Redesigning Warehouse Layout PT XYZ Using Class-Based and CRAFT Methods

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ABSTRACT

PT XYZ has a warehouse that serves as a Temporary Storage Area (TPS) for imported and exported goods. Currently, the import area of the warehouse has a rack capacity of 2,940 pallet positions, consisting of 14 single-deep racks and 24 double-deep racks. However, the number of goods received and stored is only 867 pallets. The random placement system of imported goods complicates the consignee's retrieval process during system failures. The utilization of racks in the import warehouse is suboptimal due to the significant unoccupied space that lacks pallets. At the same time, there is a necessity for additional specialized areas to accommodate large-dimensional goods. This study utilizes the class-based storage policy to categorize goods based on their characteristics using the CRAFT (Computerized Relative Allocation of Facilities Techniques) method, one of the methods for obtaining a warehouse layout that matches the needs and dimensions available. This research results in the classification of three main classes: Class A represents 77% of consignees with over 4 pallets, while Class B and C account for 15% and 8%, respectively, with a total requirement of 867 pallets. After rearranging the rack layout in the warehouse using the CRAFT method, the space utilization reaches 67.53%, which is not far from the initial condition. Meanwhile, rack utilization increases to 93.83% from the initial 31.45%, resulting in a new area to accommodate large-sized goods and business expansion, totaling 505.44 m², or approximately 9.5% of the total imported goods area.

ARTICLE INFO

1. Introduction

A warehouse is a facility typically owned by an organization or company that serves as a storage location for goods. Providing better and more responsive services to meet customer needs is the primary reason organizations build and operate warehouses. The main function of a warehouse is to serve as a temporary storage facility (Indriyani, 2020). Additionally, warehouses also function to protect goods from hazards and external influences that could cause damage to the goods. Layout design is a crucial decision in determining the long-term efficiency and effectiveness of operations (Heragu, 2016). Warehouse layout is a design aimed at minimizing total costs while maximizing the utilization of space, placement processes, and material handling methods. A well-designed layout is essential, given that material handling costs account for 20% to 50% of the total operational budget of manufacturing companies (Stephens & Meyers, 2013). In the construction of new warehouses, layout planning is essential to reduce relocation costs, material handling, time efficiency, and the accuracy of item placement. Even large manufacturing companies change department layouts every 2 or 3 years (Matai et al., 2010). Warehouses with high activity levels, where goods enter and exit in large quantities daily, undoubtedly require adequate procedures and facilities, making the role of the warehouse crucial. Therefore, a good warehouse must have an appropriate layout.

PT XYZ is a company engaged in the Logistics and Hinterland Development business cluster. PT XYZ operates branch offices and operations, one of which is in the Tanjung Priok Port Area, North Jakarta. The bustling port activity, where numerous items are brought in and brought out daily, necessitates a special location for temporary storage, given that the terminal cannot hold all the containers entering and leaving the port. One of the facilities owned by PT XYZ is the Cargo Distribution Center (CDC) Warehouse located in the Port Area. PT XYZ's CDC Warehouse is used as a Temporary Storage Place (TPS) for imported and exported goods before they are delivered to the consignee (goods owner). The goods handled at PT XYZ's CDC Warehouse are LCL (Less Container Load) goods, meaning that within one container, there are multiple consignees and several loading and unloading companies (PBM).

The warehouse of PT XYZ in the import goods area experiences a higher level of activity compared to the export goods area, with the highest Sheed Occupancy Ratio (SOR) or warehouse utilization rate recorded on July 6, 2022, at 43.59%. Currently, the storage policy used in all storage areas is Randomized Storage, where goods are stored randomly in the warehouse without grouping based on consignee, type, function, or the time when the goods are needed. The CDC Warehouse also supported by a Warehouse Management System (WMS), allowing for accurate and real-time tracking of the quantity and location of goods. The implementation of WMS technology in this warehouse is not without challenges, including human error, such as forklift operators failing to scan goods or racks, and Wi-Fi signal issues, which can lead to data input failures. These problems are exacerbated by the random placement of goods, making it difficult to locate them when the Shipping Agent takes the goods, especially when the goods belong to a single consignee. This situation is further complicated if the goods are spread out in distant locations, leading to increased costs and time for retrieving the goods.

There is a gap between the actual field conditions and the ideal situation for accommodating all goods on the racks and floor areas in the Warehouse. The placement of goods between the racks and the floor is unbalanced, resulting in many empty racks while the floor area experiences an excess of capacity just like in Figure 1 and Figure 2. This impacts material handling movements and the time required for retrieving goods. Due to these issues, there is a need for a redesign of the import warehouse layout that is more organized and efficient. This redesign aims to minimize the distance for material handling transfers, simplify the search for goods in case of system errors, and create additional space for oversized goods.

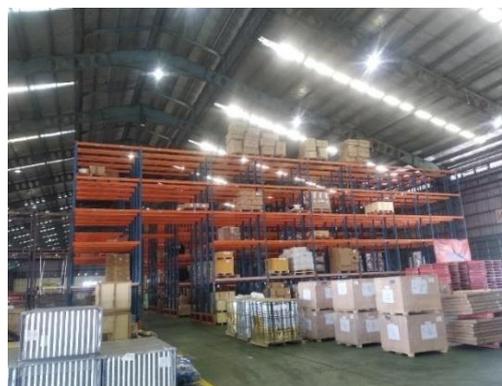**Figure 1.**   Piling of goods in the aisle and floor areas

Figure 2.   Example of empty shelf location points

Considering these problems, it is thought necessary to reorganize the import warehouse's layout in a more systematic and effective way to reduce material handling distances, make it easier to find items in the event of system mistakes, and set aside extra room for big items. Layout becomes a crucial decision in determining the long-term efficiency and effectiveness of an operation (Stephens & Meyers, 2013). Warehouse layout is a design aimed at minimizing total costs through the efficient use of space, placement processes, and material handling methods. A good layout is highly essential, considering that material handling costs contribute to 20%-50% of the total operational budget in manufacturing companies (Nyemba et al., 2020). In the construction of a new warehouse, layout planning is necessary to reduce relocation costs, material handling, time efficiency, and the accuracy of item placement. Even large manufacturing companies change department layouts every 2 or 3 years (Stephens & Meyers, 2013). A high-activity warehouse where goods enter and exit in large quantities daily certainly requires adequate procedures and facilities, making the role of the warehouse highly important. Therefore, a good warehouse must have the right layout.

While maintaining the current layout conditions, the author will consider the utilization of empty pallet areas and export areas (if necessary) and maximize the use of racks in the regular import goods storage area. In this study, the Class-Based Storage and CRAFT methods are used to find the optimal area layout to streamline the storage process by maximizing rack utilization in the warehouse. The Class-Based Storage method is chosen for its advantages in storage efficiency, ease of retrieval, and order fulfillment because goods with similar characteristics are placed in the same class. Meanwhile, the CRAFT method aims to minimize material handling costs such as distance flow, product, and transportation unit costs. Compared to BLOCKPLAN or PFAST methods, the CRAFT method focuses on a systematic approach that aids in determining a structured factory layout, making it easier to facilitate layout changes and ensure the future use of the new layout is more efficient (Irani et al., 2000).

In previous research (Nur & Maarif, 2018), the proposed design of the warehouse layout was discussed using the Class-Based Storage method and CRAFT to fullfill the need for accurate item retrieval, followed arranging the layout of finished goods in the warehouse to obtain additional allocation for storage allowance area. This research focuses on permanent storage for finished goods products from a supplier. Meanwhile, in this current research, the use of the Class-Based Storage method and CRAFT is employed to group types of goods based on the pallet quantity owned by many consignees and to find the optimal area size to streamline the storage process by maximizing rack utilization in the temporary storage area warehouse. This study is limited to the import warehouse of PT XyZ, specifically focusing on the storage area for regular imported goods. The research solely concentrates on imported goods arriving, being stored, and leaving on the day when the warehouse has its highest SOR (Stock Out Ratio) value, which is on July 6, 2022.

2. Literature Review

2.1 Warehouse Layout

According to (Warman, 2004), a warehouse is a building used for storing merchandise. In general, the purpose and function of warehousing are to maximize the utilization of available resources. Warehouse resources and warehousing encompass equipment, space, and personnel (Indriyani, 2020). Warehouse layout is a design aimed at minimizing the total cost by seeking the best guidance between space utilization and goods handling (Stephens & Meyers, 2013). Warehouse design should consider the speed of goods movement. Fast-moving items are better placed near the point of retrieval, reducing repetitive back-and-forth movements. In general, the objectives of goods storage methods are maximizing the utilization of building utilities, maximizing goods maintenance, maintaining a neat and organized warehouse appearance. A good warehouse layout involves utilizing available space effectively and efficiently to minimize total storage and material handling costs. Factors to consider in warehouse design include building height, aisle shape and size, warehouse location and orientation, as well as the type of racks used for storage. Additionally, docking areas and the level of automation involved in storage and retrieval should also be considered (Heragu, 2016).

2.2 Storage of Goods

Two techniques for storing goods in a warehouse are item layout and racking system (Mecalux, 2021). The arrangement of goods in a warehouse, commonly referred to as item layout, is a method of placing items to facilitate

retrieval, accelerate, and enhance the warehouse's efficiency in storing and fulfilling requests for items from those in need. These parties can be divided into two groups: inbound and outbound from the warehouse. Inbound parties are those who request items and are within the company, such as other departments within the company. On the other hand, Outbound Warehouse refers to external parties, such as customers or demand-side entities outside the company. Racking system is a method for increasing capacity without the need to expand the warehouse by stacking goods at specific points. Additionally, it can also be used to categorize goods, making the warehouse appear more organized without requiring additional space.

2.3 Item Layout

When planning the layout of goods in a warehouse, it is important to consider several key aspects such as effective control systems and a well-structured speed measurement system. The speed measurement system categorizes goods based on their flow speed, dividing them into three types: fast-moving, medium-moving, and slow-moving items. Effective inventory control can be implemented based on these three flow categories (Warman, 2004). For fast-moving items, they should be placed in accessible areas to facilitate easy retrieval. Medium-moving items fall between fast and slow-moving categories. Slow-moving items are typically positioned in the back of the warehouse, which may be less accessible, as they have a lower frequency of entry and exit or infrequent inventory turnover. By organizing goods based on their flow speed, it is expected that inventory control during retrieval will be more straightforward, leading to increased warehouse efficiency.

2.4 Warehouse Storage Methods

Several methods are used to organize the storage location of goods, such as Dedicated Storage Method, Randomized Storage Method, Class-Based Storage Method, and Shared Storage Method (Apak et al., 2016). Different warehousing methods serve varying purposes based on their utilization and requirements. The Dedicated Storage Method designates specific storage locations for each product, ensuring precise inventory control and easy retrieval but may not be space efficient. Randomized Storage Method places items in available space without fixed locations, offering flexibility for businesses with dynamic inventories but potentially leading to less organized storage. Class-Based Storage Method groups similar items based on characteristics, streamlining material handling for efficient storage and retrieval (Apak et al., 2016). Lastly, Shared Storage Method allows multiple products to occupy the same locations, making it suitable for businesses with diverse inventories, although efficient management may require advanced slotting algorithms (Apak et al., 2016). The choice of method hinges on factors like product nature, turnover rate, available space, and business needs, often involving a combination of these methods to optimize overall warehouse efficiency.

2.4.1 Class-Based Storage Method

This method is a combination of randomized storage and dedicated storage methods. It divides the existing goods into three, four, or five classes based on the throughput (T) and storage ratio (S) comparisons. This approach makes the arrangement of the storage area more flexible by dividing it into several sections. Each section can be randomly filled with various types of goods that have been classified based on their type and size. The items that are needed most frequently are categorized as Class A and placed closest to the I/O Point, while Class B and Class C are in more distant areas (Apak et al., 2016).

2.4.2 CRAFT (Computerized Relative Allocation Facilities Technique)

CRAFT is a heuristic technique-based program that relies on the interpretation of "Quadratic Assignment" in the layout design process, with the fundamental criterion of minimizing material handling costs. These costs are represented as a function of the distance traveled (Purnomo, 2004). The CRAFT method involves exchanging the positions of activity locations in the initial layout with the aim of finding a better solution based on material flow. Subsequent exchanges lead toward a layout that approaches the minimum material handling cost. CRAFT is an improvement program that seeks an optimal design through gradual layout improvements (Hadiguna & Setiawan, 2008). It evaluates the layout by exchanging the locations of each department.

CRAFT can accommodate irregularly shaped or non-rectangular departments placed anywhere as desired. To use the CRAFT method, input in the form of material handling costs is required. This input typically consists of the cost per unit per distance traveled (material handling cost per unit distance/OMH per unit distance). The application

of the CRAFT method in the data processing phase entails a systematic and algorithm-based approach to determine the optimal layout configuration. This process incorporates advanced analysis and evaluation techniques, harnessing the power of computer algorithms to streamline the redesign of the warehouse layout. The critical data for this endeavor is derived from the meticulous calculations and meticulous arrangement of Class-Based categories.

2.5 Previous research

The current research builds upon the methodologies and objectives of previous studies conducted by Juliana and Handayani (2016), Chan and Chan (2011), Alfarokhi (2018), Johan and Suhada (2018), and Karonsih et al. (2013) in the field of warehouse optimization. Juliana and Handayani (2016) focused on minimizing travel distance by improving product storage layout using class-based storage and CRAFT method, which aligns with the objective of the current research. Similarly, Felix (2011) aimed to minimize distance and time in storage layout research, a goal shared with the current study. Alfarokhi (2018) utilized a class-based storage policy to optimize warehouse storage location and travel distance, which resonates with the objective of maximizing rack utilization in the temporary storage area pursued in the current research. Johan and Suhada (2018) and Karonsih et al. (2013) both applied the class-based method to address objectives related to distance and layout optimization, with Johan Suhada (2018) focused on layout efficiency and Karonsih et al. (2013) incorporated CRAFT application, providing a foundation for the current study's approach. Therefore, the current research draws upon and extends the methodologies by Integrating Class-Based Storage and CRAFT. The objectives of these studies are to optimize storage processes in the context of import warehouses.

3. Methodology

This study falls under applied research or a case study that applies specific concepts, methods, and techniques to analyze and improve an existing warehouse layout or develop new solutions. The object of this research is the CDC Warehouse of PT XYZ located in the Tanjung Priok Port Area, North Jakarta. Figure 3 shows the workflow of this research.
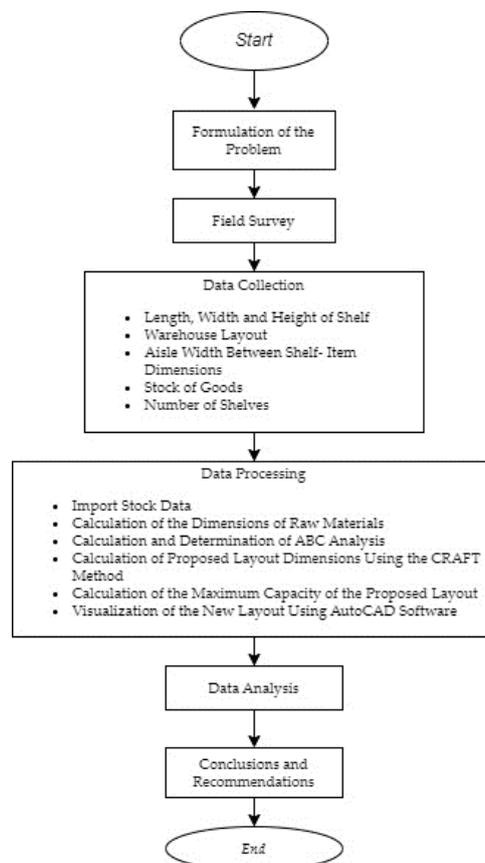

Figure 3.   Flow Diagram

During the problem formulation phase, the study identifies and encapsulates key issues and challenges relevant to the selected topic, guiding subsequent research and analysis. This serves as the starting point for focused research, ultimately contributing valuable insights and solutions. In the preliminary survey phase, fieldwork surveys are conducted to gain firsthand insights into the company's current condition and business processes, facilitating the identification of challenges. Data collection involves gathering primary data through direct observations at the PT XYZ CDC warehouse and secondary data with consent to access historical data. Data processing is guided by the supervising institution and logistics engineering program faculty, leading to research findings and recommendations for the company, further analyzed in the results analysis phase. This comprehensive examination includes solutions derived from data categorization, employing both quantitative and qualitative analysis methods to generate feasible solutions with a potential positive impact on the company's challenges. The conclusion and recommendations stage concludes the study research, drawing conclusions and offering improvement recommendations based on data processing considerations.

4. Results

This section marks a pivotal juncture in the research, where we embark on the journey of data processing, calculations, and in-depth analysis. The data processing phase commences with a comprehensive ABC classification analysis, which serves as the foundational pillar for shaping the subsequent warehouse layout. The results derived from this classification analysis will not only guide the layout design but also play a pivotal role in optimizing storage efficiency and logistics operations. Following the ABC classification analysis, a meticulous examination and analysis will ensue, scrutinizing both the existing warehouse layout and the proposed layout. This comparison will be rooted in two key metrics: space utilization and rack usage. These critical aspects of warehouse management will be assessed and evaluated to gauge the tangible impact of the proposed layout changes.

It is important to underscore that the dataset under scrutiny comprises a total of 867 pallets. These pallets originate from a diverse spectrum of 181 different consignees, rendering the dataset both extensive and representative. The utilization of this extensive dataset ensures that the research findings and subsequent recommendations are founded on a robust and comprehensive understanding of PT XYZ's warehouse operations. As we delve deeper into the analysis, the goal is to unlock insights that will empower PT XYZ to enhance its warehousing efficiency and operational excellence.

4.1 Class-Based Calculation Results

The classification of goods is a pivotal aspect of this research, and it revolves around a comprehensive assessment of the pallet ownership held by each consignee. To establish these class criteria, an exhaustive exploration of the number of pallets allocated to each consignee was conducted, driven by insightful interviews and interactions with key stakeholders deeply entrenched within PT XYZ's warehouse ecosystem. The resulting class criteria represent a meticulously calibrated framework intricately designed to align with the nuanced storage requirements and preferences of each consignee. These criteria have not materialized in isolation but have evolved through collaborative dialogues and deliberations with the warehouse coordinator. This dynamic exchange of insights and expertise has further refined the class criteria, rendering them a robust reflection of PT XYZ's warehousing realities.

- Class A includes consignees with more than 4 pallets.
- Class B includes consignees with 2 to 3 pallets.
- Class C includes consignees with only 1 pallet.

The percentage for each class category is determined using the maximum percentage reference from Pareto law requirements while considering the storage and retrieval (S/R) level in the warehouse (Hadiguna & Setiawan, 2008).

- 75% < Total percentage frequency of Class A < 80% of the overall total pallets
- 10% < Total percentage frequency of Class B < 15% of the overall total pallets
- 5% < Total percentage frequency of Class C < 10% of the overall total pallets

The determination of percentage frequency for items in each category is derived through a precise mathematical computation. This involves dividing the total number of pallets within each category – Class A, comprising 667 pallets; Class B, encompassing 129 pallets; and Class C, accounting for 71 pallets – by the overall quantity of pallets received throughout the observation period, which precisely amounts to 867 pallets. The detailed breakdown and calculation for the pallet count within each category shed light on the meticulous process involved in this classification are shown in Equation (1), (2), and (3).

$$\text{Total percentage of Class A pallets} = \frac{667}{867} \times 100\% \qquad (1)$$
$$= 76.93\%$$
$$\text{Total percentage of Class B pallets} = \frac{129}{867} \times 100\% \qquad (2)$$
$$= 14.88\%$$
$$\text{Total percentage of Class C pallets} = \frac{71}{867} \times 100\% \qquad (3)$$
$$= 8.19\%$$

Table 1 shows the summary of the ABC classification calculation results for each class in accordance with the grouping criteria for each class and the Pareto principle.

Table 1. ABC classification results.

Class	Information	Amount Number of Pallets	Percentage
Class A	Consignees with more than 4 pallets	667 pallets	77%
Class B	Consignees with 2 to 3 pallets	129 pallets	15%
Class C	Consignees with only 1 pallet.	71 pallets	8%

4.2 Layout Design Results using CRAFT

The CRAFT method initiates a meticulous processing procedure aimed at deriving the layout dimensions and spatial configuration. This method harnesses the power of computer algorithms coupled with sophisticated analysis and evaluation techniques to achieve the pinnacle of efficiency in the warehouse layout redesign. The fundamental bedrock of this process lies in the data garnered from the Class-Based classification and intricate calculations. Within the ambit of this method, the proposed Warehouse's dimensions are meticulously ascertained for each class. In this particular study, Class A accommodates 55 consignees or departments, Class B encompasses 55, and Class C comprises 71. To optimize storage capacity, each rack features six tiers, with a capacity of accommodating two pallets per tier. These pallets are of standardized dimensions, measuring 1.1 meters by 1.2 meters. The layout design outcomes for each class, considering the pre-existing conditions within PT XYZ's CDC Warehouse, are presented below. These results reflect a harmonious blend of data-driven insights and the imperatives of practical warehouse management, poised to enhance the efficiency and functionality of the warehouse environment.

4.2.1 Class A

Table 2 providing information dimensions of Class A facilities along with the layout results based on the proximity between departments from the analysis and output of the CRAFT method. The initial stage of this method involves entering the quantity of data objects observed in Class A, which consists of 55 consignees with distinct Bill of Lading (B/L) numbers, or in the CRAFT method, referred to as departments.

Table 2. Information about Class A Facilities

Scale-m/unit	1	Cells
Length-m	16	16
Width-m	21	21
Area-sq.m	336	336

Table 2 contains data that the researcher needs to input regarding the length and width of the warehouse layout plan. This data is obtained through iterations, which consider various factors and the actual warehouse dimensions as constraints. After determining the required area and the data regarding the area needs of each Class A consignee, the next step is to design the warehouse layout for Class A using CRAFT with the assistance of Excel software. Figure 4 shows an overview of the layout for Class A consignees after processing the data using the CRAFT method.
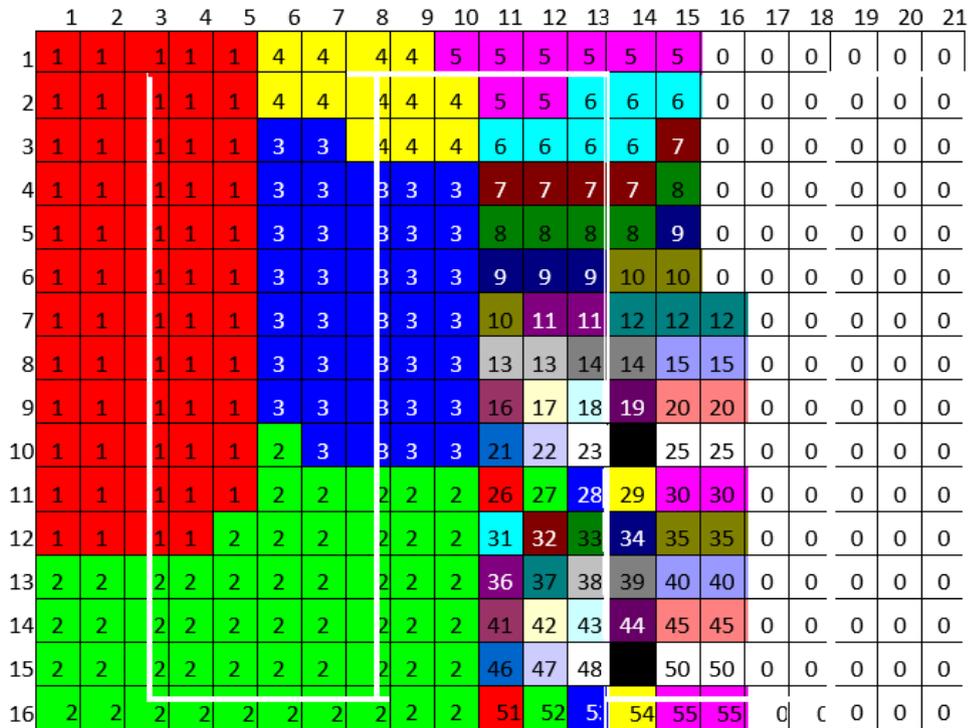
Figure 4. The Layout Results of the CRAFT Method for Class A

4.2.2 Class B

Table 3 providing information on the dimensions of Class B facilities along with the layout results based on the proximity between departments from the analysis and output of the CRAFT method. The initial stage of this method involves entering the quantity of data objects observed in Class B, which consists of 55 consignees or, in the CRAFT method, referred to as departments.

Table 3. Information about Class B Facilities

Scale-m/unit	1	Cells
Length-m	11	11
Width-m	12	12
Area-sq.m	132	132

Table 3 contains data that the researcher needs to input regarding the length and width of the warehouse layout plan. Subsequent to that, the CRAFT method was utilized to generate the layout for the Class B consignees. Figure 5 shows the layout overview for Class B consignees after processing the data using the CRAFT method.
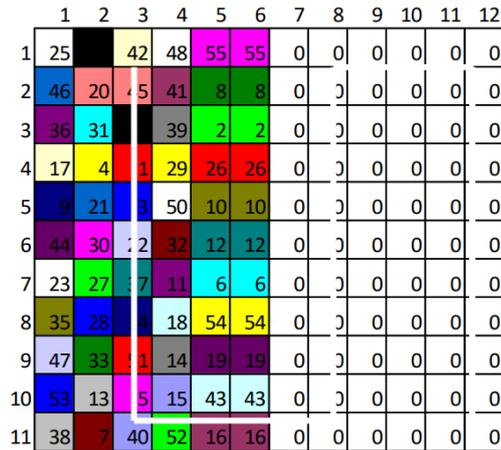
Figure 5. The Layout Results of the CRAFT Method for Class B

4.2.3 Class C

Table 4 presents critical information on the dimensions of Class C facilities and the layout results derived from the CRAFT method analysis and output regarding department closeness. These results are rooted in an analysis considering the spatial proximity between 55 consignees or departments within Class C.

Table 4. Information about Class A Facilities

Scale-m/unit	1	Cells
Length-m	15	15
Width-m	10	10
Area-sq.m	150	150

Table 4 contains data that the researcher needs to input regarding the length and width of the warehouse layout plan. Subsequently, the layout for Class C cosignees was created using the CRAFT method. Figure 6 shows an overview of the layout for Class C consignees after processing the data using the CRAFT method.
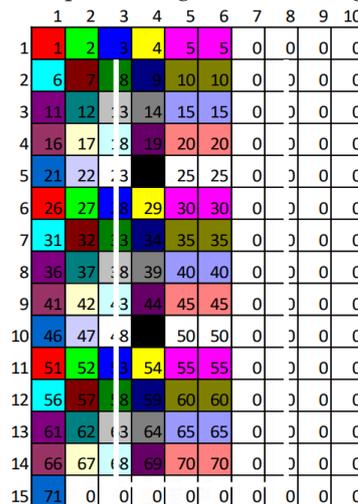

Figure 6. The Layout Results of the CRAFT Method for Class C

4.3 The Calculation of the Total Shelf Requirement for the Import Warehouse Area

The calculation serves the purpose of establishing the overall shelving requirements for accommodating various designated areas. It involves a detailed assessment to ascertain the placement and total space allocation for each class. The percentages allocated to each class are derived from the total pallet count within their respective categories. Specifically, Class A constitutes 77%, Class B accounts for 15%, and Class C comprises 8% of the total pallet count. Consequently, the total shelving capacity amounts to 1056 pallets, distributed across the different classes in the following manner, shown in Table 5.

Table 5. Shelf Requirement Calculation

Class	Percentage	Space	Shelf Requirement
A	77%	812	12.3 single deep rack
B	15%	157	2.4 single deep rack
C	8%	86	1.3 single deep rack

A dynamic visualization for the innovative layout of PT XYZ's Import CDC warehouse is created by utilizing determined shelf requirements and insights that were gained from the data processing using the CRAFT methodology. This visualization captures not only summarize planning and area allocation, but also the essence of efficiency and operational optimization, which are essential to the main goals of this redesign effort, in addition to careful planning and strategic spatial allocation.

4.4 Comparison of Existing and Proposed Layouts

Upon completion of conducting thorough calculations with the utilization of the CRAFT Method, it is determined that 42 meters by 42 meters area is required to store imported goods using racks, including the required aisle spaces. This comprehensive analysis has provided a clear perspective on the spatial requirements for the efficient warehousing of goods. To offer a more lucid depiction, let's delve into a comparative analysis between the existing configuration of PT XYZ's CDC Warehouse and the proposed layout, which has been meticulously redesigned for enhanced efficiency. Illustrating this comparison, Figure 7 shows below offer a visual representation of the initial warehouse layout, providing a point of reference for the subsequent layout transformation discussions.
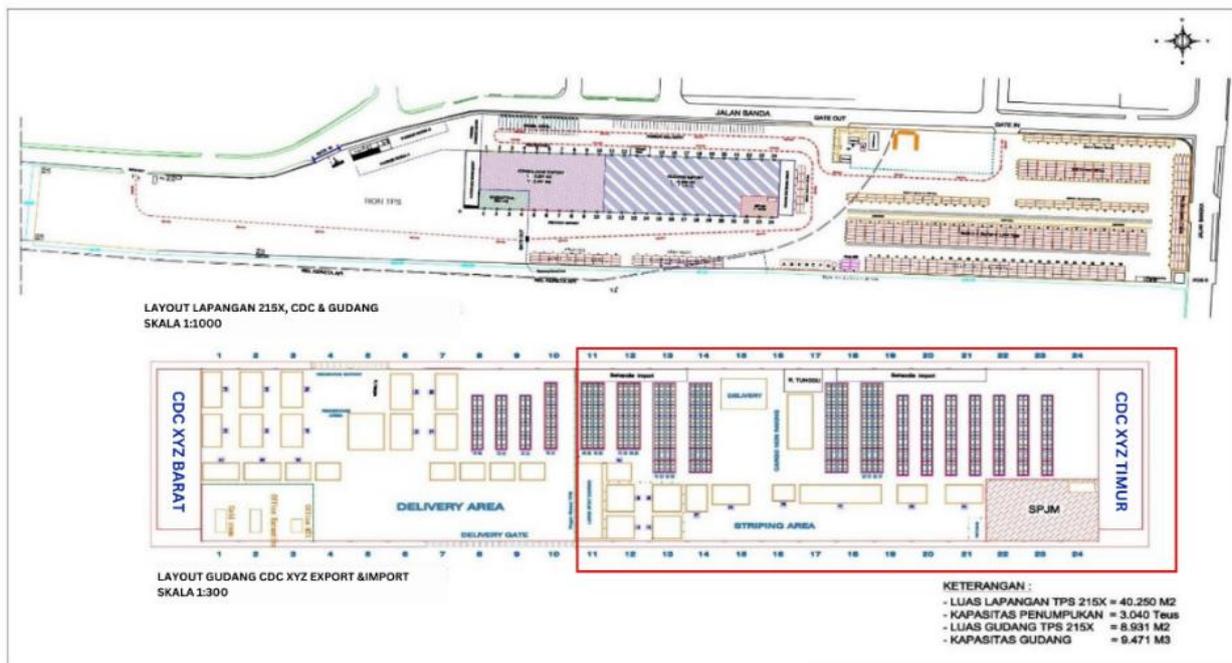

Figure 7. Overview of the initial layout of the Import CDC warehouse

The warehouse layout of Import CDC Banda PT XYZ underwent a comprehensive redesign, incorporating the principles of ABC categorization and the CRAFT method, resulting in a novel plan aimed at addressing the challenges highlighted throughout this study. The culmination of these efforts is showcased in the top view presented in Figure 8 shows a comprehensive visual representation of the revised layout. Meanwhile, Figure 9 shows the intricacies of the rack arrangement from a frontal perspective, providing valuable insights into the organization of goods within the warehouse. To further complete the point of view, Figure 10 provides a side view of the racks, thoughtfully annotated to depict the interconnecting aisles and their role in facilitating efficient material handling and storage.
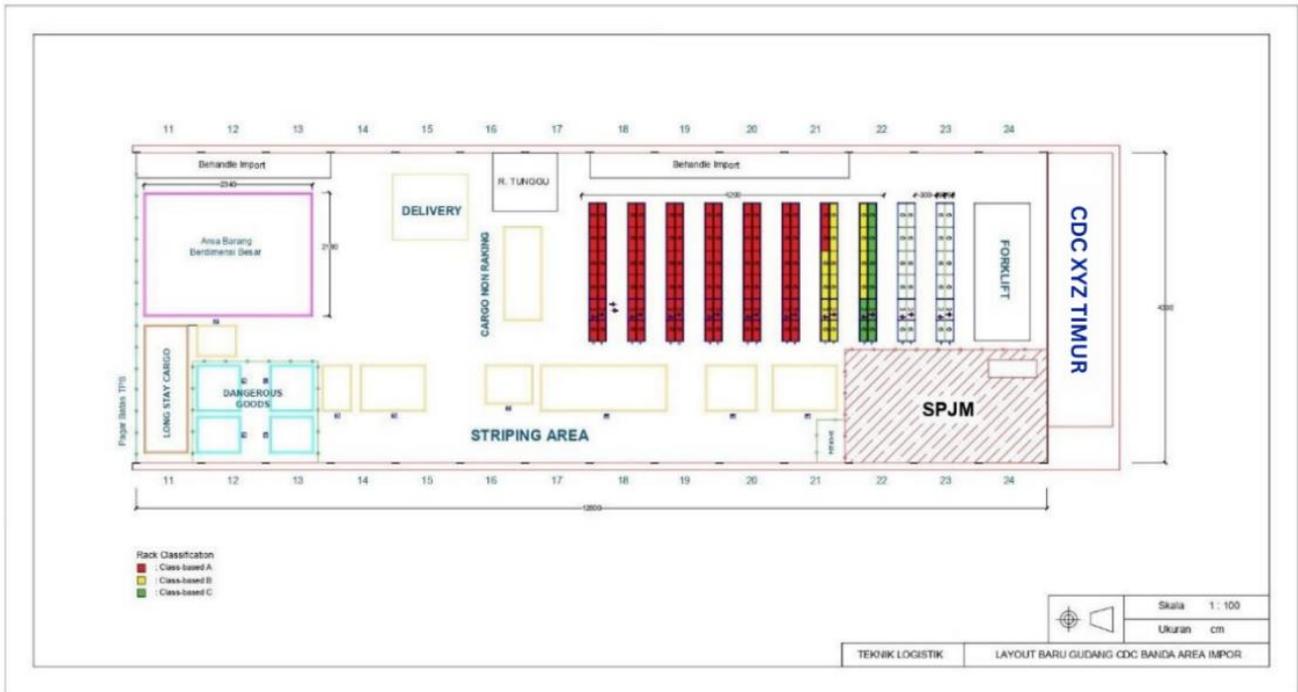

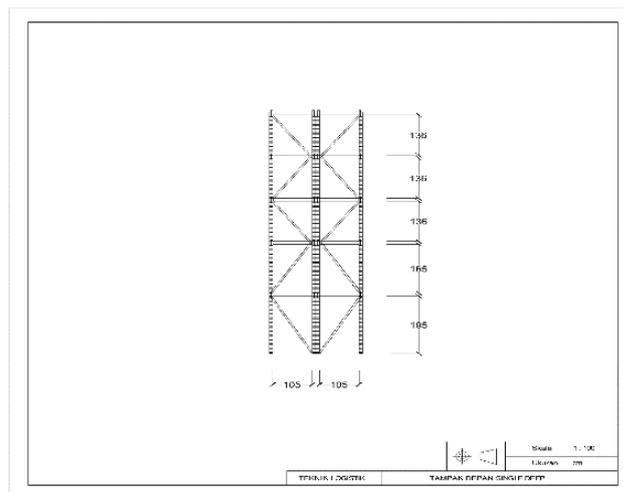**Figure 8.**   Overview of the proposed layout of the Import CDC warehouse

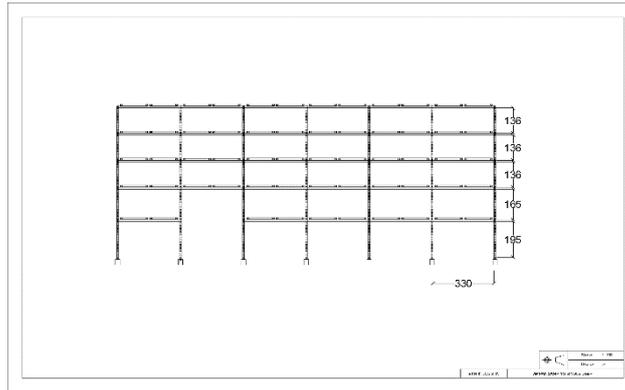**Figure 9.**   Overview the proposed racking system front view of the Import CDC warehouse.

Figure 10.   Overview the proposed racking system side view of the Import CDC warehouse.

4.4.1 Initial Layout Utility Calculations

Calculations were carried out to determine the total area and racks that can be accommodated in the CDC Banda import warehouse under the current conditions. The import warehouse area measured 123 meters by 43 meters. The import warehouse area is capable of accommodating 2,940 pallets. Thus, there are 2,073 spaces for empty pallets in a total block area of 3,638.88 m^3 after subtracting the existing 867 pallets. The import warehouse area and total block area accommodate a total of 14 single-deep racks and 24 double-deep racks.

Space Utility	= (Total block area / Space area) x 100%
	= (3.638,88 / 5.375) x 100%
	= 67,70%
Rack Utility	= (Total area used / Total area of rack) x 100%
	= (1.144,44 m^2 / 3.638,88 m^2) x 100%
	= 31,45%
Residual Utility	= 100% - Rack utility
	= 100% - 31,45%
	= 68,55%

4.4.2 Proposed Layout Utility Calculations

Extensive calculations were meticulously conducted to ascertain the comprehensive spatial and storage requirements for PT XYZ's latest CDC Banda import warehouse, leveraging the most recent receiving data as of July 6, 2022. Through rigorous analysis, it was discerned that the newly designed warehouse dimensions, calibrated to efficiently accommodate 867 pallets following the rigorous CRAFT methodology, span an impressive expanse of 42 meters by 43 meters. This spatial configuration results in a warehouse space encompassing 1,806 m^2, uniquely equipped to house a total of 924 pallet spaces, thoughtfully complemented by 57 spaces exclusively designated for empty pallets. The cumulative spatial allocation translates into a remarkable total block area, spanning an expansive 1219.68 m^2. This comprehensive spatial analysis underscores the meticulous planning and strategic spatial utilization that underpin the redesigned layout, ensuring optimal efficiency in PT XYZ's import warehousing operations.

Space Utility	= (Total block area / Space area) x 100%
	= (1.219,68 / 1.806) x 100%
	= 67,53%
Rack Utility	= (Total area used / Total area of rack) x 100%
	= (1.144,44 m^2 / 1,21968 m^2) x 100%
	= 93,83%
Residual Utility	= 100% - Rack utility
	= 100% - 93.83%
	= 6,16%

5. Discussions

The current layout, characterized by randomized storage, leads to extended material handling distances, and complicates the retrieval process, especially during system failures. In contrast, the proposed layout utilizes the Class-Based Storage and CRAFT (Computerized Relative Allocation of Facilities Techniques) method to effectively minimize these distances. This strategic reorganization not only simplifies the retrieval process by grouping similar items together but also enhances overall operational efficiency. The introduction of Class-Based Storage in the proposed layout also aids in minimizing system errors and simplifies the search process. Goods are grouped by similar characteristics, making them easier to locate.

The existing condition of PT XYZ's CDC Warehouse reveals that it possesses a rack capacity capable of accommodating 2,940 pallets, and the current room utilization rate stands at approximately 67.70%. However, it's crucial to note that only 867 pallets are received and stored within this space, leaving a substantial 2,073 pallets unused. In simpler terms, a mere 31.45% of the total existing rack capacity is being used. This situation underscores the inefficiency in the utilization of available resources and the underperformance of the warehouse's capacity. Upon conducting meticulous calculations using the CRAFT method, it was established that the necessary number of racks to adequately store all 924 pallet-sized goods would result in a rack utilization rate of 93.83%. While this represents a significant improvement in the rack utilization aspect, the overall room utilization, which stands at approximately 67.575%, remains relatively unchanged when compared to the initial layout configuration. This outcome arises from the fact that the proposed layout design primarily focuses on optimizing rack utilization without altering the physical floor area of PT XYZ's CDC Import Warehouse. Instead, it strategically adjusts the utilization of the existing racks. This analysis underscores the potential for PT XYZ to substantially enhance its warehouse efficiency by optimizing rack usage, effectively reducing the substantial underutilization observed in the initial setup. Such improvements not only enable the company to better utilize its existing resources but also potentially open avenues for accommodating increased inventory or diversifying its storage capabilities to meet future business demands.

Based on the proposal, the double-deep racks on the right and left of the delivery points will be removed. However, the double-deep racks on the right side of the delivery points will not be considered as this area will be used for single-deep racks. It is known that the dimensions of the tallest double-deep racks are 21.6 meters by 0.9 meters, with a total of 16 double-deep racks on the left side of the delivery points and 3 aisles with a width of 3 meters. These adjustments to the rack configuration, particularly the removal of the double-deep racks on the left side, signify a substantial transformation in the warehouse's layout. By repurposing this space, PT XYZ's CDC Import Warehouse can enhance its storage capacity and operational efficiency, providing a strategic advantage in managing its inventory and responding to customer demands more effectively.

Double Deep Shelf Area = Length x Width

= length of shelves x ((number of shelves x width per shelf) + (number of aisles x width of aisles))

= 21,6 m x ((16 x 0,9) + (3 x 3)) m

= 21,6 m x 23,4 m

= 505.44 m^2

As a result of the removal of 16 double-deep racks situated on the left side of the delivery points, there is now an opportunity to allocate a significant floor area for accommodating oversized goods. The calculated floor area dimension for this purpose is approximately 505.44 m2, which is equivalent to 9.5% of the total available warehouse area. This newfound space presents an exciting prospect for PT XYZ, as it can be harnessed as a valuable expansion zone for storing oversized goods. This strategic move not only optimizes the existing warehouse layout but also provides the company with the capacity to diversify and broaden its business operations within a larger sector, potentially leading to increased revenue and market reach. Table 6 shows a comparison table of the existing layout and the proposed layout.

Table 6. The comparison table of existing and proposed layout

Aspect	Existing Layout	Proposed Layout
Purpose		
1. Minimize distance for material transfers	High material handling distance	Reduced material handling distance using CRAFT
2. Simplify search for goods	Random placement causes retrieval difficulties	Class-based storage simplifies retrieval
3. Space for oversized goods	Limited space for oversized goods	Additional 505.44 sq. meters for oversized goods
Method Used	Randomized Storage	Class-based storage and CRAFT method
Rack Utilization	31.45% (underutilized space)	Increased to 93.83% (optimized space use)
Space Utilization	67.70% (inefficient layout)	67.53% (efficient layout without altering footprint)

6. Conclusion

The current layout, characterized by randomized storage, leads to extended material handling distances and complicates the retrieval process, especially during system failures. In contrast, the proposed layout utilizes the Class-Based Storage and CRAFT (Computerized Relative Allocation of Facilities Techniques) method to effectively minimize these distances. This strategic reorganization not only simplifies the retrieval process by grouping similar items together but also enhances overall operational efficiency. The introduction of Class-Based Storage in the proposed layout also aids in minimizing system errors and simplifies the search process. Goods are grouped by similar characteristics, making them easier to locate.

Based on the comprehensive redesign of the warehouse layout carried out in this research, it is evident that the implementation of the proposed alterations results in a room utilization rate of approximately 67.53%, which, interestingly, does not deviate significantly from the initial condition. However, a remarkable transformation is observed in rack utilization, which has surged from the initial 31.45% to an impressive 93.83%. This significant increase in rack utilization is a testament to the effectiveness of the warehouse layout changes proposed and executed in this study.The implications of these modifications extend beyond mere numbers. The revamped layout not only optimizes space but also brings about a more structured and efficient arrangement of goods within PT XYZ's CDC Warehouse. This enhanced efficiency streamlines warehouse operations, contributing to smoother logistics processes and overall operational excellence. Furthermore, the proposed improvements generate an additional floor area spanning 505.44 m^2, equivalent to 9.5% of the total available area. This newfound space holds great promise, serving as a versatile zone for storing large-sized goods. Consequently, it provides PT XYZ with the strategic advantage of expanding its business into a broader sector and extending its customer base.

As a suggestion for future research endeavors, exploring the integration of advanced technologies and automation systems in warehouse layout redesign would be beneficial. These innovations can potentially further optimize efficiency and productivity in warehouse operations. Additionally, future research could involve a comparative analysis between the CRAFT method employed in this study and alternative warehouse layout redesign approaches, shedding light on the relative merits and demerits of different methodologies in diverse contexts.

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