Sainteks: Jurnal Sain dan Teknik
E-ISSN: 2685-8304
Volume 8 Nomor 02 Tahun 2026
http://ejournal.uicm.ac.id/index.php/sainteks/

# *Proposed Improvement of Finished Goods Warehouse Layout Using FSN Analysis and CBS Method at PT XYZ*

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***Abstract:*** *PT XYZ is a company operating in the Fast Moving Consumer Goods (FMCG) industry that produces snack products. Based on observations, it was identified that the finished goods warehouse layout at PT XYZ is not yet optimally organized. This condition has resulted in several operational issues, such as increased travel distance of material handling and longer time required for order picking and preparation activities. These problems potentially reduce warehouse operational efficiency, and negatively impact the company's distribution performance. This study aims to propose an improved finished goods warehouse layout at PT XYZ by implementing FSN (Fast Moving, Slow Moving, and Non Moving) analysis and the CBS (Class Based Storage) method. FSN analysis is applied to classify products according to their movement frequency, while the CBS method is used to arrange products based on their respective movement classes to create a more structured storage system. The data used in this study include product movement data, warehouse dimensions and layout, storage capacity requirements, material handling distances, and material handling times. The evaluation of the proposed warehouse layout shows an improvement in efficiency. In the existing layout, the total material handling distance is 14,333.40 meters, while after the implementation of the proposed layout becomes 13,520.10 meters, resulting in a reduction of 813,30 meters. In addition, the material handling time in the existing layout is 71,836.76 seconds, and after the implementation of the proposed layout it becomes 30,297.89 seconds, resulting in a reduction of 41,538.87 seconds. These results indicate that the application of FSN analysis combined with CBS method can improve operational efficiency of the finished goods warehouse at PT XYZ. The proposed layout is expected to serve as an alternative solution for improving warehouse management, particularly in reducing material handling distance and time, as well as supporting smoother warehouse operations.*
Keywords: Class Based Storage, Finished Goods Warehouse, FSN Analysis, Storage Capacity, Warehouse Layout.

DOI: https://doi.org/10.37577/sainteks.v8i02.1093
Received: 04, 2026. Accepted: 08, 2026. Published: 09, 2026

## INTRODUCTION

Indonesia is one of the countries experiencing rapid industrial development, particularly in the fast-moving Consumer Goods (FMCG) sector. Products in this sector are characterized by high turnover rates and relatively stable demand, requiring companies to respond quickly and efficiently to market needs. The rapid growth of the industry has also intensified competition among companies. Therefore, companies are required to enhance efficiency across various operational aspects, including production processes, supply chain management, and product distribution.

Warehouse management refers to activities related to the control and handling of materials within a warehouse, including storage, order processing, inbound and outbound handling, and inventory control (Samuel et al., 2023; Suntoro, 2020; Bhagya,2019). Warehouses not only function as storage facilities but also play a crucial role in ensuring product availability, supporting on time delivery, improving operational efficiency, and maintaining product quality so that goods remain in good condition and ready for distribution to customers. These functions must be supported by an effective warehouse layout design, which directly contributes to improving operational efficiency. An optimized layout can enhance responsiveness to customer demand while creating a safer and more productive working environment (Triana & Kartika, 2023). Therefore, warehouse layout optimization is a critical challenge in ensuring efficient storage and retrieval operations (Fatmawati & Rahmawati, 2025).

PT XYZ is a company operating in the snack food industry and manages three types of warehouses, namely raw material and packaging warehouse, finished goods warehouse, and general warehouse. The finished goods warehouse applies a randomized storage system, where products are placed in any available location without a fixed pattern (Isnaeni & Susanto, 2021; Shiau & Huang, 2020). The implementation of this method at PT XYZ leads to increased travel time and distance during picking activities, as it is not supported by a structured and accurate storage location recording system. This condition results in prolonged item search times and delays in product delivery. Therefore, an initial observation was conducted in the finished goods warehouse of PT XYZ to describe the actual condition as presented in Table 1, by collecting data on 20 product types through 30 random search activities to measure the time required to locate items until reaching the warehouse In/Out area.

**Table 1 Random Product Search Time Data in the Warehouse**

| Search No. | Product Searched | Actual Time (s) | Item Location Found | Time When Location is Known (s) |
|---|---|---|---|---|
| 1. | FGA Bread BB 72 | 82 | R5.9 | 44 |
| 2. | FGA Bread BB 180 | 78 | R6.8 | 42 |
| 3. | FGA Bread BC 78 | 112 | R7.9 | 50 |
| 4. | FGA Bread BC 195 | 109 | R3.8 | 46 |
| 5. | FGB Bread BB 160 | 148 | R2.10 | 60 |
| 6. | FGB Bread BC 160 | 121 | R1.2 | 40 |
| 7. | FGB Bread BB 180 | 124 | R2.2 | 44 |
| 8. | FGB Bread BC 195 | 113 | R8.12 | 52 |
| 9. | FGC Bread BV 72 | 145 | R1.9 | 44 |
| 10. | FGC Bread BC 78 | 114 | R4.10 | 50 |
| 11. | FGA Bread TBC 120 | 103 | R4.4 | 38 |
| 12. | FGA Bread TBB 85 | 53 | R10.1 | 30 |
| 13. | FGA Choux PSCO 33 | 32 | SB.3 | 15 |
| 14. | FGA Choux PSCE 33 | 20 | R9.1 | 9 |
| 15. | FGA Choux PSCO 72 | 44 | R8.2 | 16 |
| 16. | FGA Choux PSCE 72 | 98 | R3.3 | 38 |
| 17. | FGA Bread TBC 60 | 79 | R7.3 | 30 |
| 18. | FGC Bread TBB 40 | 80 | R7.4 | 36 |
| 19. | FGA Pastry AC 51 | 89 | R8.8 | 30 |
| 20. | FGC Choux SC 72 | 72 | R5.4 | 34 |
| 21. | FGA Bread BB 72 | 70 | R6.3 | 32 |
| 22. | FGA Bread BB 180 | 73 | R6.4 | 34 |
| 23. | FGA Bread BC 78 | 74 | R6.5 | 30 |
| 24. | FGA Bread BC 195 | 148 | R1.10 | 56 |
| 25. | FGB Bread BB 160 | 151 | R2.9 | 50 |
| 26. | FGB Bread BC 160 | 146 | R2.7 | 52 |

| | | | | |
|---|---|---|---|---|
| 27. | FGB Bread BB 180 | 134 | R1.6 | 48 |
| 28. | FGB Bread BC 195 | 78 | SA.4 | 26 |
| 29. | FGC Bread BV 72 | 42 | SR9.2 | 20 |
| 30. | FGC Bread BC 78 | 39 | SC.5 | 18 |

Based on Table 1, it can be observed that unorganized product placement contributes to prolonged search times in the warehouse. This is indicated by the significant difference between the actual condition and the condition when the product location is known, suggesting that the storage placement system is not yet well structured. This condition further indicates that products have not been classified based on their characteristic, resulting in a suboptimal picking process, particularly under high demand conditions where speed and accuracy are critical. The longer the picking process takes, the greater the potential delay in order preparation and shipment. Consequently, this condition may adversely affect the distribution process, particularly in terms of on time delivery performance to customers. The product delivery timeliness data at PT XYZ are presented in Table 2.

**Table 2 On Time Delivery Performance Data**

| Month | On Time Delivery Percentage |
|---|---|
| November 2024 | 84.39% |
| December 2024 | 71.77% |
| January 2025 | 88.22% |
| February 2025 | 80.85% |
| March 2025 | 89.82% |
| April 2025 | 92.26% |
| May 2025 | 84.70% |
| June 2025 | 94.14% |
| July 2025 | 98.74% |
| August 2025 | 91.67% |
| September 2025 | 97.31% |
| October 2025 | 94.59% |

Based on Table 2, the on-time delivery performance during the period from November 2024 to October 2025 has not yet reached 100% and exhibits a fluctuating pattern. This condition indicates that delivery performance remains suboptimal and delays still occurring. One of the factors that potentially contributes to this condition is the prolonged product search time in the warehouse due to an unstructured storage placement system.

In warehouse management, several storage methods are commonly applied, including dedicated storage, randomized storage, shared storage, and class-based storage. The dedicated storage method assigns a fixed storage location to each product type, thereby facilitating retrieval but lacking flexibility in space utilization when product volumes fluctuate. Randomized storage and shared storage offer greater flexibility in space utilization, but items are not grouped based on specific characteristics. In contrast, the class based storage method enables the grouping of products into different classes according to their popularity or movement frequency (Viarani et al., 2023; Yevita Nursyanti et al., 2024).

In the finished goods warehouse of PT XYZ, the number of stored products is fluctuating and the storage location recording system is not yet well structured. Therefore, a storage approach is required that can classify products while maintaining both optimal and flexible space utilization. To address these issues, this study proposes a warehouse layout improvement using Fast, Slow, and Non-Moving (FSN) analysis and the Class Based Storage (CBS) method. FSN analysis is applied to classify products based on their movement level, while the CBS method is used to determine storage placement based on this classification. The integration of these two approaches lies in the use of FSN analysis results as the basis for implementing the CBS method, such that products with higher movement rates are positioned closer to the In/Out areas to improve time efficiency and travel distance (Viarani et al., 2023; Yevita Nursyanti et al., 2024).

Previous research has addressed various issues related to warehouse layout and operational efficiency. The study conducted in the raw material warehouse of PT XYZ, a company engaged in the manufacture of corrugated carton boxes, applied the Class Based Storage (CBS) method through two improvement scenarios (Fitri et al., 2023). The result showed that the initial raw material transfer time of 100.79 minutes was reduced to 85.17 minutes under the first scenario, while the second scenario, which combined with CBS method with the addition of one forklift, reduced the transfer time to 43.19 minutes, representing a 52.6% reduction. A similar study addressed disorganized product placement that hindered warehouse operations and resulted in suboptimal space utilization (Aditya & Dahda, 2025). The application of CBS and FSN analysis reduced material handling cost by 41.7%, from IDR 6,558,992.00 to IDR 3,825,480.00 per month, and reduced material handling moment by 42%. Another study applied the CBS method to the raw material warehouse (Rahmawaty & Mashudi, 2024), resulting in a reduction in material movement distance from 16,172,250 meters to 7,007,975 meters per month and a decrease in material handling costs from IDR 109,971,300 to IDR 47,654,230 per month.

Based on these previous studies, CBS method and FSN analysis have demonstrated their effectiveness in improving warehouse layout and material handling efficiency. The novelty of this study lies in integrating FSN analysis with the Class Based Storage method in a finished goods warehouse within the FMCG snack food industry. This study also considers the operational requirements of the food industry, where rapid product picking and distribution are essential. Furthermore, the previous studies reviewed generally evaluate layout improvements based on specific performance measures, such as travel distance, material handling time, or cost. In contrast, this study evaluates the proposed layout based on material handling time, travel distance, and storage capacity for each product category.

## METHODOLOGY

The research method employed in this study is a quantitative descriptive approach. Quantitative research is defined as an approach that emphasizes the collection and analysis of quantitative data, namely data in the form of numerical values or variables (Wajdi et al., 2024). This study adopts a quantitative approach, as it utilizes numerical data, including inventory levels, product movement frequency, and material handling distance and time to measure and analyze the condition of the finished goods warehouse layout at PT XYZ. This study was conducted over a a year period from November 2024 to October 2025, with the population comprising all activities within the finished goods warehouse during that period. The sample consists of the entire population, including product types, product movement data, warehouse layout, material handling distance, and material handling times observed throughout the study period. The conceptual framework of this study is presented in Figure 1.

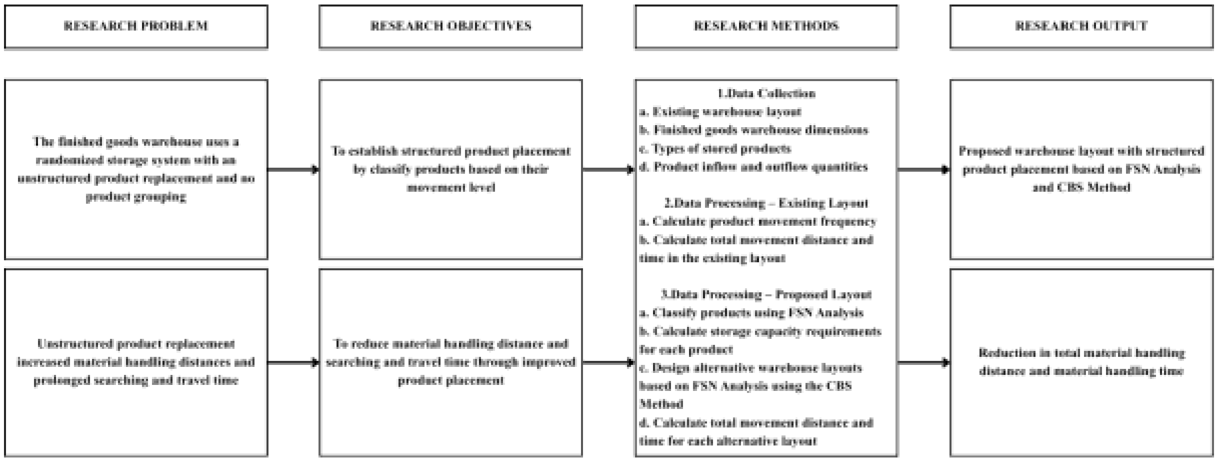


**Figure 1. Research Framework**

In this study, the analytical methods employed include FSN analysis (Fast, Slow, and Non-Moving) and the CBS (Class Based Storage) Method. FSN analysis is used to classify products based on their movement levels, thereby identifying categories of fast moving, slow moving, and non-moving items (Puspita & Hadi, 2025). This classification is determined based on the frequency of product movements during the study period.

The result of the FSN classification is subsequently used as the basis for implementing the CBS method. The CBS method is a class-based storage approach that groups products into specific areas according to their movement characteristics. Products classified as fast moving are placed in areas close to In/Out areas, while slow moving and non-moving products are assigned to areas farther from the In/Out areas (Viarani et al., 2023; Yevita Nursyanti et al., 2024). Subsequently, a proposed warehouse layout is developed based on the result of the FSN analysis and the implementation of the CBS method to improve operational efficiency, particularly by minimizing material handling distance and time. Material handling distance is measured using the rectilinear method, while material handling time is measured through direct observation.

## RESULTS AND DISCUSSION

### 1. Warehouse Utilization

Warehouse utilization is calculated to assess the extent to which storage space is used relative to the total warehouse capacity. A higher utilization value indicates more efficient use of storage space within the warehouse (Kemklyano et al., 2021; Yevita Nursyanti et al., 2024). The following presents the utilization calculation for the existing layout.

The known data include:

a. Finished goods warehouse area of 402,20 m$^2$
b. Non storage area of 193,2 m$^2$
c. Storage area of 191,75 m$^2$

Warehouse utilization is calculated using the following formula (Kemklyano et al., 2021; Yevita Nursyanti et al., 2024):

$$\text{Warehouse utilization} = \frac{\text{Total utilized block area}}{\text{Storage warehouse area}} \text{ x } 100\% \quad (1)$$

$$\text{Warehouse utilization} = \frac{191{,}75 \text{ m}^2}{402{,}20 \text{ m}^2 - 193{,}2 \text{ m}^2}$$

$$\text{Warehouse utilization} = 91{,}75\%$$

Based on the calculation results, the warehouse utilization under the existing layout is 91,75%. This indicates that the storage space utilization is relatively optimal. However, the high utilization level also suggests that the warehouse operates under relatively dense conditions. However, material handling activities remain feasible due to the availability of a non-storage area of 193.2 $m^2$, which functions as movement paths for handling equipment and operational activities.

**2. FSN Analysis**

FSN analysis is conducted as an initial stage of data processing to classify products based on their movement levels. In this study, the finished goods warehouse at PT XYZ stores a total of 20 product types. Through FSN analysis, products are classified into three categories, namely fast moving (TOR $> 3$), slow moving ($1 \leq$ TOR $\leq 3$), and non moving (TOR $< 1$) (Puspita & Hadi, 2025). The results of this classification are subsequently used as the basis for storage assignment and layout design using the CBS method.

a. Final Inventory Calculation

The final inventory calculation is conducted to determine the quantity of goods available at the end of the period, which is subsequently used as the initial inventory for the following period (Ardiansyah & Yuliawati, 2025). As an example, the calculation of final inventory for the product FGA Bread BB 72 for the November 2024 period is presented using the following formula (Ardiansyah & Yuliawati, 2025):

$$Pak = Paw + Pms - Ppk \quad (2)$$

$Pak = 643 + 3390 - 2613$

$Pak = 1420$ (representing the final inventory value of FGA Bread BB 72).

b. Average Inventory Calculation

The average inventory calculation is conducted to determine the average quantity of goods available during the observation period (Ardiansyah & Yuliawati, 2025). As an example, the calculation of average inventory for the product FGA Bread BB 72 for the November 2024 period is presented using the following formula (Ardiansyah & Yuliawati, 2025):

$$Prt = \frac{Paw + Pak}{2} \quad (3)$$

$Prt = \frac{643+1420}{2}$

$Prt = 1031{,}5$ (representing the average inventory value of FGA Bread BB 72).

c. Partial Turnover Ratio Calculation

The partial turnover ratio calculation is conducted to determine the level of inventory turnover within each period (Ardiansyah & Yuliawati, 2025). As an example, the calculation of the partial turnover ratio for the product FGA Bread BB 72 for the November 2024 period is presented as follows:

$$TORp = \frac{Pmk}{Prt} \quad (4)$$

$TORp = \frac{2613}{1031{,}5}$

$TORp = 2{,}53$ (representing the partial turnover ratio of FGA Bread BB 72).

d. Storage Time Calculation (Wsp)

The storage time calculation is conducted to determine the average duration a product remains in the warehouse until it is dispatched (Ardiansyah & Yuliawati, 2025). As an example, the calculation of storage time for the product FGA Bread BB 72 for the November 2024 period is presented as follows:

$$Wsp = \frac{jhp}{TORp} \tag{5}$$

$$Wsp = \frac{264}{2,53}$$

$Wsp = 104{,}3$ (representing the storage time of FGA Bread BB 72).

e. Turnover Ratio Calculation (TOR)
The turnover ratio calculation is conducted to describe the level of inventory turnover within one year (Ardiansyah & Yuliawati, 2025). As an example, the calculation of turnover ratio for the product FGA Bread BB 72 for the November 2024 period is presented as follows:

$$TOR = \frac{jht}{Wsp} \tag{6}$$

$$TOR = \frac{365}{104,3}$$

$TOR = 3{,}50$ (representing the turnover ratio of FGA Bread BB 72).

f. Product Classification
Product classification is conducted to determine the level of inventory turnover based on the average turnover ratio value. The average TOR value serves as the basis for classifying products into fast moving (TOR > 3), slow moving (1 ≤ TOR ≤ 3), and non moving (TOR < 1) (Yanuar, 2020). The complete classification results based on TOR values are presented in Table 3.

**Table 3 Classification of Products**

| No. | Product Name | Average TOR Value | FSN Classification |
|---|---|---|---|
| 1 | FGA Bread BB 72 | 6,44 | F |
| 2 | FGA Bread BB 180 | 0,96 | N |
| 3 | FGA Bread BC 78 | 1,32 | S |
| 4 | FGA Bread BC 195 | 4,10 | F |
| 5 | FGB Bread BB 160 | 1,43 | S |
| 6 | FGB Bread BC 160 | 7,95 | F |
| 7 | FGB Bread BB 180 | 8,28 | F |
| 8 | FGB Bread BC 195 | 5,90 | F |
| 9 | FGC Bread BV 72 | 15,44 | F |
| 10 | FGC Bread BC 78 | 8,51 | F |
| 11 | FGA Bread TBC 120 | 6,12 | F |
| 12 | FGA Bread TBB 85 | 20,78 | F |
| 13 | FGA Choux PSCO 33 | 0,95 | N |
| 14 | FGA Choux PSCE 33 | 1,38 | S |
| 15 | FGA Choux PSCO 72 | 2,85 | S |
| 16 | FGA Choux PSCE 72 | 1,56 | S |
| 17 | FGA Bread TBC 60 | 1,90 | S |
| 18 | FGC Bread TBB 40 | 8,10 | F |
| 19 | FGA Pastry AC 51 | 1,66 | S |
| 20 | FGC Choux SC 72 | 1,10 | S |

Based on the classification results in Table 3, a total of 10 products are categorized as fast moving (50%), indicating a high level of movement. Eight products are classified as slow moving (40%), and two products are categorized as non moving (10%), indicating low movement levels. These findings indicate that the majority of products stored in the finished goods warehouse at PT XYZ fall into the fast moving category, thereby requiring higher priority in storage access and handling (Candrianto et al., 2020).

However, the FSN classification in this study is based on the average turnover ratio during the observation period, which represents the historical movement characteristics of the products. Under actual warehouse operating conditions, product movement may change over time due to fluctuations in demand, order patterns, and inventory levels. This condition indicates that the FSN classification should be periodically updated to reflect changes in product movement patterns (G & Narmadha, 2026).

### 3. Storage Capacity Requirements

The determination of storage capacity requirements is conducted using historical inventory data for each product type. The results of this calculation are used to determine the number of pallets required for each product, which serve as the basis for warehouse layout design. The storage capacity requirements for each product are presented in Table 4. As an example, the calculation of storage capacity requirements for the product FGA Bread BB 72 is presented as follows:

Pallet requirement = $\frac{1.665}{60}$

Pallet requirement = 28 pallets for the product FGA Bread BB 72.

**Table 4 Storage Capacity Requirement Calculation**

| No. | Product Name | Final Inventory (Ctn) | Average Inventory (Ctn) | Capacity per Pallet (Ctn) | Pallet Requirement |
|---|---|---|---|---|---|
| 1. | FGA Bread BB 72 | 19.977 | 1.665 | 60 | 28 |
| 2. | FGA Bread BB 180 | 9.204 | 767 | 24 | 32 |
| 3. | FGA Bread BC 78 | 17.093 | 1.425 | 60 | 24 |
| 4. | FGA Bread BC 195 | 2.303 | 192 | 24 | 8 |
| 5. | FGB Bread BB 160 | 7.509 | 626 | 25 | 26 |
| 6. | FGB Bread BC 160 | 571 | 48 | 25 | 2 |
| 7. | FGB Bread BB 180 | 3.361 | 281 | 25 | 12 |
| 8. | FGB Bread BC 195 | 2.963 | 247 | 25 | 10 |
| 9. | FGC Bread BV 72 | 16.052 | 1.338 | 60 | 23 |
| 10. | FGC Bread BC 78 | 19.501 | 1.626 | 60 | 28 |
| 11. | FGA Bread TBC 120 | 1.462 | 122 | 40 | 4 |
| 12. | FGA Bread TBB 85 | 1.262 | 106 | 40 | 3 |
| 13. | FGA Choux PSCO 33 | 25.690 | 2.141 | 72 | 30 |
| 14. | FGA Choux PSCE 33 | 26.200 | 2.184 | 72 | 31 |
| 15. | FGA Choux PSCO 72 | 13.518 | 1.127 | 45 | 26 |
| 16. | FGA Choux PSCE 72 | 15.405 | 1.284 | 45 | 29 |
| 17. | FGA Bread TBC 60 | 3.905 | 326 | 84 | 4 |
| 18. | FGC Bread TBB 40 | 7.589 | 633 | 84 | 8 |
| 19. | FGA Pastry AC 51 | 21.948 | 1.829 | 88 | 21 |
| 20. | FGC Choux SC 72 | 11.706 | 976 | 45 | 22 |

Based on the calculation results presented in Table 4, each product exhibits different storage capacity requirements. A summary of storage capacity requirements based on FSN classification is presented in Table 5.

**Table 5 Storage Capacity Requirements**

| FSN Category | Number of Products | Total Pallet Requirement |
|---|---|---|
| Fast Moving (F) | 10 products | 126 pallets |
| Slow Moving (S) | 8 products | 183 pallets |
| Non Moving (N) | 2 products | 62 pallets |
| **Total** | **20 products** | **371 Pallets** |

Based on Table 5, the total storage capacity requirement in the finished goods warehouse at PT XYZ is 371 pallets. The slow-moving category has the largest storage capacity requirement, amounting to 183 pallets, despite having lower moving frequency compared to the fast-moving category. This indicates that slow moving products tend to maintain relatively higher inventory levels, thereby requiring larger storage space. The fast-moving category accounts for a total storage capacity requirement of 126 pallets across 10 product types. These products exhibit high movement frequency and therefore require placement in storage areas with higher access priority support efficient picking and dispatching activities (Candrianto et al., 2020). Meanwhile, the non-moving category has a total storage capacity requirement of 62 pallets across two product types. These products have low movement frequency and can be assigned to storage areas with lower access priority (Candrianto et al., 2020).

## 4. Material Handling Distance Calculation in the Existing Layout

The calculation of material handling distance is conducted by determining the coordinate points for each storage block. Subsequently, the distance between the In or Out area and each storage location is calculated based on these predefined coordinates. Distance measurement is performed using the rectilinear method, which calculates travel distance along orthogonal paths in both horizontal and vertical directions (Salvano et al., 2025; Sari & Oktora, 2025). An example of the material handling distance calculation for product movement from the In area to a storage block R.1.1.1 and back to the Out area is presented as follows:

a. Distance calculation from the In area to storage block R1.1.1

$$d_{ij} = |13-0,65| + |20,5-14,375|$$
$$= 12,35+6,125$$
$$= 18,475$$

b. Distance calculation from storage block R1.1.1 to the Out area

$$d_{ij} = |13-0,65| + |20,5-14,375|$$
$$= 12,35+6,125$$
$$= 18,475$$

After obtaining both distances, the total travel distance is calculated by summing these values. The total material handling distance for storage block R1.1.1, which stores product FGA Bread BB 72, is 18,475 m + 18,475 m = 36,95 m.

Based on the overall calculation results, each storage block has a different distance relative to the warehouse In/Out area. The total material handling distance in the existing layout is 14.333,40 m.

## 5. Material Handling Time Calculation in the Existing Layout

The material handling time in the existing layout is evaluated to determine the duration required by warehouse operators to perform product searching, picking, and transporting activities until the goods reach the warehouse Out area. The measurement of material handling time is conducted using a stopwatch through direct observation of operator movements. The total material handling time is obtained by summing the duration of all related activities, as presented in Table 6.

**Table 6 Total Material Handling Time in the Existing Layout**

| | |
|---|---|
| Total searching time (s) | 48.324,95 |
| Total dispatching time (s) | 23.511,81 |
| Total time (s) | **71.836,76** |

Based on Table 6, the total material handling time in the existing layout is 71.836,76 seconds, which is equivalent to 19 hours 57 minutes and 16 seconds.

## 6. Proposed Layout Design

The current condition of the finished goods warehouse at PT XYZ utilizes a racking system as the primary storage facility, consisting of 118 storage blocks. These include 84 four tier rack blocks, 12 two tier rack blocks, and 22 staging area blocks that support warehouse operations. The proposed layout design for the finished goods warehouse at PT XYZ is developed based on the results of the FSN analysis and product classifications. The layout alternative is arranged according to product classification while considering actual warehouse conditions, as illustrated in Figure 2.

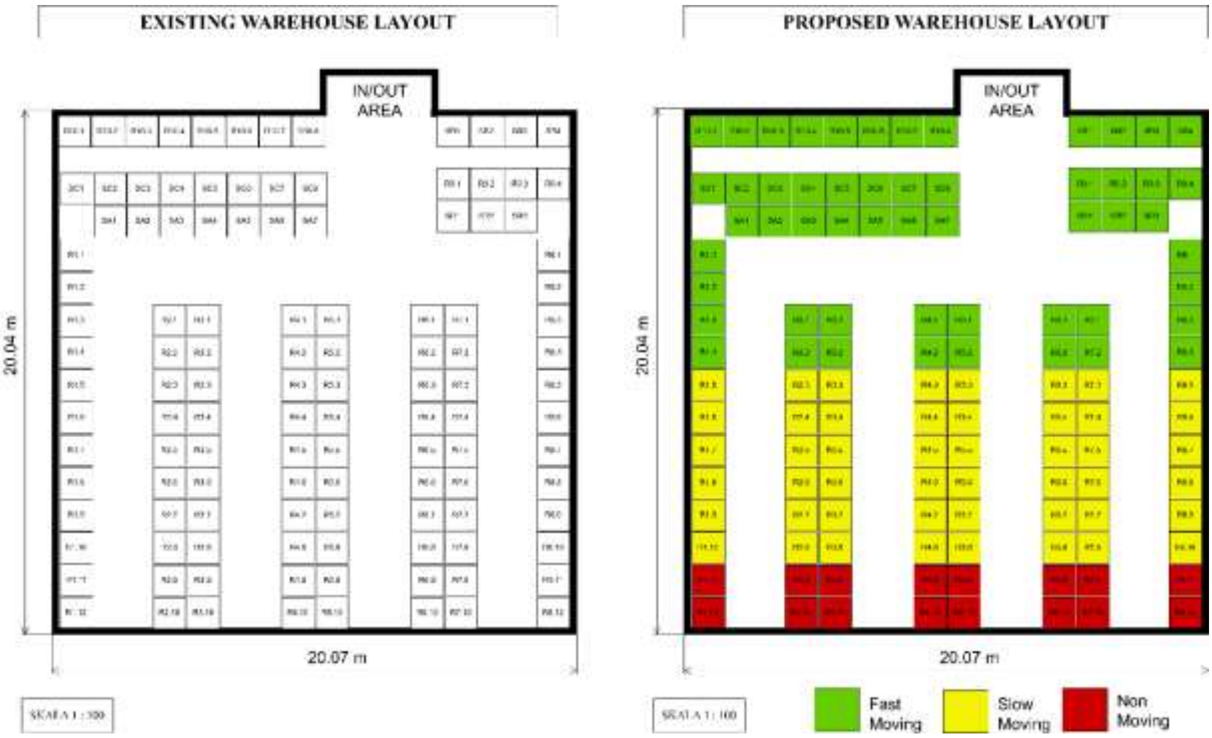


**Figure 2. Existing and Proposed Layout of the Finished Goods Warehouse**

As shown in Figure 2, the proposed layout does not involve any modifications to the physical structure of the warehouse. Instead, it focuses on rearranging storage locations based on FSN analysis and the CBS method to facilitate product retrieval and improve operational efficiency.

This approach is justified by the warehouse utilization results, which indicate that the existing layout has already achieved a relatively optimal level of space utilization.

**7. Evaluation of Material Handling Distance Based on the Proposed Layout**

The evaluation of material handling distance is conducted to identify the differences in travel distance between the existing and proposed warehouse layouts. The proposed layout is developed based on the results of FSN classification and the implementation of the CBS method, such that storage block allocation is aligned with the movement characteristics of each product category.

Material handling distance is calculated by measuring the distance from each storage block to the In/Out area using the rectilinear method. A comparison of material handling distances between the existing and proposed layouts is presented in Table 7.

**Table 7 Comparison of Material Handling Distance between Existing and Proposed Layouts**

| Product Name | Product Classification | Existing Layout (meters) | Proposed Layout (meters) | Difference (meters) |
|---|---|---|---|---|
| FGA Bread BB 72 | F | 1.305,75 | 1.060,60 | 245,15 |
| FGA Bread BB 180 | N | 1.282,00 | 1.731,20 | -449,2 |
| FGA Bread BC 78 | S | 885,5 | 1.276,80 | -391,3 |
| FGA Bread BC 195 | F | 418,4 | 141,2 | 277,2 |
| FGB Bread BB 160 | S | 866,4 | 1.105,50 | -239,1 |
| FGB Bread BC 160 | F | 115,15 | 68,1 | 47,05 |
| FGB Bread BB 180 | F | 454,75 | 284,4 | 170,35 |
| FGB Bread BC 195 | F | 437,5 | 229,2 | 208,3 |
| FGC Bread BV 72 | F | 865,25 | 453,95 | 411,3 |
| FGC Bread BC 78 | F | 1.149,25 | 735,4 | 413,85 |
| FGA Bread TBC 120 | F | 221,55 | 112,9 | 108,65 |
| FGA Bread TBB 85 | F | 142,95 | 56,55 | 86,4 |
| FGA Choux PSCO 33 | N | 1.043,90 | 1.355,20 | -311,3 |
| FGA Choux PSCE 33 | S | 1.167,10 | 1.031,95 | 135,15 |
| FGA Choux PSCO 72 | S | 943,05 | 1.141,30 | -198,25 |
| FGA Choux PSCE 72 | S | 1.058,60 | 966,8 | 91,8 |
| FGA Bread TBC 60 | S | 123,1 | 104,6 | 18,5 |
| FGC Bread TBB 40 | F | 373,95 | 182,8 | 191,15 |
| FGA Pastry AC 51 | S | 744,95 | 680,95 | 64 |
| FGC Choux SC 72 | S | 734,3 | 800,7 | -66,4 |
| **Total Material Handling Distances** | | **14.333,40** | **13.520,10** | **813,30** |

Based on Table 7, the total material handling distance in the proposed layout decreases by 813.30 meters compared to the existing layout. This reduction is primarily attributed to the relocation of fast moving products to areas closer to the In/Out area, resulting in shorter travel distances for high frequency picking activities.

The comparison results also indicate that not all products experience a reduction in travel distance. Some products exhibit increased travel distances due to their relocation to storage areas that are relatively farther from the In/Out area. This occurs for products with lower movement frequency, allowing storage areas to the In/Out area to be prioritized for high movement products. Despite these increases, the proposed layout overall successfully reduces the total material handling distance compared to the existing layout.

## 8. Evaluation of Material Handling Time Based on the Proposed Layout

The evaluation of material handling time is conducted to assess the impact of the proposed warehouse layout on the efficiency of picking activities in the finished goods warehouse at PT XYZ. The proposed layout is developed based on FSN classification, where products are categorized into fast moving, slow moving, and non moving groups and subsequently assigned to storage zones using the CBS method.

In the existing layout, product placement follows a randomized approach, resulting in fast moving products not being located near the In/Out area. This condition leads to longer picking times, as warehouse operators must spend additional time locating products. In contrast, in the proposed layout, fast moving products are positioned closer to the In/Out area, while slow moving and non moving products are assigned in areas with lower access priority (Viarani et al., 2023; Yevita Nursyanti et al., 2024).

Material handling time is measured through direct observation of operator activities, including product searching, picking, and transporting goods to the Out area. Measurements are conducted for both the existing and proposed layouts to enable a comparative analysis, as presented in Table 8.

**Table 8 Comparison of Material Handling Time between Existing and Proposed Layouts**

| Product Name | Product Classification | Existing Layout (seconds) | Proposed Layout (seconds) | Difference (seconds) |
|---|---|---|---|---|
| FGA Bread BB 72 | F | 5.559,32 | 2.484,26 | 3.075,06 |
| FGA Bread BB 180 | N | 7192,13 | 3.265,48 | 3926,65 |
| FGA Bread BC 78 | S | 4427,55 | 2.381,83 | 2045,71 |
| FGA Bread BC 195 | F | 1656,09 | 327,43 | 1328,65 |
| FGB Bread BB 160 | S | 4.615,53 | 2.280,17 | 2.335,37 |
| FGB Bread BC 160 | F | 266,57 | 110,36 | 156,2 |
| FGB Bread BB 180 | F | 2284,65 | 799,23 | 1485,42 |
| FGB Bread BC 195 | F | 2054,76 | 864,96 | 1189,8 |
| FGC Bread BV 72 | F | 4.782,71 | 856,08 | 3.926,63 |
| FGC Bread BC 78 | F | 4770,98 | 2.088,15 | 2682,83 |
| FGA Bread TBC 120 | F | 873,04 | 452,71 | 420,33 |
| FGA Bread TBB 85 | F | 553,2 | 81,15 | 472,06 |
| FGA Choux PSCO 33 | N | 5657,24 | 2.779,29 | 2877,95 |
| FGA Choux PSCE 33 | S | 6.070,78 | 2.158,01 | 3.912,78 |
| FGA Choux PSCO 72 | S | 5.082,12 | 2.434,34 | 2.647,78 |
| FGA Choux PSCE 72 | S | 5079,53 | 2.342,43 | 2737,09 |
| FGA Bread TBC 60 | S | 858,63 | 317,93 | 540,7 |
| FGC Bread TBB 40 | F | 1402,21 | 229,437 | 1172,77 |
| FGA Pastry AC 51 | S | 3892,95 | 1.463,60 | 2429,36 |
| FGC Choux SC 72 | S | 4756,79 | 2.581,05 | 2175,74 |
| **Total Material Handling Time** | | **71.836,76** | **30.297,89** | **41.538,87** |

Based on Table 8, the total material handling time in the existing layout is 71.836,76 seconds, equivalent to 19 hours 57 minutes and 16 seconds. In contrast, the proposed layout reduced the total time to 30.297,89 seconds, equivalent to 8 hours 24 minutes and 57 seconds. Therefore, the implementation of the proposed layout results in a reduction of 41.538,87 seconds, or approximately 11 hours 32 minutes and 18 seconds.

Although the proposed layout reduces the total material handling time, the results also show that material handling time can vary significantly among products. This variation is influenced not only by the distance between the storage locations and the In/Out area, but also by operational conditions specific to each product, such as searching activities, picking processes, and other related activities. Therefore, the material handling time calculated in this study represents the operational conditions during the observation period.

### 9. Limitations and Future Research

This study has several limitations. The measurement of material handling time is based on observations of operator activities, which may cause the measurement results to be influenced by operational conditions during the observation period. In addition, this study evaluates improvements in material handling efficiency based on the application of FSN classification and the CBS method, but does not consider the costs associated with implementing the proposed layout.

Future research can incorporate material handling costs as an additional evaluation indicator to assess not only improvements in material handling time and travel distance, but also potential cost savings resulting from the proposed layout. In addition, future research can compare other warehouse layout methods to identify alternative layouts that may provide greater improvements in material handling efficiency.

## CONCLUSION

Based on the results of this study, it can be concluded that the finished goods warehouse layout at PT XYZ in its existing condition is not optimally organized, as product placement is conducted without classification based on movement characteristics. This condition leads to reduced operational efficiency, as indicated by the high material handling distance and time. Through the implementation of FSN analysis and the CBS method, the warehouse is divided into three primary zones consisting of fast moving, slow moving, and non moving product categories. The required storage capacity is 126 pallets for fast moving products, 183 pallets for slow moving products, and 62 pallets for non moving products. The proposed layout is developed by grouping products based on FSN classification and the CBS method, where fast moving products are positioned closest to the In/Out area, followed by slow moving and non moving products. This arrangement results in a total material handling distance of 13,520.10 meters in the proposed layout compared to 14.333,40 meters in the existing layout, indicating a reduction of 813,30 meters. In terms of time performance, the total material handling time in the proposed layout is 30.297,89 seconds, whereas the existing layout requires 71.836,76 seconds. The implementation of the proposed layout therefore reduces material handling time by 41.538,87 seconds, which is equivalent to 11 hours 32 minutes and 18 seconds.

Theoretically, this study contributes to the application of FSN classification combined with the CBS method in warehouse storage location assignment by demonstrating its potential to improve material handling efficiency based on product movement levels. Positioning fast moving products closer to the In/Out area can reduce product searching time and picking distance. From a managerial perspective, the findings can be used as an alternative approach to improving the finished goods warehouse layout by assigning storage locations according to product movement levels. The proposed storage allocation can improve warehouse operational efficiency by reducing material handling time and product travel distance.

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