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Design of a Raw Material Warehouse Layout Utilizing The Class-Based Storage Method For the Textile and Textile Products Industry

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Abstract

The COVID-19 pandemic has caused competition in the industrial sector to become increasingly fierce. So entrepreneurs in the induction sector must create new strategies to maximize company support facilities. One of the company's supporting facilities is a warehouse. Entrepreneurs can benefit from the proposed raw materials warehouse layout design by utilising the Class-Based Storage Method. This method facilitates the retrieval of raw materials and offers a streamlined process. This Method procedure comprises several stages: counting the number of pallets stored in a warehouse that is 191 pallets, determine the hallway and the dimensions of the warehouse, storage media with algorithms determine the depth of the line and allocate floor space with Larson algorithm. We receive a suggested design for the raw materials warehouse plan, including the storage area size of 148.32 m², total distance moved out of the entire feedstock is 1727.65m with a total Material Handling costs for raw materials is Rp 600,289.

Keywords
Warehouse Layout, Class-Based Storage, MHACS

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INTRODUCTION

In this era of rapid advancement and progress, the COVID-19 pandemic has intensified competition in the industrial sector, compelling companies to enhance their business processes in order to boost competitiveness and enhance consumer satisfaction. The textile and textile products industry, like many others, has been affected by the epidemic. The textile industry in Indonesia is a vital sector in the manufacturing industry. It holds a prominent position as a national priority industry due to its significant contribution to economic growth . This business also generates substantial employment prospects and promotes heightened domestic and international investment [1]. According to the report of Indonesian's Ministry of Industry 2020 [2], the textile sector employs 3.65 million people, accounting for approximately 18.79% of all employment in the manufacturing industry .

According to data from the Central Bureau of Statistics 2022[3], there has been a decrease in the percentage of employees in the textile manufacturing sector. The workforce proportion was 1% in 2019, and it is projected to decrease to 0.82% in both 2020 and 2022. This decrease leads to the cessation of employment relationships. According to the Ministry of Industry's report in 2020 [2], the number of employees who were laid off in the textile industry owing to the pandemic reached 1.5 million. In addition, the use of low-tech machinery also needs to improve the efficiency of the domestic textile industry, leading many to opt for importing rather than manufacturing domestically[1]. Based on the Central Bureau of Statistics's data 2022[3], the gross domestic product (GDP) at constant prices (ADHK) for the textile and apparel industry amounted to IDR 34.85 trillion in the third quarter of 2022. The value experienced a year-on-year growth of 8.09%, amounting to IDR 32.24 trillion. While the growth rate remains strong, it has decelerated compared to the previous quarter, specifically by 13.74% on a year-over-year basis. One factor contributing to this is the decrease in utilisation across all sub-sectors of the textile industry. Entrepreneurs in the induction sector must devise innovative tactics to enhance competition by optimising personnel productivity and leveraging corporate resources. A warehouse is one of the company's auxiliary facilities [4].

An effective warehouse is designed to prevent company losses and save costs, consequently enhancing operational efficiency and service delivery [5]. Proper storage of items is crucial to maintain their quality and quantity until the end customer uses them [6]. Warehouses can exert a significant impact on company enterprises [7]. The company necessitates a well-designed layout for the warehouse to provide efficient and seamless operations [8]. Warehouse layout refers to the strategic arrangement of facilities in order to efficiently receive and distribute items to clients while minimising overall expenses [9]. A practical arrangement might demonstrate a methodical and pleasant workspace [10]. An optimal warehouse plan is characterised by efficient product movement and storage that preserves the quality of stored commodities [11]. Johan and Suhada 2018[8] propose optimising the warehouse layout to streamline the tasks of product retrieval, storage, and release. Effective management significantly influences the level of operational efficiency and effectiveness [5].

Nevertheless, despite the awareness among firms regarding the significance of an efficient warehouse plan that facilitates the retrieval of resources and commodities, there are still companies that need to pay more attention to this aspect. Factors such as haphazard placement of raw materials, lack of clear organisation for each stored material, and restricted warehouse space significantly impede the productivity of a production process [11]. This is due to the prolonged time required to locate raw materials and the resulting high expenses associated with material handling. Textile business entrepreneurs must possess a spacious raw material warehouse plan and have already established the specific location for each raw material based on the problem at hand [12]. Companies must optimise the layout of the raw yarn warehouse to enhance the efficiency of workers in locating raw materials. The proposed warehouse layout design utilises the class-based storage method to categorise yarn raw materials depending on their respective suppliers. This approach can significantly benefit entrepreneurs by providing an efficient warehouse layout and facilitating the easy retrieval of raw materials for enterprises that may not prioritise this aspect.

METHODE

Preliminary Observations

This stage of research involves doing observations at the company and reviewing reference books and periodicals connected explicitly to the subject at hand. It serves as the initial stage of the research process. Theory serves as the foundation for determining the necessary data for data processing and analyzing the outcomes. In order to accurately identify the problem.

Data Collection

Information was gathered to fulfil the requirements of the research. Data was gathered via observation and solicitation of archival corporate data. This data offers insights into the company's state and facilitates the data processing procedure. Primary data is gathered regarding the process flow within the raw material warehouse, the number of raw materials held, the specific type of material handling equipment employed, and the maximum capacity for stacking pallets. Secondary data include the collection of information regarding the process flow inside the raw material warehouse, the quantity of raw materials received and distributed, as well as company policies.

Preliminary Warehouse Assessment

This stage assesses the initial state of the raw material warehouse by employing a material handling audit checklist sheet to ascertain the initial condition of the warehouse's location. Twenty-four criteria were selected from a total of 130 criteria in the material handling audit check sheet based on the research conducted by Tompkins et al. [13]. The assessment of the potential to enhance productivity is contingent upon the state of the warehouse under examination and the necessity of repairing the criteria. The selected criteria in this research are the ones that require repair if they are present in the warehouse in order to compute the proportion of issues occurring in the warehouse. The higher the percentage of problems, the poorer the state of the facility. The research was carried out in September 2023 at enterprises within the textile and textile product industry. The focus of this research was the Yarn Raw Material Warehouse.

Designing Warehouse Layout Using Class-Based Storage Method

The warehouse layout was enhanced with the implementation of the class-based storage technique. This storage approach, based on classifying raw materials, facilitates the creation of a flexible and economical structure for a raw material warehouse. It only requires a small space. The materials can be arranged arbitrarily inside their respective classification groups. The necessary steps to enhance the warehouse layout using the class-based storage method include assessing the requirements for the raw material warehouse, establishing the dimensions and pathways of the aisles, identifying the entry and exit routes, determining the primary routes, specifying the dimensions of the storage slots, calculating the length of the storage zones, selecting the appropriate storage media, performing calculations using the Larson Algorithm, allocating floor space, implementing the Larson Classification Algorithm, prioritizing groups, and creating layout designs [14].

Assessment of Proposed Warehouse

This step assesses the outcomes of the proposed warehouse design that has been formulated. The evaluation process involves the utilization of a material handling evaluation sheet and a material handling audit checklist sheet. The material handling assessment sheet is utilized to ascertain the expenses associated with relocating items to the intended warehouse. In contrast, the material handling audit checklist sheet is employed to assess the state of the planned warehouse [15].

Analysis of the Design

This stage presents the findings of the analysis conducted on the design of the raw materials warehouse layout, comparing it with the initial plan. The objective is to observe a decrease in the percentage of issues and the distance required to transport raw materials.

RESULT AND DISCUSSION

Assessment of the Warehouse's Initial State

The evaluation derived from the material handling audit check sheet yields a negative number, indicating a problem if the criteria are present in the warehouse. The evaluation results revealed that 18 criteria in the initial warehouse were identified as problematic, namely Delays in material moving, Long hauls, Cross traffic, Obstacles to material flow, Poor

workplace layout for material, Disorderly storage, Cluttered workspace, Rehandling, Operators traveling for supplies material, Backtracking of material, Automatic identification system not used, MH equipment running empty, Randomized storage, No ABC storage classification, Aisles and storage locations not clearly marked, MH equipment does not fit through doors, Waste and trash containers located near docks, and Manual stock locator system. In contrast, 6 criteria were not found in the initial warehouse and hence did not contribute to any issues, namely Manual handling, Inadequate handling equipment, Insufficient handling equipment, Idle handling equipment, Excessive MH equipment maintenance cost, and No one-way aisles. Based on these findings, the percentage of criteria indicating problems can be computed as follows:
The percentage of criteria indicating problems (P):

$$P = \frac{Number\ of\ criteria\ indicating\ problem\ in\ the\ initial\ warehouse}{Number\ of\ criteria\ utilized\ in\ the\ evaluation} \text{ x } 100\% \quad (1)$$

$$P = \frac{18}{24} \text{x } 100\%$$

$$P = 75\%$$

The problem presentation results, which were calculated to be 75%, indicate the need to construct the raw material warehouse for the yarn in order to decrease the problem percentage. The opportunity for improvement lies in several criteria, including delays in material transportation, cross traffic, obstacles hindering material flow, inadequate workplace layout for material handling, disorderly storage, a cluttered workplace, random storage practices, and the absence of ABC storage classification, all of which contribute to the disorganized layout of the raw material warehouse. To enhance the current conditions and address the areas that require improvement, it is imperative to optimize the layout of the raw material warehouse. This includes addressing issues such as lengthy transportation routes, operators travelling for material supplies, and underutilization of automatic identification systems. By rectifying these issues, the process of searching for raw materials can be expedited.

Designing Warehouse Layout Using the Class-Based Storage Method - Determining Raw Material Warehouse Needs

The calculation of raw material warehouse requirements involves determining the necessary number of pallets for each raw material housed in the warehouse. The number of pallets can be determined using equation

$$Number\ of\ pallets = \frac{Maximum\ Initial\ Stock + Maximum\ Acceptance}{Capacity\ Per\ Pallet} \quad (2)$$

Formula 2 can be used to compute the number of pallets required for each raw material in the yarn raw material warehouse, assuming a pallet capacity of 30 boxes. As an illustration, the computation for determining the number of pallets required for BSY 130-60 AF material is as follows:

$$Number\ of\ pallets = \frac{74+142}{30} = 7{,}2 \approx 8\ Pallets$$

Based on these calculations, it is determined that the quantity of BSY 130-60 AF material is 8 pallets. The warehouse will get a total allocation of 191 pallets can be seen in Table 1.

Table 1. Number of Pallets and Space Requirements for Each Raw Material

NO	Thread Type	Maximum Initial Stock (Box)	Maximum Acceptance (Box)	Number of Pallets
LOCAL				
1	BSY 130-60 AF	74	142	8
2	BSY 135-108	24	4	1
3	DTY 150-48 AX	332	815	39
4	DTY 150-144 AX	9	136	5
5	DTY 300-96 AX	221	227	15
6	DTY 75-72 AX	167	167	12
7	SDY 150-96 AF	34	35	3
8	FINE 130-072	84	157	9
9	FINE SD 080-048	6	0	1
10	SENS 160-48 AA	0	48	2
11	NSY 160-048 AF	42	158	7
12	DTY 150/72 ALS	234	0	8
IMPORT				
13	DTY 75-72F AW RECRON	200	311	18
14	SCY 100 D/24 SD	5	0	1
15	FDY 75D-36 SD	0	670	23
16	DTY 150D/48F	0	2	1
17	DSD 100 D/24 F SPH	31	16	2
18	DSD 200 D/48 F SPH	15	14	1
19	DTTK 180-96F	225	0	8
ETC				
20	COV DTY 75/36-40	6	0	1
21	CD 40	16	0	1
22	DTY 75D/72F	24	94	4
23	SDY 75D/72F	19	20	2
24	RAYON 30/1 TWIST S	5	10	1
25	RAYON 30/1 TWIST Z	5	10	1
26	CD 12 SA	9	0	1
27	FINE 130-072 M	16	18	2
28	VISCOSE RAYON 120/30	30	130	6
29	POLYESTER 150-48	0	0	0
30	TR 20/1	90	130	8
Total Allocation				191

Identifying Aisles and Measurements

Prior to classifying the placement of raw materials in the proposed warehouse, it is essential to establish the route and measurements of the intended raw material storage facility. The primary route is determined by taking into account the entrance and exit points. The primary route selected is the one with the lowest distance, minimal turns, and maximized straight segments. The recommended specifications for the width of the main line for hand pallets, as stated by Tompkins et al. [13], range from 2.5 m to 3 m. The slot sizes are determined according to the dimensions of the pallets utilized in the warehouse. Slots serve as a representation of the most basic unit in organizing space. The slot dimensions and storage zone length can be seen in Table 2.

Table 2. Slot Dimensions and Storage Zone Length

	Length	**Width**
***Slot* (S)**	1,2 m	1,2 m
Storage Zone Length (L)	16 *slots*	

The storage media for raw material storage in the planned warehouse can be defined as floor stacks with a width of 2 slots and a length of 10 slots, based on the current storage zones. To determine the storage capacity per storage site, refer to Table 3.

Table 3. Floor Space Requirements and Storage Capacity Per Storage Location

Storage Media	Floor Space Requirements Per Storage Location (*Slots*)	Storage Capacity Per Storage Location (*Pallets*)
2-*deep floor stack*	2	4
10-*deep floor stack*	10	20

Determining Raw Material Storage Capacity

Prior to implementing the row depth method, it is imperative to ascertain the average inventory level in order to establish the minimum row depth needed in the storage location. Thus, the average inventory level value represents the quantity of pallets per raw material that will be held in the warehouse. Subsequently, the storage depth is computed utilizing the Row Depth Algorithm, equation 3.

Row Depth Algorithm (3)

Input : n, h_j (j=1,..,n), s_j (j=1,..,n), α, h_{min}, d_{max}, d_{min}
Output : N_j , d_j
Step 0. *Let* j = 1
Step 1. *IF* $h_j < h_{min}$
Go to Step 5
ELSE
Go to Step 2
Step 2. *Let* $N^* = [(1+ \alpha)\, s_j / d_{max}\, h_j]$
$d_j = [(1+ \alpha)\, s_j / N^*\, h_j]$
Step 3. *IF* $d_j \geq d_{min}$
Go to Step 4
ELSE
Go to Step 5
Step 4. *Let* $N_j = N^*$
Go to Step 6
Step 5. *Let* $d_j = 0$
$N_j = F(s_j)$
Step 6. *IF* j < n
Let j = j +1
Go to Step 1

ELSE STOP

With the notation:

n : number of items stored;
j : stored item number;
h_j : stack height of each item;
s_j : *average inventory level for each item;*
α : percentage of honeycombing;
h_{min} : minimum stack;
d_{max} : maximum storage depth;
d_{min} : minimum storage depth;
N_j : storage location requirements per item;
d_j : optimal storage depth per item;
N^* : current storage location requirements;
$F(s_j)$: shelf design function.

The algorithm allows for the calculation of storage location requirements and optimal storage depth for each raw material. The number of items stored is 30, and the maximum height for all raw materials is two pallet stacks, as they are directly stacked on the floor. The allowance for honeycombing is set at 25% to avoid creating a vacuum in the warehouse. The maximum depth is limited to 10 rows of previously identified storage media, while the minimum depth is set at two rows of previously identified storage media. Here is an illustration of how to determine the necessary storage space and ideal depth of raw materials for BSY 130-60 AF material.

Input : $n = 30$, $h_1 = 2$, $s_1 = 8$, $\alpha = 25\%$, $h_{min} = 1$, $d_{max} = 10$, $d_{min} = 2$
Output : N_1 , d_1
Step 1. *SINCE* $h_1 > h_{min}$
Go to Step 2
Step 2. *Let* $N^* = [(1+ 0{,}25)\ (8) / (10)(2)] = 0{,}5 \approx 1$
$d_1 = [(1+ 0{,}25)\ (8) / (1)\ (2)] = 5$
Step 3. *SINCE* $d_1 \geq d_{min}$
Go to Step 4
Step 4. *Let* $N_1 = 1$
Go to Step 6
Step 6. *SINCE* $1 < 30$
Let $j = 1 + 1 = 2$
Go to Step 1

Perform algorithmic computations until either all raw materials have been processed or until j reaches a value of 30. Based on these calculations, it is determined that the necessary storage capacity for BSY 130-60 AF material is 1 unit, and the ideal depth for storing rows is 5.

Proposed Distribution of Warehouse Floor Space

Once the storage location requirements and ideal storage row depth are determined, the following step is to categorize the raw materials into groups. The suppliers of the raw materials, such as local suppliers and foreign suppliers, determine the categorization of raw yarn warehouses. Table 4 shows the group for the storages.

Table 4. Group For Each Storage Media

Storage Medium	Number of Clases	Number of Brand-Codes	Percentage of Brand-Codes	Number of Pallets	Percentage of Pallets
2-deep floor	1	11	37	27	14
10-deep floor	2	19	63	164	86
Total	3	30	100	191	100

Once the raw materials are grouped, a classification algorithm is employed to ascertain the arrangement of these groups. The sorting of raw materials near the door of the yarn raw material warehouse is determined based on the throughput of each raw material. To calculate the throughput, employ the subsequent procedure:

$$Throughtput = \left(\frac{Acceptance\ Average}{Carrying\ Capacity}\right) + \left(\frac{Average\ Expenditures}{Carrying\ Capacity}\right) \quad (4)$$

Here is an example calculation for the throughput of BSY 130-60 AF raw materials. The average reception is 84 boxes, the average expenditure is 82 boxes, and the transit capacity is 30 boxes.

$$Throughtput = \left(\frac{84}{30}\right) + \left(\frac{82}{30}\right) : 5{,}53 \approx 6$$

Once the throughput for each raw material has been obtained, a classification algorithm can be computed. The computations for classification algorithms can be performed in the following manner:

Classification Algorithms: (5)

Input : n, t_j (j = 1,..,n), N_j (j = 1,...,n), d_j (j = 1,...,n), L, d_{max}
Output : R_j, r_j, C_k (k = 1,...,m), D_k (k = 1,...,m), I_k (k = 1,...,m)
Step 0. *Let* k = 0
Step 1. *FOR* j = 1 *to* n
Let $R_j = t_j / N_j$
Step 2. *FOR* j = 1 *to* n
Rank R_j *in descending order*
Let r_j = *rank of item* j
Step 3. *FOR* l = 0 *to* d_{max}
Let k = k +1
$C_k = \emptyset$
$I_k = 0$
FOR i =1 *to* n
FORALL j *such that* r_j = i *AND* d_j = l
(a) *IF* $I_k + N_j \leq L$
Let $C_k = C_k \cup j$
$I_k = I_k + N_j$
$D_k = d_j$
(b) *IF* $I_k + N_j > L$
Let k = k +1
$C_k = \emptyset$
$I_k = 0$
Go to (a)
Step 4. *STOP*

With notation:

t_j : *throughput of each item;*
R_j : ratio of throughput to storage requirements;
r_j : ranking of items;
k : *index for class;*
C_k : *set of items in class;*
I_k : many storage locations required for the group;
D_k : storage media for classes.

The subsequent computation pertains to the classification technique for BSY 130-60 AF material.

Input : n = 30, tj = 6, Nj = 1 *pallet*, dj = 5 *pallets*, L = 16 *slots*, d_{max} = 10 *pallets.*
Output : Rj, rj, Ck , Dk, Ik.
Step 0. *Let* k = 0
Step 1. *FOR* j = 1 *to* n
Let Rj = 6 / 1 = 6
Step 2. *FOR* j = 1 *to* n
Rank Rj *in descending order*
Let rj = *rank of item* j
Step 3. *FOR* l = 0 *to* d_{max}
Let k = k +1
Ck = Ø
Ik = 0
FOR i =1 to n
FORALL j *such that* rj = i AND dj = l
Ik + Nj ≤ L
Let Ck = Ck ∪ j
Ik = 0 + 1
Dk = 5

Carry out algorithmic calculations until the last raw material or until j = 30. Based on this algorithm, you can find out the order of placement of groups of raw materials and the order of raw materials based on throughput and storage location requirements. The results of the classification algorithm calculation can be seen in Table 5.

Table 5. Classification Algorithm Calculation Results

NO	Thread Type	Acceptance Average	Average Expenditures	Boxes Transported	*Throughput (tj)*	Nj	dj	Rj	rj
	LOCAL								
1	BSY 130-60 AF	84	82	30	6	1	5	6	4
2	BSY 135-108	1	5	30	1	1	1	1	14
3	DTY 150-48 AX	336	316	30	22	3	9	733,333	3
4	DTY 150-144 AX	23	22	30	2	1	4	2	10
5	DTY 300-96 AX	48	59	30	4	1	10	4	7
6	DTY 75-72 AX	43	71	30	4	1	8	4	8
7	SDY 150-96 AF	20	21	30	2	1	2	2	11
8	FINE 130-072	107	121	30	8	1	6	8	1
9	FINE SD 080-048	0	1	30	1	1	1	1	15
10	SENS 160-48 AA	8	8	30	1	1	2	1	16
11	NSY 160-048 AF	57	46	30	4	1	5	4	9

NO	Thread Type	Acceptance Average	Average Expenditures	Boxes Transported	*Throughput (tj)*	Nj	dj	Rj	rj
12	DTY 150/72 ALS	0	6	30	1	1	5	1	17
	IMPORT								
13	DTY 75-72F AW RECRON	156	131	30	10	2	6	5	6
14	SCY 100 D/24 SD	0	1	30	1	1	1	1	18
15	FDY 75D-36 SD	112	0	30	4	2	8	2	12
16	DTY 150D/48F	1	1	30	1	1	1	1	19
17	DSD 100 D/24 F SPH	9	7	30	1	1	2	1	20
18	DSD 200 D/48 F SPH	9	5	30	1	1	1	1	21
19	DTTK 180-96F	0	0	30	0	1	5	0	26
	ETC								
20	COV DTY 75/36-40	0	0	30	0	1	1	0	27
21	CD 40	0	0	30	0	1	1	0	28
22	DTY 75D/72F	16	16	30	2	1	3	2	13
23	SDY 75D/72F	12	13	30	1	1	2	1	22
24	RAYON 30/1 TWIST S	4	5	30	1	1	1	1	23
25	RAYON 30/1 TWIST Z	4	5	30	1	1	1	1	24
26	CD 12 SA	0	0	30	0	1	1	0	29
27	FINE 130-072 M	6	12	30	1	1	2	1	25
28	VISCOSE RAYON 120/30	84	74	30	6	1	4	6	5
29	POLYESTER 150-48	0	0	30	0	0	0	0	30
30	TR 20/1	119	116	30	8	1	5	8	2

The process involves ranking each raw material that is stored, followed by ranking the current classes.

$$^{*} = \sum r_j / |C_k| \qquad (6)$$

With $|C_k|$ is the number of sets of items in that class. [14]

The raw materials are categorized according to their suppliers, forming several classes of raw materials. These classes are then reevaluated to decide which class is most likely to be selected for further processing. The raw materials are ranked individually, and then the current classes are ranked based on their rankings. Here is an illustration of how to calculate the rankings of different supplier groups in the local area.

$$Rk^{*} : \frac{1+3+4+7+8+9+10+11+14+15+16+17}{12} : 10$$

The results of the ranking of raw material classes can be seen in Table 6.

Table 6. Raw Material Class Ranking Results

NO	Thread Type	rj	Ck	Dk	Ik	R*k
LOCAL						
8	FINE 130-072	1		6	1	
3	DTY 150-48 AX	3		9	3	
1	BSY 130-60 AF	4	C1	5	1	10
5	DTY 300-96 AX	7		10	1	
6	DTY 75-72 AX	8		8	1	

NO	Thread Type	rj	Ck	Dk	Ik	R*k
11	NSY 160-048 AF	9		5	1	
4	DTY 150-144 AX	10		4	1	
7	SDY 150-96 AF	11		2	1	
2	BSY 135-108	14		1	1	
9	FINE SD 080-048	15		1	1	
10	SENS 160-48 AA	16		2	1	
12	DTY 150/72 ALS	17		5	1	
IMPORT						
13	DTY 75-72F AW RECRON	6		6	2	
15	FDY 75D-36 SD	12		8	2	
14	SCY 100 D/24 SD	18		1	1	
16	DTY 150D/48F	19	C2	1	1	17
17	DSD 100 D/24 F SPH	20		2	1	
18	DSD 200 D/48 F SPH	21		1	1	
19	DTTK 180-96F	26		5	1	
ETC						
30	TR 20/1	2		5	1	
28	VISCOSE RAYON 120/30	5		4	1	
22	DTY 75D/72F	13		3	1	
23	SDY 75D/72F	22		2	1	
24	RAYON 30/1 TWIST S	23		1	1	
25	RAYON 30/1 TWIST Z	24	C3	1	1	21
27	FINE 130-072 M	25		2	1	
20	COV DTY 75/36-40	27		1	1	
21	CD 40	28		1	1	
26	CD 12 SA	29		1	1	
29	POLYESTER 150-48	30		0	0	

The classification algorithm calculations and class rankings result in the creation of a storage zone for the layout of the raw material warehouse for yarn. This storage zone consists of 2 classes with ten rows each and 1 class with two rows. The classes are ranked in the following order of priority: Local, with an average ranking of 10; Import, with an average ranking of 18; and Others, with an average ranking of 20. When developing the layout of the raw materials warehouse, it is advised to position the Local class closer to the entrance. Subsequently, the Import class is followed by the And Others class.

Generating a Layout Plan

Upon conducting calculations to ascertain the classification and positioning of raw yarn materials in the warehouse, the layout design is created using AutoCAD tools—a design proposal for the arrangement of the raw yarn material warehouse depicted in Figure 1. From the classification algorithm calculations and class rankings, a storage zone for the layout of the yarn raw material warehouse is produced with 2 classes with 10 rows and 1 class with 2 rows.

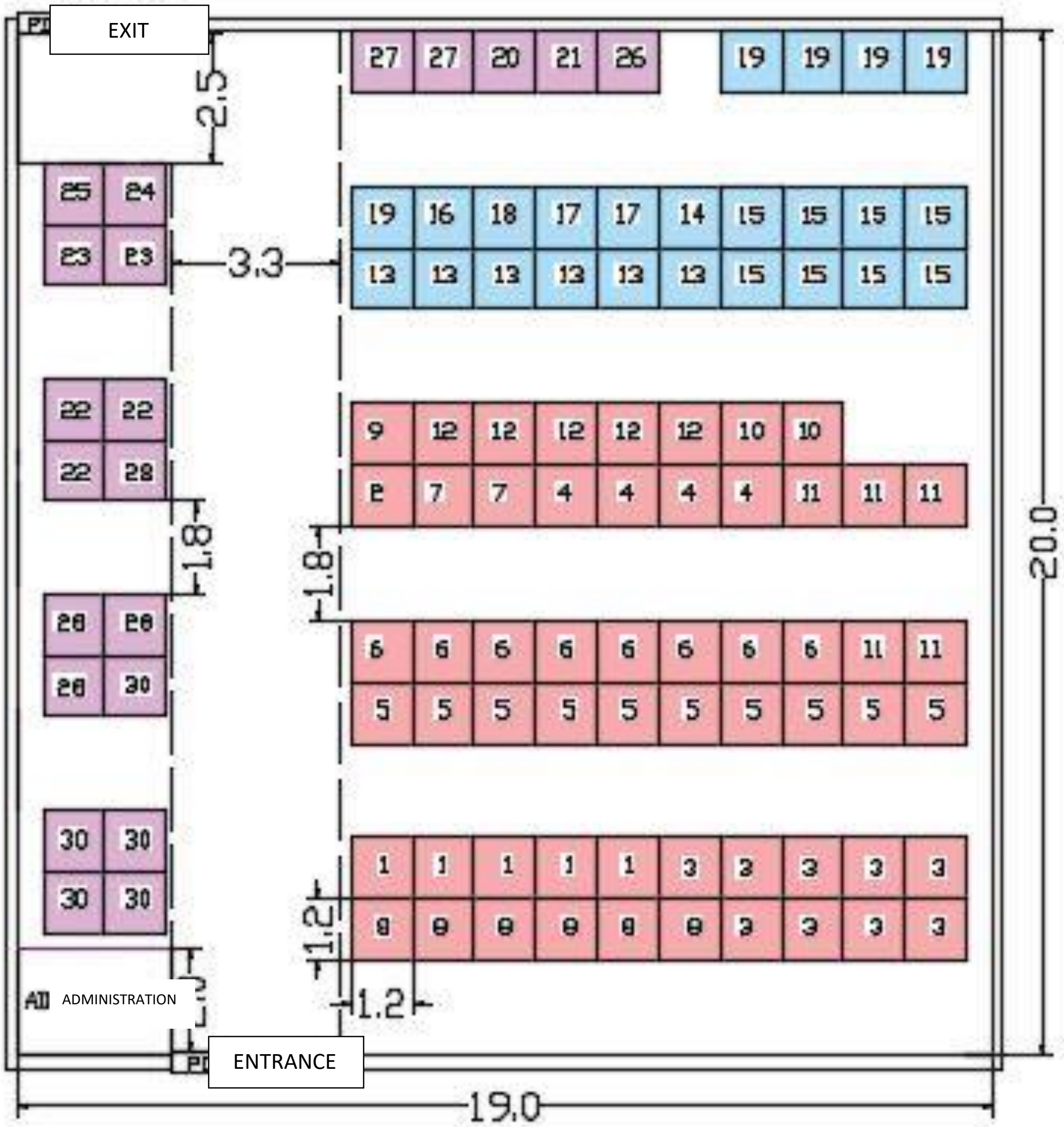

Figure 1 Design of Proposed Yarn Raw Material Warehouse

Assessment of the Findings from the Proposed Warehouse Design

Assess the outcomes of the suggested warehouse layout by utilizing a material handling assessment sheet and a material handling audit check sheet. The material handling assessment sheet is utilized to compute the expenses associated with the transportation of raw materials, taking into account the suggested design of the warehouse layout. The material handling audit check sheet is utilized to assess and compare the original state of the warehouse with the conditions that arise as a result of the projected warehouse design. The entire moving cost, calculated using the material handling evaluation sheet based on the suggested warehouse layout plan, amounts to IDR 600,289.-. The results of the material handling evaluation sheet calculation on the proposed raw material warehouse layout design can be seen in Table 7.

Table 7. Material Handling Evaluation Sheet Calculation Results

From	*To*	*From*	*To*	*Distance* (m)	**Moving Costs**	
I	1	Entrance	BSY 130-60 AF	8,47	Rp	9.759
I	2	Entrance	BSY 135-108	12,7	Rp	9.876
I	3	Entrance	DTY 150-48 AX	11,44	Rp	9.840
I	4	Entrance	DTY 150-144 AX	17,5	Rp	10.009
I	5	Entrance	DTY 300-96 AX	8,47	Rp	9.759
I	6	Entrance	DTY 75-72 AX	12,7	Rp	9.876
I	7	Entrance	SDY 150-96 AF	13,87	Rp	9.909
I	13	Entrance	DTY 75-72F AW RECRON	16,94	Rp	9.992
I	14	Entrance	SCY 100 D/24 SD	27,17	Rp	10.278
I	15	Entrance	FDY 75D-36 SD	28,37	Rp	10.311
I	16	Entrance	DTY 150D/48F	22,37	Rp	10.145
I	17	Entrance	DSD 100 D/24 F SPH	24,77	Rp	10.211
I	18	Entrance	DSD 200 D/48 F SPH	23,57	Rp	10.178
I	19	Entrance	DTTK 180-96F	28,37	Rp	10.311
I	20	Entrance	COV DTY 75/36-40	23,57	Rp	10.178
I	21	Entrance	CD 40	24,77	Rp	10.211
I	22	Entrance	DTY 75D/72F	14,3	Rp	9.920
I	23	Entrance	SDY 75D/72F	17,3	Rp	10.003
I	24	Entrance	RAYON 30/1 TWIST S	22,2	Rp	10.139
I	25	Entrance	RAYON 30/1 TWIST Z	23,4	Rp	10.172
I	26	Entrance	CD 12 SA	25,97	Rp	10.245
I	27	Entrance	FINE 130-072 M	21,17	Rp	10.111
I	28	Entrance	VISCOSE RAYON 120/30	10,1	Rp	9.804
I	30	Entrance	TR 20/1	8,9	Rp	9.770
1	O	BSY 130-60 AF	Exit	31,32	Rp	10.391
2	O	BSY 135-108	Exit	35,55	Rp	10.511
3	O	DTY 150-48 AX	Exit	34,29	Rp	10.475
4	O	DTY 150-144 AX	Exit	40,35	Rp	10.644
5	O	DTY 300-96 AX	Exit	31,32	Rp	10.391
6	O	DTY 75-72 AX	Exit	35,55	Rp	10.511
7	O	SDY 150-96 AF	Exit	36,72	Rp	10.541
8	O	FINE 130-072	Exit	27,08	Rp	10.275
9	O	FINE SD 080-048	Exit	39,79	Rp	10.627
10	O	SENS 160-48 AA	Exit	46,55	Rp	10.816
11	O	NSY 160-048 AF	Exit	43,95	Rp	10.744
12	O	DTY 150/72 ALS	Exit	40,99	Rp	10.660
13	O	DTY 75-72F AW RECRON	Exit	39,79	Rp	10.627
14	O	SCY 100 D/24 SD	Exit	50,02	Rp	10.910
15	O	FDY 75D-36 SD	Exit	51,22	Rp	10.943
16	O	DTY 150D/48F	Exit	45,22	Rp	10.777
17	O	DSD 100 D/24 F SPH	Exit	47,62	Rp	10.843

From	*To*	*From*	*To*	*Distance* (m)	Moving Costs	
18	0	DSD 200 D/48 F SPH	Exit	46,42	Rp	10.810
19	0	DTTK 180-96F	Exit	51,22	Rp	10.943
20	0	COV DTY 75/36-40	Exit	46,42	Rp	10.810
21	0	CD 40	Exit	47,62	Rp	10.843
22	0	DTY 75D/72F	Exit	37,15	Rp	10.555
23	0	SDY 75D/72F	Exit	40,15	Rp	10.638
24	0	RAYON 30/1 TWIST S	Exit	45,05	Rp	10.774
25	0	RAYON 30/1 TWIST Z	Exit	46,25	Rp	10.807
26	0	CD 12 SA	Exit	48,82	Rp	10.877
27	0	FINE 130-072 M	Exit	44,02	Rp	10.744
28	0	VISCOSE RAYON 120/30	Exit	32,95	Rp	10.439
30	0	TR 20/1	Exit	31,75	Rp	10.405
		Total		1727,65	Rp	600.289

As a result of the evaluation of the proposed raw material layout design, there was a reduction in the problem criteria found in the proposed warehouse, to 4 criteria which were still found in the warehouse. From these results, the percentage of problems that occur in the proposed warehouse can be calculated, namely as follows:

The percentage of criteria indicating problems : 4/24x 100%

: 16.6 %

From the results of the calculated problem presentation, it was found to be 16.6%, this shows a decrease in the problem percentage of 58.4% in the raw material warehouse which was initially 75%.

CONCLUSIONS

Based on the conducted data processing, it was determined that 75% of the issues were attributed to the initial warehouse circumstances. Consequently, the company must develop a warehouse layout specifically for yarn raw materials. The findings of the proposed arrangement of the yarn raw material warehouse were achieved utilizing the class-based storage strategy, which involved categorizing raw materials according to their sources, such as local or imported. The suggested design utilizes a storage area measuring 148.32 m^2, accommodating a total of 191 pallets. The overall distance travelled for transportation is 1727.65 meters, and the total expenditure for relocating the raw materials amounts to Rp 600,289. Additional investigation is vital to examine the expenses and information systems in order to enhance firm efficiency and production.

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