring advanced design and technology integration. One of the most critical aspects that determine warehouse efficiency is its layout. The design of a warehouse layout directly influences material handling, operational flow, and overall productivity. As emphasized by Heizer and Render (2009), the objective of warehouse layout planning is to minimize total operating costs by finding an optimal balance between space utilization and material handling expenses. A well-designed layout ensures that goods move through the warehouse with minimal delays, reducing unnecessary handling and transportation within the facility.

The concept of warehouse layout extends beyond mere arrangement of storage racks and aisles. It involves strategic planning to optimize the movement of goods, improve accessibility, and enhance throughput efficiency. The placement of products based on their movement frequency is a widely recognized principle; fast-moving items should be positioned closer to picking or dispatch areas to reduce travel time and minimize labor costs. This approach aligns with Apple's (1990) assertion that the positioning and structural design of a warehouse significantly influence material handling efficiency. Effective layout planning must also consider factors such as order-picking strategies, safety regulations, space for material handling equipment, and future scalability to accommodate business growth.

An exemplary case of the relevance of warehouse design is found in PT. ABC. PT. ABC headquartered in Singapore. Specializing in precision manufacturing services, the company offers integrated production planning and high-quality injection molding solutions for diverse industries, including office automation, electrical and electronic components, automotive, connectors, and computer-related products. As a company that serves multiple sectors with high precision requirements, PT. ABC relies heavily on efficient warehouse operations to ensure uninterrupted production and timely delivery. The effectiveness of its storage systems and material handling processes directly affects its ability to maintain quality standards and meet client demands in a competitive global market.

## Method

The research methodology employed in this study combines both qualitative and quantitative approaches through the use of interviews and observations as the primary techniques for data collection. These methods were chosen to ensure the accuracy and reliability of the information obtained, as they provide direct insights from the actual operational environment and relevant personnel within the company. The process began with a scheduled visit to PT. ABC, where on-site observations were conducted to examine the existing warehouse layout, storage practices, material flow, and handling activities. In addition, structured interviews were carried out with key stakeholders, including warehouse supervisors and operational staff, to gather detailed information on current practices, challenges faced, and improvement opportunities.

Data collection was categorized into two distinct types: primary data and secondary data. Primary data were collected through direct observations of the warehouse facilities and processes, complemented by interviews to validate observed practices and gain an understanding of operational constraints. The observation phase focused on identifying current material storage methods, movement patterns, and the efficiency of space utilization within the warehouse. Meanwhile, the interviews provided qualitative insights regarding warehouse management policies, existing performance metrics, and perceived areas for improvement.

Secondary data, on the other hand, were obtained through an extensive literature review. This included examining relevant academic research papers, industry best practices, technical reports, journal articles, and credible online sources that discuss warehouse management, layout optimization, and material handling systems. These references served as benchmarks for developing improvement strategies and aligning the proposed solutions with global standards in warehouse design. For the development of the proposed warehouse layout, two specific methodologies were applied: Dedicated Storage and the 5S approach. The Dedicated Storage method, commonly referred to as fixed-location storage, involves assigning a permanent location to each specific product within the warehouse. This approach minimizes confusion and reduces search time by ensuring that every item is consistently stored in its designated space. By implementing dedicated storage, the warehouse can achieve better organization, streamline picking processes, and reduce handling inefficiencies.

The second methodology applied was the 5S system, a Japanese workplace organization technique that focuses on maintaining order, cleanliness, and discipline in operational areas. The term 5S represents five Japanese words Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain). The implementation began with Seiri, the sorting phase, which involved identifying and removing unnecessary items from the warehouse to maximize usable space. This was followed by Seiton, which required arranging necessary items in a systematic manner to ensure easy accessibility. The Seiso stage emphasized regular cleaning of the warehouse to maintain a safe and efficient work environment. Seiketsu aimed to standardize these processes through consistent procedures and visual management tools, while Shitsuke focused on instilling a culture of discipline among warehouse staff to sustain improvements over the long term.

Both methods were integrated into the design process to ensure the proposed layout not only optimized storage space but also enhanced operational efficiency, safety, and cleanliness. To visualize and validate the proposed design, the team utilized FlexSim software for developing two-dimensional (2D) and three-dimensional (3D) models of the warehouse layout. These simulations allowed for an accurate representation of material flow, accessibility, and travel paths within the redesigned warehouse, enabling the identification of potential bottlenecks and inefficiencies prior to actual implementation.

The final stage of the methodology involved analyzing the relationship between space requirements, throughput levels, and travel distances for each storage block relative to the input/output (I/O) points. Additionally, recommendations were formulated for the selection of appropriate material handling equipment and storage methods based on the characteristics of the materials stored. Inventory management strategies were also incorporated, including the calculation of key parameters such as Reorder Point (ROP), Economic Order Quantity (EOQ), and Safety Stock (SS), to support effective inventory control.

This systematic approach ensured that the proposed warehouse layout was designed with careful consideration of functional requirements, ergonomic principles, and operational feasibility. The entire project was carried out collaboratively by a team of students participating in the Innovative Smart Warehouse Design competition, promoting teamwork and practical problem-solving aligned with real-world industrial practices.

## Result and Discussion

The results of this project focus on analyzing the existing warehouse layout and developing an improved design for PT. ABC's finished goods warehouse, modeled within the TA building. The discussion explores the rationale behind layout optimization, the interpretation of material profiles, space requirements, throughput analysis, rectilinear distances, and overall operational implications.

The initial observation revealed that the existing warehouse layout lacked efficiency in terms of product placement, movement flow, and space utilization. The arrangement did not fully align with the movement characteristics of different products, causing longer travel distances for high-frequency items. This inefficiency directly impacts material handling time, increases labor costs, and raises the potential for congestion during peak operations. Hence, an optimized design was proposed using Dedicated Storage and 5S methodology, complemented by FlexSim 2D and 3D visualization tools for layout simulation.

**Material Profile Analysis**

The material profile analysis was essential for understanding product characteristics such as size, weight, incoming and outgoing quantities, and packaging dimensions. Table 1 illustrates that the products under consideration included Keycaps Keyboard, Case Keyboard Mekanik, Soket Konektor Kabel, Case Fan Heatsink, and Konektor 20/24 pin ATX Motherboard. Among these, Keycaps Keyboard had the highest incoming quantity at 221,184 units and outgoing at 112,128 units, while Soket Konektor Kabel also recorded high figures of 27,000 incoming and 14,000 outgoing. These high-frequency items demand strategic positioning in proximity to input/output (I/O) points to reduce handling time. Conversely, products with lower turnover such as Case Keyboard Mekanik (240 incoming, 170 outgoing) can be positioned further away.

Table 1. Material Profile Category Connectors and Computer Related Products

| Tipe Produk | Rata-rata terima (unit) | Rata- rata kirim (unit) | Ukuran produk | Ukuran Box | Ukuran Slot | Berat Produk (gr) |
|---|---|---|---|---|---|---|
| Keycaps Keyboard | 221.184 | 112.128 | 2 cm | 30x20x20 cm | 150 | 2gr |
| Case Keyboard Mekanik | 240 | 170 | 35x15x3 cm | 175x75x8 | 150 | 300 gr |
| Soket Konektor Kabel | 27000 | 14000 | 5 cm | 50x25x10 cm | 150 | 3 gr |
| Case Fan Heatsink | 1200 | 720 | 8x8x2,5 cm | 40x40x5 cm | 150 | 500 gr |
| Konektor 20/24 pin ATX Motherboard | 90000 | 48500 | `3x3x1,5cm | 12x12x75 | 150 | 10 gr |

The weight and size dimensions of products also influenced storage planning. For example, Keycaps Keyboard, although small in weight (2 grams), requires significant volumetric space due to large incoming quantities, necessitating compact but accessible storage. Similarly, heavier items such as Case Fan Heatsink (500 grams) require shelves that can withstand load while ensuring ergonomic handling. These characteristics formed the foundation for dedicated storage allocation.

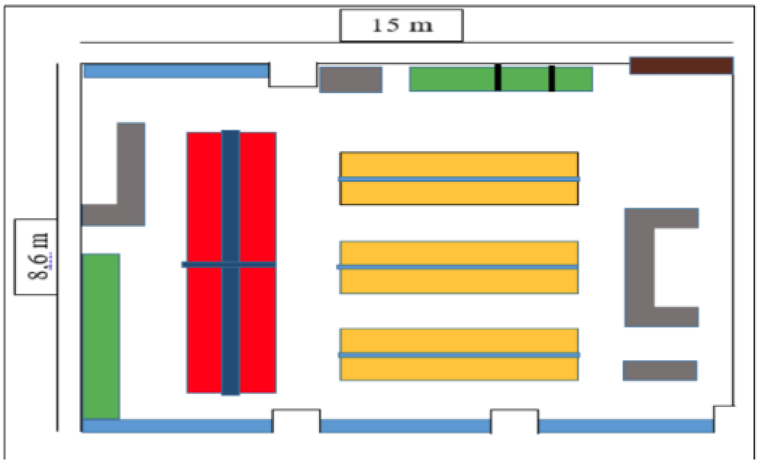



Figure 1. 2D design of the TA building warehouse before repairs

## Space Requirement and Racking Configuration

Table 2 details the space requirement analysis, which determines the number of shelves and racks needed to store the projected inventory. The proposed layout required 12 racking units with a total floor space of 198,720 $cm^2$. Aisle width was standardized at 170 cm, providing sufficient clearance for forklifts and manual handling, while a 20 cm safety clearance ensured compliance with safety standards. The overall warehouse floor area was recorded at 655,800 $cm^2$, with 29,870 $cm^2$ allocated as workspace. This configuration balances storage density and maneuverability, enabling efficient material flow.

Table 2. Space Requirement

| Tipe Produk | Ukuran produk | Ukuran Box | Rata-rata terima (produk) | Rata- rata kirim (produk) | Jumlah produk (per box) | Jumlah box | Kapasitas slot/ shelves (box) | Kebutuhan slot/ shelves (s) | Kebutuhan Rak | Block Cap | Sj |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Keycaps Keyboard | 2 cm | 30x20x20 cm | 221184 | 112128 | 1500 | 147 | 28 | 5 | 2 | 147 | 1500 |
| Case Keyboard Mekanik | 35x15x3 cm | 175x75x8 | 240 | 170 | 67 | 4 | 1 | 3 | 1 | 4 | 67 |
| Soket Konektor Kabel | 5 cm | 50x25x10 cm | 27000 | 14000 | 100 | 270 | 13 | 21 | 7 | 270 | 100 |
| Case Fan Heatsink | 8x8x2,5 cm | 40x40x5 cm | 1200 | 720 | 50 | 24 | 10 | 2 | 1 | 24 | 50 |
| Konektor 20/24 pin ATX Motherboard | 3x3x1,5cm | 12x12x75 | 90000 | 48500 | 771 | 117 | 115 | 1 | 1 | 117 | 771 |
| | | | | | | | | Racking unit | 12 | 562 | |
| | | | | | | | | Racking floor spaces | 198720cm2 | 93,4995 m2 | |
| | | | | | | | | Aisles Width | 170cm | | |
| | | | | | | | | Clearance | 20cm | | |

By analyzing slot capacity per rack and required storage slots per product, it was concluded that high-turnover items like Keycaps Keyboard and Soket Konektor Kabel required multiple racks (e.g., 147 and 270 boxes, respectively), while lower-frequency items occupied fewer slots. This categorization aligns with the ABC classification principle, where high-demand items receive priority access in the layout.

## Throughput and Handling Efficiency

Throughput analysis (Table 3) evaluated inbound and outbound movement to estimate put-away and picking capacity. Keycaps Keyboard recorded the highest throughput, with 147 units received and 75 units dispatched during the observation period. Consequently, these products were positioned in Rack A, located closest to the main entrance and exit, to minimize travel distance and handling time. In contrast, Case Keyboard Mekanik had minimal movement (4 units received, 3 dispatched), justifying its placement in Rack E, which is situated farther from the I/O point.

Table 3. Throughput

| Tipe Produk | Rata-rata Terima | Rata-Rata Kirim | Put-away Cap. | Picking Cap. | T/ S (Terima) | T/ S (Kirim) | T/S Total |
|---|---|---|---|---|---|---|---|
| Keycaps Keyboard | 147 | 75 | 5 | 5 | 28 | 15 | 43 |
| Case Keyboard Mekanik | 4 | 3 | 4 | 4 | 1 | 1 | 2 |
| Soket Konektor Kabel | 270 | 140 | 21 | 21 | 13 | 7 | 20 |
| Case Fan Headsink | 24 | 14 | 2 | 2 | 10 | 7 | 17 |
| Konektor 20/40 pin ATX Motherboard | 117 | 63 | 1 | 1 | 115 | 63 | 178 |

Such arrangement not only reduces operational fatigue but also supports Lean principles by eliminating unnecessary motion waste. By clustering frequently accessed items near picking zones, the design improves order fulfillment speed, reduces congestion, and enhances workflow synchronization.

Travel Distance and Rectilinear Optimization

A critical aspect of warehouse design is minimizing travel distance, which directly correlates with labor productivity and time efficiency. Rectilinear distance mapping (Figure 1.4) was employed to measure the distance between storage racks and I/O points in straight-line movements along grid coordinates. Table 1.4 and Table 1.5 summarize these calculations. For instance, Rack A (Keycaps Keyboard) recorded a total distance of 21 units, while Rack D (housing ATX Motherboard connectors) had a longer distance of 17.5 units for inbound and outbound combined.

Table 4. Rectilinear Distance

| Tipe Rak | Koordinat | | | | | | D (in) | D (out) |
|---|---|---|---|---|---|---|---|---|
| | x (in) | y (in) | x(out) | y (out) | x (rak) | y (rak) | | |
| A | 11,5 | 17 | 11,5 | 2 | 8,5 | 14,5 | 5,5 | 15,5 |
| B | 11,5 | 17 | 11,5 | 2 | 1,5 | 14,5 | 12,5 | 15 |
| C | 11,5 | 17 | 11,5 | 2 | 5,5 | 9,5 | 13,5 | 13,5 |
| D | 11,5 | 17 | 11,5 | 2 | 9 | 4,5 | 15 | 2,5 |
| E | 11,5 | 17 | 11,5 | 2 | 1,5 | 4,5 | 15 | 15 |

Table 5. Total Distance

| Nama Produk | Tipe Rak | T/ S (Terima) | T/ S (Kirim) | D (in) | D (out) | D Total |
|---|---|---|---|---|---|---|
| Konektor 20/40 pin ATX Motherboard | D | 115 | 63 | 15 | 2,5 | 17,5 |
| Keycaps Keyboard | A | 28 | 15 | 5,5 | 15,5 | 21 |
| Soket Konektor Kabel | C | 13 | 7 | 13,5 | 13,5 | 27 |
| Case Fan Headsink | B | 10 | 7 | 12,5 | 15 | 27,5 |
| Case Keyboard Mekanik | E | 1 | 1 | 15 | 15 | 30 |

Although products like ATX connectors require 115 inbound and 63 outbound transactions, their physical attributes and stacking requirements necessitate specific positioning. The challenge lies in balancing throughput with space constraints. Therefore, items with high-frequency and smaller dimensions were placed closer to reduce cumulative travel time, whereas bulky or less-frequent items were positioned in peripheral zones. This strategic allocation minimizes congestion at high-traffic nodes and distributes workflow evenly across the facility.

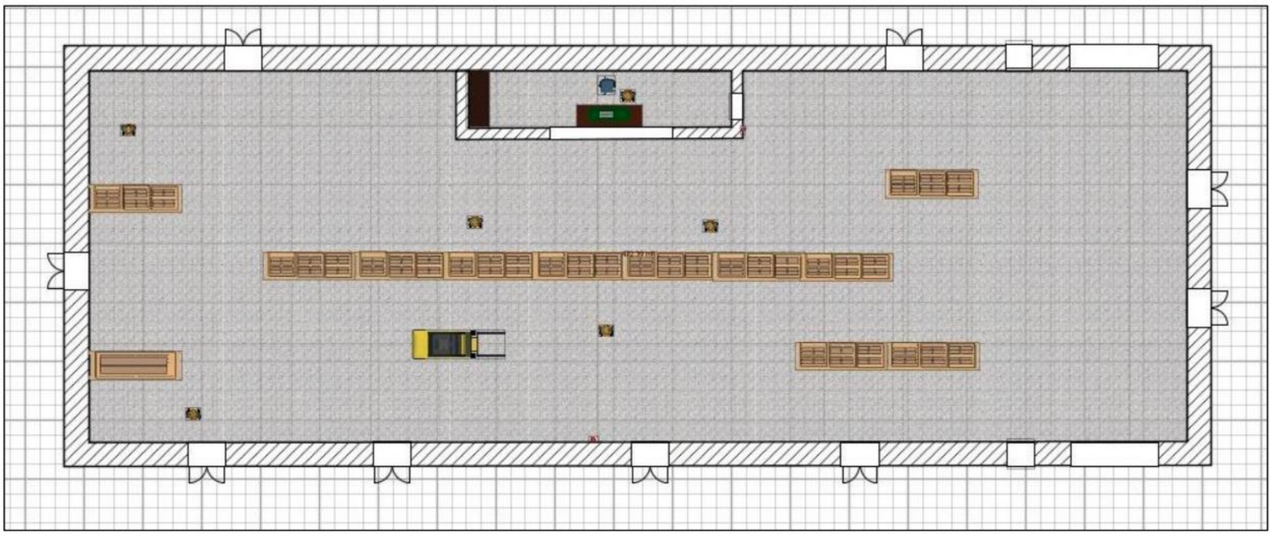
**Application of Dedicated Storage and 5S**

The Dedicated Storage method ensured that each product type occupied a fixed location within the warehouse, eliminating ambiguity during retrieval and reducing picking errors. Combined with 5S methodology, this approach enhanced workplace organization. The implementation began with Seiri (Sort), where unnecessary items were removed, creating additional storage capacity. Seiton (Set in order) optimized rack labeling and signage for easy navigation. Seiso (Shine) introduced routine cleaning schedules to maintain hygiene and operational safety. Seiketsu (Standardize) codified these practices into standard operating procedures (SOPs), while Shitsuke (Sustain) fostered employee discipline to uphold continuous improvement.

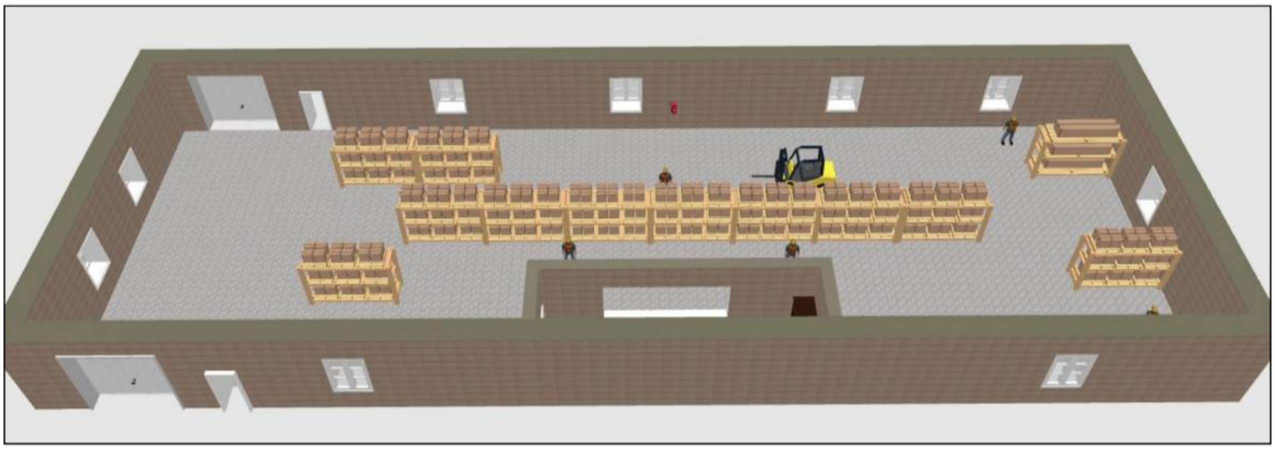
These lean principles not only improved physical arrangement but also contributed to intangible benefits such as safety compliance, reduced risk of inventory misplacement, and enhanced operational visibility.

**Integration of Technology: FlexSim 3D Modeling**

The use of FlexSim software allowed the team to visualize the proposed layout in both 2D and 3D formats (Figures 2 and 3). This technological integration facilitated a comprehensive simulation of material flows, enabling scenario testing for rack positioning, aisle configurations, and clearance optimization before actual implementation. Virtual modeling provided actionable insights, such as identifying potential bottlenecks in high-traffic zones and validating space allocation based on real throughput data. This predictive capability reduced implementation risks and improved decision-making accuracy.



Figures 2. 2D design of proposed improvements that have been adjusted by PT. ABC products



Figures 3. 3D design of proposed improvements that have been customized by PT. ABC products

**Operational Impact of the Proposed Design**

The redesigned warehouse layout delivers tangible operational benefits. By prioritizing accessibility for high-throughput items, the design minimizes travel distances and accelerates picking and put-away cycles. The optimized aisle width and clearance enhance safety, reducing the likelihood of accidents involving forklifts or pallet jacks. Additionally, the improved space utilization increases storage capacity without requiring physical expansion, aligning with cost minimization objectives.

From a strategic perspective, the proposed design enhances the company's agility in responding to fluctuating demand and seasonal peaks. Faster processing times translate to improved order fulfillment rates, which bolster customer satisfaction and strengthen PT. ABC's competitive position in the market.

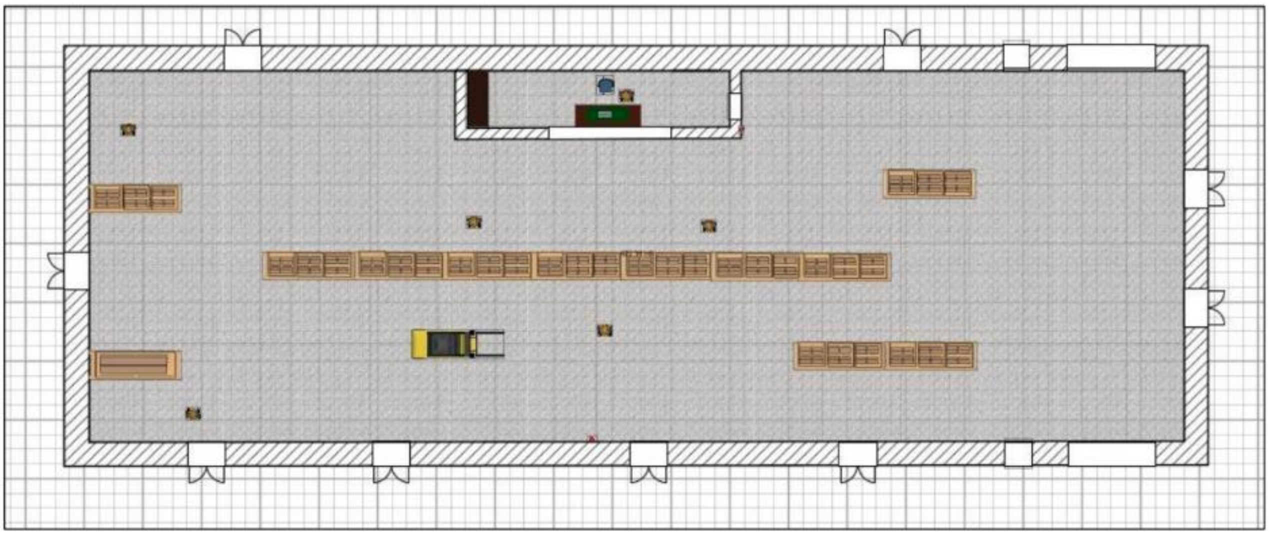


Figure 2. 2D design of the proposed repair that has been adjusted by PT. ABC products

Figure 3. 3D design of the proposed repair that has been adjusted by PT. ABC products

## Conclusion

Following the process of data collection, analysis, and the application of the Dedicated Storage method combined with the 5S approach to the finished goods warehouse at PT. ABC supported by direct observations at the TA warehouse several significant findings were obtained regarding the optimization of warehouse layout and operational efficiency. The study determined that the total storage space required to accommodate the existing inventory is approximately 198,720 $cm^2$, which necessitates the use of 12 racking units. The proposed design includes an aisle width of 170 cm to facilitate safe and efficient movement of forklifts and material handling equipment, as well as a clearance of 20 cm to comply with safety standards and avoid congestion. Additionally, a working space of 29,870 $cm^2$ is allocated within the warehouse, while the overall facility occupies an area of 655,800 $cm^2$.

To ensure systematic product placement and to facilitate easier loading and unloading activities, specific procedures for organizing items within the warehouse are highly recommended. First, products with a high frequency of inbound and outbound movement should be positioned in storage areas closest to the entrance and exit points. Conversely, products with lower turnover rates should be placed further from these access points. This arrangement minimizes travel distance during put-away and picking processes, thereby reducing handling time and decreasing the frequency of forklift movement across the warehouse floor. Implementing this strategy aligns with lean principles by eliminating unnecessary motion, ultimately enhancing overall productivity.

Second, to avoid confusion and errors during retrieval or inventory checks, each storage location must be dedicated to a single product type. Under no circumstances should two or more different products share the same storage area. This principle is consistent with the Dedicated Storage method, which assigns fixed locations for every product category, making warehouse operations more organized and reducing the risk of misplacement.

Finally, a stacking standard of a maximum of three levels should be strictly enforced. When placing products on racks, the first available empty slot in the closest location should be filled before moving to the next. Subsequent items should then be stacked following the same guideline, ensuring that stability and safety are maintained throughout the storage process. This approach not only optimizes space utilization but also prevents accidents caused by overstacking or uneven weight distribution.

Overall, the application of Dedicated Storage and 5S principles combined with these structured procedures contributes to improved efficiency, safety, and operational discipline within the warehouse. By reducing travel distances, standardizing storage practices, and implementing clear stacking rules, the warehouse can achieve a higher level of productivity, minimize waste, and maintain an organized environment that supports continuous improvement.

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