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Layout Design by Comparing Dedicated Storage Method and Class-Based Storage Method of Spare Parts Warehouse at Phthalic Anhydride (PA) Company

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ABSTRACT

A warehouse is a fixed facility or building that can store goods, raw materials, and finished materials used during production. Therefore, an effective warehouse layout design can help smooth production and storage processes. PT XYZ is a company that produces Phthalic Anhydride (PA). The company has a spare parts warehouse that stores materials, such as mechanical spare parts, electrical spare parts, chemicals, and consumables. The company's problem is that the storage layout's design is not organized, and the materials are not neatly arranged, so it takes time to search and ignore the types of fast-moving and slow-moving materials. Therefore, the purpose of this research is to redesign the layout of the company's warehouse to make it more efficient. The implementation of this research uses a comparison of 2 methods to choose the most optimal one to use, namely dedicated storage and class-based storage. The dedicated Storage method is used as fixed storage because the material place has been determined. In contrast, class-based storage is a method of grouping goods according to each group's type, size, and block boundaries. The results of the calculation of dedicated storage amounted to 472.75m. In comparison, the results of the calculation of class-based storage showed a total jar of 498.1m with an initial layout distance of 529.75m. Then, the most optimal layout proposal uses a dedicated storage layout proposal. Based on the implementation of the research, the benefits obtained from using this method are shortening the retrieval distance and making it easier for employees to find materials.

Keywords: *warehouse, layout, design, dedicated storage, class-based storage*

Introduction

In the industrial world of era 4.0 in Indonesia from year to year, which is increasingly advanced, followed by developments in various sectors[1]. Every company wants to dominate the market for the products it produces.[2]. Therefore, every company has several factors to achieve success, one of which is to continue to increase effectiveness and efficiency in everything, namely having a storage place.[3]. With a neat arrangement. Storage is the storage of products produced by the company itself, or it could also be the storage of material goods that support the continuity of the production process in the company. The company stores products and material goods in the warehouse or warehouse.

A warehouse is a facility or building that is fixed and in which there is a material place, namely a rack. [4]The warehouse also stores goods, raw materials, and finished materials used during a company's production process.[5][6]. Therefore, an effective warehouse layout design can help smooth production and storage processes.[7] The warehouse also facilitates the process of moving goods and finding goods to achieve the desired goals. The main function of the warehouse is to maintain and care for the stored material until the item is used or sent. [8]. The warehouse layout also manages storage space and material handling to maximize space, reduce storage costs, and increase productivity by minimizing the distance to store and retrieve the material. [9].

PT XYZ is a company that produces products, namely Phthalic Anhydride (PA). In the spare parts warehouse at PT XYZ stores, several types of materials are grouped into four parts: mechanical spare parts, electrical spare parts, chemicals, and consumable materials. Problems in the manufacturing industry are often encountered, for example, in layouts that are considered trivial but greatly affect the company's competitiveness. Therefore, layout is the main thing that must be considered when planning warehouse use[10]. Layout can be interpreted as an effort to place all equipment (materials or materials)

in the factory to optimize production costs[11]. Problems in warehouses that are often encountered are related to the capacity of storage space for materials to be stored and layout arrangements that are less effective, so problems occur in the process of getting in and out of goods [12]. The problem in the spare parts warehouse at PT XYZ is that the spare parts material storage layout is still random, and the materials are not neatly arranged, so it takes time at a decent retrieval distance when employees search for materials. There is no appropriate grouping of spare parts.[13]. The PT XYZ warehouse still uses the randomized or random and irregular storage method, which is not according to type and ignores fast-moving and slow-moving spare parts [14].

With the above problems, this study aims to redesign the warehouse's layout to make it more efficient, organized, and tidy, facilitating material handling activities. [15]It also shortens the distance between the exit and the material storage rack. Layout planning facilitates the application of various methods, namely Dedicated Storage, Shared Storage, and Class-Based Storage.[16]These methods can help redesign the warehouse layout more efficiently. Dedicated storage is often referred to as designated and fixed storage because the location of each material has been determined.[17].[18]Shared storage is a method that organizes the layout of warehouse space by applying the FIFO principle (first in, first Out), where the fastest goods are sent to the area closest to the exit. Meanwhile, Class-based storage combines the criteria of dedicated storage and randomized storage that can group types of products based on criteria and size and provide block boundaries for each group so that storage is still random.[19].

In this study, two layout methods were taken as a comparison, namely the dedicated storage method and class-based storage, to produce the most optimal layout[7], it can be seen that the problems that occur in the warehouse need a more organized and efficient layout design proposal, [20] The dedicated Storage (fixed location) method has the advantage of setting a special storage location for each product, allowing the warehouse to have a better distance between the door and the storage area. [21]. The class-based storage method is a method of storing material divided by class grouping according to the results of throughput (T) with storage (S) [22].

Research Methods

In the implementation of this research, the first step that must be taken is to understand the problems that occur in the warehouse and conduct a review to obtain appropriate data on the problem that will be the object of the research.[23]. The data collected are primary and secondary data, and primary data collection consists of warehouse layout, storage area, and product type. In contrast, secondary data is the average data in and out of goods in the warehouse.[24]The data is taken through direct observation at the PT XYZ warehouse. In the planning stage of the dedicated storage method, the first step is to calculate the storage space requirements for material goods placed in a specific location, and only one type is placed in the storage location.[25].Then, calculate the throughput based on storage and dispensing activities in the warehouse, [26] In and out, the handling material flow process uses a trolley to transport goods. Continued Ranking, where the results of the previous calculation of the Throughput value are divided by the space requirement (T I am running a few minutes late; my previous meeting is over. S) and the storage area layout in the dedicated storage method. The class-based storage method classifies based on the throughput value into classes A (high), B (medium), and C (low), [7] then determines the storage area based on the class from the closest to the farthest to the I / O warehouse door and designs a class-based storage layout. Data processing is assisted by using Microsoft Excel and Microsoft Visio software to redesign the layout of facilities in the warehouse. After that, a comparison is made on which of the two methods is more relevant in the PT XYZ warehouse.

Results and Discussion

In the spare parts warehouse at PT XYZ, the area is around 21x20 m, and the warehouse is patent and cannot be changed. For material storage, it is placed on a rack with two types of sizes, namely rack A with a size of 4.5m x 0.5m, which totals 16 shelves, while rack B is slightly smaller with a size of 2.5m x 0.5m, which totals ten shelves. The warehouse has four material groups: mechanical spare parts, electrical spare parts, chemicals, and consumer goods. Shelf A stores Mechanical spare parts and Consumable goods, and Shelf B is where chemicals and Electrical spare parts are stored. The initial layout and placement of shelves in the spare parts warehouse at PT XYZ can be seen in the picture.

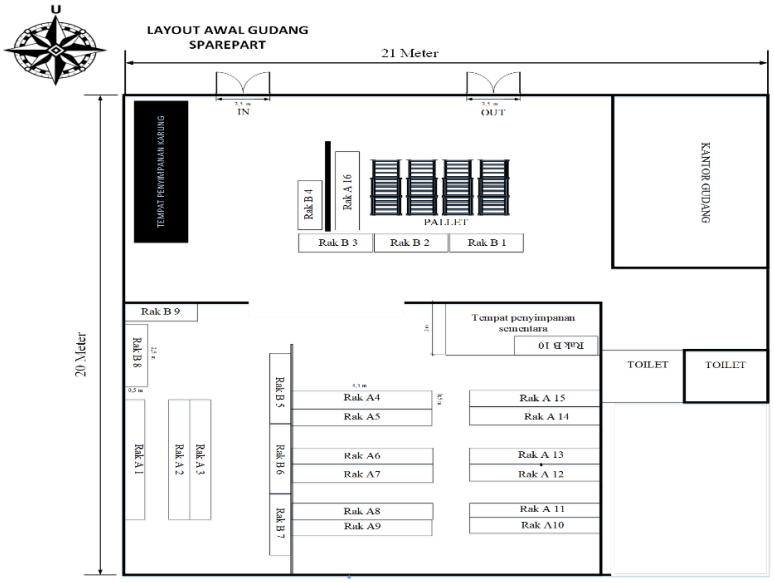

Figure 1. Initial Layout of Spare Parts Warehouse

Table 1. Initial Layout Displacement Data

Blok	Dock	X1	Y1	X2	Y2	Distance(M)	Total Distance (M)
Rack A 1	I	1	1	2.75	6	6.75	20.75
	O	2.5	2	12.5	6	14	
Rack A 2	I	1	1	1.75	6	5.75	18.75
	O	2.5	2	11.5	6	13	
Rack A 3	I	1	1	0.75	6	5.25	18.25
	O	2.5	2	11	6	13	
Rack A 4	I	1	1	5.75	6.5	10.25	19.75
	O	2.5	2	8	6.5	9.5	
Rack A 5	I	1	1	5.75	6	9.75	17.75
	O	2.5	2	8	6	8	
Rack A 6	I	1	1	5.75	4.5	8.25	15.75
	O	2.5	2	8	4.5	7.5	
Rack A 7	I	1	1	5.75	4	7.75	13.75
	O	2.5	2	8	4	6	
Rack A 8	I	1	1	5.75	2.5	6.25	11.75
	O	2.5	2	8	2.5	5.5	
Rack A 9	I	1	1	5.75	2	5.75	11.25
	O	2.5	2	8	2	5.5	
Rack A10	I	1	1	10.75	2	10.75	12.25
	O	2.5	2	3.5	2	1.5	
Rack A11	I	1	1	10.75	2.5	11.25	14.25
	O	2.5	2	3.5	2.5	3	
Rack A12	I	1	1	10.75	4	12.75	16.25
	O	2.5	2	3.5	4	3.5	
Rack A13	I	1	1	10.75	4.5	13.25	18.25
	O	2.5	2	3.5	4.5	5	
Rack A14	I	1	1	10.75	6	14.75	20.25
	O	2.5	2	3.5	6	5.5	
Rack A15	I	1	1	10.75	6.5	15.25	32.05
	O	2.5	2	3.5	6.5	16.8	
Rack A16	I	1	1	2.75	17.8	18.55	32.15
	O	2.5	2	5.1	17.8	13.6	
Rack B 1	I	1	1	8.8	13	19.8	32.55
	O	2.5	2	0.75	13	12.75	
Rack B 2	I	1	1	6.2	13	17.2	29.05

	O	2.5	2	3.35	13	11.85	
Rack B 3	I	1	1	3.6	13	14.6	31.85
	O	2.5	2	5.95	13	17.25	
Rack B 4	I	1	1	2	15.8	15.8	25.05
	O	2.5	2	5.75	15.8	9.25	
Rack B 5	I	1	1	1.25	8	7.25	16.5
	O	2.5	2	8.25	8	9.25	
Rack B 6	I	1	1	1.25	5.5	4.75	11.5
	O	2.5	2	8.25	5.5	6.75	
Rack B 7	I	1	1	1.25	3	2.25	15.5
	O	2.5	2	8.25	3	13.25	
Rack B 8	I	1	1	3.4	9.5	10.9	28.9
	O	2.5	2	12.5	9.5	18	
Rack B 9	I	1	1	3.4	10	11.4	27.9
	O	2.5	2	12.5	10	16.5	
Rack B 10	I	1	1	8.25	8.5	14.75	17.75
	O	2.5	2	3.5	8.5	3	
Total							**529.75**

Table 1 shows the initial layout displacement data in the spare parts warehouse, which results from calculating the distance between the storage rack and the exit/entrance (In / Out). X1 and Y1 symbolize the exit/entrance with a coordinate point 0.0. The distance of the storage rack to the predetermined shelf is symbolized by X2, Y2 [4][16]After finding the calculations' results in Table 1, the next step is to perform calculations using the dedicated storage method, as shown in Table 2.

Calculation of Dedicated Storage Data

Table 2. Calculation of Dedicated Storage Method

Material	Reception	Delivery	Slot hood	SR	Throughput	T / S	By Group
Mechanical Spare part							
Glove Valve	336	269	100	3.4	12	3.6	26.3
Sprocket	570	485	100	5.7	21	3.7	
Gear	300	234	100	3.0	11	3.6	
Bearing	420	340	100	4.2	15	3.6	
Shapt Sleeve	60	30	100	0.6	2	3.0	
Bolt	1800	1170	100	18.0	59	3.3	
Dynamo Thrust	780	312	100	7.8	22	2.8	
Dynamo	210	74	100	2.1	6	2.7	
Electrical Spare part							
Vinyl Electrical Insulation	300	195	50	6.0	10	1.7	4,2
Led	90	38	50	1.8	3	1.4	
TL Lamp	60	9	50	1.2	1	1.2	
Chemical							
Nitrogen Liquid	300	75	50	6.0	8	1.3	6,2
Sulfuric Acid	150	90	50	3.0	5	1.6	
Sodium Hydrogen	90	50	50	1.8	3	1.6	
Sampling Glass	600	498	50	12.0	22	1.8	
Consumable Materials							
Cat	300	108	100	3.0	8	2.7	23,8
Penetrating Oil	258	155	100	2.6	8	3.2	
Grenda Stone	780	601	100	7.8	28	3.5	
Welding Wire Electrode	1500	1035	100	15.0	51	3.4	
Gloves	300	240	100	3.0	11	3.6	
Mask	900	882	100	9.0	36	4.0	
GTA 007 Thinner	300	207	100	3.0	10	3.4	

Total	**119.9**	**350**

The results of the calculations carried out are shown in Table 2. In Mechanical spare parts, there are the results of the calculation of Space Requirement (SR) with the formula [3]

$$SR = \frac{\text{average revenue}}{rack\ storage\ capacity}. \quad (1)$$

After finding the SR result, continue by calculating the activity (throughput) using the formula.

$$Tj = \frac{average\ revenue}{transport\ capacity} + \frac{average\ delivery}{transport\ capacity} \quad (2)$$

The next step is to calculate the ratio of throughput to storage (T/S) with the formula.

$$\frac{T}{S} = \frac{throughput}{space\ requirement} \quad (3)$$

Then, using a dedicated storage method, we found the final result for mechanical spare parts of 26.3. Likewise, electrical spare parts do the same calculation as mechanical spare parts and find the final result of 4.2. In the calculation of chemicals, we get the final result of 6.2, and in the calculation of consumables, we get the final result of 23.8.

Design of Proposed Dedicated Storage Layout

After determining the throughput value and space requirements, the next step is to design a warehouse layout, as shown in Figure 2 below.

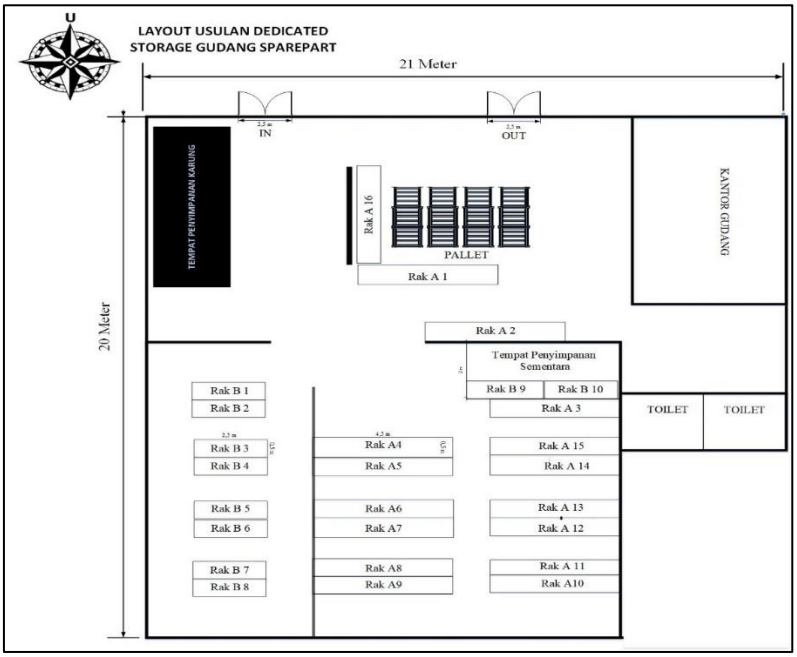

Figure 2. Proposed Layout Dedicated Storage

Having determined the layout design model with the dedicated storage method, the next step is calculating the distance of moving the shelves in the storage area to the exit. The displacement distance data can be seen in Table 3

Table 3. Dedicated Storage Layout Displacement Data

Blok	*Dock*	*X1*	*Y1*	*X2*	*Y2*	*Distance(M)*	*Total Distance (M)*
RACK A 1	I	1	1	2.75	13	13.75	27.35
	O	2.5	2	5.1	13	13.6	
RACK A 2	I	1	1	5.6	10.5	14.1	20.45

	O	2.5	2	2.85	10.5	6.35	
RACK A 3	I	1	1	10.75	8	16.75	22
	O	2.5	2	3.25	8	5.25	
RACK A 4	I	1	1	5.75	6.5	10.25	19.75
	O	2.5	2	8	6.5	9.5	
RACK A 5	I	1	1	5.75	6	9.75	17.75
	O	2.5	2	8	6	8	
RACK A 6	I	1	1	5.75	4.5	8.25	15.75
	O	2.5	2	8	4.5	7.5	
RACK A 7	I	1	1	5.75	4	7.75	13.75
	O	2.5	2	8	4	6	
RACK A 8	I	1	1	5.75	2.5	6.25	11.75
	O	2.5	2	8	2.5	5.5	
RACK A 9	I	1	1	5.75	2	5.75	11.25
	O	2.5	2	8	2	5.5	
RACK A 10	I	1	1	10.75	2	10.75	12.25
	O	2.5	2	3.5	2	1.5	
RACK A 11	I	1	1	10.75	2.5	11.25	14.25
	O	2.5	2	3.5	2.5	3	
RACK A 12	I	1	1	10.75	4	12.75	16.25
	O	2.5	2	3.5	4	3.5	
RACK A13	I	1	1	10.75	4.5	13.25	18.25
	O	2.5	2	3.5	4.5	5	
RACK A 14	I	1	1	10.75	6	14.75	20.25
	O	2.5	2	3.5	6	5.5	
RACK A 15	I	1	1	10.75	6.5	15.25	32.05
	O	2.5	2	3.5	6.5	16.8	
RACK A 16	I	1	1	2.75	17.8	18.55	27.65
	O	2.5	2	5.1	17.8	9.1	
RACK B 1	I	1	1	2.5	8.5	9	23.5
	O	2.5	2	11	8.5	14.5	
RACK B 2	I	1	1	2.5	8	8.5	21.5
	O	2.5	2	11	8	13	
RACK B 3	I	1	1	2.5	6.5	7	19.5
	O	2.5	2	11	6.5	12.5	
RACK B 4	I	1	1	2.5	6	6.5	12.25
	O	2.5	2	5.75	6	5.75	
RACK B 5	I	1	1	2.5	4.5	5	15.5
	O	2.5	2	11	4.5	10.5	
RACK B 6	I	1	1	2.5	4	4.5	13.5
	O	2.5	2	11	4	9	
RACK B 7	I	1	1	2.5	2.5	3	11.5
	O	2.5	2	11	2.5	8.5	
RACK B 8	I	1	1	2.5	2	2.5	17.5
	O	2.5	2	11	2	15	
RACK B 9	I	1	1	5.75	8.5	12.25	19.5
	O	2.5	2	1.75	8.5	7.25	
RACK B 10	I	1	1	8.25	8.5	14.75	17.75
	O	2.5	2	3.5	8.5	3	
TOTAL							**472.75**

ABC Class-Based Storage Classification

Table 4 shows the results of classifying into ABC, where the determination of classes is based on the throughput frequency of goods in and out of the warehouse. After finding the throughput percentage, the ABC class grouping is carried out on the storage rack. The table below shows the results.

Table 4. ABC Classification results

Material	Throughput (T)	Percentage Throughput	Cumulative Percentage Throughput		Percentage Number of Items	Percentage Storage of value	Rack
Bolt	59	17%	17%				Rak A1 & Rak B 9
Welding Wire	51	14%	31%				Rak A9
Electrode Mask	36	10%	42%				Rak A 10
Grenda Stone	28	8%	50%	A	31.8	68%	Rak A 11
Sampling Cup	22	6%	56%				Rak A 16
Thust Dynamo	22	6%	62%				Rak A 2 + Rak B 8
Sprocket	21	6%	68%				Rak A 3 + Rak B 7
Bearing	15	4%	72%				Rak A 4
Glove Valve	12	3%	76%				Rak A 5 +Rak B 10
Glove	11	3%	79%				Rak A12
Gear	11	3%	82%				Rak A 6
Gta 007 Thinner	10	3%	85%				Rak A 13
Electrical Solation	10	3%	88%	B	40.9	26%	Rak B 4
Penetrating Oil	8	2%	90%				Rak A 15
Paint	8	2%	92%				Rak A 14
Nitrogen Liquid	8	2%	95%				Rak B 1
Dynamo	6	2%	96%				Rak A 7
Sulfuric Acid	5	1%	98%				Rak B 2
Sodium Hydrogen	3	1%	98%	C	27.3	5%	Rak B 3
Led	3	1%	99%				Rak B 5
Shapt Sleeve	2	1%	100%				Rak A 8
TL Lamp	1	0%	100%				Rak B 6
Total	**350**				**100.0**	**100%**	

Design of Proposed Class-Based Storage Layout

In the class-based storage re-layout design, it has been determined that goods are stored based on the class A, B, and C grouping. The next step is to design a warehouse layout, as shown in Figure 3 below.

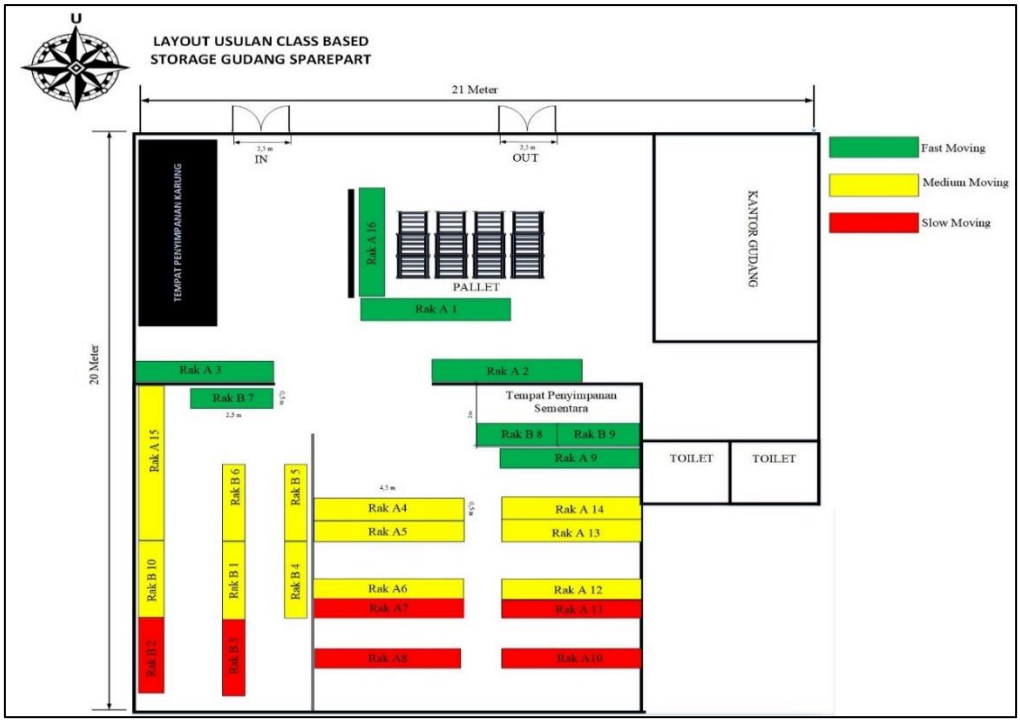

Figure 3. Proposed Layout Class-Based Storage

Having determined the layout design model with the class-based storage method, the next step is calculating the distance to move the shelves according to the class grouping in the storage area to the exit. The displacement distance data can be seen in Table 5.

Table 5. Class-Based Storage Layout Displacement Data

Blok	*Dock*	*X1*	*Y1*	*X2*	*Y2*	*Distance(M)*	*Total Distance (M)*
RACK A 1	I	1	1	2.75	13	13.75	27.35
	O	2.5	2	5.1	13	13.6	
RACK A 2	I	1	1	5.6	10.5	14.1	22.95
	O	2.5	2	2.85	10.5	8.85	
RACK A 3	I	1	1	4.25	10.5	12.75	25.5
	O	2.5	2	10.75	10.5	12.75	
RACK A 4	I	1	1	5.75	6.5	10.25	19.75
	O	2.5	2	8	6.5	9.5	
RACK A 5	I	1	1	5.75	6	9.75	17.25
	O	2.5	2	8	6	7.5	
RACK A 6	I	1	1	5.75	4	7.75	14.25
	O	2.5	2	8	4	6.5	
RACK A 7	I	1	1	5.75	3	6.75	12.75
	O	2.5	2	8	3	6	
RACK A 8	I	1	1	5.75	2.5	6.25	11.75
	O	2.5	2	8	2.5	5.5	
RACK A 9	I	1	1	10.75	2	10.75	19.5
	O	2.5	2	3.25	2	8.75	
RACK A10	I	1	1	10.75	10	18.75	20.75
	O	2.5	2	3.5	10	2	
RACK A11	I	1	1	10.75	3	11.75	14.75
	O	2.5	2	3.5	3	3	
RACK A12	I	1	1	10.75	4	12.75	17.75
	O	2.5	2	3.5	4	5	
RACK A13	I	1	1	10.75	6	14.75	20.25
	O	2.5	2	3.5	6	5.5	
RACK A14	I	1	1	10.75	6.5	15.25	24.25
	O	2.5	2	3.5	6.5	9	

RACK A15	I	1	1	4.25	10	12.25	36.3
	O	2.5	2	10.75	10	24.05	
RACK A16	I	1	1	2.75	17.8	18.55	24.65
	O	2.5	2	5.1	17.8	6.1	
RACK B 1	I	1	1	0.75	5.5	4.75	11.5
	O	2.5	2	8.25	5.5	6.75	
RACK B 2	I	1	1	2.5	3	3.5	13
	O	2.5	2	11	3	9.5	
RACK B 3	I	1	1	0.75	3	2.25	11.5
	O	2.5	2	8.25	3	9.25	
RACK B 4	I	1	1	1	5.5	4.5	14.25
	O	2.5	2	6.25	5.5	9.75	
RACK B 5	I	1	1	1	8	7	16.75
	O	2.5	2	6.25	8	9.75	
RACK B 6	I	1	1	0.75	8	7.25	20.8
	O	2.5	2	8.25	8	13.55	
RACK B 7	I	1	1	2.25	9.8	10.05	23.8
	O	2.5	2	9.75	9.8	13.75	
RACK B 8	I	1	1	5.75	8.5	12.25	19.5
	O	2.5	2	1.75	8.5	7.25	
RACK B 9	I	1	1	8.25	8.5	14.75	19.25
	O	2.5	2	3.5	8.5	4.5	
RACK B 10	I	1	1	4.25	5.5	7.75	18
	O	2.5	2	10.75	5.5	10.25	
TOTAL							498.1

In comparing the design results of the dedicated storage layout, the overall total was obtained (472.75 m), While in Class-based storage, it got results (498.1 m). The difference in the proposed layout design of the two methods is 25.6m, as seen in Table 6. Based on calculations that have been carried out with a comparison of 2 methods between dedicated storage and class-based storage methods, the method that is suitable for implementation in the PT XYZ warehouse is the dedicated storage method because the proposed mileage is the most optimal, shortening the retrieval distance and making it easier for employees to find materials. After all, the materials have been grouped according to type.

Table 6. Distance Comparison Results

No	Layout	*total distance*
1	Initial Layout	529.75
2	Proposed Dedicated storage	472.75
3	Proposed Class-Based Storage	498.1

Conclusion

Based on the discussion results on the comparison between the dedicated storage method and the Class-based storage method, the layout design of dedicated storage results from the total obtained (472.75 m) while Class-based storage gets the results (498.1 m.). The most efficient layout design is the dedicated storage method, which in the dedicated method has a FIFO storage system and is fixed storage, which can make it easier for warehouse employees to find these items. Therefore, the selected layout is the layout design of the dedicated storage method.

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