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Proposed Warehouse Layout Improvement for Optimizing Travel Distance and Material Handling Costs Using the ABC Method at PT X

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ABSTRACT

The research employed a quantitative descriptive approach using warehouse operational data, including picking frequency, rack coordinates, and material movement information. Inventory items were classified into three categories—Class A (fast-moving), Class B (medium-moving), and Class C (slow-moving)—based on usage frequency. Subsequently, warehouse rack positions were rearranged according to ABC priorities, followed by recalculation of travel distances and material handling costs. The findings indicate that the proposed warehouse layout significantly improves operational efficiency for frequently moved products. The total travel distance for Class A items decreased from 1,662 meters to 1,272 meters, representing a reduction of 23%, while Class B items decreased from 807 meters to 771 meters, equivalent to a 4% reduction. Consequently, material handling costs for Class A and Class B movements also decreased proportionally. Although Class C travel distance increased from 279 meters to 705 meters, this change is considered acceptable because slow-moving items contribute minimally to warehouse movement frequency. The study concludes that integrating ABC classification with Rectilinear distance measurement effectively optimizes warehouse layout by reducing travel distance and material handling costs while improving storage efficiency for high-frequency inventory.

A. INTRODUCTION

Warehouse management is an essential component of supply chain operations because it directly influences storage efficiency, order fulfillment speed, and material handling costs. In manufacturing and distribution companies, ineffective warehouse layouts frequently result in excessive travel distance, increased handling time, and higher operational costs. Poor inventory arrangement may also disrupt warehouse productivity, particularly when fast-moving products are stored far from receiving or shipping points. Therefore, an effective warehouse layout design is necessary to support efficient material flow and operational performance.

Warehouse layout optimization focuses on minimizing unnecessary movement while ensuring that storage space is utilized effectively. One of the critical challenges in warehouse operations is determining the optimal storage position for inventory items based on movement frequency. Products with high movement intensity should ideally be located closer to loading or dispatch areas to reduce travel distance and improve picking efficiency. Conversely, products with low movement frequency can be stored farther away without significantly affecting warehouse performance.

Several studies have investigated warehouse optimization using different storage allocation methods. The ABC classification method is among the most widely applied approaches because it categorizes inventory items according to movement frequency or contribution level. Items in Class A typically represent high-frequency products requiring priority placement, while Class B and Class C items represent medium- and low-frequency products respectively. Previous studies have demonstrated that ABC-based warehouse arrangements can significantly reduce picking distance and improve material flow efficiency (Fazrin & Ludiya, 2023; Karabacak & Ertekin, 2023; Lai et al., 2024).

Despite extensive implementation of ABC analysis in warehouse management, many studies primarily focus on inventory categorization without integrating precise distance measurement approaches to quantify operational efficiency improvements. Moreover, warehouse optimization studies frequently emphasize storage allocation while providing limited analysis regarding the impact on material handling costs. Consequently, there remains a need for an integrated approach capable of simultaneously evaluating rack placement, travel distance reduction, and material handling cost efficiency.

To address this gap, the present study integrates ABC classification with the Rectilinear (Manhattan) distance method to redesign warehouse rack arrangements at PT X. The Rectilinear distance approach is particularly suitable because warehouse movement generally follows aisle-based orthogonal travel paths rather than direct Euclidean movement. By combining inventory classification and coordinate-based distance measurement, this study provides a more practical and measurable framework for warehouse layout optimization.

The novelty of this research lies in the integration of ABC-based storage prioritization, coordinate-based warehouse layout redesign, and material handling cost evaluation to assess operational efficiency comprehensively. Unlike prior studies that focus mainly on distance reduction, this study also evaluates the economic implications of warehouse redesign through material handling cost calculations involving labor and material handling equipment.

Therefore, this study aims to optimize warehouse layout at PT X by rearranging rack placement according to ABC classification and evaluating its effectiveness through Rectilinear distance calculations and material handling cost analysis. The findings are expected to contribute both theoretically to warehouse optimization studies and practically to managerial decision-making in warehouse operations.

B. METHODS

1. ABC Method

This research uses a quantitative descriptive research design with a case study approach on inventory management activities at the company being studied. This approach was chosen to analyze inventory characteristics based on their usage value and importance using the ABC classification method, thus providing recommendations for warehouse rack layout for more effective inventory control. The data sources used consisted of primary and secondary data. Primary data were obtained through direct observation of the warehouse layout and interviews with those responsible for inventory management, while secondary data were obtained from company documents, such as material usage data, purchasing data, inventory values, and warehouse layout. The observation period was conducted over five months, from June to October, so the data used could represent material usage patterns across several operational cycles. This period was chosen to minimize the influence of seasonal fluctuations on the classification results.

ABC analysis is a classification method used to separate items or products based on their importance, whether in terms of usage, frequency of demand, or contribution to total value (Karabacak et al., 2023). In the context of facility layout, this method is used to group and place items or components based on their importance and movement in the production or distribution process. ABC classification typically consists of (Mulyadi, 2023):

a. Class A: Items with the highest value or frequency of use-typically around 20% of items receive 80% of the value
b. Class B: Items with medium value-typically 30% of items receive 15% of the value
c. Class C: Items with the lowest value or frequency-typically 50% of items contribute only 5% of the value

In layout design, this principle is applied to place category A items in the closest or most accessible locations, thereby speeding up processing and reducing transfer costs (Patra et al., 2023). The purpose of using the ABC method is to improve operational efficiency by placing frequently used items in strategic and easily accessible locations, minimizing the time and cost of moving goods or materials in the production or distribution process, optimizing storage space and workflow, so that the system becomes more organized and responsive to demand. Here are the steps to improve warehouse layout using the ABC analysis method (Saffanah et al., 2023)

a. Identify Warehouse Problems
   Conduct observations to identify key issues such as stockpiling, excessive moving distances, and inefficient retrieval processes. Then, document the existing layout and storage processes to compare them with proposed improvements.
b. Collecting Inventory Data
   Collect necessary data such as item names, retrieval frequency, and the volume or quantity of each item.
c. ABC Value Calculation
   Calculate the cumulative contribution of goods based on frequency of use using the formula: $Total\ value = Frequency\ of\ use$ Then, sort the values from highest to lowest.
d. Goods Classification
   Classify goods into three classes :
   - Class A: 0–20% of items contributing 70–80% of the value (fast-moving).
   - Class B: 30% of items contributing 15–25% of the value (slow-moving).
   - Class C: 50–60% of items contributing 5–10% of the value (very slow-moving).
e. Analysis and Evaluation of the Initial Layout
   Analyze and evaluate whether class A items are easily accessible or located in remote areas, and whether class C items occupy strategic space that should be reserved for class A items.
f. Design the Proposed Layout
   Rearrange the warehouse layout based on the classification of class A items closer to the exit or storage door, and class B and C items placed further away according to their priority of use.

g. Efficiency Calculation Simulation
   Compare the moving distance or picking time between the initial layout and the proposed layout. Calculate the time or distance savings obtained from the new layout.
h. Implementation and Recommendations
   Recommend implementing the layout gradually, then adjusting the system and visual controls in the warehouse (color labeling storage shelves based on ABC classification). By grouping items based on their importance, companies can create efficient, cost-effective, and productive layouts. This method also helps manage workspace and time, making production or distribution processes smoother and more responsive to operational needs (Yuliana et al., 2016)

2. Distance Measure

There are several systems used to measure the distance from one location to another, and the measurement method chosen depends largely on the availability of qualified

personnel, the time required to collect data, and the type of material handling system used (Supriyadi et al., 2019). Rectilinear distance, or Manhattan distance, is the distance measured along a perpendicular line. The following formula is used to measure rectilinear distance.

$$dij = |xi - xj| + |yi - yj| \quad (1)$$

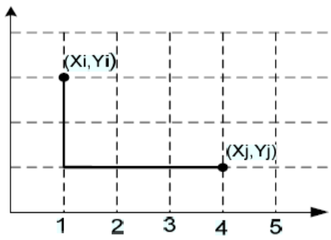


Figure 1. Rectilinear Distance

In layout analysis, distances between locations are measured using the Euclidean distance method. This method was chosen because it provides an estimate of the shortest distance between department center points or storage locations, making it suitable for evaluating layout efficiency and simplifying material movement calculations in conditions without significant physical obstacles.

3. Solving Step

To provide a logical overview of the steps in completing this research, the following describes all activities carried out during the research process. Identification of data sources and the data collection process is carried out through several techniques as follows (Titong, 2024):

- Direct observation, namely observing the process in the field to understand actual warehouse operations and material flows.
- Literature review, namely searching for relevant theories and scientific references related to warehouse layout, ABC analysis, and material handling costs.
- Documentation, namely collecting data from documents available at PT X such as inventory records, transaction histories, and warehouse layout drawings.

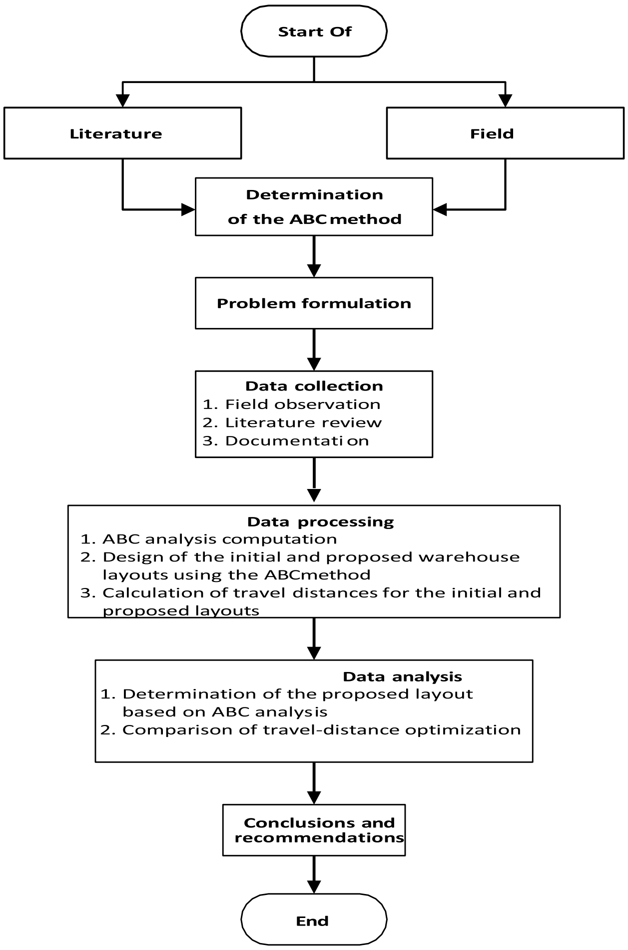


Figure 2. Solving Step

To ensure the accuracy of the classification results, the ABC analysis results were cross-checked by re-verifying usage data, unit prices, annual consumption values, and cumulative percentage calculations. Furthermore, the grouping results were compared with actual data and confirmed with the company to ensure that each item had been classified according to its priority level.

C. RESULT AND DISCUSSION

1. ABC Method Category Calculation

In this step, the results of data collection taken from the warehouse of PT X are obtained by identifying the type of goods, product items, as well as analyzing and observing the frequency of goods retrieval based on product input and output data, so that these data become inputs for frequency calculations. In addition to the number of goods, the frequency of goods retrieval is collected for the last 6 months, and the average values are calculated on a monthly basis to ensure that the dataset reflects typical warehouse operating conditions. After that, the goods are categorized based on the data available in the company, so that the data structure of goods in the warehouse becomes very complete and comprehensive and can be used as a basis for ABC classification and layout improvement analysis. After the data collection, an ABC analysis calculation is carried out with the provision of determining the category class if the cumulative result of the percentage of the frequency of use of goods is 70%, it falls into category A (fast moving), 71-90% falls into category B (slow moving) and 91-100% falls into category C (very slow moving). From the calculation results, the following results were obtained:

Table 1 Data Collection On The Frequency Of Use Of Goods At PT

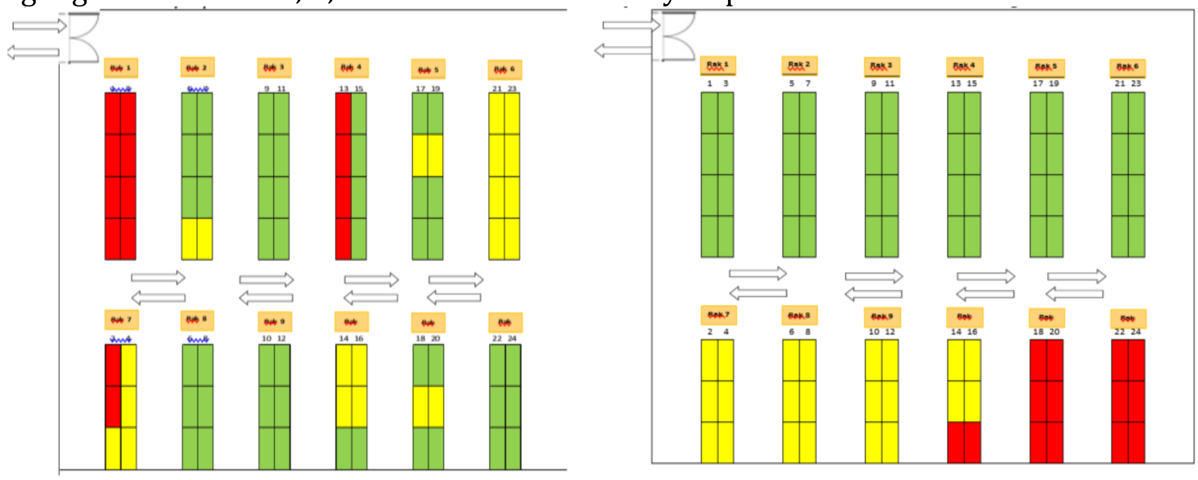
No.	Item type	Usage Frequency	Percentage	Cumulative Percentage	Class
1	Quarantine products	220	30%	30%	A
2	Medical devices	189	26%	55%	A
3	Finished products (finished goods)	135	18%	73%	A
4	Packaging materials	78	11%	84%	B
5	Raw materials	56	8%	91%	B
6	Non-drug products (non-pharmaceutical products)	63	9%	100%	C
Total		**741**			

Data source: processed from company data.

2. Warehouse Layout Distance Calculation

Based on the results of the ABC analysis, which classified items into three categories, the next step involved mapping these classifications to the initial warehouse rack layout in order to analyze the existing spatial arrangement. The following section presents the processed data and spatial identification outcomes for each of the three categories: green for fast-moving

items, yellow for slow-moving items, and red for very slow-moving items. The distribution of these categories can be seen in the illustration below, which visually highlights how Class A, B, and C items are currently dispersed across the warehouse racks.

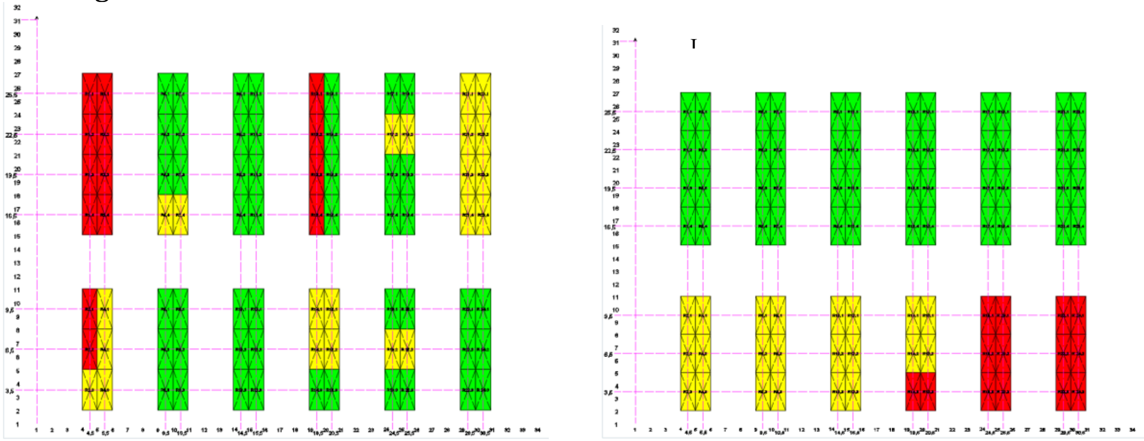


Initial Layout ABC Repair Layout

Figure 3 Layout Image Based on ABC Analysis

Based on the image above, significant changes in material placement are evident between the Initial Layout and the ABC Repair Layout. In the initial layout, materials classified as A, B, and C were scattered across multiple shelves, resulting in a disorganized storage location based on frequency of use. This situation potentially increased operator movement distances, search time, and material handling costs. After improvements using the ABC Analysis method, the storage layout became more structured. Category A materials, which have the highest usage or consumption value, are placed in areas closest to the entrance or retrieval area, facilitating access and reducing movement time. Category B materials are placed in intermediate positions within easy reach, while Category C materials are placed farther away due to their relatively low frequency of retrieval.

In determining the distance between warehouse racks, the researcher conducted direct observations by referring to the scaled measurements provided in the company's existing warehouse layout documents (Rahman et al., 2024). The layout was then converted into a coordinate system, enabling the identification of the precise coordinates of each rack relative to the receiving point at the entrance and the dispatch point at the exit. The following figure presents the resulting coordinate-based representation of the warehouse layout, which forms the basis for subsequent rectilinear distance and material handling cost calculations.



Initial Layout ABC Repair Layout

Figure 4 The Initial Coordinate Mapping of Warehouse Layout Based on ABC Analysis

After determining the initial scale of the warehouse layout, the distance between points was calculated using the Rectilinear (Manhattan) distance measurement method, which sums horizontal and vertical travel along orthogonal paths. A total of 85 coordinate points were identified, each representing the distance from the receiving point to every rack location in the warehouse, as summarized in the following layout representation

Table 2 Tables of Initial Layout Distance Calculations for Class A

Layout	Rack Number	From	To	Item Class	Total Distance
Intial Layout	1-48	R5.1-R24.3	Destination Point (A)	A	1662
	1-22	R2.3-R23.4		B	807
	1-14	R1.1-R13.4		C	279
Layout	**Rack Number**	**From**	**To**	**Item Class**	**Total Distance**
ABC Repair Layout	1-48	R1.1-R23.4	Destination Point (A)	A	1272
	1-22	R2.1-R16.2		B	771
	1-14	R14.3-R24.3		C	705

Example of Rectilinear Distance Calculation:

$d_{ab} = |x_a - x_b| + |y_a - y_b| \ldots \ldots\ldots\ldots\ldots \quad (1)$

$d_{R1.1, A} = |x_{R1.1} - x_A| + |y_{R1.1} - y_A|$

$d_{R1.1, A} = |4{,}5 - 1| + |25{,}5 - 31| = 9$ meters

The initial calculation shows that rack utilization is determined based on the ABC classification, consisting of 48 racks for category A, 22 racks for category B, and 14 racks for category C.

Material Handling Cost Calculation

To evaluate whether the redesigned warehouse layout provides a better economic outcome, a material handling cost analysis is conducted by comparing the total cost per movement in the initial and improved layouts. This calculation considers the handling activities and resources used by PT X in operating its warehousing system, including travel distance, movement frequency, labor, and material handling equipment such as forklifts, hand pallet trucks, pallets, and human operators. In this context, material handling cost analysis represents the collection and processing of operational data required to determine the total material handling cost, integrating distance moved, handling frequency, labor wages, and equipment usage into a single economic performance measure for.

Table 3 Material Handling Cost Calculation

Information	Small forklift	Large forklift	Hand PalletTruck	Pallet	Human Operator
Price	Rp 130,000,000	Rp 375,000,000	Rp 4,245,750	Rp 320,000	Rp -
Economic Life	5	5	8	0	0
Working Hours / day	8	8	8	8	8
Working days/ Moth	21	21	21	21	21
Salvage value / year	Rp 26,000,000	Rp 75,000,000	Rp 530,719	Rp -	Rp -
Depreciation / year	Rp 20,800,000	Rp 60,000,000	Rp 464,379	Rp -	Rp -
Slavage Value / Month	Rp2,166,667	Rp6,250,000	Rp 44,227	Rp -	Rp -
Depreciation Cost /Month	Rp 1,733,333	Rp 5,000,000	Rp 38,698	Rp -	Rp -
Electricity Cost /Month	Rp 38,682	Rp 179,886	Rp -	Rp -	Rp -
Maintenance Cost / Month	Rp 749,994	Rp 1,500,009	Rp 35,007		
Basic Salary / Month	Rp -	Rp -	Rp -	Rp -	Rp 4,482,914
Operator wage / Month	Rp 8,405,460	Rp 8,405,460	Rp 8,405,460	Rp 8,405,460	Rp -
Number Of MHE Unit	2	1	10	1550	15
Frequency/Month	741	741	741	741	741
Travel Distance/M	2748	2748	2748	2748	2748
OMH/Month	Rp 3,977	Rp 5,490	Rp 3,086	Rp 3,059	Rp 24,470

Using these data, the material handling cost can be calculated using the following general cost equation:

1. Small or large forklift material handling costs

$$\text{Depreciation} = \frac{Asset\ Price - Resual\ Valuei}{Economic\ life}$$

$$= \frac{Rp.130.000.000 - Rp.26.000.000}{5\ year} = \frac{20.800.000}{21}$$

$$= Rp\ 1.733.333/Month$$

$$\text{MHC/Month} = \frac{depreciation + energy\ cost + maintenance\ cost + opertor\ wage}{travel\ distance}$$

$$= \frac{Rp.1.733.333 + Rp.38.682 + Rp.749.994 + 8.405.460}{2748\ meter}$$

$$= Rp\ 3.977\ Meter/Movement$$

2. Human material handling costs

$$\text{MHC/Month} = \frac{Gaji\ Opeartor\ x\ jumlah}{Jarak\ Tempuh} = \frac{4.482.914\ x\ 15}{2748}$$

From these calculations, the material handling cost per movement for each type of material handling equipment is obtained as follows:

Table 4 Material Handling Cost Calculation

Material Handling	MH Cost
Small forklift	Rp 3,977
Large forklift	Rp 5,490
Hand pallet truck	Rp 3,086
Pallet	Rp 3,059
Human Operator	Rp 24,470
Total	**Rp 40,080**

The total material handling cost per movement across all equipment types is Rp 40,080. After that, calculate the results using the distance x cost equation so that the final result is as follows.

Table 5 Comparing Distance Calculation Results for Each Layout

Class	Catagory	Initial Distance (m)	Improved Distance (m)	Initial OMH (Rp)	Improved OMH (Rp)	Difference (Rp)	Reduction (Rp)
A	Fast Moving	1662	1272	Rp 66,613,758	Rp 50,982,371	Rp 15,631,387	23%
B	Medium Moving	807	771	Rp 32,344,948	Rp 30,902,050	Rp 1,442,897	4%
C	Slow Moving	279	705				

D. CONCLUSION AND SUGGESTIONS

Conclusion

This study demonstrates that warehouse layout optimization using the ABC classification method combined with Rectilinear (Manhattan) distance analysis effectively improves warehouse operational efficiency at PT X. The implementation of ABC classification successfully categorized inventory according to movement frequency into Class A (fast moving), Class B (medium moving), and Class C (slow moving), thereby enabling more strategic rack placement based on operational priorities.

The redesigned warehouse layout significantly improved travel efficiency for frequently moved inventory. The total travel distance for Class A products decreased from 1,662 meters to 1,272 meters, representing a 23% reduction, while Class B products decreased from 807 meters to 771 meters, equivalent to a 4% reduction. Although the travel distance for Class C products increased from 279 meters to 705 meters, this increase represents an acceptable operational trade-off because these products exhibit relatively low movement frequency and therefore contribute minimally to overall warehouse activities.

In addition to travel distance improvement, the redesigned layout also generated economic benefits through reduced Material Handling Cost (MHC). The results indicate that Class A material handling cost decreased by 23%, from Rp 66,613,758 to Rp 50,982,371, while Class B costs decreased by 4%, from Rp 32,344,948 to Rp 30,902,050. These findings confirm that reducing travel distance contributes directly to warehouse operational cost efficiency.

Overall, this study confirms that integrating ABC classification, coordinate-based Rectilinear distance measurement, and Material Handling Cost analysis provides an effective framework for warehouse layout optimization. The findings contribute both practically and theoretically by offering a measurable approach to improving warehouse efficiency through strategic inventory placement and cost-oriented operational evaluation.

Suggestions

Based on the findings of this study, several recommendations are proposed for both managerial implementation and future research development.

Managerial Recommendations

1. Periodic ABC Reclassification

PT X is recommended to conduct periodic ABC classification evaluations because inventory movement frequency and demand patterns may change over time. Continuous reassessment will help maintain warehouse efficiency and ensure that fast-moving products remain in strategically optimal locations.

2. Warehouse Layout Monitoring and Adjustment
   The company should periodically review rack allocation and warehouse traffic patterns to prevent congestion and maintain operational efficiency. Storage layouts should remain adaptive to changing inventory characteristics and operational demands.
3. 3. Integration with Warehouse Management System (WMS)
   PT X is encouraged to integrate the ABC classification system into a Warehouse Management System (WMS) to improve inventory visibility, picking accuracy, and real-time storage decision-making. Such integration may further optimize warehouse performance and reduce operational errors.
4. Optimization of Slow-Moving Inventory Areas
   Although increased travel distance for Class C products is operationally acceptable, PT X may consider implementing dedicated storage zones, multi-tier shelving, or buffer areas to improve accessibility for slow-moving items without disrupting efficiency gains achieved for Classes A and B.

Suggestions for Future Research

1. Integration with Other Storage Policies
   Future studies are recommended to combine the ABC method with alternative warehouse optimization approaches, such as Dedicated Storage, Shared Storage, Class-Based Storage, or CRAFT algorithms, to obtain broader comparative insights into warehouse efficiency improvement.
2. Inclusion of Additional Performance Variables
   Subsequent research may include additional warehouse performance indicators, such as picking time, order fulfillment speed, operator workload, equipment utilization, and service level performance, to achieve a more comprehensive operational evaluation.
3. Simulation-Based Warehouse Analysis
   Future studies may also incorporate warehouse simulation models to evaluate layout robustness under varying demand volumes, fluctuating product categories, or operational disruptions. Simulation analysis would improve predictive decision-making and support long-term warehouse planning.
4. Multi-Objective Optimization Approach
   Further research is encouraged to investigate warehouse optimization using multi-objective decision-making models that simultaneously consider travel distance, space utilization, labor productivity, and operational cost efficiency.

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REFERENCES

Annas, Mohammad, and Humairoh Humairoh. 2022. "Redesigning of Industrial Warehouse Layout Using CADD." Dinasti International Journal of Management Science 4 (1): 57–69. https://doi.org/10.31933/dijms.v4i1.1403.

Arini, Ratih Windu. 2024. "Improvement of the Layout for Placement of Raw Materials for Tube and Tape Commodities Using the ABC Analysis Method." Jurnal Informasi, Sains Dan Teknologi 7(1): 161–78. https://doi.org/10.55606/isaintek.v7i1.214.

Aqil Siraj, Muhammad. 2024. "Proposed Improvements to Layout Design and Cost Analysis of Warehouse Material Handling Using Class Based Storage, CRAFT, and Dedicated Storage Methods at PT. Plastic Rays of Hope." Jurnal Ilmiah Teknik Industri Dan Inovasi 2 (2): 39–60.

Damayanti, Rina, dan Abdul Hakim. 2024. "Optimizing Raw Material Warehouse Layout by Combining ABC Analysis Method and Dedicated Storage to Minimize Material Handling Distance." Jurnal Ilmiah Teknik dan Manajemen Industri 3 (1): 20–35.

Dayera, Musa Bundaris Palungan, Febrian Ohello. 2024. "G-Tech : Jurnal Teknologi Terapan." G-Tech : Jurnal Teknologi Terapan 8 (1): 186–95.https://ejournal.uniramalang.ac.id/index.php/gtech/article/view/1823/1229.

Fauzi, Muhammad Rizky, and Athika Sidhi Cahyana. 2021. "Proposed Production Layout Using Total Closeness Rating (Tcr) Method and Corelap Algorithm in Cv. Faris Collections." Procedia of Engineering and Life Science 1 (2). https://doi.org/10.21070/pels.v1i2.935.

Fazrin, Nabila, and Eka Ludiya. 2023. "Application of the ABC Method in Improving the Raw Material Warehouse Layout at PT. Alfa Polymer Indonesia." Studi Ilmu Manajemen Dan Organisasi 4(1): 13–25. https://doi.org/10.35912/simo.v4i1.1049.

Guzmán-Martínez, Jorge, José A. Heredia-Zavoni, and Jorge-Efrén A. Castillo-García. 2024. "Optimizing Warehouse Layout Using Classification by ABC and Simulation for Small to Medium Enterprises (SMEs)." Journal of Industrial Engineering and Management 17 (1): 1–18. https://doi.org/10.3926/jiem.4132.

Gwynne Richards. 2017. Warehouse Management: A Complete Guide to Improving Efficiency and Minimizing Costs in the Modern Warehouse. 3rd ed. Kogan Page Publishers. https://books.google.co.id/books?id=bDw7DwAAQBAJ&lpg=PP1&ots=zW7QGCVSnB&dq = warehouse VI-2 management&lr&pg=PA79#v=onepage&q=warehouse Management&f=false.

Hadi Satria Adil Wicaksana, HSA and Mudayat, M. 2023. "BAB I.Pdf." Analysis of the Implementation of Warehouse Functions on the Smooth Operation of Pt. Warehouse. Indonesian Port, Gresik Branch.

Haryanto, Edi, dan Fitriana Nur Indah Sari. 2023. "Implementation of the ABC Classification Method to Increase the Efficiency of Picking Up Goods at the Spare Parts Warehouse." Jurnal Rekayasa Industri 8 (1): 1–12. https://doi.org/10.26760/jri.v8i1.7944.

Hermawan, Arief, Cempaka Chandra Kirana, Fayza Andani, Gina Natasya Novitasari, Mochammad Azriel Fahrezi, Khoirul Aziz Husyairi, and Tina Nur Ainun. 2024. "Analysis of Shelf Layout in Retail Stores Using ARC and TCR Methods (Case Study at Supermarket X)." Jurnal Penelitian Manajemen Dan Inovasi Riset 2 (3): 263–74. https://doi.org/10.61132/lokawati.v2i3.908.

Isnaeni, Safira et al. 2021. "Application of the Class Based Storage Method to Improve Finished Goods Warehouse Layout (Case Study of Finished Goods Warehouse K PT Hartono Istana Teknologi)." Industrial Engineering Online Journal 10.

Karabacak, Taha, and Şeyda Ertekin. 2023. "A Comparative Study of Storage Allocation Policies: Dedicated, Shared, and Class-Based Storage Using Simulation." International Journal of Production Research 61 (18): 6112–6130. https://doi.org/10.1080/00207543.2023.2201315.

Kusumawardana, R. A. F., dan S. R. Desty. 2024. "Proposed Improvement of Warehouse Layout using Shared Storage Method and Computerized Relative Allocation of Facilities Technique (CRAFT) to Reduce Material Handling Costs." Jurnal Optimasi Sistem Industri 23 (1): 15–28. https://doi.org/10.25077/josi.v23i1.611.

Lai, Yanjun, Yuxin Li, Kaiwei Wang, and Yanping Li. 2024. "Warehouse Layout Optimization Considering Multiple Objectives: Space Utilization and Material Handling Distance." Expert Systems with Applications 237 (Part A): 119865. https://doi.org/10.1016/j.eswa.2023.119865.

Lubis, Arsyad. 2024. Warehousing and Logistics Management: Concepts, Strategies and Applications.Jakarta: Penerbit Lentera Ilmu.

Mulyadi, Asep. 2023. Industrial Facility Layout Optimization: Theory and Implementation. Bandung: CV Alfabeta.

Nugroho, Dwiki, dan Ratna Hidayati. 2022. "Improvement of Warehouse Layout using a Combination of ABC Analysis Method and Traveling Salesman Problem (TSP) at PT. Maju Jaya." Jurnal Ilmiah Teknik Industri 10 (2): 112–25. https://doi.org/10.24912/jitiuntar.v10i2.1583.

Patra, Sudipta, and Soumen Pal. 2023. "Improving Warehouse Efficiency through Aisle Design and Location Assignment: An Integrated ABC and Traveling Salesman Problem Approach." Supply Chain Management: An International Journal 28 (5): 635–652. https://doi.org/10.1108/SCMIJ-07-2022-0268.

Purnomo, Bambang Herry, Andrew Setiawan Rusdianto, and Muhammad Hamdani. 2019. "Layout Design of Production Facilities for Ribbed Smoked Sheet (RSS) Processing in Gunung Pasang Panti, Jember Regency." Jurnal Agroteknologi 7 (2): 167–77. https://jurnal.unej.ac.id/index.php/JAGT/article/view/2272.

Rahman, M. T., S. M. R. Karim, and J. L. R. Koster. 2024. "Effectiveness of Hybrid Storage Systems in Minimizing Order Picking Time in E-commerce Warehouses." Computers & Industrial Engineering 190: 109968. https://doi.org/10.1016/j.cie.2024.109968.

Saffanah, Silmi, Rani Aulia Imral, and Ayu Anggraeni Sibarani. 2023. "Proposed Production Floor Layout Design Using SLP and Blocplan Methods for Cutting Steel Pipe Products in CV. ABC in Cileungsi." Jurnal Rekayasa Sistem Industri 8 (2): 1–27. https://ejournal.upbatam.ac.id/index.php/rsi/article/download/6625/31 33.VI-3

Supriyadi, Supriyadi, Dedi Setiawan, and Dadi Cahyadi. 2019. "Factory Layout Redesign Using Computerized Relative Allocation of Facilities Techniques (CRAFT) Algorithm Method." Jurnal INTECH Teknik Industri Universitas Serang Raya 5 (2): 75–80. https://doi.org/10.30656/intech.v5i2.1820.

Titong, Fitri Sylvianti. 2024. "Application of the Fifo (First in First Out) Method in Maintaining Warehouse Effectiveness at PT. Mutiara Luwuk Bintang Lestari" 5 (10): 3762–68.

Tang, Xiaoli Xinming, Jingxia Suo, Chao Li, Mengze Du, Chaoyue Wang, Dandan Hu, Chunhui Duan, et al. 2018. "Thesis Analysis of Finished Goods Warehouse Layout Design to Increase Storage Space Capacity in PT South Pacific Viscose's Nonwoven Warehouse." BMC Microbiology 17 (1): 1–14. ttps://doi.org/10.1016/j.biotechadv.2018.09.003%0Ahttp://dx.doi.org/10.1016/j.bbamem.2015.10.011%0Ahttp://www.ncbi.nlm.nih.gov/pubmed/27100488%0Ahttp://www.ncbi.nlm.nih.gov/pubmed/26126908 %0Ahttp://dx.doi.org/10.1016/j.cbpa.2017.03.014%0Ahttps://doi.org/.

Yuliana, Lina, Evi Febianti, and Lely Herlina. 2016. "Proposed Improvements to Warehouse Layout Using the CRAFT Method (Case Study in K-Store Warehouse, Krakatau Junction)." Jti 4 (2): 1–5. https://jurnal.untirta.ac.id/index.php/jti/article/view/1433/1138.Chandra, Tintin. 2016. "Penerapan Algoritma North West Corner Dalam Penyelesaian Masalah Transportasi." Jurnal TIMES 5(1):12–16. doi: 10.51351/jtm.5.1.2016393