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Facility Layout Planning Optimization in a Family Restaurant Using Systematic Layout Planning and Ergonomic Approach

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Abstract

Rasa Raga Restaurant by Gemintang is a newly established food industry located in Depok, Indonesia. To provide the best possible service to customers, it is important for restaurants to continuously improve their operations. By having an optimal facility layout, restaurants can improve their workflow and operational efficiency, and improve customer service. This study seeks to evaluate Rasa Raga Restaurant's current facility layout using systematic layout planning (SLP) to enhance process efficiency within the restaurant and ergonomic approach using Ovako Working Posture Assessment System (OWAS) posture evaluation analysis. The data were identified through on-site observations and it was found that the layout of the kitchen and bar is still not effective for workers' movement and material handling, and the space still can be optimized. Subsequently, an SLP analysis was conducted, employing Activity Relationship Chart (ARC), Activity Relationship Diagram (ARD), and Activity-Area Diagram (AAD) methodologies. Finally, a suitable layout and facilities arrangement along with the preparation table adjustable height recommendation feature was proposed to solve Rasa Raga Restaurant's problems and achieve optimization objectives. The improved layout shows that the placement between stations is made based on their relationship as analyzed in ARC and ARD. An additional feature of adjustable height applied to the preparation table has been proven to make workers' posture more comfortable when working.

Keywords
Restaurant, Facility Layout, Systematic Layout Planning, Material Handling, Ergonomic

1. Introduction
1.1 Background
The Indonesian economy grew in all sectors in 2010. Based on the distribution of Gross Domestic Product (GDP) by economic sector or field of activity at current prices, it shows the role and development of the economic structure from year to year. The three main sectors are manufacturing, agriculture, and trade, as well as hotels and restaurants, which contributed nearly 54.8% in 2010. This was caused by, among other things, an increase in the number of restaurants in Indonesia. In 2011, the Central Bureau of Statistics (BPS) recorded that there were 2,977 restaurant owners in Indonesia, which had increased by 83.3% compared to data from 2007.

In this competitive landscape of the restaurant industry, it is important for restaurants to continuously improve their operations and provide the best possible service to customers. One way to improve the restaurant's operations is by having an optimal facility layout. Inefficient layout design creates a distance route that is also not efficient. By having a well-designed layout, restaurants can have efficient workflow, proper circulation and movement, and increased customer satisfaction and loyalty.

As a result, we are motivated to research and improve the layout of Rasa Raga Restaurant, a family restaurant located in Depok, West Java, Indonesia. The restaurant can accommodate up to 250 guests, has indoor and outdoor areas, and a rooftop that is both aesthetic and functional. Rasa Raga Restaurant serves a variety of special menus made with the standards and taste of a five-star hotel that will give customers an enjoyable experience and meet their needs.

Based on the results of observations, one of the problems obtained is the customers' waiting time for their orders to be served is considered too long and needs to be reduced. Apart from the customers' perspective, there are also several problems experienced by workers, namely the ineffectiveness of worker movement due to the facilities layout in the kitchen and bar that is not designed according to material handling and the height of the food preparation table that make workers need to bend over to do their work. Therefore, this research will redesign the layout of facilities in the kitchen and bar of the restaurant and also provide recommendations for the food preparation table to provide comfort to workers in Rasa Raga restaurant.

1.2 Problem Identification
Inefficient facility layout can result in a variety of wastes in the production process. For example, the distance between raw material storage that is located too far from the food preparation table is causing the cooking process to take longer and requiring a layout redesign. The facilities layout of Rasa Raga restaurant, especially in the kitchen and the bar are suboptimal, which allocates workers' movement and time for preparing food and beverage orders to become ineffective and inefficient. The raw materials in the kitchen that are not located in one designated place also make the workers' movement when cooking ineffective. Moreover, due to the design of the material preparation table that is not ergonomic, the workers get fatigued easily and need to bend over to do their work.

1.3 Research Purpose
The researchers' purpose of a study in Rasa Raga restaurant is to achieve certain goals, which are to identify and analyze the facilities layout of the restaurant and the design of the preparation table, and to provide recommendations for effective and efficient facility layout and preparation table's height feature at Rasa Raga restaurant.

2. Literature Review
2.1 Facility Layout Planning and Material Handling
Stephens and Meyers (2013) defined facilities planning as a multi-faceted process, influenced by numerous factors and variables that are not always necessarily in concert and at times may even have a contradictory impact on the decision-making process. It is also described as the integrated planning of a product's component flow, be it goods or services, into an operational system to gain the most effective and efficient interrelation between workers, materials, machines, tools, material handling, and semi-finished goods from one part to the other (Apple 1990). It has specific objectives of facilitating the manufacturing process, minimizing material handling, maintaining flexibility of arrangement and operation, and providing employee convenience, safety, and comfort in doing the work.

While planning, one could base it on a previous layout, such as the developed model of a gas compression station which was able to reduce total pipeline cost by 21.6% (Farizal et al. 2020). Another thing to consider is material handling which is defined simply as moving material (Stephens and Meyers 2013). As its improvements could positively affect workers, new facility layout design must be planned and maintained correctly. In a paper regarding warehouse layout design, Wibowo et al. (2016) classified products into three groups, which are fast-moving, slow-moving, and idle-moving. Grouping products in such a way could help plan the most effective layout for material or in this case product movement.

2.2 Systematic Layout Planning (SLP)

Muther and Hales (2015) stated that systematic layout planning is a universal approach and a specific set of procedures to follow when planning a layout project. It rated the various activities, relationships, and alternatives involved in any layout project. It is made up of four phases, which are location, overall layout, detail layouts, and installation. Meanwhile, its pattern consisted of five sections, including an analysis of inputs and possible types of layout, establishment and visualization of relationships, analysis of the space required for process machinery and equipment necessary, adjustment modification for limitations, and evaluation of cost and intangibles which ended with approval. In a paper by Erwanda (2023) regarding the layout design of Copra factory facilities using SLP, the method produced some alternative solutions, which were then evaluated using the Arena simulation model.

2.3 Operation Process Chart

Operation Process Chart (OPC) is a diagram depicting the steps in transforming raw materials into finished goods. It includes information such as production time, materials used, and machines used. OPCs are used to identify and analyze inefficiencies in production processes.

2.4 Time Standard

Manufacturing relies on time standards to enhance efficiency and resource management, conveyed through metrics like decimal minutes, hours per unit, and pieces per hour. These standards, established by analyzing standard data, set accurate benchmarks for performance. Adhering to these standards leads to higher efficiency levels, aiding facility planning by determining the required workforce and equipment for meeting production goals (Stephens and Meyers 2013).

2.5 Activity Relationship Chart (ARC)

According to Wignjosoebroto, S., (1992), the Activity Relationship Chart is a simple method or technique in planning the layout of facilities or departments based on the level of relationship, often expressed in "qualitative" assessments and tends to be based on the subjective considerations of each facility/department. The research methodology used in this study includes data collection and analysis.

When categorizing the proximity levels of activities at a workstation, a set of guidelines using specific symbols for each proximity level has been established by Muther. These are:
A = Absolutely necessary, indicating that certain activities must be close to each other.
E = Extremely important, suggesting these activities should be situated near one another.
I = Important, denoting a preference for these activities to be located close together.
O = Ordinary, indicating no significant impact on operations regardless of where these activities are placed.
U = Unnecessary, implying no requirement for these activities to be connected in terms of placement.
X = Exclusion necessary, advising that certain activities should be kept separate from each other.

These symbols, representing various degrees of relationship, are documented along with their justifications in an Activity Relationship Chart.

2.6 Activity Relationship Diagram

Activity Relationship Diagram (ARD) is also called the affinity analysis diagram as it shows the relationship of every department, office, or service area with every other department and area (Stephens and Meyers 2013). It is a visualized diagram of the ARC. The diagram then used the same closeness codes to reflect the importance of each relationship. The codes consisted of A, E, I, O, U, and X in order of most necessary and important to least as explained in the previous section.

2.7 Area Allocation Diagram
Area Allocation Diagram (AAD) is a follow-up process step from the previous ARC in determining the level of importance between existing objects. The AAD is used to translate the ARC into a physical layout. This shows that some objects must be close to the activities of other objects, and vice versa. Therefore, it can be said that the relationship between activities affects the level of proximity between the layout of the objects.

2.8 Ergonomic Approach on Facilities and Workstation Design
Ergonomics plays a crucial role in creating effective and safe workplaces and artifacts, enhancing user comfort and safety. Prolonged use of poorly designed workstations, including kitchen tables, can lead to Musculoskeletal disorders (MSDs) such as carpal tunnel syndrome, tendonitis, and neck syndromes. The ergonomic design aims to minimize these risks (Rahman et al. 2020).

The Ovako Working Posture Assessment System (OWAS), a method conceptualized within the context of industrial ergonomics, is pivotal for creating safe and comfortable restaurant kitchen workstations. With its inception in the steel industry for evaluating postures during the repair of smelting furnaces, OWAS has evolved to address ergonomic concerns by categorizing work postures into four risk levels, from acceptable to those necessitating immediate change (Gómez-Galán et al. 2017). The combination of these categories then results in a posture code that corresponds to a certain level of action category:
Action Category 1: Postures that are acceptable as they are.
Action Category 2: Postures that are not ideal and should be looked at shortly.
Action Category 3: Postures that should be corrected as soon as possible.
Action Category 4: Postures that should be corrected immediately.

OWAS, applied in restaurant kitchens, analyzes chefs' and staff postures during tasks like chopping and cooking. Evaluating back, arms, legs, and weight handling and coding each posture helps identify ergonomic risks and develop interventions to reduce Musculoskeletal Disorders (MSDs). Proven effective in healthcare and housework, OWAS can improve kitchen workstation design, enhancing safety, ergonomics, and worker well-being, leading to better productivity (Gómez-Galán et al. 2017).

3. Methods
This study focuses on designing the effective layout for Rasa Raga Bar and Kitchen and an ergonomic design table for workers in the kitchen based on the problems analyzed in current layout. An integrated methodology of Systematic Layout Planning and OWAS Posture Evaluation is proposed. Figure 1 demonstrates the complete flow of the proposed methodology (Figure 1).

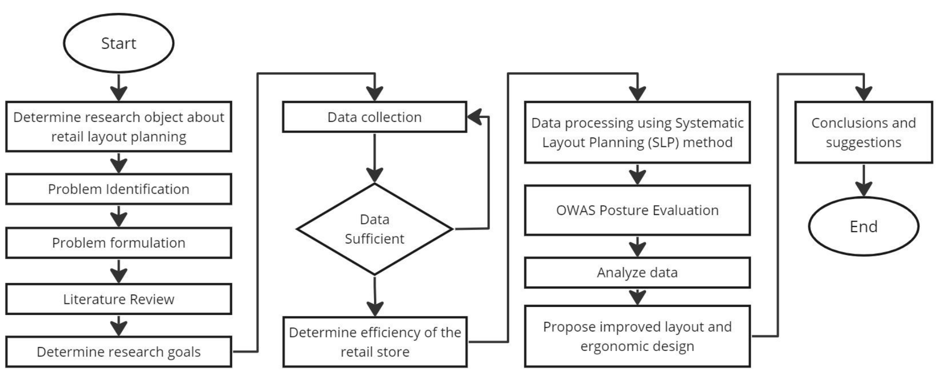


Figure 1. The Flowchart of the Proposed Methodology

4. Data Collection

4.1 Research Location

Our object of research is a family hangout place in Sawangan, Depok called Gemintang. It has a restaurant, which is called Rasa Raga, as well as several other facilities such as a library, kiosks, and a multipurpose room. In this research, we focus on the area of the restaurant, especially regarding the kitchen and coffee bar facilities.

4.2 Observation Data

4.2.1 Facility Component

In conducting this research, direct observations were made on-site to count and measure every detail of the furniture dimensions within various areas including the dining space, cashier station, kitchen, and bar. These measurements will be utilized in analyzing the results and providing recommendations for the layout design.

4.2.2 Takt Time, Standard Time, Capacity, and Efficiency

4.2.2.1 Takt Time

In our analysis, we calculate the takt time for a restaurant with a 12-hour shift or 720 minutes of production time. After deducting a 30-minute daily break, the actual work time is 690 minutes. Considering an 85% standard worker performance efficiency, the effective productive time is 586.5 minutes (690 minutes × 85%). Given the goal to produce 180 dishes per day, the takt time, which is the pace of production needed to meet customer demand, is calculated as 586.5 minutes divided by 180 dishes, resulting in a takt time of approximately 3.2583 minutes per dish. This calculation is essential for optimizing production efficiency in the restaurant.

4.2.2.2 Standard Time

Route Sheets are created for finished and processed food items. These sheets outline the sequence of steps that are necessary for customers to obtain a particular item, be it a finished good or a processed one. This sequence, known as routing, tracks the item from its initial step through subsequent stages until it is ready for customer acquisition (Stephens and Meyers 2013). The document detailing this sequence is referred to as Route Sheets. Table 1 and Table 2 express the specifics of each operation, the type of equipment used, the duration taken, and the cycle time involved in the purchasing sequence for the chosen product in the restaurant.

Table 1. Route sheet for Processed Food

Operation	Operation Description	Equipment Type	Takt Time (min/pc.)	Avg. Cycle Time (sec)	Avg. Cycle	Pc./ Hr	Hr/ Piece	Hr/ 1000 Pc.
T-2	Go to unoccupied table		3,25833	40,000	0,667	90	0,01111	11,11
O-4	Order for food or drink	Menu or Smartphone		180,000	3,000	20	0,05000	50,00
O-5	Receive the order			300,000	5,000	12	0,08333	83,33
I-2	Check the order			10,000	0,167	360	0,00278	2,78
O-6	Consuming food and drinks	Cutlery		2400,000	40	1,5	0,66667	666,67
O-7	Pay the order	Wallet or Smartphone		180,000	3,000	20	0,05000	50,00
T-3	Exit the restaurant			10,000	0,167	360	0,00278	2,78

Table 2. Route sheet for Finished Food

Operation	Operation Description	Equipment Type	Takt Time (min/pc.)	Avg. Cycle Time (sec)	Avg. Cycle	Pc./ Hr	Hr/ Piece	Hr/ 1000 Pc.
O-4	Order for food or drink	Menu or Smartphone	3,25833	180,000	3,000	20	0,05000	50,00
O-5	Receive the order			300,000	5,000	12	0,08333	83,33
O-7	Pay the order	Wallet or Smartphone		180,000	3,000	20	0,05000	50,00

4.2.2.3Efficiency

In our study, we focus on the capacity and efficiency of the Rasa Raga restaurant. The restaurant, with 10 dining tables in its indoor section, has a food production capacity of 180 dishes per day. This is calculated by multiplying the production rate of 1.5 units per hour by the 12-hour operational period and the number of tables. For efficiency, calculated as actual capacity (91 dishes per day) divided by maximum capacity (180 dishes), the restaurant operates at 50.56% efficiency. This analysis is crucial for identifying operational strengths and areas for improvement.

4.3 Existing Layout

4.3.1 Existing Rasa Raga Restaurant Layout

The existing layout design in Figure 2 is made to analyze further the improvement needed in the facility layout design.

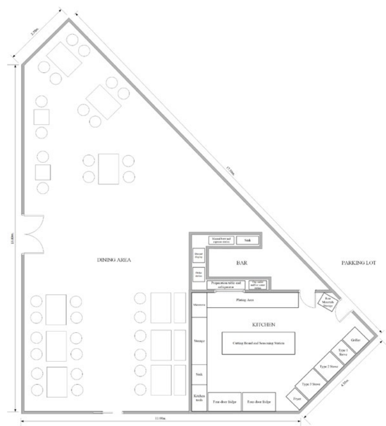


Figure 2. Existing Rasa Raga Restaurant Layout

4.3.2 Existing Layout Calculation for Area Size

The existing facilities in the restaurant are identified to calculate the total area with material flow, including the kitchen and bar as shown in Table 3.

Table 3. Kitchen and Bar Area Calculation on Existing Layout

Code	Departement	Material Flow	Area (m2)
K	Order Station	K to L	0.67
L	Raw material storage	L to M	0.6
M	Preparation Table and Refrigerator	M to N, O, P	1.08
N	Manual Brew & Espresso Station	N to P	0.36
O	Dessert Display	O to M	0.72
P	Cup Sealer and Hot Water Station	P to M	0.72
Q	Sink		0.72
Total Area with Material Flow			4.2

Code	Departement	Material Flow	Area (m2)
A	Parking LOT	A to B	1050
B	Raw material storage	B to D	0.6
C	Refrigerator	C to D, G	1.79
D	Cooking Area (Stove. Fryer. Griller)	D to E	2.16
E	Cutting Board & Seasoning Station	E to H	2.21
F	Pre-made Food Station	F to G	0.78
G	Microwave (Heating Station)	G to H	0.36
H	Plating Area		1.98
I	Sink (Dishwashing)		0.72
J	Kitchen Tools		1.08
Total Area with Material Flow			1061.68

4.4 Material Handling

4.4.1 Material Handling Cost for Iced Tea

Below are the calculations of material cost handling based on human resources. The calculations are done using the standard minimum wage of Depok City and with the assumption that there are approximately 91 portions sold within a day. The material handling cost calculation of iced tea can be seen below in Table 4.

Table 4. Material Handling Cost Calculation of Iced Tea

Material Handling Cost (Iced Tea)									
No.	**From**	**To**	**Material Handling**	**Distance (m)**	**Cost of Material Handling**	**Frequency**	**Material Handling Cost (Worker)**	**Material Handling Cost (Tools)**	**Total Material Handling Cost**
1	Parking Lot	Raw Material Storage	Man, Cart	5.00	Rp2,030	8	Rp76,981	Rp232,915	Rp309,896
2	Order Station	Preparation Table and Refrigerator	Man	0.12	Rp2,030	8	Rp1,848	Rp0	Rp1,848
3	Preparation Table and Refrigerator	Cup Sealer and Hot Water Station	Man	0.18	Rp2,030	8	Rp2,771	Rp0	Rp2,771
4	Cup Sealer and Hot Water Station	Preparation Table and Refrigerator	Man	0.18	Rp2,030	8	Rp2,771	Rp0	Rp2,771
5	Preparation Table and Refrigerator	Cup Sealer and Hot Water Station	Man	0.18	Rp2,030	8	Rp2,771	Rp0	Rp2,771
6	Cup Sealer and Hot Water Station	Preparation Table and Refrigerator	Man	0.18	Rp2,030	8	Rp2,771	Rp0	Rp2,771
7	Preparation Table and Refrigerator	Cup Sealer and Hot Water Station	Man	0.18	Rp2,030	8	Rp2,771	Rp0	Rp2,771
Total Distance				**1.02**	**Total Cost**		**Rp92,685**	**Rp232,915**	**Rp325,600**

4.4.2 Material Handling Cost for Beef Steak

Below are the calculations of material cost handling based on human resources. The calculations are done using the standard minimum wage of Depok City and with the assumption that there are approximately 91 portions sold within a day. The material handling cost calculation of beef steak can be seen below in Table 5.

Table 5. Material Handling Cost Calculation of Beef Steak

Material Handling Cost (Steak)									
No.	**From**	**To**	**Material Handling**	**Distance (m)**	**Cost of Material Handling**	**Frequency**	**Material Handling Cost (Worker)**	**Material Handling Cost (Tools)**	**Total Material Handling Cost**
1	Parking Lot	Raw Material Storage	Man, Cart	5.00	Rp5,746	8	Rp217,880	Rp232,915	Rp450,795
2	Refrigerator	Cooking Area (Stove. Fryer. Griller)	Man	0.12	Rp5,746	8	Rp5,229	Rp0	Rp5,229
3	Raw material storage	Cutting Board & Seasoning Station	Man	0.12	Rp5,746	8	Rp5,229	Rp0	Rp5,229
4	Cooking Area (Stove. Fryer. Griller)	Plating Area	Man	0.30	Rp5,746	8	Rp13,073	Rp0	Rp13,073
5	Cutting Board & Seasoning Station	Plating Area	Man	0.12	Rp5,746	8	Rp5,229	Rp0	Rp5,229
6	Pre-made Food Station	Plating Area	Man	0.18	Rp5,746	8	Rp7,844	Rp0	Rp7,844
Total Distance				**0.84**	**Total Cost**		**Rp254,484**	**Rp232,915**	**Rp487,399**

4.5 Workers

Rasa Raga restaurant has 11 employees including one restaurant captain, one cashier, two people in the barista team, and five waitresses. It also has three kitchen staff per shift, morning and night. Each employee is responsible for a specific task, allowing them to focus on their work and be more efficient. It allows the restaurant to run smoothly and gives customers a positive experience.

5. Results and Discussion

5.1 Operation Process Chart

The operation process chart of the most favorite food and beverage ordered in Rasa Raga Restaurant, namely Beef Steak and Iced Tea, respectively is made in Figure 3.

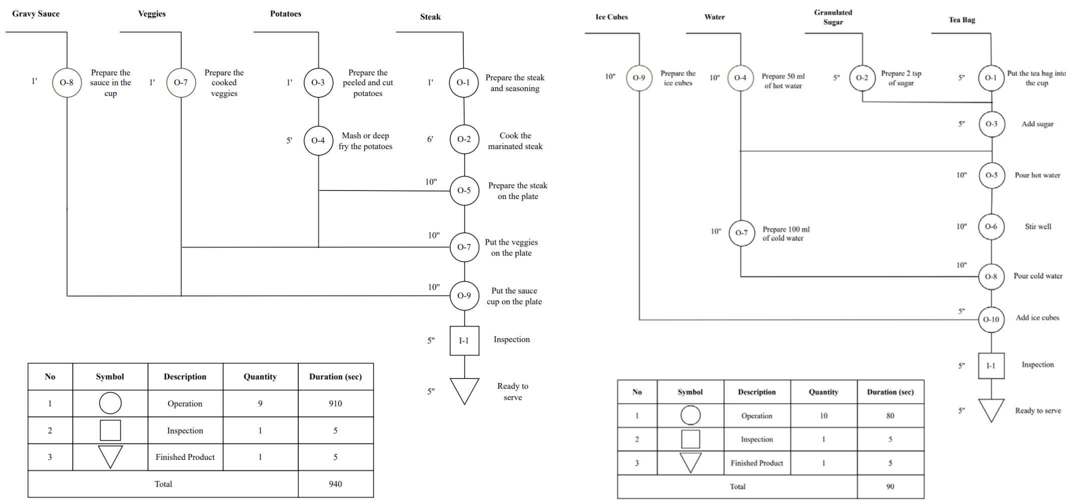
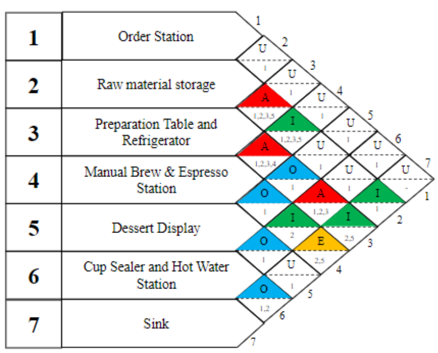


Figure 3. Operation Process Charts for Beef Steak and Iced Tea

5.2 Activity Relationship Chart (ARC)

Based on the ARC on the bar station, it can be seen the degree of proximity between the 7 locations. Each station relationship is identified through the activity relationship chart in Figure 4 The importance level codes and reasons for importance are shown in the figure below.

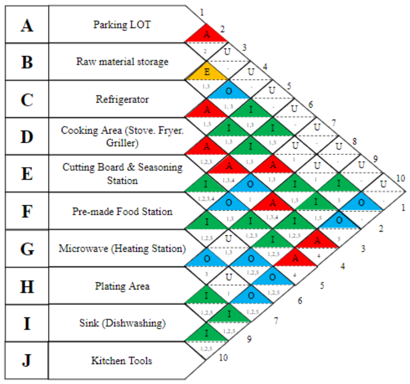


Code	Reason
A	Absolutely necessary
E	absolutely necessary
I	Important
O	Ordinary
U	Unimportant
X	Undesirable closeness

Code	Reason
1	Adjacent work order
2	Speed of worker movement
3	Material flow between two workstation
4	Use the same equipment
5	Hygine of materials or equipments used

Figure 4. Activity Relationship Chart for Iced Tea

Based on the ARC on the kitchen, it can be seen the degree of proximity between the 10 locations. Each station relationship is identified through the activity relationship chart in Figure 5. The importance level codes and reasons for importance are shown in the figure below.



Code	Reason
A	Absolutely necessary
E	absolutely necessary
I	Important
O	Ordinary
U	Unimportant
X	Undesirable closeness

Code	Reason
1	Adjacent work order
2	Speed of worker movement
3	Material flow between two workstation
4	Use the same equipment
5	Hygine of materials or equipments used

Figure 5. Activity Relationship Chart for Beef Steak

5.3 Activity Relationship Diagram (ARD)

ARD is used as supporting data for the location of the proximity of workstations which is depicted with boxes and descriptions in the existing Rasa Raga Restaurant Layout. Detailed Activity Relationship Diagram (ARD) of the bar and the kitchen can be seen in Figure 6 and Figure 7, equipped with a material flow path from one workstation to another, indicated by a red arrow.

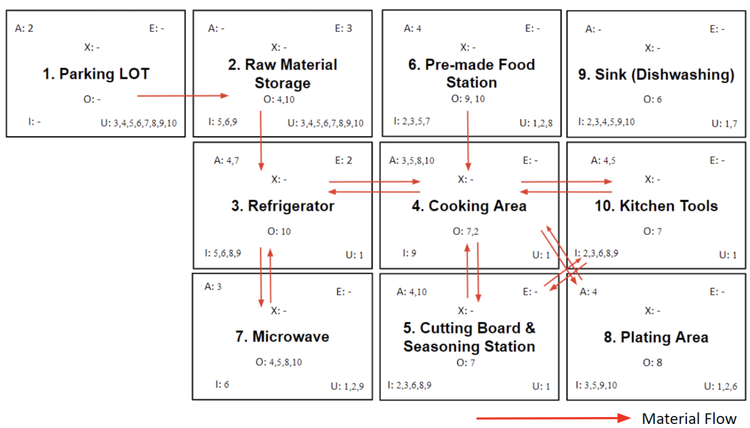


Figure 6. Kitchen Activity Relationship Diagram (ARD)

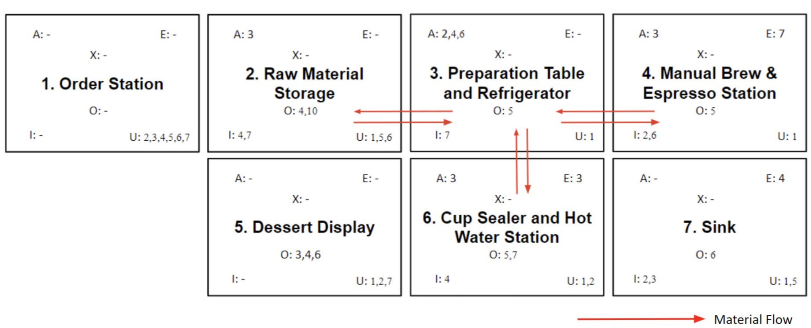


Figure 7. Bar Activity Relationship Diagram (ARD)

5.4 Area Allocation Diagram (AAD)

In Figure 8, the design of the Area Allocation Diagram (AAD) of Rasa Raga Restaurant is an initial description of the proposed facility layout, where this layout combines the ARD and ARC for the proximity between every department in the restaurant.

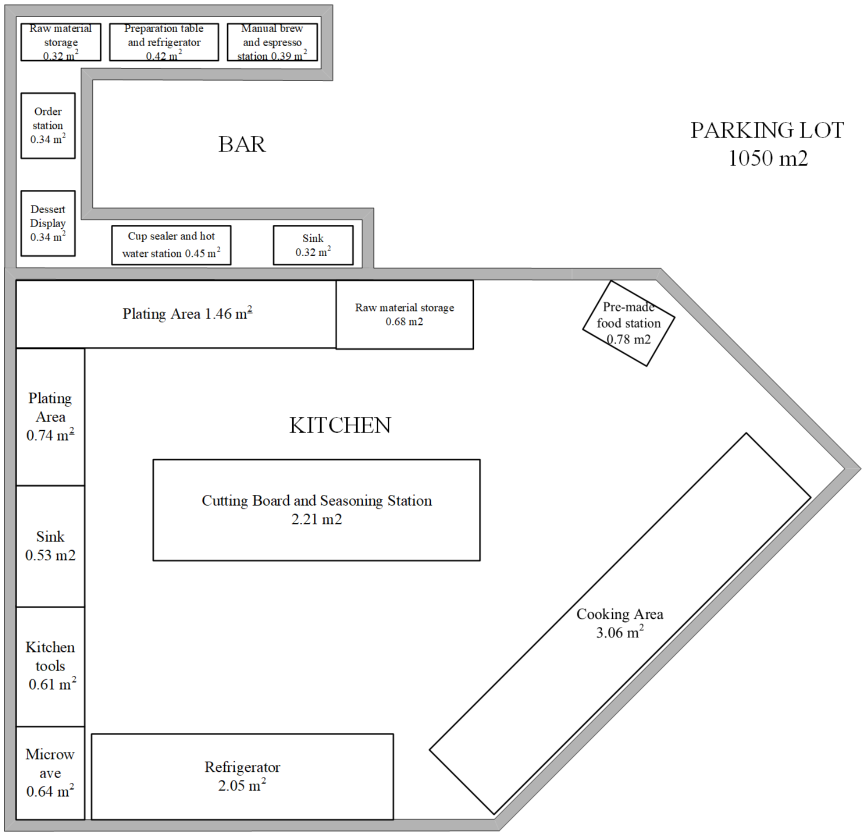


Figure 8. Rasa Raga Restaurant Area Allocation Diagram (AAD)

5.5 OWAS (Ovako Working Posture Assessment System) Posture Evaluation

The researchers used Jack Human Simulation software to recreate the kitchen environment in Figure 9 and evaluate the ergonomic posture analysis of the workers at Rasa Raga Restaurant using OWAS method. The OWAS analysis results in Figure 9 show a score of three. This indicates that the work posture may have harmful effects on the musculoskeletal system. Therefore, improvements are needed to the design of the preparation table used by the workers to improve worker efficiency and prevent fatigue.

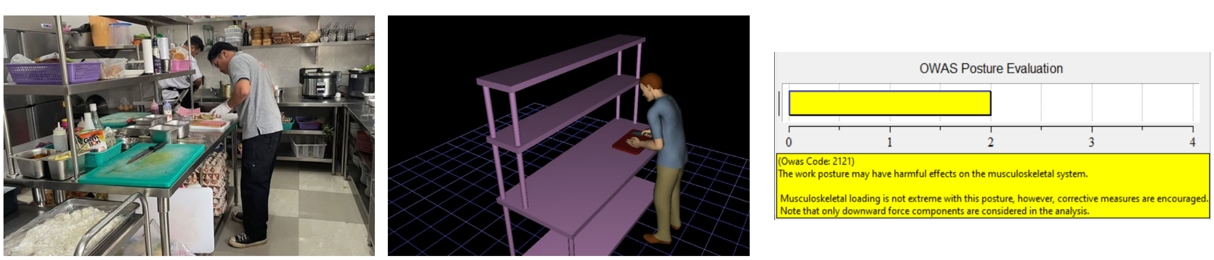


Figure 9. A worker prepares food in the kitchen and OWAS Posture Evaluation Using Jack Human Simulation Software

5.6 Proposed Improvement

5.6.1. Proposed Layout Improvement

After implementing ARC, ARD, and AAD according to the flow of Systematic Layout Planning, the researchers proposed a new layout improvement that can be implemented by Rasa Raga Restaurant to meet the optimization goals. Based on these three factors, researchers can determine the optimal layout for the new space, considering both employee activity and material flow. The bar and kitchen layout recommendations, including new workstation proximity and area, can be seen in Figure 10 and Figure 11.

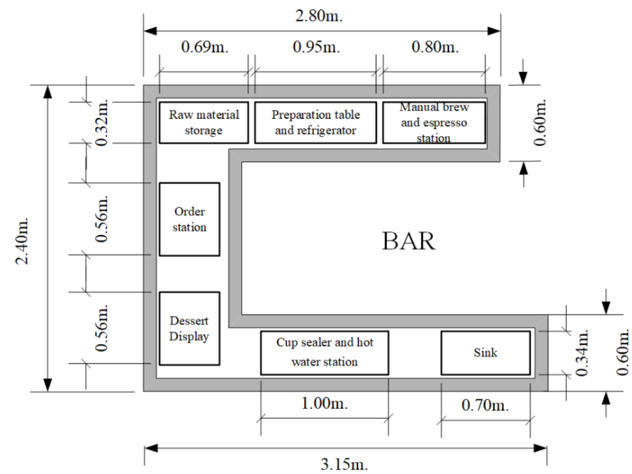


Figure 10. Recommendation for Bar Layout

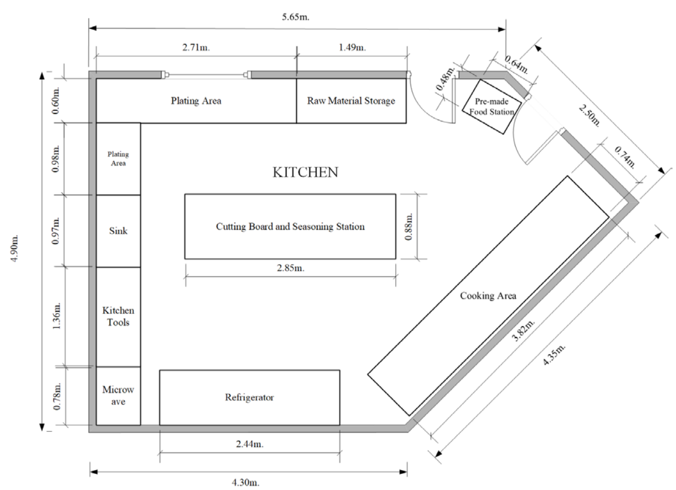


Figure 11. Recommendation for Kitchen Layout

5.6.2. Proposed Ergonomic Design

After conducting a postural analysis using the OWAS method, it is necessary to improve the design of the preparation table. The researchers suggest an adjustable height feature to accommodate workers with the body height of percentiles 5%, 50%, and 95%. This adjustable feature could make the workers change the preparation table's height to the range of 110–130 cm. This recommendation has been shown to reduce the likelihood of musculoskeletal disorders in workers during the food preparation process, which leads to increased effectiveness and reduces fatigue in workers. Below is the result of the analysis using Jack Human Simulation software after the implementation of the adjustable height feature on the preparation table at Rasa Raga Restaurant in Figure 12. The OWAS posture score decreases to one, meaning the work posture seems normal and natural for the workers.

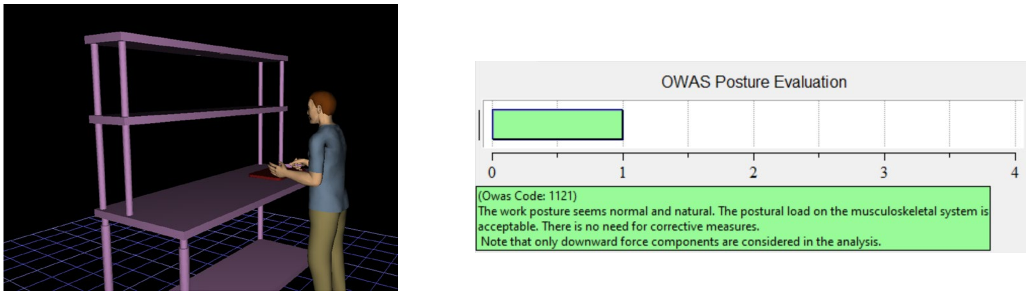


Figure 12. OWAS Posture Evaluation After Improvement Using Jack Human Simulation Software

6. Conclusion

Facilities planning is a multifaceted process that is influenced by numerous factors and variables which can be done through several methods. In this paper, the researchers considered systematic layout planning, which is realized by the application and analysis of OPC, time standards, ARC, ARD, and AAD to create an optimal layout plan. We also analyze the ergonomics of the workers to improve their work by using the OWAS method. These methods then resulted in the recommendation layout, which changes the placement of stations to put them closer to another station they shared a closer relationship with by following the result we have gotten from the ARC and ARD analysis and was then visualized in the AAD. Another recommendation is for the preparation table to have an adjustable height feature to make workers' posture more comfortable when working. Further research could be done on the restaurant to validate this recommendation and continuously improve the conditions of the restaurant.

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