Warehouse Design under Class-Based Storage Policy Based on Entry-Item-Quantity Analysis: A Case Studyin Lamongan City

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Warehouse Design under Class-Based Storage Policy Based on Entry-Item-Quantity Analysis: A Case Study

Sekarsari Utami Wijaya[1)], Rahayu Johanna[1)] , Muhammad Faisal Ibrahim[1)]

[1]*Department of Logistics Engineering, Universitas Internasional Semen Indonesia, Gresik, Indonesia*

[1]Corresponding author: sekarsari.wijaya@uisi.ac.id

Abstract. In an effort to minimize the impact of unpredictable demand, the company will make an inventory policy. The warehouse as a place for storing goods before being distributed to consumers has an essential role in ensuring supply sustainability in the supply chain system. Many problems occur in the warehouse which causes a decrease in warehouse performance which has an impact on the company's operations. One of the things that play an essential role in increasing the efficiency of warehouse operations is the warehouse layout design. Class-based storage policies are used to regulate the procedures for storing goods into 3 classifications. Classification is obtained based on Pareto's law by considering the level of storage and retrieval activity. Entry-Item-Quantity (EIQ) analysis is an analysis that involves three main factors of logistics distribution, namely, E (Order Entry), I (Item), and Q (Quantity) which is applied to further analyze frequently ordered products, so that it can support the layout warehouse. UD. XYZ is a distributor that sells many kinds of materials for roofs. This study considers determining the number of racks needed by Entry Item Quantity-Class Based Storage analysis. Furthermore, this study will compare the warehouse layout based on IK, IQ, EN, and EQ. It aims to obtain the best improvement in the warehouse layout that has the smallest expected distance. Based on the analysis that has been done, the warehouse shall provide 14 type 1 racks and 13 type 2 racks. The smallest expected distance, the best warehouse layout design. IQ analysis results in the best warehouse layout design.

Keywords: Class-Based Storage analysis, EIQ analysis, EQ analysis, warehouse.

INTRODUCTION

In practice, every trade tends to have a whole uncertainty about demand. It has encouraged the traders to make policies about the inventory system. Its aims to anticipated unpredictable demand. The policy about inventory systems prompts traders to provide a facility that will be used for a warehouse for storing goods. A warehouse is a facility used as a temporary storage place for goods before being distributed to end consumers. These goods can be raw materials, work in process, and or finished goods. Warehouses play an important role in maintaining the suitability of supply to demand in the supply chain system [1]. Some of the problems that often occur in warehouses include difficulty in moving goods, accumulation of goods, long searching for goods, and lack of capacity. Moving goods that spend a lot of time causing high costs in material handling. Delays occur due to the length of time it takes to search for items. In addition, the pile of goods that are too high makes it difficult to withdraw goods. Warehouse layout is one of the things that affect the efficiency and effectiveness of the warehouse. The appropriate warehouse layout design will play a role in increasing operating efficiency [2].

Class-based storage policies are usually used to regulate goods storage procedures that divide goods into three classes, namely classes A, B, and C [3]. Its classifications are based on the law of Pareto by considering storage and retrieval (S/R) activity rate. This method produces a layout design for the storage area of all kinds of goods based on their class. Racks are designed to increase storage capacity, the displacement of workers, and retrieval system goods. It is also designed to minimize the distance traveled workers as possible.

Entry-Item-Quantity (EIQ) analysis is applied to further analyze frequently ordered products, so that it can support the distribution center layout. According to [4], EIQ is an analysis involving three main logistics distribution factors namely, E (Order Entry), I (Item), and Q (Quantity). This analysis proposes the improvement of warehouse layout design based on IK (items by order number) is the order frequency of product items purchased by the seller. IQ (Item Quantity) is the number of each kind of goods ordered and purchased by the seller. EN (Entry Quantity) is the number of items purchased by the customer. EQ (Entry Quantity) is the order quantity of customer [5]. EIQ can determine the amount of the rack used in the improved layout of the warehouse by Class-Based Storage.

Previous research about Class-Based Storage with Entry Item Quantity Analysis was conducted by [6]. The differences between previous research and this research is the design of racks. On previous research, a type 1 rack was designed consisting of 2 the level. First level was to utilize pallet wheeled furnished with a brace or lock the wheels and second level used steel as material for making store shelves. Whereas, this experimental design a rack type 1 designed consisting of 2 levels. All of levels use steel materials for making store shelves. Another research that used Class-Based Storage with Entry Item Quantity Analysis is[4]. This difference between two research studies is characteristic goods. According to research by [4], characteristic goods were cigarettes that are distributed to local distributors. Whereas, characteristic goods of this paper is materials for roofs. So, the novelty of this article is about the design of rancks and characteristics of goods.

UD. XZY is a distributor that sells many kinds of materials for roofs. The materials are consist of roofs, tin roof, asbestos roof, roof ridge cap, galvalume roof, and spandex roof. Several problems that were already described had also occurred in this distributor. This study considers determining the number of racks needed by Entry-Item Quantity-Class Based Storage analysis. Furthermore, this study will compare the warehouse layout based on IK, IQ, EN, and EQ. It aims to obtain the best improvement in the warehouse layout that has the smallest expected distance for UD. XYZ.

METHODS

In general, there are five steps to determine the number of racks and the best layout of the warehouse. First, classify goods using the Class-Based Storage method based on IK, IQ, EN, and EQ. The threshold for determining the ABC split is close to 20%, 30%, and 50% of the cumulative percentage of goods ordered. Calculation of the Class-Based Storage as follows: sort the data IK/IQ/EN/EQ from largest to smallest, calculate the cumulative frequency of data IK/IQ/EN/EQ, calculate the percentage of cumulative frequency, and classify the type of goods into A, B, or C class based on threshold determined before. Second, design shelving storage racks. Design storage racks are depended on the heavy and dimensions of goods, the high and wide of the level. Third, calculate the number of racks as storage. Racks are used to store the equipment in the warehouse. This study uses two types of racks, namely, type 1 racks and type 2 racks.

Figure 1 shown the type 1 racks; the rack is used to store roof and roof ridge cap. Type 2 racks are used to store tin roof, asbestos roof, galvalume roof, and spandex roof, shown in Figure 2. To determine how many racks are needed, it can be obtained by calculating the average of recorded stock of goods each day. Then, divide the average of the recorded stock each day by rack capacity.

FIGURE 1. Type 1 Racks

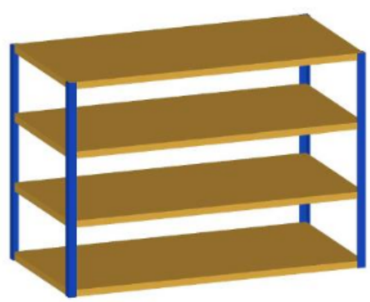

FIGURE 2. Type 2 Racks

Fourth, design warehouse layout by racking systems. Design layout warehouse is adapted to reflect the shelf space defined in the previous step. Last, calculate the expected distance. According to [7], expected distance is the distance that is expected from storage to entry points and freight out of goods. The expected distance for the entire picking path can be calculated by first finding the probability of entering a node and multiplying it by the probability of each arc going out of the node and the distance along the arc [7]. Distance calculation uses Euclidean Distance. The formula is as follow:

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \tag{1}$$

where

x_i = x coordinate of the i-th center of facility
x_j = x coordinate of the j-th center of facility
y_i = y coordinate of the i-th center of facility
y_j = y coordinate of the j-th center of facility
d_{ij} = distance between the i-th and j-th center of facility

The best warehouse layout design between IK, IQ, EN, and EQ has a minimum expected distance value.

RESULTS AND DISCUSSION

The total size of UD. XYZ warehouse about 260 m^2. Its length is about 20 m^2 and its width about 13 m^2. Only 110 m^2 of total warehouse size is used to store the materials. The existing warehouse layout design shown in Figure 3 does not consider the distance between the aisle in every location of materials.

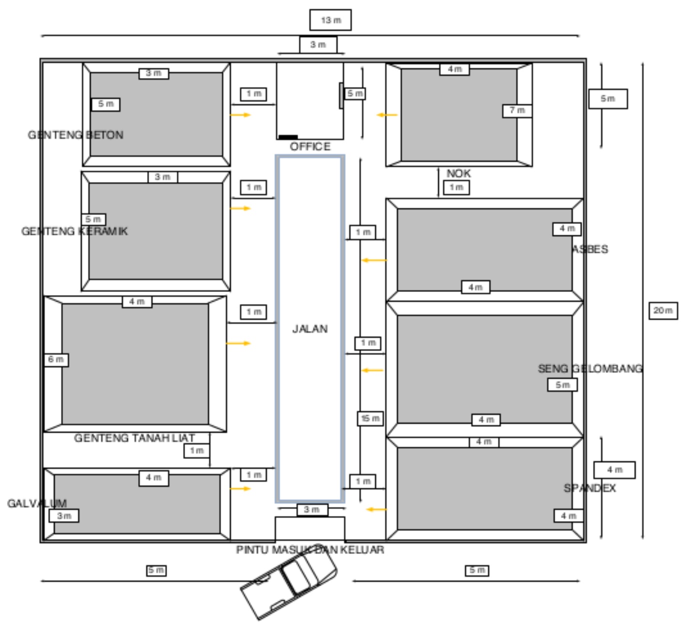

FIGURE 3. The Existing Warehouse Layout UD. XYZ

The IK, IQ, EN, EQ, and stock of materials data are collected. Data is collected for six months (November 2020 until April 2021). The four alternative EIQ (IK, IQ, EN, EQ) data is used to classify the Class-Based Storage method. Table 1 shows the result of EIQ data processing approached Class-Based Storage method. The number of materials ordered in class A is the smallest because the proportion of class A about 1% - 20% of accumulated percentage. The highest number of material ordered is in class C because the proportion of class C about the smallest 50% - 100% of accumulated percentage. Class A materials shall be stored in racks near from access door, class B materials shall be stored in racks between class A and class C, and class C materials shall be stored in the common racks due to weak flexibility. This result is suitable as study conducted by [5], the storage position for goods provided for small retailers shall be arraged in accordance with the result of the ABC classification. Class A products (1% - 20% of accumulated item percentage) shall be stored in the automatic stereoscopic shelves owing to high values and strong flexibility, class C products (20% - 50% of accumulated item percentage) shall be stored in the common shelves due to weak flexibility, and class B products (50% - 100% of accumulated item percentage) shall be jointly stored in the automatic stereoscopic shelves with class A product.

TABLE 1. The Result of Classification EIQ Calculated by Class Based Stroge Method

Classi-fication	**IK**		**IQ**		**EN**		**EQ**	
	Quantity	**Category**	**Quantity**	**Category**	**Quantity**	**Category**	**Quantity**	**Category**
A-class	109	7	244.500	6	95	7	102.057	6
B-class	166	12	417.600	13	142	12	158.573	12
C-class	288	30	645.871	30	228	30	272.241	31
Total	**554**	**48**	**1.307.971**	**49**	**465**	**49**	**532.871**	**49**

The materials in the warehouse will be stored in racks based on the Class-Based Storage method. The stock of materials is used to determine the number of racks. According to the IK and EN calculation, the warehouse shall provide 14 type 1 racks and 16 type 2 racks. The area is needed about 49,88 m^2. Meanwhile according to the IQ and EQ calculation, the warehouse shall provide 14 type 1 racks and 13 type 2 racks. The area is needed about 45,46 m^2. —the total area of UD. XYZ about 260 m^2 (**TABLE 2**). The area owned UD. XYZ can provide the area required.

TABLE 2. The Number of Racks and Spaces Needed

Type of Rack	**Materials**	**The Number of Levels**	**The Height between Levels (m)**	**Capacity (unit)**	**The Number of Racks**	**The Dimensions (m^2)**	**The Space Needed (m^2)**
IK and EN Analysis							
Type 1	Roof and roof ridge cap	2	1	450	14	1x1=1	14
Type 2	Tin roof, asbestos roof, galvalume roof, and spandex roof	3	0,5	100	16	2,2 x 1,1= 2,42	38,72
Total					**30**	**49,88**	
IQ and EQ Analysis							
Type 1	Roof and roof ridge cap	2	1	450	14	1x1=1	14
Type 2	Tin roof, asbestos roof, galvalume roof, and spandex roof	3	0,5	100	13	2,2x1,1=2,42	31,46
Total					**30**	**45,46**	

According to EIQ analysis, four warehouse layout designs are proposed based on IK, IQ, EN, and IQ. The racks are laid under the quantities required. The materials are also stored in accordance with the result of EIQ-Class-Based Storage analysis (**FIGURE 4**).

The in and out materials data are used for performing calculations on the probability expected distance. Expected distances are calculated by multiplicating the probability of the materials movement from rack to access door and the total distance of the materials movement from rack to access door. Expected distance conducted adapted to the layout of already made from the analysis entry items quantity. So, there is four value of expected distance (**TABLE 3**). The in and out total distances are same because there is only one access door to in and out the materials. The highest expected distance, the worst warehouse layout design. EN analysis result the worst warehouse layout design because the total expected distance is about 138,32. The smallest expected distance, the best warehouse layout design. EQ analysis results in the best warehouse layout design. The nearest expected distance can affect the time for material handling. The material handling in IQ's layout design is more effective than others ad also it can affect the costs. It's cost will be more efficient than others. So that, the warehouse layout design proposed to UD. XYZ is the IQ analysis warehouse layout design.

TABLE 3. The Expected Distance

EIQ Analysis	The In Distance (in meter)	The Out Distance (in meter)	Total Expected Distance (in meter)
Existing	196,01	196,01	196,01
IK	174,96	174,96	174,96
IQ	138,32	138,32	138,32
EN	175,84	175,84	175,84
EQ	143,92	143,92	143,92

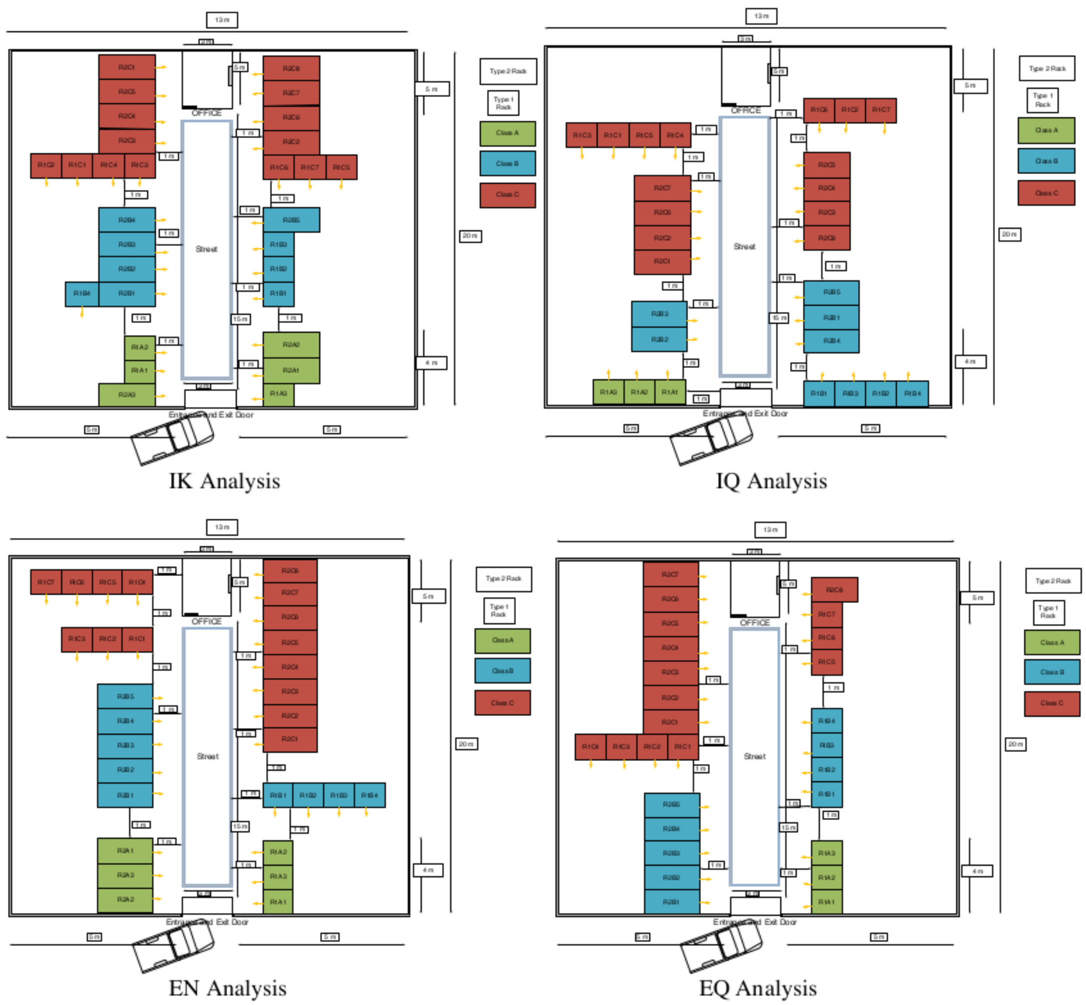

FIGURE 4. The Warehouse Layout Design

CONCLUSIONS

Warehouse storage is an essential step in the logistics process, which directly reflects the status of the material before and in circulation and serves as the basis for the company in evaluating the materials' production and sales. Based on the analysis that has been done, the warehouse shall provide 14 type 1 racks and 13 type 2 racks. The smallest expected distance, the best warehouse layout design. IQ analysis results in the best warehouse layout design. So that, the warehouse layout design proposed to UD. XYZ is the IQ analysis warehouse layout design.

The weakness of this research is the racks only have two levels on type 1 racks and three levels on type 2 racks. Recommendations for the further research are examining what happens if the type 1 racks can be broken up into three or more partitions and the type 2 racks broken up into four or more partitions with the stonger material of racks to improve the distance estimate and increase the capacity of warehouse. Finally, the next research also try to build a simulation model to gain more insights and validate the expected distance calculations.

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