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Enhancing Storage Efficiency: Class-Based Warehouse Layout Design of Indonesian Manufacturing Company

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Abstract

PT XYZ, a service company specializing in marine and offshore projects, experienced inefficiencies in warehouse operations due to a poor layout and a lack of an item coding system. This study aims to improve storage efficiency by designing a warehouse layout using the class-based storage method. ABC classification was applied to categorize 45 items into fast-, medium-, and slow-moving classes based on throughput. The analysis covered space requirements, movement distance, and handling costs. The proposed layout improved space utilization by 15.87%, reduced goods movement distance by 19.586 meters, and decreased handling costs by IDR 49.454.650. It also enhanced operational performance by reducing item retrieval and placement times by 0.38% and 0.22%, respectively. These results indicate that class-based storage is effective in optimizing warehouse efficiency.

Keywords: Warehouse Layout, Class-Based Storage, Storage Efficiency, ABC Classification

1. Introduction

The logistics sector includes transportation and warehousing. Various aspects help run an industry. One of them is storage, which has an important function to keep the production process running smoothly. This contributes to ensuring products reach customers in a timely and cost-effective manner in the process from production to delivery. Warehouse layout is a factor that affects the efficiency and effectiveness of the warehouse. A well-designed layout contributes to improved productivity and overall business performance. Items stored in warehouses typically include raw materials, semi-finished goods, spare parts, and finished products [1].

PT. XYZ, established in 2016, is located in Komplek Bintang Industrial Park II, Tanjung Uncang, Batam Citu. The company specializes in turnkey installation, accommodation systems, and HVAC ducting for the marine and oil & gas industries. An efficient warehouse layout not only enhances operational performance but also improves worker safety. Given the complexity of its projects, optimizing the warehouse layout is essential for increasing competitiveness and ensuring the continuity of the company's operation.

Based on direct observation at PT. XYZ warehouse, as shown in **Figure 1**, it was found that the absence of item codes results in inefficient storage practices. This issue hinders the identification and organization of products, ultimately reducing warehouse operational productivity. Furthermore, certain items such as helmets and bags should not be stored in the warehouse, as they disrupt space efficiency and hinder access to essential tools.

Figure 1. Storage Inefficiency

Helmets are considered a burden in the warehouse, as they occupy space that could otherwise be used to store more essential or work-related equipment. The storage of items necessary for warehouse operations should be prioritized, particularly when warehouse capacity is limited. In addition, nitrogen storage must comply with practical and safety standards applicable to chemicals and other hazardous gases.

Figure 2. Storage Disorganization

Another issue observed in the PT. XYZ warehouse, as shown in **Figure 2**, is an inefficient storage system. In this situation, items are placed haphazardly in any available space without consideration for item grouping or the frequency of incoming and outgoing goods, which can negatively impact the company's operational efficiency. This irregular arrangement of products leads to suboptimal utilization of warehouse space and may ultimately reduce overall storage capacity [2].

In warehouse management, selecting the appropriate solutions is crucial for optimizing space, enhancing storage efficiency, and ensuring easy access to goods. One of the most widely applied strategies involves categorizing items based on their contribution to operations, which supports a more structured storage layout. The objective of this study is to optimize storage capacity and compare the efficiency of the warehouse layout before and after improvements. It is expected that the findings of this study will contribute significantly to improving the efficiency of item storage in the warehouse.

2. Literature Review

A warehouse is a facility designated to store various types of goods, both on a large and small scale, based on production stages and consumer demand. It plays a vital role as a storage center for various goods, including raw materials that will be processed into finished products ready for distribution [3].

Storage space strategic layout planning aims to ensure the consistent, smooth running of the production process. The purpose of this layout design is to manage the work area and all production facilities in an optimized way by considering the material budget and other budgets related to storage space so that the production process runs efficiently [4].

The class-based storage system organizes goods into specific classes or categories based on factors such as demand level, retrieval frequency, or physical characteristics. High-demand items are placed in more accessible locations. The main advantage of this approach is improved picking efficiency, as frequently retrieved items are stored in easily reachable areas. However, implementing this system requires thorough analysis to determine the appropriate classification of products and their optimal storage locations.

In warehouse layout design, distance measurements play a crucial role in optimizing operational efficiency and minimizing the time and cost involved in picking, storing, and moving goods. Distance measurements used to design warehouse layouts are rectilinear, euclidean, and squared euclidean distance [5]. Among these, rectilinear distance is widely applied in warehouse environments, where movement typically follows perpendicular paths along aisles.

The rectilinear distance between two points is calculated as: $d_{ij} = |x - a| + |y - b|$. (1)

Where:

- d_{ij} = distance from slot ij to the I/O point
- x = x-coordinate of the I/O point
- y = y-coordinate of the I/O point
- a = x-coordinate of the midpoint of the target slot
- b = y-coordinate of the midpoint of the target slot

Previous studies have applied ABC classification and class-based storage to improve warehouse layout efficiency. However, many lacked integration with quantitative throughput data or a systematic zoning method. For instance, Nugraha, Safitriani, dan Putong (2022) classified items based on packaging size, while Rauf and Radyanto (2022) minimized travel distance without analyzing movement patterns. Others, like Gozali (2020) and Ifa & Windy (2021), implemented class-based storage with limited classification depth or context-specific approaches.

This study advances prior work by employing a structured ABC classification based on actual throughput data and translating it into an optimized class-based storage layout. It offers practical insights for mid-scale Indonesian manufactures facing spatial and resource limitations, a context still underrepresented in warehouse design literature. Lin and Ma (2021) demonstrated the effectiveness of cross-ABC classification, which integrates multiple classification criteria to enhance storage efficiency and shelf arrangement in a supermarket distribution center [8]. Similarly, Silva (2022) emphasized the importance of optimizing ABC zone sizes in manual warehouses to reduce travel distances and improve material handling efficiency through strategic zone dimensioning [9].

The implementation of a class-based storage method can reduce storage time by taking into account the timing of product entry and retrieval in the warehouse [6].

3. Research Methods

This descriptive quantitative research involves data collection, analysis, and interpretation using the class-based Storage method. The ABC categorization is a technique for grouping items based on their importance in warehouse operations, aiming to reduce the time required for item retrieval. ABC classification divides goods into three main categories: A, B, and C, based on their throughput or relevance in the storage process.

Data collection in this research at PT. XYZ was conducted using various methods. One of them is direct observation to understand the actual conditions within the company. Observations were carried out the evaluate the effectiveness of the current warehouse layout, identify existing problems, and understand the workflow and methods used for storing goods.

Data collection in this research at PT. XYZ was conducted using various methods. One of the primary methods was direct observation to understand the actual conditions within the company. These observations aimed to evaluate the effectiveness of the existing warehouse layout, identify emerging issues, and analyze the workflow and item placement methods.

The information collected was used to develop recommendations for designing a more efficient and organized warehouse layout. Interviews were conducted through direct communication with relevant informants, including storemen, foremen, and warehouse operational staff. The interviews focused on aspects such as the goods storage system, the processes of receiving and dispatching items, goods movement, causes of product damage, and other relevant factors.

By integrating information from multiple sources, this study was able to formulate more appropriate recommendations to improve storage efficiency. Documentation served as a complementary method to interviews and observations, providing supporting evidence to validate to interviews and observations, providing supporting evidence to validate the research findings.

To gain a deeper understanding of storage efficiency through the class-based storage approach, a careful and systematic data analysis is required. The workflow of the class-based storage method is illustrated in **Figure 3** below.

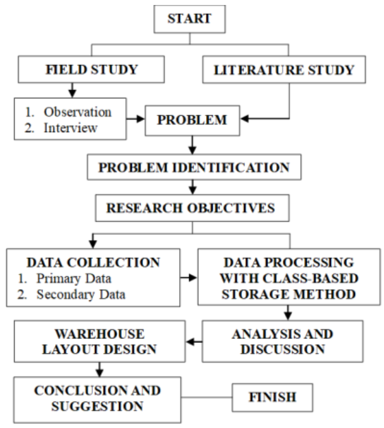

Figure 3. *Research Flow Chart*

Figure 3 presents the research flow, starting with field observations and interviews, along with a literature review to identify warehouse layout problems at PT. XYZ. After defining the problem and research objective, primary and secondary data were collected and analyzed using the class-based storage method. The results were used to design an improved warehouse layout, followed by analysis and conclusions to support recommendations.

The processes of data processing utilizing the class-based storage technique are as follows:

1. Calculation of Space Requirement
   To evaluate how efficient the warehouse space is being used, the space requirement ratio is calculated using the following formula:

$$SR = \frac{\text{Maximum Storage Quantity}}{\text{Storage Capacity}} \quad (2)$$

   This ratio helps assess whether the allocated storage space is sufficient for current inventory demands or if adjustments are needed to avoid overstocking or underutilization.
2. Throughput Calculation
   This calculation helps prioritize item placement by identifying high-throughput items that should be located closer to picking or I/O points to improve operational efficiency. The formula is as follows:

$$\text{Throughput} = \frac{\text{Frequency of Entry and Exit of Goods per Type of Goods}}{\text{Total Frequency of Entry and Exit of All Goods}} \quad (3)$$

3. Aisle Area

$$\text{Aisle Area} = \sqrt{(\text{Length})^2 + (\text{Width})^2} \quad (4)$$

4. Item Classification
   This process classifies items into fast-moving, medium-moving, and slow-moving categories according to their respective throughput, in order to support efficient inventory management.
5. Calculation of Product Placement
   Assignment = T/S (5)
   Where:

- T = Total area required
- S = Available space

6. Calculation of Moving Distance

$$\text{Moving Distance} = |X1 - X2| + |Y1 - Y2| \quad (6)$$

where:
- X1, Y1 = Coordinates of the I/O point
- X2, Y2 = Coordinates of the storage location

7. Warehouse Space Utilization Calculation
Warehouse utilization is calculated to measure how efficiently the available space is used. The following formula is applied:

$$\text{Warehouse Utility} = \frac{\text{Utilized Space } (m^2)}{\text{Available Space } (m^2)} \times 100\% \quad (7)$$

8. Warehouse Layout Design
Following data analysis, a new warehouse layout is designed to improve the efficiency of goods storage and retrieval processes.

(**Source:** Ifa Saidatuningtyas, 2021)

4. Results and Discussion

Classifications of Items

PT. XYZ implements a well-organized goods management system by categorizing inventory into two main types: raw materials and work tools.

Table 1. Raw Material Data

No	Raw Material
1	3/4" Mild Steel Bolt
2	Aluminum Foil Tape 2" x 48mm
3	No. 11 Welding Glass
4	Concrete Nails 2"
5	Welding Cable 200a
6	PVC Pipe 4"
7	PVC Elbow 45° 2"
8	Silicone Sealant
9	Thinner Kangaroo 3.5L
10	Super Best 3.5mm SS Drill Bit
11	Blind Rivet Kledy 1/8" x 5/8"
12	Cutting Disc 4" WD
13	Welding Wire RB-26 2.6mm
14	Ceiling Screw 6 x 5/8"
15	Grinding Eye End Brush 3"

Table 1 presents the raw materials used by PT. XYZ, including items such as ¾" mild steel bolts, 2" x 48mm aluminum foil tape, No. 11 welding glass, welding cables, PVC pipes, and solvents. Each item is specified to support efficient inventory management.

Through detailed classification and strategic placement, PT. XYZ ensures that all raw materials are readily accessible when needed, thereby enhancing operational efficiency in the production process.

Table 2. Work Tool Data

No.	Work Tool
1	Heat Gun / Pipe Welding
2	Yamato Cutting Torch
3	F Claimp 10"
4	Scissors
5	Hammer
6	Ring Wrench
7	Spana Wrench
8	Wrench
9	5m meter
10	Screwdriver
11	Tubing Cutter
12	M10 Rivet Pliers
13	Black Big Elbow
14	Crocodile Pliers
15	M10 Press Pliers
16	5ft Ladder
17	I Meite Nail Gun 7116BL
18	Water Pass
19	Bosch Drill
20	Makita Baby Grinder
21	Circular Saw
22	Hacksaw
23	Tolsen Seated Drilling Machine
24	Fixtec Sandpaper Machine
25	Fujiyama Welding Travo
26	Jig Saw
27	Cutting Pliers
28	Electric Solder
29	Ampere Pliers
30	500A Welding Stang

PT. XYZ also maintains a diverse and well-organized inventory of work tools, encompassing a wide range of essential equipment used in the production process. Among the recorded tools are heat guns/pipe welding tools, Yamato cutting torches, various types of clamps and cutters, as well as general tools such as hammers, ring wrenches, adjustable wrenches, and screwdrivers. In addition, more specialized tools such as tubing cutters, different types of pliers, drilling machines, and gauges are also included.
As detailed in **Table 2**, the complete inventory of work tools used at PT. XYZ comprises 30 essential items. These tools support a wide range of operational activities and are systematically organized to optimize workflow and minimize retrieval time during the production process.

Storage and Distribution System

Commodities are stored on designated storage racks based on their type, while work tools are placed in appropriate locations such as shelves, pallets, or directly on the warehouse floor. The goods dispensing system involves collecting items in the loading area, where warehouse personnel perform a final verification. Once verified, the goods are loaded onto delivery vehicles and transported to the designated project sites.

Material Handling

The most essential material handling tools at PT. XYZ are hand pallets and trolleys. Hand pallets are used to lift and transport palletized goods, helping to save time and reduce the risk of injury. Trolleys, equipped with wheeled platforms and ergonomic handles, facilitate the movement of items of various sizes and weights, thereby enhancing operational efficiency. These two tools play a vital role in PT. XYZ warehouse operations by improving work efficiency, minimizing the potential for workplace injuries, and supporting overall productivity.

Inventory Demand Data

To optimize inventory and supply chain management, PT. XYZ collected comprehensive data on raw material demand from January 2023 to March 2024. **Table 3** summarizes this data, showing the total and average monthly demand for 15 raw materials. This data serves as the basis for ABC classification, enabling efficient storage by prioritizing frequently used items and minimizing handling time and cost.

Table 3. Raw Material Demand Data

No	Raw Material	Goods Demand Data (Jan 2023 - Mar 2024)	Average Demand (Jan 2023 - Mar 2024)
1	3/4" Mild Steel Bolt	3.750	250
2	Aluminum Foil Tape 2" x 48mm	556	37
3	No. 11 Welding Glass	78	5
4	Concrete Nails 2"	2.740	183
5	Welding Cable 200a	75	5
6	PVC Pipe 4"	790	53
7	PVC Elbow 45° 2"	483	32
8	Silicone Sealant	412	27
9	Thinner Kangaroo 3.5L	249	17
10	Super Best 3.5mm SS Drill Bit	4.450	297
11	Blind Rivet Kledy 1/8" x 5/8"	13.050	870
12	Cutting Disc 4" WD	1.315	88
13	Welding Wire RB-26 2.6mm	3.822	255
14	Ceiling Screw 6 x 5/8"	3.600	240
15	Grinding Eye End Brush 3"	2.274	152

The raw material item Blind Rivet Kledy 1/8” x 5/8” recorded the highest demand, with a total of 13.050 units requested during the observed period. In contrast, Welding Glass No. 11 had the lowest demand, with only 78 units requested over the 15 months.

Table 4. Work Tool Demand Data

No	Work Tool	Goods Demand Data (Jan 2023 - Mar 2024)	Average Demand (Jan 2023 - Mar 2024)
1	Heat Gun / Pipe Welding	36	2,40
2	Yamato Cutting Torch	31	2,07
3	F Claimp 10"	17	1,13
4	Scissors	158	10,53
5	Hammer	41	2,73
6	Ring Wrench	90	6,00
7	Spana Wrench	36	2,40
8	Wrench	33	2,20
9	5m meter	444	29,60
10	Screwdriver	59	3,93
11	Tubing Cutter	26	1,73
12	M10 Rivet Pliers	23	1,53
13	Black Big Elbow	235	15,67
14	Crocodile Pliers	39	2,60
15	M10 Press Pliers	11	0,73
16	5ft Ladder	31	2,07
17	I Meite Nail Gun 7116BL	11	0,73
18	Water Pass	43	2,87
19	Bosch Drill	16	1,07
20	Makita Baby Grinder	8	0,53
21	Circular Saw	7	0,47
22	Hacksaw	26	1,73
23	Tolsen Seated Drilling Machine	1	0,07
24	Fixtec Sandpaper Machine	6	0,40
25	Fujiyama Welding Travo	6	0,40
26	Jig Saw	7	0,47
27	Cutting Pliers	37	2,47
28	Electric Solder	34	2,27
29	Ampere Pliers	8	0,53
30	500A Welding Stang	22	1,47

In addition to raw materials, PT. XYZ also collected demand data for work tools used in daily operations. **Table 4** summarizes the total and average monthly demand for 30 types of work tools between January 2023 to March 2024. This data supports the ABC classification process to optimize tool placement and accessibility within the warehouse.

The 5M Meter was the most frequently requested work tool, with a total demand of 444 units during the observed period. In contrast, the Tolsen Seated Drilling Machine had the lowest demand, with only one unit requested over the 15-month span.

Inventory Movement Data

In this study, goods movement data is utilized to investigate and evaluate the effectiveness of PT. XYZ warehouse operations. The data, covering the period from January 2023 to March 2024, provides a comprehensive overview of warehouse activities over 15 months. The objective of this analysis is to identify item movement patterns and assess the efficiency of the storage and retrieval processes.

To support this analysis, **Table 5** presents goods movement data, including entry, exit, and frequency values for both raw materials and work tools. These figures highlight usage intensity, enabling better layout decisions to improve storage and retrieval efficiency.

Table 5. Goods Entry and Exit Data

No	Raw Material	Enter	Exit	Frequency	Percentage (%)
1	3/4" Mild Steel Bolt	3900	3750	7650	96%
2	Aluminum Foil Tape 2" x 48mm	656	556	1212	85%
3	No. 11 Welding Glass	123	78	201	63%
4	Concrete Nails 2"	3090	2740	5830	89%
5	Welding Cable 200a	115	75	190	65%
6	PVC Pipe 4"	790	790	1580	100%
7	PVC Elbow 45° 2"	488	483	971	99%
8	Silicone Sealant	484	412	896	85%
9	Thinner Kangaroo 3.5L	295	249	544	84%
10	Super Best 3.5mm SS Drill Bit	4550	4450	9000	98%
11	Blind Rivet Kledy 1/8" x 5/8"	13350	13050	26400	98%
12	Cutting Disc 4" WD	1535	1315	2850	86%
13	Welding Wire RB-26 2.6mm	4020	3822	7842	95%
14	Ceiling Screw 6 x 5/8"	6800	3600	10400	53%
15	Grinding Eye End Brush 3"	2466	2274	4740	92%

No.	Work Tool	Enter	Exit	Frequency	Percentage (%)
1	Heat Gun / Pipe Welding	36	36	72	100%
2	Yamato Cutting Torch	31	31	62	100%
3	F Claimp 10"	17	17	34	100%
4	Scissors	168	158	326	94%
5	Hammer	41	41	82	100%
6	Ring Wrench	90	90	180	100%
7	Spana Wrench	36	36	72	100%
8	Wrench	33	33	66	100%
9	5m meter	444	444	888	100%
10	Screwdriver	74	59	133	80%
11	Tubing Cutter	26	26	52	100%
12	M10 Rivet Pliers	23	23	46	100%
13	Black Big Elbow	235	235	470	100%
14	Crocodile Pliers	39	39	78	100%
15	M10 Press Pliers	11	11	22	100%
16	5ft Ladder	31	31	62	100%
17	I Meite Nail Gun 7116BL	11	11	22	100%
18	Water Pass	43	43	86	100%
19	Bosch Drill	16	16	32	100%
20	Makita Baby Grinder	8	8	16	100%
21	Circular Saw	7	7	14	100%
22	Hacksaw	26	26	52	100%
23	Tolsen Seated Drilling Machine	1	1	2	100%
24	Fixtec Sandpaper Machine	6	6	12	100%
25	Fujiyama Welding Travo	6	6	12	100%
26	Jig Saw	7	7	14	100%
27	Cutting Pliers	37	37	74	100%
28	Electric Solder	34	34	68	100%
29	Ampere Pliers	8	8	16	100%
30	500A Welding Stang	22	22	44	100%

Some raw materials and work tools exhibit high usage rates, highlighting their critical role in daily operations. Blind Rivet Kledy 1/8” x 5/8” recorded the highest usage among raw materials, while the 5M Meter was the most frequently used item in the work tool category.

Initial Warehouse Layout

The initial layout of PT. XYZ warehouse adopts a combination of fixed and random location storage methods, in which each product is assigned a designated location. This approach is intended to reduce travel distance during goods handling and enhance overall productivity. The warehouse layout was initially designed to maximize storage capacity while ensuring easy access and maintaining a smooth workflow. Efficient space organization is a key factor in supporting the effectiveness of daily operations.

PT. XYZ operates a storage warehouse with dimensions of 750 cm (length) x 500 cm (width) x 300 cm (height). The design focuses on optimizing the available space, with entrance and exit doors strategically positioned each measuring 215 cm in height and 105 cm in width to support efficient goods movement. The overall configuration of the initial warehouse, including rack placement, access path, and storage zones, is illustrated in **Figure 4**.

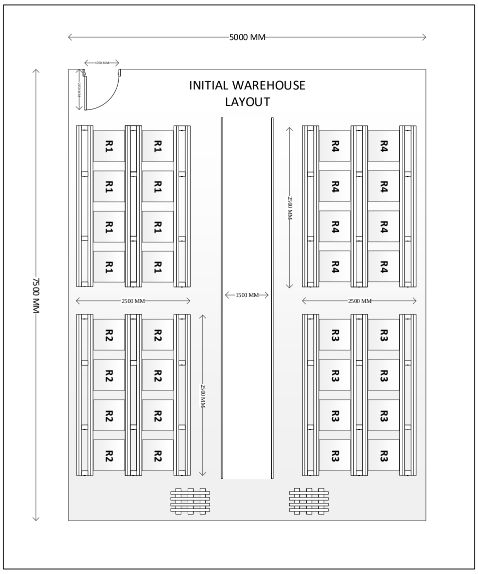

Figure 4. Initial Warehouse Layout

Space Requirement

The calculation of space requirements is conducted to determine the amount of space needed to store inventory efficiently. This is done by dividing the maximum quantity of inventory by the storage capacity per slot, and then multiplying the result by the dimensions of the material.

To support the warehouse layout planning, the space requirements of each item were calculated based on its dimensions and quantity. **Table 7** presents the existing space requirements for all 45 raw materials and work tools stored in the PT. XYZ warehouse.

Table 7. Space Requirement Existing

No	Item Name	Space Requirement (m2)	Area Space Requirement (m2)
1	Aluminum Foil Tape 2" x 48mm	0,0001	1,728
2	No. 11 Welding Glass	0,0001	0,000324
3	Concrete Nails 2"	0,0004	0,000408
4	Ceiling Screw 6 x 5/8"	0,0006	0,000576
5	Grinding Eye End Brush 3"	0,0004	0,023104
6	Mild Steel Bolt 3/4"	0,0005	0,000475
7	200a Welding Cable	0,0005	0,25
8	Super Best 3.5mm SS Drill Bit	0,0006	0,00126
9	Blind Rivet Kledy 1/8" x 5/8"	0,0005	0,00024
10	4" WD Cutting Disc	0,0005	0,05202
11	RB-26 Welding Wire 2.6mm	0,0005	0,00455
12	Hammer	0,0005	0,12
13	Screwdriver	0,0005	0,0075
14	M10 Rivet Pliers	0,0005	0,0375
15	Alligator Pliers	0,0005	0,0625
16	Cutting Pliers	0,0005	0,05
17	Electric Solder	0,0005	0,025
18	Welding Stang 500A	0,0005	3
19	PVC pipe 4"	0,0005	2,9464
20	PVC Elbow 45° 2"	0,0005	0,013005
21	Silicone Sealant	0,0005	0,075
22	Thinner Kangaroo 3.5L	0,0007	0,21
23	Heat Gun / Pipe Welding	0,0005	0,1875
24	Yamato Cutting Torch	0,0005	0,3
25	F Claimp 10"	0,0006	0,12
26	Scissors	0,0005	0,08
27	Ring Wrench	0,0005	0,04
28	Spana Wrench	0,0005	0,1
29	Wrench	0,0005	0,0625
30	5m Meter	0,0004	0,01
31	Tubing Cutter	0,0005	0,05
32	Black Big Elbow	0,0005	0,3
33	M10 Press Pliers	0,0005	0,05
34	5ft Ladder	0,0003	1,875
35	Nail Gun I Meite 7116BL	0,0005	0,3
36	Water Pass	0,0005	0,1
37	Bosch Drill	0,0005	0,1
38	Makita Baby Grinder	0,0005	0,1
39	Circular Saw	0,0004	0,6
40	Hacksaw	0,0005	0,1
41	Tolsen Seated Drilling Machine	0,0002	0,39
42	Fixtec Sandpaper Machine	0,0004	0,18
43	Fujiyama Welding Travo	0,0005	0,75
44	Jig Saw	0,0002	0,05
45	Ampere Pliers	0,0005	0,064
	Total	**0,021**	**14,52**

Table 8. New Space Requirement

No	Item Name	Space Requirement (m2)	Area Space Requirement (m2)
1	Aluminum Foil Tape 2" x 48mm	0,0001	2,16
2	No. 11 Welding Glass	0,0002	0,000648
3	Concrete Nails 2"	0,0006	0,000612
4	Ceiling Screw 6 x 5/8"	0,0006	0,000576
5	Grinding Eye End Brush 3"	0,0005	0,02888
6	Mild Steel Bolt 3/4"	0,0007	0,0006175
7	200a Welding Cable	0,0008	0,4
8	Super Best 3.5mm SS Drill Bit	0,0010	0,0021
9	Blind Rivet Kledy 1/8" x 5/8"	0,0005	0,00024
10	4" WD Cutting Disc	0,0006	0,065025
11	RB-26 Welding Wire 2.6mm	0,0006	0,00546
12	Hammer	0,0010	0,375
13	Screwdriver	0,0005	0,12
14	M10 Rivet Pliers	0,0005	0,0075
15	Alligator Pliers	0,0005	0,0375
16	Cutting Pliers	0,0006	0,078125
17	Electric Solder	0,0005	0,05
18	Welding Stang 500A	0,0005	0,025
19	PVC pipe 4"	0,0005	3
20	PVC Elbow 45° 2"	0,0010	5,8928
21	Silicone Sealant	0,0010	0,02601
22	Thinner Kangaroo 3.5L	0,0007	0,1
23	Heat Gun / Pipe Welding	0,0010	0,3
24	Yamato Cutting Torch	0,0006	0,375
25	F Claimp 10"	0,0008	0,16
26	Scissors	0,0007	0,114285714
27	Ring Wrench	0,0007	0,05
28	Spana Wrench	0,0006	0,111111111
29	Wrench	0,0007	0,083333333
30	5m Meter	0,0005	0,0125
31	Tubing Cutter	0,0005	0,05
32	Black Big Elbow	0,0005	0,3
33	M10 Press Pliers	0,0005	0,05
34	5ft Ladder	0,0005	3,75
35	Nail Gun I Meite 7116BL	0,0005	0,3
36	Water Pass	0,0005	0,1
37	Bosch Drill	0,0005	0,1
38	Makita Baby Grinder	0,0005	0,1
39	Circular Saw	0,0004	0,6
40	Hacksaw	0,0005	0,1
41	Tolsen Seated Drilling Machine	0,0002	0,39
42	Fixtec Sandpaper Machine	0,0004	0,18
43	Fujiyama Welding Travo	0,0005	0,75
44	Jig Saw	0,0002	0,05
45	Ampere Pliers	0,0005	0,064
	Total	**0,026**	**20,47**

Following the redesign of the warehouse layout using the class-based storage method, **Table 8** outlines the updated space requirements for each of the 45 stored items. Compared to the previous layout, the new arrangement reflects changes in item positioning and grouping based on demand and classification.

This table shows the unit space requirement and the total area occupied by each item under the new layout configuration. The optimization resulted in better space utilization, increasing the total occupied area from 14.52 m² (initial) to 20.47 m², ensuring better accessibility and reduced handling time for high-priority items. The 5.95 m² increase results from a more systematic arrangement and more efficient space allocation for each item type in the proposed warehouse layout.

Throughput Calculation

Throughput is calculated by dividing the frequency of inbound and outbound movements of each item type by the total frequency of movements for all item types. This measurement provides a clear overview of how actively each type of goods moves within the warehouse system between January 2023 – March 2024.

Table 9. Raw Material Throughput

No	Raw Material	Frequency	Throughput
1	3/4" Mild Steel Bolt	7650	0,100
2	Aluminum Foil Tape 2" x 48mm	1212	0,016
3	No. 11 Welding Glass	201	0,003
4	Concrete Nails 2"	5830	0,076
5	Welding Cable 200a	190	0,002
6	PVC Pipe 4"	1580	0,021
7	PVC Elbow 45° 2"	971	0,013
8	Silicone Sealant	896	0,012
9	Thinner Kangaroo 3.5L	544	0,007
10	Super Best 3.5mm SS Drill Bit	9000	0,118
11	Blind Rivet Kledy 1/8" x 5/8"	26400	0,346
12	Cutting Disc 4" WD	2850	0,037
13	Welding Wire RB-26 2.6mm	7842	0,103
14	Ceiling Screw 6 x 5/8"	6500	0,085
15	Grinding Eye End Brush 3"	4740	0,062
	Total	**76406**	**1,000**

Table 9 shows the throughput of raw materials based on usage frequency. Items with higher throughput are considered high-priority and should be placed in easily accessible locations to optimize retrieval time and storage efficiency.

The highest throughput is Blind Rivet Kledy 1/8” x 5/8” (0.346), while the lowest is Welding Cable 200a (0.002). Applying the ABC classification, high-throughput items such as Blind Rivet, Concrete Nails, and Cutting Disc fall into Class A and are prioritized for strategic placement. This supports a class-based storage approach that improves warehouse efficiency by reducing travel distance and handling time.

Table 10. Work Tools Throughput

No.	Work Tools	Frequency	Throughput
1	Heat Gun / Pipe Welding	72	0,023
2	Yamato Cutting Torch	62	0,020
3	F Claimp 10"	34	0,011
4	Scissors	326	0,105
5	Hammer	82	0,026
6	Ring Wrench	180	0,058
7	Spana Wrench	72	0,023
8	Wrench	66	0,021
9	5m meter	888	0,286
10	Screwdriver	133	0,043
11	Tubing Cutter	52	0,017
12	M10 Rivet Pliers	46	0,015
13	Black Big Elbow	470	0,151
14	Crocodile Pliers	78	0,025
15	M10 Press Pliers	22	0,007
16	5ft Ladder	62	0,020
17	I Meite Nail Gun 7116BL	22	0,007
18	Water Pass	86	0,028
19	Bosch Drill	32	0,010
20	Makita Baby Grinder	16	0,005
21	Circular Saw	14	0,005
22	Hacksaw	52	0,017
23	Tolsen seated drilling machine	2	0,001
24	Fixtec Sandpaper Machine	12	0,004
25	Fujiyama Welding Travo	12	0,004
26	Jig Saw	14	0,005
27	Cutting Pliers	74	0,024
28	Electric Solder	68	0,022
29	Ampere Pliers	16	0,005
30	500A Welding Stang	44	0,014
	Total	**3109**	**1,000**

Table 10 presents the throughput of work tools, indicating their relative usage frequency. High-throughput tools are prioritized for placement in easily accessible locations to improve operational efficiency. The highest throughput was recorded for the 5M Meter (0.286), while the lowest was the Tolsen Seated Drilling Machine (0.001).

To support storage decisions, ABC classification is applied, where high-frequency tools (Class A) are placed near work areas to minimize retrieval time and improve efficiency.

Aisle Area

The aisle area is based on the dimensions and operational requirements of the material handling equipment to ensure the safe and efficient movement of goods.

The following section presents the calculation of the required aisle area.

Trolley capacity 300 Kg:

Diagonal = $\sqrt{p^2 + l^2}$ (8)

= $\sqrt{0{,}9^2 + 0{,}6^2}$

= 1,08 m

Allowance (10%) = 0,1 x 1,08 = 0,108 m (9)

Aisle Width Requirement = 1,08 + 0,108

= 1,188 m ≈ 1,2 m (10)

An aisle width of 1.2 meters is required to ensure safe and efficient movement of trolleys, minimizing obstruction during storage and retrieval operations within the warehouse.

Hand Pallet capacity 3 Ton:

Diagonal = $\sqrt{p^2 + l^2}$

= $\sqrt{1{,}15^2 + 0{,}55^2}$ = 1,27 m

Allowance (10%) = 0.1 x 1.27 = 0.127 m

Aisle Area = 1.27 + 0.127 = 1.397 m ≈ 1.4 m

An aisle width of approximately 1.4 meters is required to ensure safe and smooth operation of the hand pallet within the warehouse environment.

Based on the calculation results, the required aisle widths are approximately 1.2 meters for the trolley and 1.4 meters for the hand pallet, ensuring safe and efficient movement within the warehouse.

Goods Movement Distance

To determine the rectilinear displacement distance, the warehouse entrance and exit are designated as the coordinate point (0,0). The displacement distance is then calculated by identifying the coordinates of each item's storage location and measuring the distance from each point to the I/O point using the rectilinear method.

Based on the calculation of goods movement distance in the initial warehouse layout using the rectilinear method, the total movement distance for all goods is 175 meters, with a total movement frequency of 79.515 times. The total workload, calculated as the product of the displacement distance and movement frequency, amounts to 399.682 meters.

The redesigned warehouse layout proposed in this study resulted in a significant reduction in goods movement distance. This outcome aligns with the findings of Silva (2022), who demonstrated that optimizing the dimensions of ABC zones in manual storage environments can significantly reduce travel distance for material handling, thereby improving operational efficiency.

Warehouse Space Utilization

To calculate warehouse utility, the block area is divided by the total warehouse area. PT. XYZ warehouse measures 750 x 500 x 300 cm, and the available warehouse floor area is determined based on these dimensions.

Warehouse area = 750 x 500 cm = 375.000 cm²

= 37.5 m²

Warehouse space utility is calculated using the ratio of the total block area to the available warehouse area. Based on the calculation, the space utility is:

$$Space\ Utilities = \frac{total\ blok\ area}{space\ area}\ x\ 100\%$$

(11)

$$= \frac{14,52}{37,5} \times 100\%$$

$$= 38,71\%$$

The warehouse is utilized at 38.71% of the total available area, indicating that there is still significant space that can be optimized for more efficient goods storage.

ABC-Based Class Formation and Sorting

The ABC classification method facilitates the categorization of items based on throughput by applying two fundamental principles: popularity and similarity. In this study, the inventory is initially divided into two major categories: raw materials and work tools. Subsequently, each item's throughput is ranked in descending order from the highest to the lowest.

Table 11. Class Formation Raw Material

No	Raw Material	Throughput Percentage (%)	Cumulatif Throughput (%)	ABC Class
1	3/4" Mild Steel Bolt	34,6%	34,6%	
2	Aluminum Foil Tape 2" x 48mm	11,8%	46,3%	
3	No. 11 Welding Glass	10,3%	56,6%	A
4	Concrete Nails 2"	10,0%	66,6%	
5	Welding Cable 200a	8,5%	75,1%	
6	PVC Pipe 4"	7,6%	82,7%	
7	PVC Elbow 45° 2"	6,2%	88,9%	
8	Silicone Sealant	3,7%	92,7%	B
9	Thinner Kangaroo 3.5L	2,1%	94,7%	
10	Super Best 3.5mm SS Drill Bit	1,6%	96,3%	
11	Blind Rivet Kledy 1/8" x 5/8"	1,3%	97,6%	
12	Cutting Disc 4" WD	1,2%	98,8%	
13	Welding Wire RB-26 2.6mm	0,7%	99,5%	C
14	Ceiling Screw 6 x 5/8"	0,3%	99,8%	
15	Grinding Eye End Brush 3"	0,2%	100,0%	

Table 11 presents the ABC classification based on cumulative throughput percentage, items are assigned to one of three classes: Class A includes items that contribute up to 56.6% of total throughput (fast-moving), Class B covers the next 38.1% up to 94.7% (medium-moving), and Class C comprises the remaining 5.3% (slow-moving). This classification reflects the actual distribution of material usage and supports efficient storage decisions in the warehouse layout.

Table 12. Raw Material Percentage

No	Type Class	Quantity	Percentage (%)
1	A	6	40%
2	B	4	27%
3	C	5	33%
	Total	**15**	**100%**

Based on **Table 12**, the results of ABC analysis based on throughput values as follows:

1. Class A accounts for 80% of the total throughput, consisting of 6 items, which represent 40% of the total raw material items.
2. Class B accounts for 15% of the total throughput, consisting of 4 items, or 27% of the total raw material items.
3. Class C accounts for the remaining 5% of the total throughput, consisting of 5 items, which is equivalent to 33% of the total raw material items.

Table 13. Classification Tool

No.	Work Tool	Throughput Percentage (%)	Cumulatif Throughput (%)	ABC Class
1	Heat Gun / Pipe Welding	28,6%	28,6%	
2	Yamato Cutting Torch	15,1%	43,7%	
3	F Claimp 10"	10,5%	54,2%	
4	Scissors	5,8%	60,0%	
5	Hammer	4,3%	64,2%	
6	Ring Wrench	2,8%	67,0%	A
7	Spana Wrench	2,6%	69,6%	
8	Wrench	2,5%	72,1%	
9	5m meter	2,4%	74,5%	
10	Screwdriver	2,3%	76,8%	
11	Tubing Cutter	2,3%	79,2%	
12	M10 Rivet Pliers	2,2%	81,3%	
13	Black Big Elbow	2,1%	83,5%	
14	Crocodile Pliers	2,0%	85,5%	
15	M10 Press Pliers	2,0%	87,5%	
16	5ft Ladder	1,7%	89,1%	B
17	I Meite Nail Gun 7116BL	1,7%	90,8%	
18	Water Pass	1,5%	92,3%	
19	Bosch Drill	1,4%	93,7%	
20	Makita Baby Grinder	1,1%	94,8%	
21	Circular Saw	1,0%	95,8%	
22	Hacksaw	0,7%	96,5%	
23	Tolsen Seated Drilling Machine	0,7%	97,2%	
24	Fixtec Sandpaper Machine	0,5%	97,7%	
25	Fujiyama Welding Travo	0,5%	98,3%	
26	Jig Saw	0,5%	98,7%	C
27	Cutting Pliers	0,5%	99,2%	
28	Electric Solder	0,4%	99,5%	
29	Ampere Pliers	0,4%	99,9%	
30	500A Welding Stang	0,1%	100,0%	

The classification of work tools based on their throughput values is summarized in **Table 13**. Class A includes tools contributing up to 67.6% of total throughput, such as the Heat Gun / Pipe Welding and Yamato Cutting Torch, indicating frequent usage. Class B tools account for the next 29% up to 96.6%, while the remaining tools are classified as Class C. This categorization supports class-based storage, where Class A tools are placed near workstations to reduce retrieval time, increase efficiency, and align with warehouse operational priorities.

Table 14. Percentage of Work Tools

No	Type Class	Quantity	Percentage (%)
1	A	11	37%
2	B	10	33%
3	C	9	30%
	Total	**30**	**100%**

Based on **Table 14**, the results of ABC analysis based on throughput values as follows:

1. Class A accounts for 80% of the total throughput, consisting of 11 items, which represent 37% of the total work tool items.
2. Class B accounts for 15% of the total throughput, consisting of 10 items, equivalent to 33% of the total work tool items.
3. Class C accounts for 5% of the total throughput,

consisting of 9 items, or 30% of the total work tool items.

Material Handling Distance in the Proposed Layout

Based on the calculation of goods movement distance using the rectilinear method, the total displacement distance is 126 meters, with a total movement frequency of 79.515 occurrences. The total workload, calculated as the product of displacement distance and frequency, amounts to 380.096 meters.

Cost Analysis of Goods Movement

1. Calculation of Current Goods Movement Costs

   Table 15 presents the calculation of goods movement costs based on the current warehouse layout. The cost is derived from the total distance traveled for material handling multiplied by the unit cost per meter. This analysis provides a baseline for evaluating the efficiency improvements in the proposed layout.

Table 15. Cost Analysis of Goods Movement

No	Name of Goods	TFMK (/month)	Total Distance (meters)	Cost/meter		Cost of Movement	
1	Aluminum Foil Tape 2” x 48mm	510	68850	Rp	2.525	Rp	173.846.250
2	No. 11 Welding Glass	81	13332	Rp	2.525	Rp	33.663.300
3	Concrete Nails 2”	13	1608	Rp	2.525	Rp	4.060.200
4	Ceiling Screw 6 x 5/8”	389	46640	Rp	2.525	Rp	117.766.000
5	Grinding Eye End Brush 3”	13	1710	Rp	2.525	Rp	4.317.750
6	Mild Steel Bolt 3/4”	105	6320	Rp	2.525	Rp	15.958.000
7	200a Welding Cable	65	7768	Rp	2.525	Rp	19.614.200
8	Super Best 3.5mm SS Drill Bit	60	5376	Rp	2.525	Rp	13.574.400
9	Blind Rivet Kledy 1/8” x 5/8”	36	2176	Rp	2.525	Rp	5.494.400
10	4” WD Cutting Disc	600	90000	Rp	2.525	Rp	227.250.000
11	RB-26 Welding Wire 2.6mm	1760	105600	Rp	2.525	Rp	266.640.000
12	Hammer	190	8550	Rp	2.525	Rp	21.588.750
13	Screwdriver	523	15684	Rp	2.525	Rp	39.602.100
14	M10 Rivet Pliers	433	13000	Rp	2.525	Rp	32.825.000
15	Alligator Pliers	316	0	Rp	2.525	Rp	-
16	Cutting Pliers	5	144	Rp	2.525	Rp	363.600
17	Electric Solder	4	62	Rp	2.525	Rp	156.550
18	Welding Stang 500A	2	0	Rp	2.525	Rp	-
19	PVC pipe 4”	22	326	Rp	2.525	Rp	823.150
20	PVC Elbow 45° 2”	5	0	Rp	2.525	Rp	-
21	Silicone Sealant	12	540	Rp	2.525	Rp	1.363.500
22	Thinner Kangaroo 3.5L	5	288	Rp	2.525	Rp	727.200
23	Heat Gun / Pipe Welding	4	330	Rp	2.525	Rp	833.250
24	Yamato Cutting Torch	59	5328	Rp	2.525	Rp	13.453.200
25	F Claimp 10”	9	931	Rp	2.525	Rp	2.350.775
26	Scissors	3	416	Rp	2.525	Rp	1.050.400
27	Ring Wrench	3	230	Rp	2.525	Rp	580.750
28	Spana Wrench	31	2820	Rp	2.525	Rp	7.120.500
29	Wrench	5,2	390	Rp	2.525	Rp	984.750
30	5m Meter	1,5	176	Rp	2.525	Rp	444.400
31	Tubing Cutter	4,1	124	Rp	2.525	Rp	313.100
32	Black Big Elbow	1,5	88	Rp	2.525	Rp	222.200
33	M10 Press Pliers	5,7	258	Rp	2.525	Rp	651.450
34	5ft Ladder	2,1	32	Rp	2.525	Rp	80.800
35	Nail Gun I Meite 7116BL	1,1	32	Rp	2.525	Rp	80.800
36	Water Pass	0,9	0	Rp	2.525	Rp	-
37	Bosch Drill	3,5	156	Rp	2.525	Rp	393.900
38	Makita Baby Grinder	0,1	3	Rp	2.525	Rp	7.575
39	Circular Saw	0,8	0	Rp	2.525	Rp	-
40	Hacksaw	0,8	0	Rp	2.525	Rp	-
41	Tolsen seated drilling machine	0,9	14	Rp	2.525	Rp	35.350
42	Fixtec Sandpaper Machine	4,9	148	Rp	2.525	Rp	373.700
43	Fujiyama Welding Travo	4,5	68	Rp	2.525	Rp	171.700
44	Jig Saw	1,1	32	Rp	2.525	Rp	80.800
45	Ampere Pliers	2,9	132	Rp	2.525	Rp	333.300
Total		**5301**	**399682**	**113625**		**Rp**	**1.009.197.050**
Total Distance Moved			**399682**	**Total Cost**		**Rp**	**1.009.197.050**

Based on the calculation of goods placement in the existing layout, the total cost of goods movement is IDR 1.009.197.050, with a total displacement distance of 399.682 meters.

2. Calculation of Class-Based Storage Goods Movement Cost

Table 16. Calculation of Class-Based Storage Goods Movement Cost

No	Name of Goods	TFMK (/month)	Total Distance (meters)	Cost/meter		Cost of Movement	
1	Blind Rivet Kledy 1/8” x 5/8”	510	0	Rp	2.525	Rp	-
2	5m Meter	4,8	72	Rp	2.525	Rp	181.800
3	Super Best SS 3.5mm Drill Bit	80,8	0	Rp	2.525	Rp	-
4	RB-26 Welding Wire 2.6mm	13,4	201	Rp	2.525	Rp	507.525
5	Mild Steel Bolt 3/4”	388,7	11660	Rp	2.525	Rp	29.441.500
6	Ceiling Screw 6 x 5/8”	12,67	190	Rp	2.525	Rp	479.750
7	Concrete Nails 2”	105,3	3160	Rp	2.525	Rp	7.979.000
8	Black Big Elbow	4,13	186	Rp	2.525	Rp	469.650
9	Scissors	2,27	136	Rp	2.525	Rp	343.400
10	Ring Wrench	21,73	978	Rp	2.525	Rp	2.469.450
11	Screwdriver	5,47	164	Rp	2.525	Rp	414.100
12	Water Pass	12	540	Rp	2.525	Rp	1.363.500
13	Hammer	4,8	288	Rp	2.525	Rp	727.200
14	Alligator Pliers	4,4	330	Rp	2.525	Rp	833.250
15	Cutting Pliers	59,2	5328	Rp	2.525	Rp	13.453.200
16	Heat Gun / Pipe Welding	8,87	665	Rp	2.525	Rp	1.679.125
17	Spana Key	3,47	208	Rp	2.525	Rp	525.200
18	Grinding Eye End Brush 3”	64,7	0	Rp	2.525	Rp	-
19	Cutting Disc 4” WD	59,7	896	Rp	2.525	Rp	2.262.400
20	PVC Pipe 4”	36,3	1088	Rp	2.525	Rp	2.747.200
21	Aluminum Foil Tape 2” x 48mm	600	27000	Rp	2.525	Rp	68.175.000
22	Electric Solder	3,07	0	Rp	2.525	Rp	-
23	Wrench	31,3	470	Rp	2.525	Rp	1.186.750
24	Yamato Cutting Torch	5,2	156	Rp	2.525	Rp	393.900
25	5ft Ladder	1,5	22	Rp	2.525	Rp	55.550
26	Tubing Cutter	4,1	0	Rp	2.525	Rp	-
27	Hacksaw	1,5	22	Rp	2.525	Rp	55.550
28	M10 Rivet Pliers	5,7	172	Rp	2.525	Rp	434.300
29	Handlebar Welding 500A	2,1	32	Rp	2.525	Rp	80.800
30	F Claimp 10”	1,1	0	Rp	2.525	Rp	-
31	Bosch Drill	0,9	42	Rp	2.525	Rp	106.050
32	PVC Elbow 45° 2”	1760	184800	Rp	2.525	Rp	466.620.000
33	Silicone Sealant	190	22800	Rp	2.525	Rp	57.570.000
34	Thinner Kangaroo 3.5L	522,8	54894	Rp	2.525	Rp	138.607.350
35	Welding Glass No. 11	433,3	39000	Rp	2.525	Rp	98.475.000
36	Welding Cable 200a	316	23700	Rp	2.525	Rp	59.842.500
37	M10 Press Pliers	3,5	312	Rp	2.525	Rp	787.800
38	Meite 7116BL Nail Gun I	0,1	10	Rp	2.525	Rp	25.250
39	Makita Baby Grinding	0,8	48	Rp	2.525	Rp	121.200
40	Ampere Pliers	0,8	36	Rp	2.525	Rp	90.900
41	Circular Saw	0,9	56	Rp	2.525	Rp	141.400
42	Jig Saw	4,9	222	Rp	2.525	Rp	560.550
43	Fixtec Sandpaper Machine	4,5	136	Rp	2.525	Rp	343.400
44	Fujiyama Welding Travo	1,1	32	Rp	2.525	Rp	80.800
45	Tolsen Seated Drilling Machine	2,9	44	Rp	2.525	Rp	111.100
Total		**5301**	**380096**	**113625**		**Rp**	**959.742.400**
Total Distance Moved			**380096**	**Total Cost**		**Rp**	**959.742.400**

After calculating the placement layout before and after the implementation of the class-based storage method, a significant improvement in warehouse operational efficiency was observed. The total distance of goods movement decreased from 399.682 meters to 380.096 meters. Additionally, the cost of goods movement was reduced from IDR 1.009.197.050 to IDR 959.742.400, as shown in **Table 16**. These results indicate that the implementation of the class-based storage method has successfully enhanced the efficiency of goods storage and retrieval in the warehouse.

Space Utilization in the New Warehouse Layout

The warehouse, with dimensions of 750 x 500 x 300 cm and a 1.5m wide center aisle, has a total area of 37.5 m².

Warehouse area = 37.5 m²

The new warehouse layout utilizes 54.58% of the total available area, indicating a significant improvement in the efficient use of storage space.

Warehouse Layout Comparison

The efficiency of product retrieval in the newly designed layout was analyzed based on time measurements using a stopwatch. The efficiency is calculated using the following formula:

$$\frac{x-y}{x}\ x\ 100\% \qquad (12)$$

Description:

x = Product picking time in the old layout

y = Product retrieval time in the new layout

This formula measures the percentage improvement in retrieval time due to the new layout design.

The results of the analysis after designing the warehouse storage layout are as follows:

1. Product Retrieval Efficiency
   The analysis shows that the average retrieval time decreased by 0.38%, with a standard deviation of 0.08%. This reduction in time indicates an improvement in retrieval efficiency after implementing the ABC classification method in the warehouse.
2. Product Placement Efficiency
   Similarly, the average placement time decreased by 0.22%, with a standard deviation of 0.07%. This reduction in placement time reflects an increase in operational efficiency, further validating the effectiveness of the class-based storage layout.

Warehouse Layout Design

The warehouse layout design using the class-based storage method has proven effective in improving storage efficiency by grouping goods based on specific classifications. Frequently used raw materials and work tools are placed in an easily accessible location, while items with lower demand are stored in more distant areas. This strategic arrangement reduces the time required for locating and retrieving items, thereby enhancing overall warehouse operational efficiency.

This approach is also supported by previous studies. Lin and Ma (2021) highlighted that accurate item classification using a cross-ABC approach can improve shelf organization and space utilization. In addition, Silva (2022) demonstrated that optimizing ABC zone dimensions in manual warehouses can significantly reduce picker travel distances, leading to improved material handling efficiency.

Table 17. Placement of Goods Based on Class-Based Storage Method

No	Name of Goods	Classification	Displacement Distance	Frequency
1	Blind Rivet Kledy 1/8” x 5/8”		0	7650
2	5m Meter		1	72
3	Super Best SS 3.5mm Drill Bit		0	1212
4	RB-26 Welding Wire 2.6mm		1	201
5	Mild Steel Bolt 3/4”		2	5830
6	Ceiling Screw 6 x 5/8”		1	190
7	Concrete Nails 2”		2	1580
8	Black Big Elbow		3	62
9	Scissors	Fast Moving	4	34
10	Ring Wrench		3	326
11	Screwdriver		2	82
12	Water Pass		3	180
13	Hammer		4	72
14	Alligator Pliers		5	66
15	Cutting Pliers		6	888
16	Heat Gun / Pipe Welding		5	133
17	Spana Key		4	52
18	3” End Brush Grinding Eye		0	971
19	Cutting Disc 4” WD		1	896
20	4” PVC Pipe		2	544
21	Aluminum Foil Tape 2” x 48mm		3	9000
22	Electric Solder		0	46
23	Wrench		1	470
24	Yamato Cutting Torch	Medium Moving	2	78
25	5ft Ladder		1	22
26	Tubing Cutter		0	62
27	Hacksaw		1	22
28	M10 Rivet Pliers		2	86
29	Handlebar Welding 500A		1	32
30	F Claimp 10”		0	16
31	Bosch Drill		3	14
32	PVC Elbow 45° 2”		7	26400
33	Silicone Sealant		8	2850
34	Thinner Kangaroo 3.5L		7	7842
35	Welding Glass No. 11		6	6500
36	Welding Cable 200a		5	4740
37	M10 Press Pliers		6	52
38	Meite 7116BL Nail Gun I	Slow Moving	5	2
39	Makita Baby Grinding		4	12
40	Ampere Pliers		3	12
41	Circular Saw		4	14
42	Jig Saw		3	74
43	Fixtec Sandpaper Machine		2	68
44	Fujiyama Welding Travo		2	16
45	Tolsen Seated Drilling Machine		1	44
Total			**126**	**79515**

Table 17 presents the placement of goods based on the class-based storage method, where items are arranged according to their ABC classification to ensure optimal accessibility and storage efficiency.

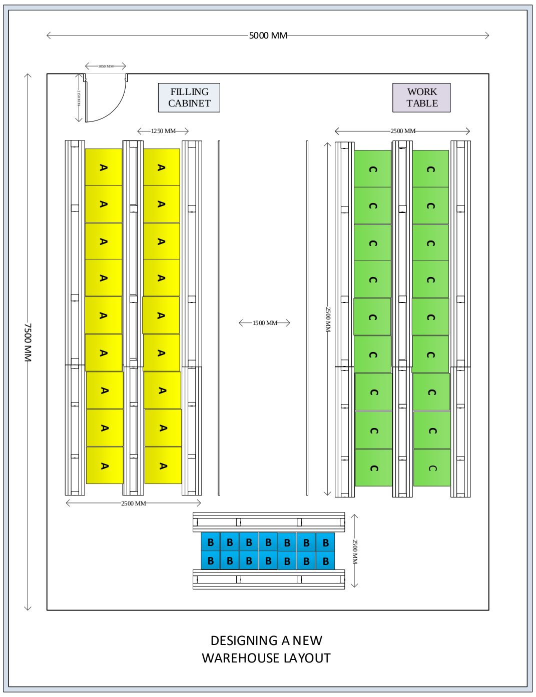

Figure 5. Newly Proposed Warehouse Layout

The implementation of the class-based storage method has improved storage efficiency by grouping items based on demand and characteristics. Frequently used raw materials and tools are positioned in easily accessible areas, while less-used items are stored farther away. This strategic placement reduces retrieval time and enhances overall warehouse operations. **Figure 5** illustrates the proposed warehouse layout based on this method.

5. Conclusions

This study evaluated the warehouse layout of PT.XYZ by applying the class-based storage method to enhance operational efficiency. The ABC classification was used to group 45 types of items based on their throughput levels, enabling a more structured placement of goods. As a result, space utilization improved by 15.87%, the material movement distance decreased by 19.586 meters, and handling costs were reduced by IDR 49.454.650. Moreover, the redesigned layout contributed to better workflow efficiency, with reductions in product retrieval and placement times by 0.38% and 0.22%, respectively.

Although focused on a single case, this study offers practical insights for mid-scale manufacturing facilities that operate under spatial budgetary constraints, especially in developing economies. The proposed class-based storage method with ABC classification can be adapted by similar warehouses regionally, providing a basis for broader applications of class-based layout approaches in the supply chain.

In addition to its practical contributions to warehouse operational efficiency, the findings also enrich the theoretical development of warehouse design and supply chain management by providing empirical evidence on the implementation of the class-based storage method with ABC classification in mid-scale manufacturing contexts. The study's implications have the potential to be replicated at national and regional levels, particularly in companies facing spatial and resource limitations. Despite these positive outcomes, the study has certain limitations. It focuses solely on the application of class-based storage in a single warehouse case and does not compare it with other layouts or storage methods.

Future research is recommended to explore alternative or hybrid storage strategies, such as dedicated, shared, or randomized storage systems, and to evaluate their effectiveness under varying operational scenarios. The integration of warehouse management systems (WMS) and simulation-based validation could also offer deeper insights into layout optimization.

References

Mulyati, E., Numang, I., & Aditya Nurdiansyah, M. (2020). Usulan Tata Letak Gudang Dengan Metode Shared Storage di PT Agility International Customer PT Herbalife Indonesia. *Jurnal Logistik Bisnis*, *10*(02), 36–41. https://doi.org/10.46369/logistik.v10i02.955

Nugraha, K. A., Safitriani, D., & Putong, C. A. (2022). Perancangan Tata Letak Gudang Dengan Metode Class Based Storage Pada Gudang Beras Yayasan Dharma Bhakti Berau Coal. *Sebatik*, *26*(2), 753–760. https://doi.org/10.46984/sebatik.v26i2.2135

Pamungkas, D. S., & Handayani, N. U. (2018). Usulan Perbaikan Tata Letak Penempatan Bahan Baku di Gudang Menggunakan Metode ABC Analysis pada PT Sandang Asia Maju Abadi Semarang. *Industrial Engineering Online Journal*, *7*, 2.

Wignjosoebroto, S. (2009). Tata letak pabrik dan pemindahan bahan.

Safira Isnaeni, N., & Susanto, N. (2021). Penerapan Metode Class Based Storage Untuk Perbaikan Tata Letak Gudang Barang Jadi (Studi Kasus Gudang Barang Jadi K PT Hartono Istana Teknologi). *Industrial Engineering Online Journal*, *10*(3).

Hapsari, I., Sutanto, D. A., Raya, J., Surabaya, K., & Arlianto, J. A. (2011). *Perbaikan Tata Letak Gudang Mesin Fotokopi Rekondisi di CV. NEC, Surabaya*. 1–5.

Saidatuningtyas, I., & Nadilla Primadhani, W. (2021). Racking System Dengan Kebijakan Class Based Storage Di Gudang Timur Pt Industri Kereta Api (Inka) Persero. *Jurnal Logistik Bisnis*, *11*(1), 37–42. https://doi.org/10.46369/logistik.v11i1.1376

Lin, Y., & Ma, Y. (2021). A new method of storage management based on ABC classification: Case study in a Chinese supermarket distribution center.

Silva, A. (2022). Estimating optimal ABC zone sizes in manual warehouses. *Robotics and Computer-Integrated Manufacturing*, 74, 102282.

Muhammad, K., Wicaksana, B. P., & Sibarani, A. A. (2023). Warehouse layout design with class-based storage approach to minimize material transfer distance. *AIP Conference Proceedings*, *2482*(February). https://doi.org/10.1063/5.0113824

Wijaya, S.U., Johanna, R., & Ibrahim, ,.M. (2023). Warehouse design under class-based storage policy based on entry-item-quantity analysis: A case study. *International Conference On Materials Engineering And Manufacturing Systems: Icmems2022*.