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Re-Layout Design of the Kalus Warehouse 1.6 Using the Class-Based Storage Method at PT XYZ

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Abstract

PT XYZ is a company engaged in the electricity sector, where the main tasks are to produce, distribute, and provide electricity to the public. PT XYZ has Distribution Parent Units, such as the Greater Jakarta Distribution Parent Unit, which is responsible for distributing electricity in Jakarta and electrical equipment such as Miniature Circuit Breakers (MCB), Molded Case Circuit Breakers (MCCB), Kilowatt Hour (kWh) Meters, and others. Problems in Kalu's Warehouse 1.6 of PT XYZ include placing less organized goods, and the First In First Out (FIFO) system needs to be fixed. This research aims to see the application of the fishbone diagram and class-based storage method in the Kalus Warehouse 1.6 of PT XYZ, which previously still used a randomized storage system, namely the placement of goods randomly in any available space. The method used is to determine the cause of the problems that have been mentioned, design a layout with a minimum total displacement distance, and optimize the allocation of types of goods. Two proposed layouts were generated based on the ranking of T/S calculation results. Then, the two layouts are compared to find the most suitable warehouse layout, which is the optimal condition with a decrease in rectilinear travel distance, which is greater than the existing travel distance. This is to be applied to the Kalus Warehouse 1.6 of PT XYZ.

***Keywords**: Layout, warehouse, class-based storage*

1. Introduction

Electrical energy is a basic human need today that is integrated with various daily activities such as errands, studying, work, and entertainment. In Indonesia, electricity consumption continues to increase in line with economic growth. Data from the Central Bureau of Statistics shows that electricity consumption in Indonesia increased exponentially from 910 kWh per capita in 2015 to 1109 kWh per capita in 2021 (Dihni, 2021).

PT XYZ is a significant company that produces, distributes, and provides electricity to the public. PT XYZ has core business activities in power generation, transmission, distribution, development, planning, construction, and sales. PT XYZ's customers include all Indonesian people who use electricity. In 2021, PT XYZ had more than 82.54 million electricity customers, an increase of 4.35% over the previous year with approximately 79 million electricity customers.

The community's electricity demand is very high, mainly because PT XYZ, the company monopolizing the electricity business in Indonesia, generated approximately 210.37 TWh of electricity from January to October 2021. Due to the absence of competitors in the same sector, PT XYZ has to work hard to meet all electricity needs and enhance customer satisfaction through effective and efficient electricity distribution. One way to improve the performance of the company's electricity distribution is by optimizing the flow of goods in and out of the company's warehouse.

Warehousing maximizes resources to meet customer demand with limited resources (Tompkins, 2004). A well-designed warehouse enhances space utilization, equipment utilization, labor efficiency, material accessibility, and protection. According to Pambudi (2016), a good warehouse ensures continuous movement of goods to avoid additional costs such as maintenance. A well-designed layout avoids congestion and high storage costs. The layout significantly influences the long-term operational efficiency of businesses.

PT XYZ has a distribution central unit, such as the Jakarta Greater Area Distribution Main Unit, responsible for distributing electricity in Jakarta. This Distribution Main Unit ensures timely electricity supply for the area's residents.

The Greater Jakarta Distribution Unit oversees the Customer Service Implementation Unit (UP3) and Distribution Regulatory Implementation Unit (UP2D), which are divided into sixteen UP3 and one UP2D. PT XYZ has one main warehouse called Gudang Kalus, with six indoor warehouses, two outdoor storage areas, and two semi-outdoor storage areas. PT XYZ still uses a

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randomized storage system where goods are placed randomly without precise storage locations and coding. This causes items with a long age to be challenging to leave the warehouse and difficulty finding things when they are to be shipped or when checking stock-taking. In addition, this randomized system also causes mixing types of goods, which makes searching for goods ineffective and wastes much time.

The long-distance between storage and the warehouse exit causes the inefficiency in the company's logistics. This impacts slow material handling, product delivery, and increased material handling costs. The company requires a new warehouse layout design to address the challenges of finding items and the ineffective implementation of the First In First Out (FIFO) method while ensuring optimal storage capacity. FIFO is a method where goods that come in first are considered first out or sold so that the final inventory value consists of an inventory of goods purchased or entered later (Putri, 2021). This research also utilizes a fishbone diagram to describe the various impacts or consequences and the causes that create or contribute to those impacts (Slameto, 2016) and to analyze the factors influencing the First In First Out (FIFO) product retrieval system. The issues are categorized into human factors, materials, machinery, procedures, and policies. This research aims to improve the warehouse layout, enhance work efficiency, and identify the causes of operators' difficulties in finding items and the ineffective implementation of the FIFO system at PT XYZ.

Several previous studies, such as Johan et al. (2018), Nesti et al. (2023), and Kemklyano et al. (2021), have examined the use of class-based storage methods, primarily focusing on manufacturing companies. However, research utilizing the class-based storage method in the field of electrical power still needs to be completed. Only the study by Lisa et al. (2023) explored a similar subject. What sets this research apart from others is the need for studies conducted on warehouse layout design at the scale of a central warehouse, as done in this study.

Based on the company's needs, the Class-Based Storage method can be selected and used to design a new warehouse layout to solve the company's problems. This flexible method is widely used to create warehouse layouts according to company needs (Johan et al., 2018).

2. Research Methods

The research method used in this research is the class-based storage method, which attempts to solve the problems. This method is flexible and widely used because it is between dedicated storage and random storage rules. This method divides products or components into three, four, or five classes based on the ratio of Throughput (T) to Storage (S). Products that belong to fast-moving products are categorized as class 1 products, followed by class 2 products, class 3, and so on. The dedicated storage rule is used to determine the location of the class, while random storage is used to determine the area within the class. Components or products are placed within these classes based on specific types and sizes.

Three main steps must be taken to implement a dedicated storage system in warehouse layout planning, according to (Permana et al., 2013), which is adjusted in this research. The layout design stages in this research using the class-based storage method are described in the Figure (1) flowchart.

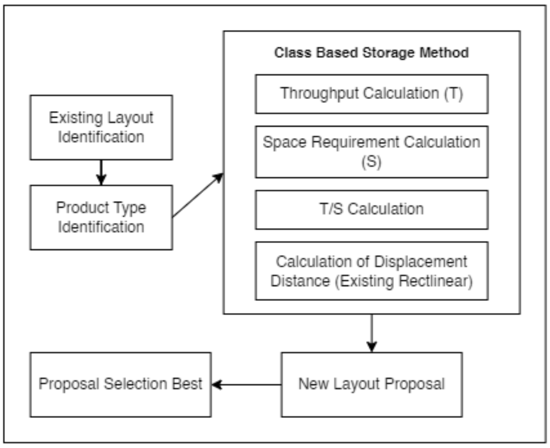

Figure 1: Flowchart of Layout Design Stages with Class-Based Storage Method

3. Results and Discussion

This section describes collecting and processing data obtained to solve the problem and find results from the trial.

3.1 Data Collection

a. Existing Warehouse Layout Condition

The company needs help with an unorganized warehouse layout, such as placing newly arrived products in empty spaces or stacks with the lowest quantity, regardless of the product dimensions within a block. This practice is commonly known as randomized storage. It leads to a need for extensive storage space, slow retrieval processes, and hindrances in material handling and delivery activities. The company's service system follows a Make-to-stock (MTO) approach. Predicting fluctuating order frequencies and lead times is challenging due to products with long storage durations and rapid in-and-out processes.

The warehouse area is directly calculated using 3m x 3m boxes as the reference. The warehouse has dimensions of 15m x 42m, with a minimum height of 7m from the entrance. The current storage capacity of the warehouse is 48 blocks, with one operational door for incoming and outgoing goods. According to the relevant agency, this configuration is because if the second door is used, the forklift would have to maneuver behind the building, resulting in a more extended loading and unloading process. Therefore, door 1 is assumed to be this study's input/output point.

The causes of FIFO not working and problems in finding goods were identified through interviews with warehouse staff and direct observation. The storage of finished goods needs to be categorized, and many goods are placed without pallets, without regard to the maximum capacity of each pallet. The current condition of the warehouse requires a forklift path that can reach all goods and pallets due to the pile of goods in front. Delivery of goods is done without regard to storage order, and operators tend to select goods in the front row. Another problem is when customers request new items from the supplier. FIFO has yet to be appropriately implemented, causing some items to expire and become unused due to lagging technology. The existing 1.6 Kalus warehouse layout is shown in Figure (2) below.

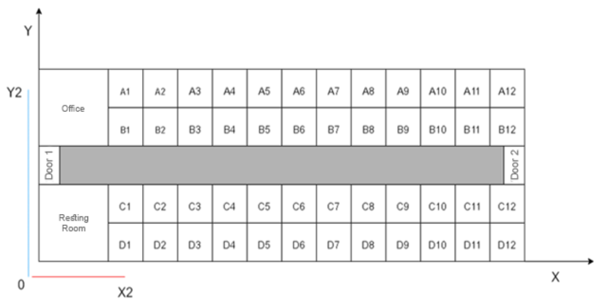

Figure 2: Existing 1.6 Kalus Warehouse Layout

b. Product Type

This research uses the class-based storage method by grouping goods based on electric current capacity. MCCB, MCB, and kWh Meter products are divided into three classes based on their electric current ability. MCCBs have a variety of specifications and sizes, MCBs have a variety of voltage limits and brands, and kWh meters have a variety of colors and different numbers of phases. The Kalus Warehouse of PT XYZ does not only store the products mentioned above; there are several other products, such as transformers, cubicles, lpsb, and others, located in different warehouses. However, this research only focuses on Kalus Warehouse 1.6 at PT XYZ, with the products shown in Figure (3) below.

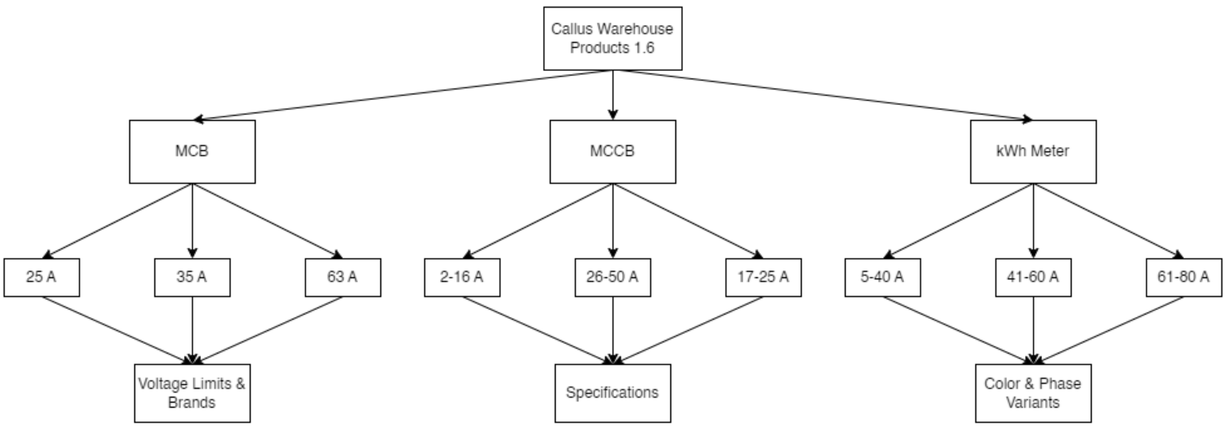

Figure 3: Hierarchy Diagram of Product Types

c. Receiving, Shipping, and Inventory of Goods

Recapitulation of data on the receipt, delivery, and inventory of finished goods (products) from several suppliers received and stored in November 2021-February 2022 is shown in Table (1, 2, and 3).

Table 1: Recapitulation of Receipt, Shipment, and Monthly Inventory of MCB Products

Data Groups	Month	Electric Current Capacity (A)		
		2-16A	**17-25A**	**26-50A**
Receiving	November 2021	13826	2000	100
	Desember 2021	8954	0	1500
	Januari 2022	13500	1850	3000
	Februari 2022	6600	1566	564
	Average Receipts	10720	1354	1291
Shipping	November 2021	34640	4583	1766
	Desember 2021	27558	4860	568
	Januari 2022	26312	5324	4532
	Februari 2022	8927	920	961
	Average Shipment	24359	3922	1957
Inventory	November 2021	16147	5761	516
	Desember 2021	11085	4106	699
	Januari 2022	7124	1955	784
	Februari 2022	5840	1658	2076

Table 2: Recapitulation of Receipt, Shipment, and Monthly Inventory of MCCB Products

Data Groups	Month	Electric Current Capacity (A)		
		25A	35A	63A
Receiving	November 2021	264	548	174
	Desember 2021	68	59	82
	Januari 2022	124	82	0
	Februari 2022	0	23	668
	Average Receipts	114	178	231
Shipping	November 2021	205	271	79
	Desember 2021	46	203	191
	Januari 2022	37	146	89
	Februari 2022	63	38	18
	Average Shipment	88	165	94
Inventory	November 2021	3490	4974	1327
	Desember 2021	3817	2479	3032
	Januari 2022	1488	1184	728
	Februari 2022	1971	1997	1468

Table 3: Recapitulation of Receipt, Shipment, and Monthly Inventory of kWh Meter Products

Data Groups	Month	Electric Current Capacity (A)		
		5-40A	**41-60A**	**61-80A**
Receiving	November 2021	0	0	1000
	Desember 2021	0	15060	130
	Januari 2022	4450	20830	2320
	Februari 2022	362	5018	150
	Average Receipts	1203	10227	900
Shipping	November 2021	11559	120	1244
	Desember 2021	4400	14587	540
	Januari 2022	1875	15739	1173
	Februari 2022	2242	4400	603
	Average Shipment	5019	8712	890
Inventory	November 2021	175651	828	13984
	Desember 2021	13372	123365	2956
	Januari 2022	38580	350242	38652
	Februari 2022	24817	52561	12013

3.2 Data Processing

a. Throughput Calculation (T)

Throughput is a calculation that determines the average flow of incoming and outgoing goods per month. Incoming Throughput is calculated by dividing the average value of monthly product receipts by the maximum storage capacity per pallet. On the other hand, Outgoing Throughput is calculated by dividing the average value of product shipments per month by the carrying capacity per pallet. The calculations for all products: Incoming Throughput, Outgoing Throughput, and Total Throughput are shown in Table (4, 5, and 6).

Table 4: Throughput MCB

No	Current Capacity	Receipt (pieces)	Shipment (pieces)	Products per Pallet (pieces)	Throughput Receipt	Throughput Send	*T* Total
1	2-16A	10720	24359	725	14.79	33.60	48.38
2	17-25A	1354	3922		1.87	5.41	7.28
3	26-50A	1291	1957		1.78	2.70	4.48

Table 5: Throughput MCCB

No	Current Capacity	Receipt (pieces)	Shipment (pieces)	Products per Pallet (pieces)	Throughput Receipt	Throughput Send	*T* Total
1	25A	114	88	95	1.2	0.93	2.13
2	35A	178	165		1.87	1.74	3.61
3	63A	231	94		2.43	0.99	3.42

Table 6: Throughput kWh Meter

No	Current Capacity	Receipt (pieces)	Shipment (pieces)	Products per Pallet (pieces)	Throughput Receipt	Throughput Send	*T* Total
1	5-40A	1203	5019	125	9.62	40.15	49.78
2	41-60A	10227	8712		81.82	69.70	151.51
3	61-80A	900	888		7.20	7.10	14.30

b. Space Requirement Calculation (S)

Space requirement is a calculation to determine the storage location of a particular product. This strategy is essential to ensuring that each type of good stock in the warehouse has several storage spaces that align with the production volume of goods Sienera et al. (2022). The number of locations is proportional to the maximum inventories of all existing products. The maximum number in this study is the maximum number of products for each pallet. The space requirement for all products is shown in Table (7, 8, and 9).

Table 7: Space Requirement MCB

No	Current Capacity	Inventory (pieces)	Products per Pallet (pieces)	Pallet Requirements	Space Requirement
1	2-16A	5840	725	8	2
2	17-25A	1658		2	1
3	26-50A	2076		3	1

Table 8: Space Requirement MCCB

No	Current Capacity	Inventory (pieces)	Products per Pallet (pieces)	Pallet Requirements	Space Requirement
1	25A	1971	95	21	5
2	35A	1997		21	5
3	63A	1468		15	4

Table 9: Space Requirement kWh Meter

No	Current Capacity	Inventory (pieces)	Products per Pallet (pieces)	Pallet Requirements	Space Requirement
1	5-40A	2481	125	20	5
2	41-60A	5256		42	11
3	61-80A	6013		48	12

c. T/S Calculation

Product placement is based on the ranking obtained from the comparison value of Throughput (T) with space requirements (S). A high T/S comparison value indicates that the product has a high level of importance because it is directly proportional to the Throughput, which is the value of the flow activity is shown in Table (10, 11, and 12).

Table 10: T/S MCB

No	Current Capacity	T Receipt	T Send	S	*T/S* Receipt	*T/S* Send	*T/S* Total	Rank
1	2-16A	14.79	33.6	2	7.40	16.8	24.20	1
2	17-25A	1.87	5.41	1	1.87	5.41	7.28	2
3	26-50A	1.78	2.7	1	1.78	2.7	4.48	3

Table 11: T/S MCCB

No	Current Capacity	T Receipt	T Send	S	*T/S* Receipt	*T/S* Send	*T/S* Total	Rank
1	25A	1.28	0.93	5	0.26	0.19	0.44	3
2	35A	1.87	1.74	5	0.37	0.35	0.72	2
3	63A	2.43	0.99	4	0.61	0.25	0.86	1

Table 12: T/S kWh Meter

No	Current Capacity	T Receipt	T Send	S	*T/S* Receipt	*T/S* Send	*T/S* Total	Rank
1	5-40A	9.62	40.15	5	1.92	8.03	9.95	2
2	41-60A	81.82	69.7	11	7.44	6.34	13.77	1
3	61-80A	7.2	7.1	12	0.60	0.59	1.19	3

d. *Rectilinear Existing*

This method calculates the distance traveled by blocks to the I/O point within the warehouse. It employs rectilinear distance with orthogonal paths between blocks. The calculation is based on a 3x3m block size and a 3m wide door at PT XYZ's Jakarta Greater Area Distribution Main Unit. After calculating the rectilinear distance for all blocks, the existing rectilinear distance represents the total average travel distance for all types of products in each class is shown in Table (13). The warehouse utilizes a randomized storage layout, placing items in available empty spaces.

Table 13: Existing Distance

No	Product Name	Current Capacity	T/S	*T/S* Average	Total Block Distance (m)	Total Average Mileage (M)
1	MCB	2-16	24.20	6,99	2736	19124,64
		17-25	7.28			
		26-50	4.48			
2	MCCB	25A	0.44			
		35A	0.72			
		63A	0.86			
3	Kwh Meter	5-40	9.95			
		41-60	13.77			
		61-80	1.19			

e. Proposed Layouts

Based on the dedicated storage method, item placement is determined by the T/S value, where items with a higher T/S value have a higher frequency of incoming/outgoing flow. Items with the highest T/S value are placed in blocks with the smallest rectilinear distance. This study ranks the T/S values from highest to lowest and the rectilinear distances from smallest to largest that can be seen in Table (14). In Layout Proposal 1, shown in Figure (4), the ranking is based on the total T/S value from highest to lowest, regardless of the item type. Each class and item type is assigned different colors to facilitate item placement within the blocks. In Layout Proposal 2, shown in Figure (5), item locations are rearranged so that items of the same type are placed within the same range. The determination of the proposed layout is based on the adjustments made to ensure that the locations are close to each other while adhering to the ranking rules of the priority scale.

The calculations and adjustment of T/S with the distance of each block for proposed layouts 1 and 2 is shown in Table (15 and 16)

Table 14: Legend of Item Placement Ranking.

Color	Rank	Product Name	Classification (A)
	1	MCB	2-16
	2	kWh Meter	41-60
	3	kWh Meter	6-5
	4	MCB	5-40
	5	MCB	17-25
	6	kWh Meter	61-80
	7	MCCB	63
	8	MCCB	35
	9	MCCB	25

Figure 4: Proposed Layouts 1

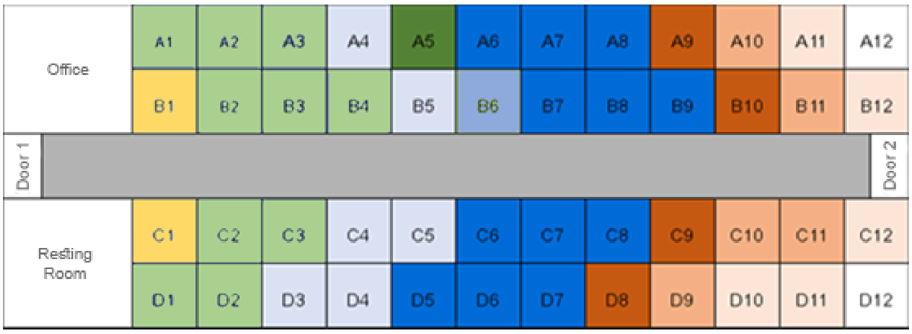

Figure 5: Proposed Layouts 2

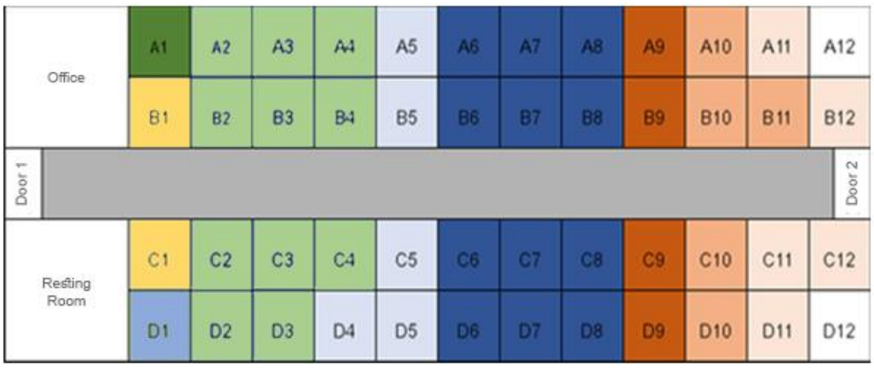

Table 15: Proposed Distance 1

No	Product Name	Electric Current Capacity	Block	T/S Receipt	T/S Send	DI	DO	Distance
1	MCB	2-16	B1	7,40	16,8	10,5	10,5	508,2
			C1			10,5	10,5	
		17-25	B6	1,87	5,41	25,5	25,5	185,64

		26-50	A5	1,78	2,7	25,5	25,5	185,64
2	MCCB	25A	D10	0,26	0,19	40,5	40,5	96,52
			A11			43,5	43,5	
			B12			43,5	43,5	
			C12			43,5	43,5	
			D11			43,5	43,5	
		35A	C10	0,37	0,35	37,5	37,5	141,48
			D9			37,5	37,5	
			A10			40,5	40,5	
			B11			40,5	40,5	
			C11			40,5	40,5	
		63A	C9	0,61	0,25	34,5	34,5	123,84
			D8			34,5	34,5	
			A9			37,5	37,5	
			B10			37,5	37,5	
3	Kwh Meter	5-40	D3	1,92	8,03	19,5	19,5	1089,52
			A4			22,5	22,5	
			B5			22,5	22,5	
			C5			22,5	22,5	
			D4			22,5	22,5	
		41-60	A1	7,44	6,34	13,5	13,5	2459,73
			B2			13,5	13,5	
			C2			13,5	13,5	
			D1			13,5	13,5	
			A2			16,5	16,5	
			B3			16,5	16,5	
			C3			16,5	16,5	
			D2			16,5	16,5	
			A3			19,5	19,5	
			B4			19,5	19,5	
			C4			19,5	19,5	
		61-80	C6	0,60	0,59	25,5	25,5	428,4
			D5			25,5	25,5	
			A6			28,5	28,5	
			B7			28,5	28,5	
			C7			28,5	28,5	
			D6			28,5	28,5	
			A7			31,5	31,5	
			B8			31,5	31,5	
			C8			31,5	31,5	
			D7			31,5	31,5	
			A8			34,5	34,5	
			B9			34,5	34,5	
Total Distance								5218,98

Table 16: Proposed Distance 2

No	Product Name	Electric Current Capacity	Block	T/S Receipt	T/S Send	DI	DO	Distance
1	MCB	2-16	B1	7.4	16.8	10.5	10.5	508.2
			C1			10.5	10.5	
		17-25	D1	1.87	5.41	13.5	13.5	52.01
		26-50	A1	1.78	2.7	13.5	13.5	85.50
2	MCCB	25A	A11	0.26	0.19	43.5	43.5	96.52
			B12			43.5	43.5	
			C11			40.5	40.5	
			D11			43.5	43.5	
			C12			43.5	43.5	
		35A	A10	0.37	0.35	40.5	40.5	141.48
			B10			37.5	37.5	
			C10			37.5	37.5	
			D10			40.5	40.5	
			B11			40.5	40.5	
		63A	A9	0.61	0.25	37.5	37.5	123.84
			B9			34.5	34.5	

			C9			34.5	34.5	
			D9			37.5	37.5	
3	Kwh Meter	5-40	D4	1.92	8.03	19.5	22.5	1143.46
			A5			22.5	22.5	
			B5			22.5	22.5	
			C5			22.5	22.5	
			D5			25.5	25.5	
		41-60	A2	7.44	6.64	16.5	16.5	2625.09
			B2			13.5	13.5	
			C2			13.5	13.5	
			D2			16.5	16.5	
			A3			16.5	16.5	
			B3			16.5	16.5	
			C3			16.5	16.5	
			D3			19.5	19.5	
			A4			22.5	22.5	
			B4			19.5	19.5	
			C4			19.5	19.5	
		61-80	A6	0.6	0.59	28.5	28.5	428.4
			B6			25.5	25.5	
			C6			25.5	25.5	
			D6			28.5	28.5	
			A7			31.5	31.5	
			B7			28.5	28.5	
			C7			28.5	28.5	
			D7			31.5	31.5	
			A8			34.5	34.5	
			B8			31.5	31.5	
			C8			31.5	31.5	
			D8			34.5	34.5	
Total Distance								5204,5

After obtaining the total mileage of the two proposals, the following calculation is carried out to calculate the percentage decrease in the existing layout's mileage to the proposed layout's mileage using the following formula.

Decrease of proposal

$$= \frac{total\ existing\ distance - total\ proposed\ distance}{total\ existing\ distance}\ x\ 100\% \quad (3.1)$$

The total distance traveled for layout proposal 1 is 5218.98 m, which has decreased by 72.71% from the entire distance of the existing layout. In proposal 2, the total distance traveled is 5204.5 m, reduced by 72.78% from the total distance of the current layout.

Providing two alternatives aims to reduce the risks associated with each option, including financial, operational, and security risks. In addition, having multiple options allows for identifying solutions that fit within constraints, such as limited budgets and resources. It allows for switching to another solution if conditions change or the initial solution does not work.

In the proposed layout 1, the placement of goods with the largest T / S will be placed in the block / blocks with the smallest distance without regard to the type of goods. So that in the optimum layout there are still many shortcomings. Therefore, adjustments are made, namely moving the location of products so that similar products are not far apart but do not violate the rules of priority scale ranking.

Grouping types of goods in the implementation of the FIFO system in the warehouse can provide great benefits, but these challenges need to be overcome with good planning, proper training, and careful monitoring so that the system can run efficiently and in accordance with the desired objectives. This is another reason for the selection of the proposed layout 2 in addition to considering the distance of goods.

4. Conclusion

The conclusions obtained from the research conducted are as follows:

- The warehouse layout design significantly impacts warehouse activities. Difficulties locating items, time-consuming search processes, and inability to implement FIFO are attributed to factors like man, tools, method, material, and environment. Causes of operator struggles include employee carelessness, limited access, mixing of item types within pallets, a high number of item variants, inconsistent storage locations, lack of layout coding, and suboptimal pallet capacity utilization. Reasons for FIFO implementation challenges involve operator behavior, limited access to stacked pallets, insufficient forklift pathways, and a lack of storage equipment supporting FIFO.

- The proposed improvements made in this research are using the class-based dedicated storage method with rectilinear distance calculations.
- There are two proposed for improvement given. However, the second proposal demonstrates a 72.78% reduction in total travel distance compared to the existing layout, meeting optimal conditions. Unfortunately, the requirement for placing similar products nearby is not fully achieved due to the condition of the company that is not fully prepared in this regard. A Standard Operating Procedure (SOP) based on FIFO is recommended, along with using racks to support FIFO implementation. In conclusion, proposal two is the preferred layout for improving Warehouse Kalus 1.6 at PT XYZ.

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