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# Shared-storage layout for redesigning the damaged-goods warehouse

Yudi Sukmono, Taufiqurrahman*, Farida Djumiati Sitania

[a]Department of Industrial Engineering, Mulawarman University, Jl. Sambaliung No. Samarinda, East Kalimantan 75119, Indonesia

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ABSTRACT

The Faculty of Engineering, Mulawarman University's equipment warehouse is divided into the office-stationery warehouse and the damaged-goods warehouse. Office-stationery warehouse stores office stationery, spare parts, and consumables. Meanwhile, the warehouse for damaged goods stores various damaged goods such as furniture, Personal Computer (PC) components, electronic goods, and laboratory equipment. The problem with the warehouse is that many items need to be better organized so they cannot be classified between furniture items, PC components, electronics, and laboratory equipment. Then another problem is the difficulty in collecting inventory data at the Faculty of Engineering, Mulawarman University. Therefore, this study proposes improvements to the warehouse's layout that is more efficient in storing goods in the damaged-goods warehouse. The method used in this study is shared storage, where fast-moving goods are stored in a storage area near the entrance and exit. The results from the shared storage method show that the damaged warehouse layout of the Faculty of Engineering, Mulawarman University, could be more optimal, causing ineffectiveness of the movement of goods that occurred in the warehouse was unorganized. The proposed redesign of the warehouse layout shows it is better than the layout. It can be seen from the placement of goods according to their classification and the effective distance between the storage area to the door.

## 1. Introduction

Facility layout can be defined as the procedure for setting up factory facilities to support the smooth production process. The arrangement utilizes the area as well as possible to place machines or other production support facilities, smooth movement of materials, temporary and permanent material storage, workers, and others [1]. Facility layout design is the activity of analyzing, designing, and installing systems to manufacture goods or services. This design is generally described as a floor plan, namely the layout of physical facilities (equipment, land, buildings, and other facilities) to optimize the relationship between personnel execution, the flow of goods, information flow, and procedures needed to achieve business objectives effectively and efficiently, economical, and safe [2].

A warehouse is a place for storing goods, including raw materials to be manufactured and finished products ready to be marketed. A good warehouse layout will affect the smooth operation of the company's internal warehousing and other important activities, including moving goods, commonly referred to as material handling [3]. The types of products stored in the warehouse directly impact the optimized layout. Factors that must be considered in warehouse layout include investment value, handling of goods, flexibility, work environment, and security or integrity of the goods stored. The warehouse is also a facility specifically designed to support the achievement of product and service goals with the least possible cost and time [4]. One effort that can minimize the cost and time of moving is by minimizing the distance of movement and the layout of the placement of goods, making stored goods affordable, and minimizing investment in equipment and the use of existing areas [5].

The layout arrangement or warehouse layout aims to determine the effectiveness of the distance in the process flow of goods from one place to another and to optimize the use of space as a location for storing goods in a place or warehouse, with the utilization of the room or warehouse must have a suitable space capacity. The layout has a strategic function because the layout determines an operation in the long term [6].

The warehouse layout will very much depend on the size and shape of the building, access to it, the type of equipment utilized, and the operation envisaged [7]. A crucial aspect of warehouse layout is aisle width. To ensure safety, we need to calculate the distance between the pallets once they have been put onto the racks [8]. There are also simulation software packages that enable us to 'build' the warehouse on a computer and simulate the operation to see which layout best fits [9].

The Faculty of Engineering, Mulawarman University's warehouses are divided into the office-stationery warehouse and the damaged-goods warehouse. Office-stationery warehouse stores office stationery, spare parts, and consumables. Meanwhile, the damaged-goods warehouse stores various damaged goods such as furniture, personal computer (PC) components, electronic goods, and laboratory equipment. The problem with damaged goods warehouses is that many items need to be better organized so they cannot be classified between furniture, PC components, electronic goods, and laboratory equipment. Then another problem is the difficulty in collecting inventory data at the Faculty of Engineering, Mulawarman University.

Various methods can be used to plan the layout of warehouse facilities, such as Random Storage [10], Dedicated Storage [11], Class-Based Storage [12], and Shared Storage [13]. For example, shared storage is a compilation of storage areas

* Corresponding author.
*Email*: qurrahmantaufiq1950@gmail.com

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based on the condition of the warehouse floor area, then sorted the area closest to the area farthest from the entrance and exit so that the placement of goods that will be sent immediately placed in the closest area and so next.

Shared storage is considered a fast movement of goods for a product if each pallet is filled in a different warehouse area from time to time [14], [15], [16]. This method combines two methods of Random Storage and Dedicated Storage. As in random storage, the same storage space can accommodate different materials from time to time. However, allocating goods to storage space is not random but carefully controlled. The advantage of the Shared Storage method is that the storage method can be used on several types of items that are stored sequentially. In addition, refilling the storage area can be done for different types of goods if the area is empty [17], [18], [19].

Based on these problems, it is necessary to redesign the layout of the damaged goods warehouse at the Faculty of Engineering, Mulawarman University, using the Shared Storage method. In addition, the relocation will organize the goods and facilitate inventory data collection at the Faculty of Engineering, Mulawarman University.

The method used in this study is the same as the method used in previous studies [20], [21], [22] using the Shared Storage Method. The Shared Storage method is to provide a proposal for redesigning the warehouse layout to maximize the capacity used. The difference between the current and previous research is that previous research examined warehouses with goods in and out flows or demand data. Meanwhile, in this study, the warehouse needed a flow of goods in and out.

Based on this background, the author is interested in researching the design of the facility layout by providing a proposal for redesigning the layout of the damaged warehouse at the Faculty of Engineering, Mulawarman University, so that the arrangement of goods and the movement of goods is more effective by using the shared storage method.

## 2. Materials and methods

The Shared Storage method combines two methods of Random Storage and Dedicated Storage. As in random storage, the same storage space can accommodate different materials from time to time. However, allocating items to storage space is not random but carefully controlled. Fast-moving materials are stored in a storage area near the I/O door. Slow-moving materials are stored in storage areas further away from the entrance and exit (I/O). Since material replenishment may not be instantaneous but occurs at a constant rate, the time taken in stock can vary widely even for the same material. Also, since different materials can reach their maximum inventory levels at different times, properly allocating materials to storage locations using shared storage can increase throughput (storage activity) and improve space utilization. This method is used in practice, and warehouse managers can distribute products to storage locations based on experience, intuition, and some rules of thumb [23].

### *2.1. Preparation phase*

A preliminary study was conducted by directly observing the problems in the damaged goods warehouse at the Faculty of Engineering, Mulwarman University. Furthermore, collecting references related to the topic to determine the right facility layout design using the Shared Storage method. The problem formulation was obtained after directly observing problems in damaged warehouses at the Faculty of Engineering, Mulwarman University. Based on the formulation of the problem, the purpose of this study is to propose a redesign of the layout of the damaged warehouse at the Faculty of Engineering, Mulawarman University, to facilitate data collection and movement of goods more effectively by using the Shared Storage. Research limitation aims to limit the research so that the researcher has a focus that is not broad and does not go off the track of the topic to be discussed.

### *2.2. Data collection phase*

In the data collection phase, primary data sources were obtained directly from the damaged goods warehouse at the Faculty of Engineering, Mulwarman University. The primary data obtained are the layout of the warehouse, the dimensional data of the goods and the dimensional data of the storage shelves. Then secondary data is also needed in the data collection stage. Finally, secondary data is obtained based on the sources of related books, studying the results of previous research, data from available companies, as well as relevant supporting literature.

### *2.3. Data processing phase*

After data have been collected, the next phase is to perform the data processing. In this phase, we determine the number of goods entering the warehouse, frequency of preparation of goods, space requirements as in Eq. (1), determination allowance of space as in Eq. (2), determination of the storage area as in Eq. (3)-(5), placement of storage areas, and distance from storage area to door using Euclidean distance.

$$\text{Space requirement} = LT \times \text{Number of items stored} \quad (1)$$

$$\text{Allowance of space} = \sqrt{(Length)^2 + (Width)^2} \quad (2)$$

$$\text{Total area needed} = \frac{\text{Number of goods}}{\text{Number of goods in 1 area}} \quad (3)$$

$$\text{Area of storage} = \text{Length of goods} \times \text{Width of goods} \times \text{Number of areas required} \quad (4)$$

$$\text{Area of storage area} = \text{Length of item} \times \text{Width of item} \times \text{Number of items in 1 area} \times \text{Number of areas needed} \quad (5)$$

### *2.4. Finishing phase*

After the data processing phase, the analysis and discussion phase will be carried out. At this phase, a discussion will be carried out based on the results of calculations on data processing using the Shared Storage method. Finally, the closing phase contains conclusions and suggestions. The conclusion is derived from the analysis and based on the research objectives. At the same time, the suggestions are used as a reference for future research to complement the shortcomings of current research.

## 3. Results and discussion

### *3.1. Data processing*

The equipment warehouse at the Faculty of Engineering, Mulawarman University, is divided into two, namely, office stationery warehouses and damaged goods warehouses. The goods stored in the damaged goods warehouse, Faculty of Engineering, Mulawarman University, consist of furniture, Personal Computer (PC) components, electronics, and laboratory equipment, as many as 986 items. The following data on the number of goods stored in the damaged goods warehouse and the layout of the damaged goods warehouse are shown in Table 1 and Fig. 1.

**Table 1.**
Data stored in damaged-good warehouse

| No | Type of goods | Item | Quantity |
|---|---|---|---|
| 1 | Furniture | Table | 92 |
| | | Chair | 112 |
| | | Cabinets | 48 |
| | | Whiteboard | 33 |
| 2 | PC component | Printers | 80 |
| | | Central Processing Unit (CPU) | 188 |
| | | Uninterruptible Power Supply (UPS) | 85 |
| | | Monitor Screen | 70 |
| 3 | Electronics | AC *Split* | 14 |
| | | Loudspeaker | 31 |
| | | LCD (Projector/Infocus) | 50 |
| | | Fan | 18 |
| | | Television | 14 |
| 4 | Laboratory equipment | Laboratory equipment | 151 |

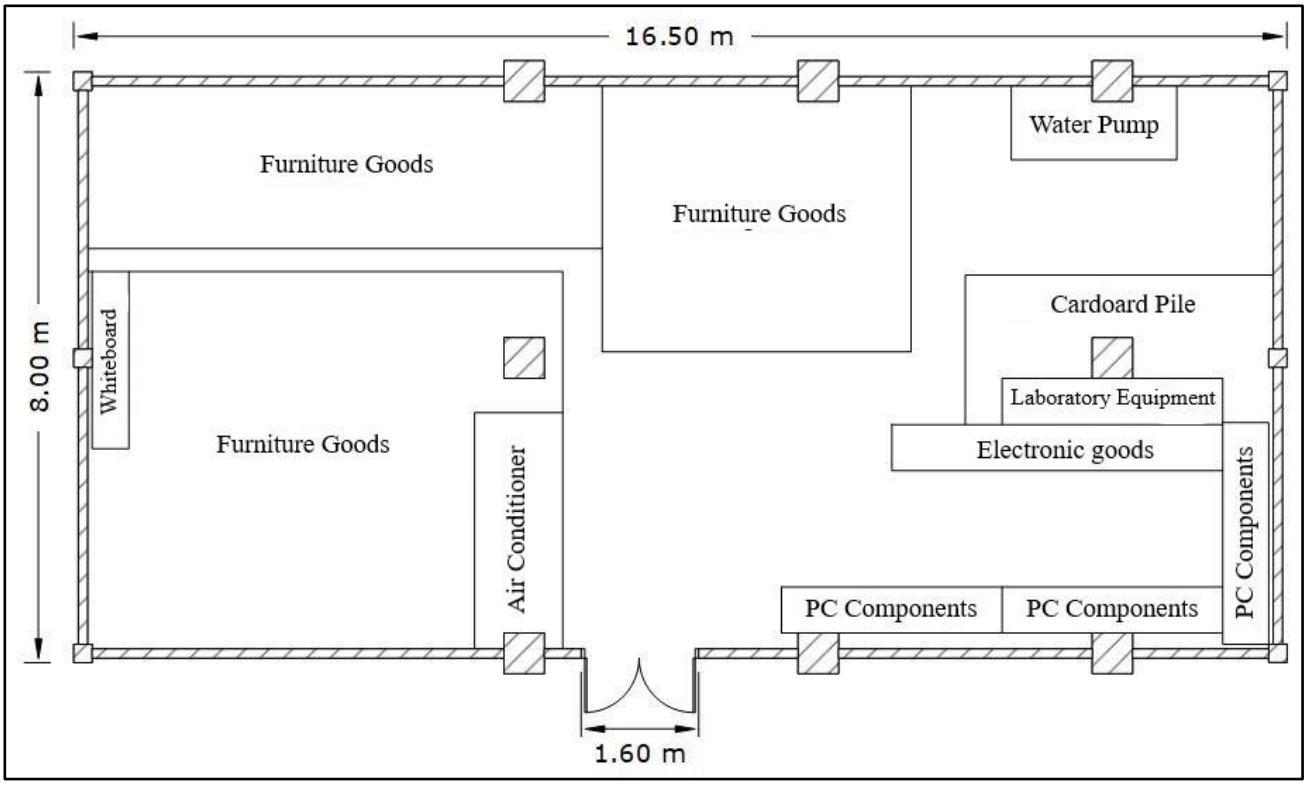


**Figure 1.** Damage-goods warehouse

**Table 2.**
Recapitulation of the area of goods storage

| No | Type of goods | Item | Quantity | Required number of areas | Area needed ($m^2$) |
|---|---|---|---|---|---|
| 1 | Furniture | Table | 92 | 19 | 13.68 |
| | | Chair | 112 | 12 | 2.64 |
| | | Cabinets | 48 | 5 | 12.60 |
| | | Whiteboard | 33 | 2 | 1.50 |
| 2 | PC component | Printers | 80 | 1 | 1.86 |
| | | Central Processing Unit (CPU) | 188 | 2 | 3.72 |
| | | Uninterruptible Power Supply (UPS) | 85 | 1 | 1.86 |
| | | Monitor Screen | 70 | 1 | 1.86 |
| 3 | Electronics | AC *Split* | 14 | 1 | 1.86 |
| | | Loudspeaker | 31 | 1 | 1.86 |
| | | LCD (Projector/Infocus) | 50 | 1 | 1.86 |
| | | Fan | 18 | 1 | 1.86 |
| | | Television | 14 | 1 | 1.86 |
| 4 | Laboratory equipment | Laboratory equipment | 151 | 1 | 1.86 |

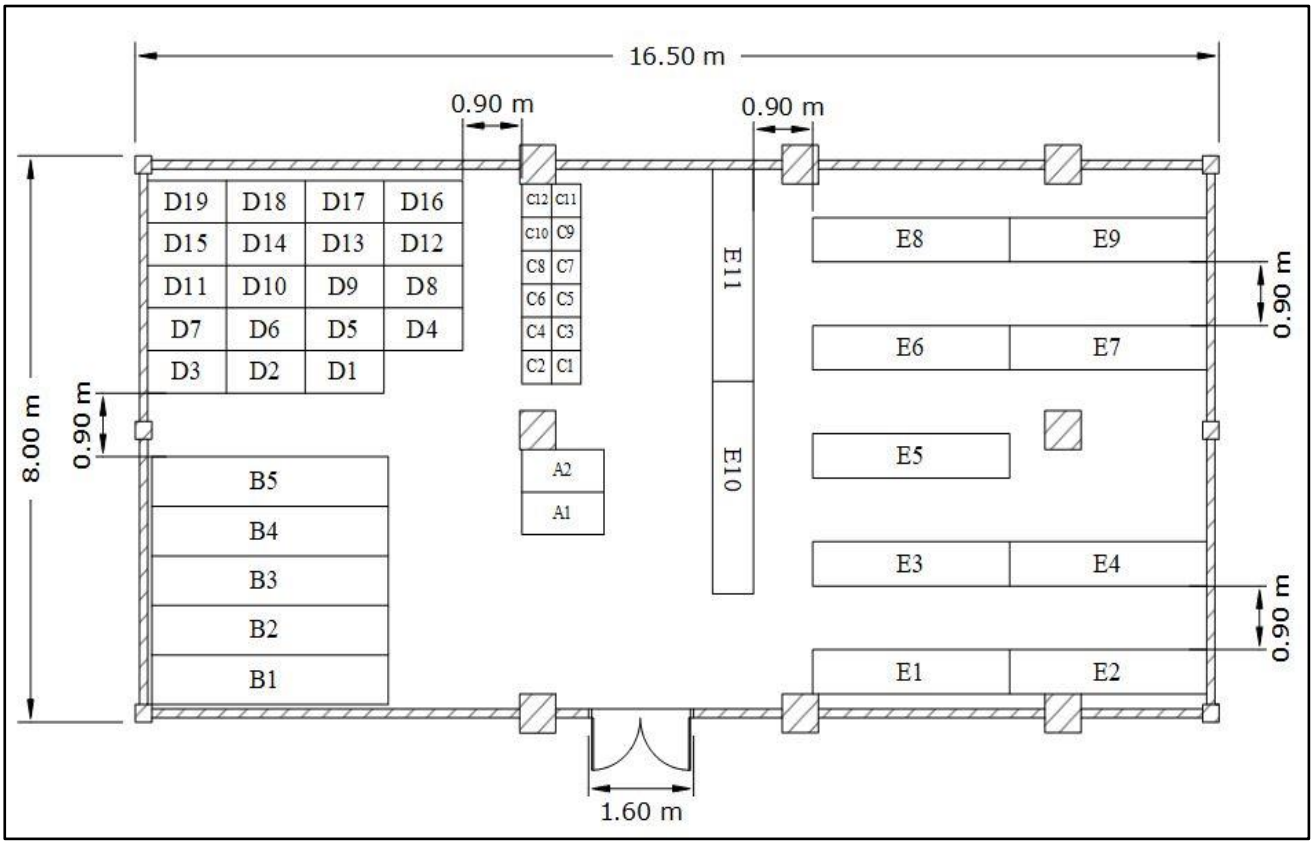


**Figure 2.** The proposed shared-storage layout

Based on the data from Table 1, the total goods that entered the warehouse for damaged goods, Faculty of Engineering, Mulawarman University, from December 2021 to January 2022, were 986 items. Based on the results of interviews with the Sub Coordinator of General and Finance Faculty of Engineering, Mulawarman University, the frequency of arranging goods in the damaged goods warehouse is carried out once at the end of each year. Therefore, there has never been a deletion of State Property caused by damaged, causing the accumulation of goods in damaged warehouses for too long. Furthermore, because the preparation is carried out once every year, from December 2021 to January 2022, the lead time is one month, and the number of items stored in the warehouse is 986. Furthermore, because the transportation of goods requires allowance for aisle or aisle space to move goods, the aisle is based on the lane requirements of the hand truck length of 0.70 m and width of 0.45 m.

The area must be considered so that the existing items have their storage area because the storage area required by each item is different. By using Eq. (1)-(5), we calculate the area need for each item and the number of areas needed. Table 2 shows the results of area needed for storage in damaged-goods warehouse. Using calculation of area needed from Table 2, the next step of the calculation is to propose the new layout based on the shared-storage method.

### *3.2. Proposed shared-storage layout*

It is possible to redesign the proposed layout of the damaged goods warehouse based on the shared storage, where fast-moving goods are stored in a storage area near the entrance and exit. Meanwhile, slow-moving goods are stored in a storage area further from the entrance and exit. Therefore, the redesign of the proposed layout for the damaged goods warehouse, as shown in Fig. 2 and Table 3.

**Table 3.**
The area of the shared-shared layout

| No | Area | Item stored |
|---|---|---|
| 1 | A1-A2 | whiteboard type furniture |
| 2 | B1-B5 | cabinets type furniture |
| 3 | C1-C12 | chair type furniture |
| 4 | D1-D19 | table type furniture |
| 5 | E1-E2 | PC component (CPU) |
| 6 | E3 | PC component (printers) |
| 7 | E4 | PC component (UPS) |
| 8 | E5 | PC component (monitor screen) |
| 9 | E6 | electronic goods (television) |
| 10 | E7 | electronic goods (LCD) |
| 11 | E8 | electronic goods (loudspeaker) |
| 12 | E9 | laboratory equipment |
| 13 | E10 | electronic goods (AC split) |
| 14 | E11 | electronic goods (fan) |

The placement of areas is organized based on the type of fast-moving items stored in the storage area near the entrance and exit. Meanwhile, slow-moving goods are stored in a storage area further from the entrance and exit. The distance between material handling starts from the entrance and exit to the storage area. First, the distance calculation is performed using the rectilinear distance. Then, the distance is measured along the track using orthogonal to each other to the point of each storage area. The results of the distance from each area to the entry/exit door is show in Table 4.

In the shared storage, the storage area is filled in order from the empty area closest to the exit. Code giving is also done to facilitate placement, determining the closest to the furthest storage area. After laying the storage area, measuring the distance, and assigning a code based on the closest distance to the entrance and exit, the layout for the damaged goods warehouse has been completed.

**Table 4.**
Code and storage area distance to door

| No | Storage area | Distance (m) |
|---|---|---|
| 1 | A1 | 4,01 |
| 2 | A2 | 4,61 |
| 3 | B1 | 6,12 |
| 4 | B2 | 6,82 |
| 5 | B3 | 7,52 |
| 6 | B4 | 8,22 |
| 7 | B5 | 8,92 |
| 8 | C1 | 6,02 |
| 9 | C2 | 6,47 |
| 10 | C3 | 6,49 |
| 11 | C4 | 6,94 |
| 12 | C5 | 6,96 |
| 13 | C6 | 7,41 |
| 14 | C7 | 7,43 |
| 15 | C8 | 7,88 |
| 16 | C9 | 7,9 |
| 17 | C10 | 8,35 |
| 18 | C11 | 8,37 |
| 19 | C12 | 8,82 |
| 20 | D1 | 9,33 |
| 21 | D2 | 10,53 |
| 22 | D3 | 11,73 |
| 23 | D4 | 8,73 |
| 24 | D5 | 9,93 |
| 25 | D6 | 11,13 |
| 26 | D7 | 12,33 |
| 27 | D8 | 9,33 |
| 28 | D9 | 10,53 |
| 29 | D10 | 11,73 |
| 30 | D11 | 12,93 |
| 31 | D12 | 9,93 |
| 32 | D13 | 11,13 |
| 33 | D14 | 12,33 |
| 34 | D15 | 13,53 |
| 35 | D16 | 10,53 |
| 36 | D17 | 11,73 |
| 37 | D18 | 12,93 |
| 38 | D19 | 14,13 |
| 39 | E1 | 4,72 |
| 40 | E2 | 7,72 |
| 41 | E3 | 6,24 |
| 42 | E4 | 9,24 |
| 43 | E5 | 7,77 |
| 44 | E6 | 9,29 |
| 45 | E7 | 12,29 |
| 46 | E8 | 10,82 |
| 47 | E9 | 13,82 |
| 48 | E10 | 4,6 |
| 49 | E11 | 7,6 |

### *3.3. Managerial implications*

The warehouse area is sufficient. It is just that suitable procedures are needed in placing goods so that the utilization of the area becomes more effective. The use of item codes in damaged warehouses can also simplify the process of placing goods in empty areas and provide information that facilitates the process of entering and exiting goods and collecting data. For the development of further research on improving warehouse layout, it is expected to compare two different warehouse layout methods. Thus, the advantages and disadvantages of each method can be known after application. However, a prior study about the method's suitability must be verified between the condition of the warehouse and its actual contents.

## 4. Conclusions

Based on the results obtained, it is known that the damaged-goods warehouse layout of the Faculty of Engineering, Mulawarman University is not optimal, causing ineffectiveness of the movement of goods that occur in the warehouse because the goods need to be better organized. The proposed redesign of the warehouse layout shows it is better than the previous layout. It can be seen from the placement of goods according to their classification. The effective distance between the storage area and the door also prefers the proposed layout.

Future studies must compare the proposed shared-storage layout and other well-known methods, such as Dedicated-Storage and Class-Based Storage.

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