REDESIGN OF FACILITIES LAYOUT USING COMPUTERIZED RELATIONSHIP PLANNING (CORELAP) AND COMPUTERIZED RELATIVE ALLOCATION OF FACILITIES TECHNIQUES (CRAFT) METHODS

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ABSTRACT

The Barokah Jaya Snack Industry is an MSME engaged in the manufacture of jipang rice and popcorn. Based on the results of direct observation, it is known that the main problem is operator complaints in picking up raw materials that are often used too far away and the placement is not close together so that the distance becomes long. This research looks for alternative solutions to problems in the scope of production in the Barokah Jaya Snack Industry, by making redesign proposals using the CORELAP (Computerized Relationship Layout Planning) and CRAFT (Computerized Relative Allocation of Facilities Technique) methods. The total displacement moment in the design using the CORELAP method is 1,978.75 meters/month, and in the design using the CRAFT method is 1,755.8 meters/month. The Material Handling Cost (OMH) for the design using the CORELAP method is Rp. 811,288/month and the design using the CRAFT method is Rp. 719,892/month. The layout resulting from the CORELAP method provides a material flow efficiency of 45.88% against the initial layout and the layout resulting from the CRAFT method provides a material flow efficiency of 51.98%. The selected layout recommendation has a total material displacement moment that is smaller than the initial layout and the smallest among the other alternative layouts. The selected layout is the layout designed using the CRAFT method, which is 1,755.8 meters/month increasing the efficiency of material flow by 51.98% and saving material transfer costs of Rp. 778,146/month.

Keywords CORELAP; CRAFT; Facility layout; Material Handling Cost
Paper type Research paper

INTRODUCTION

In an industry, facility layout is one of the main foundations in increasing productivity from the running of production process activities in the company. The layout of the facility itself is one of the factors that plays an important role in increasing efficiency in a company. A company must be able to have the right production system so that its products are of high quality and accessible to customers. The decision to meet these consumer needs includes a good and proper facility layout. The Barokah Jaya Snack Industry is an MSME engaged in the manufacture of jipang rice and popcorn. Based on the results of direct observations in the field, it is known that the main problem is operator complaints in taking raw materials that are often used too far away and the placement is not close together so that the distance becomes long. The very high moment of material movement is caused by the inaccurate location arrangement between stations. This high moment of material movement is caused by stations that have a close relationship but are located far apart. This research looks for alternative solutions to problems in the scope of production in the Barokah Jaya Snack Industry, by making redesign proposals using the CORELAP (Computerized Relationship Layout Planning) and CRAFT (Computerized Relative Allocation of Facilities Technique) methods. Area allocation using the CORELAP method is carried out by placing areas one by one that have a relationship with the previous area, so that you can find out the condition of the existing layout to get good layout efficiency. In the allocation using the CRAFT method by exchanging stations in the initial layout conditions to obtain a more appropriate solution based on the activity relationship map. So for the next exchange it is done by looking for layout conditions to obtain the shortest material handling distance.

METHOD

In the research method there are five stages that need to be carried out, namely the preliminary stage which consists of field studies, problem identification, problem formulation, research objectives and literature study. The next stage is the data collection stage which is divided into two, namely primary data and secondary data. Next is the data processing stage using the CORELAP method and the CRAFT method. The next stage is analysis and discussion. And the last stage are conclusions and suggestions.

Data Processing and Collection

Barokah Jaya Snack Industry has 6 work stations that are used to make jipang products. The following is a data table for the size of each station and its coding.

TABLE I. DATA ON THE SIZE OF EACH WORK STATION AND WORK STATION CODE

Work Station	Area Size		Wide (m²)	Code
	Length (m)	Width (m)		
Raw Material Warehouse	3,2	3	9,6	A
Oven	3	1,2	3,6	B
Fying	1,4	1	1,4	C
Cutting	2,8	1,5	4,2	D
Packaging	3,7	2,7	9,99	E
Gluing	2,5	2,2	5,5	F

Initial Layout

The initial production floor layout can be described in Block Layout.

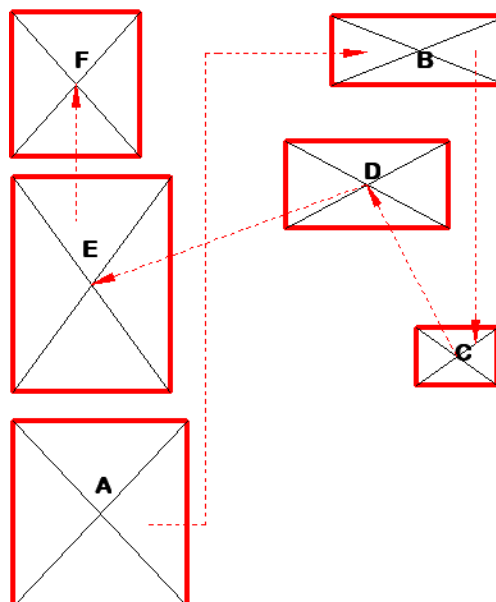Figure 1. Initial Block Layout

Calculation of Initial Block Layout Coordinate Points

Calculation of coordinates serves to determine the distance between work stations. To determine the value of the initial block layout coordinates for the Barokah Jaya Snack Industry, it is assisted by using the AutoCad version 2014 software. The coordinate values for each work station can be seen in the following table.

TABLE II. COORDINATE VALUE OF EACH WORK STATION

Work Station	Coordinate Value	
	X	Y
A	1,5	1,6
B	6,99	9,61
C	7,65	4,32
D	6,1	7,29
E	1,35	5,56
F	1,08	9,03

Calculation of Distance Between Work Stations

To calculate the distance between work stations, the rectilinear distance formula is used. The rectilinear distance formula is as follows.

$$dij = |Xi - Xj| + |Yi - Yj| \qquad (1)$$

The results of calculating the overall distance between stations for the initial layout can be seen in the following table.

TABLE III. DISTANCE BETWEEN PRELIMINARY LAYOUT WORKSTATIONS

	A	B	C	D	E	F
A		13,5	8,87	10,29	3,81	7,01
B	13,5		4,63	3,21	9,69	6,49
C	8,87	4,63		1,42	5,06	1,86
D	10,29	3,21	1,42		6,48	3,28
E	3,81	9,69	5,06	6,48		3,2
F	7,01	6,49	1,86	3,28	3,2	

Determination of the Frequency of Material Movement for Each Work Station

The frequency of moving material between work stations is obtained by calculating the average production for one month divided by the transport/transfer capacity of each product. The following table summarizes the frequency of material movement between work stations.

TABLE IV. FREQUENCY OF MATERIAL MOVEMENT BETWEEN WORK STATIONS

No	Starting Station	Destination Station	Number of Operators (people)	Movement Frequency (times/month)
1	A	B	1	125
2	B	C	1	125
3	C	D	1	125
4	D	E	1	125
5	E	F	1	125

Calculation of the Total Moment of Material Movement in the Initial Layout

The frequency of material movement between each work station in the Barokah Jaya Snack Industry can be seen in the following table. Calculation of the moment of displacement is carried out by the following formula.

$$Z_{A-B} = f_{A-B} \; x \; d_{A-B} \qquad (2)$$

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The following table calculates the total moment of movement at each work station in the Barokah Jaya Snack Industry.

TABLE V. MOMENTS OF TRANSFER OF MATERIALS BETWEEN STATIONS

No	Starting Station	Destination Station	Movement Frequency (times)	Station Distance	Displacement Moment (meter/month)
1	A	B	125	13,5	1687,5
2	B	C	125	4,63	578,75
3	C	D	125	1,42	177,5
4	D	E	125	6,48	810
5	E	F	125	3,2	400
			Total		3653,75

Calculation of the Total Cost of Material Handling in the Initial Layout

The process of moving material handling is done manually or by using human power, so the calculation of human or labor costs is obtained using the components of the worker's salary.

Operator salary per month is Rp. 1.500.000

Effective working days in one month is 25 days

- Operator salary per day $= \frac{1.500.000}{25} =$ Rp. 60.000
- Movement distance per day $= \frac{\Sigma\ Momen\ Perpindahan}{25\ days} = \frac{3.653,75}{25} = 146,15$ m/days
- Human cost per meter $= \frac{Salary\ per\ day}{Moving\ distance\ per\ day} = \frac{60.000}{146,15} =$ Rp. 410/m

An example of calculating the total cost of material handling from work station A to work station B.

The frequency of switching from A to B = 125 times/month

The distance traveled from A to B   = 13,5 m

OMH from A to B   = Rp. 410/m

The total cost of material handling from A to B is

OMH = Frequency x Distance x Human Cost per meter

OMH = 125 x 13,5 m x Rp. 410/m

OMH = Rp. 691.875

The following table calculates the total cost of material handling at each work station in the Barokah Jaya Snack Industry.

TABLE VI. MATERIAL HANDLING COSTS IN THE INITIAL LAYOUT

No	Starting Station	Destination Station	Movement Frequency (times)	Station Distance	Material Handling Cost (Rp/m)	Total Material Handling Cost (Rp/m)
1	A	B	125	13,5	410	Rp. 691.875
2	B	C	125	4,63	410	Rp. 237.288
3	C	D	125	1,42	410	Rp. 72.775
4	D	E	125	6,48	410	Rp. 332.100
5	E	F	125	3,2	410	Rp. 164.000
			Total			Rp. 1.498.038

Data Processing Using the Corelap Method

The calculation of the CORELAP method uses the proximity relationship expressed by the Total Closeness Rating (TCR) as the basis for calculating the choice of work station placement. Data Activity Relationship Chart (ARC) is then converted into numbers with a ranking based on the TCR value.

TABLE VII. DETERMINATION OF RELATIONSHIP LEVEL ACTIVITY RELATIONSHIP CHART

	Degree of Closeness	Description	Total Closeness Rating
A	*Absolutely Necessary*	Absolute need to be brought closer	5
E	*Especially Important*	Very important close	4
I	*Important*	It's important to be close	3
O	*Ordinary*	Usually close	2
U	*Unimportant*	No need to get closer	1
X	*Indesirable*	Not expected closer	0

The following is a recapitulation table of the Activity Relationship Chart for each work station in the Barokah Jaya Snack Industry.

TABLE VIII. RECAPITULATION OF ACTIVITY RELATIONSHIP CHART

	A	B	C	D	E	F
A		A	U	U	U	O
B	A		A	U	U	U
C	U	A		A	U	U
D	U	U	A		A	O
E	U	U	U	A		A
F	O	U	U	O	A	

The next step is to convert the ARC value according to the predefined TCR value. The following table summarizes the results of the conversion of TCR values.

TABLE IX. CALCULATION OF TCR VALUE

No	Starting Station	Destination Station	ARC Code	TCR Value
1	A	B	A	5
2	B	C	A	5
3	C	D	A	5
4	D	E	A	5
5	E	F	A	5

The following is a table of TCR values for all work stations in the Barokah Jaya Snack Industry.

TABLE X. TCR VALUES FOR ALL WORK STATIONS

	A	B	C	D	E	F	Luas (m^2)	A	E	I	O	U	X	TCR
A		A	U	U	U	O	12,58	1	0	0	1	3	0	10
B	A		A	U	U	U	9,28	2	0	0	0	3	0	13
C	U	A		A	U	U	1,4	2	0	0	0	3	0	13
D	U	U	A		A	O	4,2	2	0	0	1	2	0	14
E	U	U	U	A		A	13,65	2	0	0	0	3	0	13
F	O	U	U	O	A		8,1	1	0	0	2	2	0	11
			Total					10	0	0	4	16	0	74

The steps for working on the CORELAP method manually are as follows:

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Determination of Allocation Sequence

a. Select a station that has the highest TCR value. If there are two stations that have the same highest TCR value, first select the station that has the larger area then, if the area is the same, then select the station with the lowest number. Station D is the station with the highest TCR value, so the station is placed at the center of the layout.

b. The next station allocated is the station that has a relationship A or E with the previously selected station. If there are several stations, then choose the highest TCR value. Station D has a link A to stations C and E, with the same TCR value. Between the two stations, station C was chosen to be allocated second because it has the smallest station number.

c. The third allocated station is the station that has an A or E relationship with the first and second selected stations. Stations C and E have relationship A with the first selected station, and have the same TCR value. Then the third station to be allocated is station E.

d. For the allocation of the next selected station that has a relationship A, E, I, O, U with the second and third selected stations. Station B has link A with the second selected station. Then the fourth station to be allocated is station B.

e. For the allocation of the next selected station that has a relationship A, E, I, O, U with the third and fourth selected stations. Station F has link A with the third selected station. Then the fifth station to be allocated is station F.

f. For the allocation of the last selected station that has a relationship A, E, I, O, U with the fourth and fifth selected stations. Station A has relationship A with the fourth selected station. Then the sixth or last station to be allocated is station A.

TABLE XI. ORDER OF WORK STATION ALLOCATION

	A	B	C	D	E	F	A	E	I	O	U	X	TCR	Sequence
A		A	U	U	U	O	1	0	0	1	3	0	10	6
B	A		A	U	U	U	2	0	0	0	3	0	13	4
C	U	A		A	U	U	2	0	0	0	3	0	13	2
D	U	U	A		A	O	2	0	0	1	2	0	14	1
E	U	U	U	A		A	2	0	0	0	3	0	13	3
F	O	U	U	O	A		1	0	0	2	2	0	11	5

Method of Allocation

Allocation is done using the western edge method. The station selected to be allocated first is placed in the center of the box diagram as shown below.
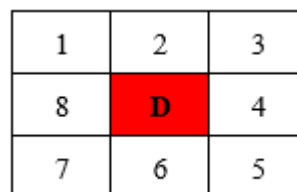

Figure 2. Work Station Placement Diagram

Number 1 is always for the location (box) on the west side of the allocated stations. The box is right next to the station that has been allocated in a vertical or horizontal direction, which has full weight according to the proximity value of the location to be determined and the previous location. The box that is right next to the station that has been allocated in a diagonal direction has a weight of 0.5 x the proximity value of the location to be determined and the previous location. positions 1, 3, 5 and 7, are fully contiguous with number 0 (initial) and positions 2, 4, 6 or 8, partially contiguous. Positions 1, 3, 5 and 7 are the newly placed stations based on the largest Weighted Placement (WP). For each WP position is the sum of the numerical values of each pair of adjacent stations. After all placement of CORELAP calculation locations for all work stations, the iteration stops. The following is a layout design generated using the CORELAP method.
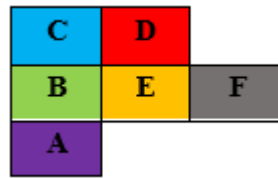
Figure 3. CORELAP Layout Results

Calculation of The Coordinate Points of the Iteration of the Corelap Method

The coordinate values of each work station can be seen in the following table.

TABLE XII. COORDINATE VALUES OF EACH CORELAP ITERATION WORK STATION

Work Station	Coordinate Value	
	X	Y
A	1,5	1,6
B	1,49	5,51
C	0,69	7,57
D	4,62	8,05
E	4,57	5,11
F	7,25	5,7

Calculation of Distance Between Work Stations with the Corelap Method

The distance between work stations is calculated using the rectilinear distance formula. The following table shows the results of calculating the overall distance between stations for the layout using the CORELAP method.

TABLE XIII. DISTANCE BETWEEN WORK STATIONS USING THE CORELAP METHOD

	A	B	C	D	E	F
A		3,9	5,16	9,57	6,58	9,85
B	3,9		1,26	5,67	2,68	5,95
C	5,16	1,26		4,41	1,42	4,69
D	9,57	5,67	4,41		2,99	0,28
E	6,58	2,68	1,42	2,99		3,27
F	9,85	5,95	4,69	0,28	3,27	

Calculation of Total Moments of Material Movement with the Corelap Method

Calculation of the total moment of movement as a result of iterations using the CORELAP method at each work station in the Barokah Jaya Snack Industry can be seen in the following table.

TABLE XIV. TOTAL MOMENTS OF MATERIAL MOVEMENT BETWEEN WORK STATIONS RESULT OF CORELAP METHOD ITERATION

No	Starting Station	Destination Station	Movement Frequency (times)	Station Distance	Displacement Moment (meter/month)
1	A	B	125	3,9	487,5
2	B	C	125	1,26	157,5
3	C	D	125	4,41	551,25
4	D	E	125	2,99	373,75
5	E	F	125	3,27	408,75
		Total			1978,75

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Calculation of the Total Cost of Material Handling with the Corelap Method

Calculation of the total cost of material handling results of iterations using the CORELAP method at each work station in the Barokah Jaya Snack Industry can be seen in the following table.

TABLE XV. TOTAL COST OF MATERIAL HANDLING RESULT OF CORELAP METHOD ITERATION

No	Starting Station	Destination Station	Movement Frequency (times)	Station Distance	Material Handling Cost (Rp/m)	Total Material Handling Cost (Rp/m)
1	A	B	125	3,9	410	Rp. 199.875
2	B	C	125	1,26	410	Rp. 64.575
3	C	D	125	4,41	410	Rp. 226.013
4	D	E	125	2,99	410	Rp. 153.238
5	E	F	125	3,27	410	Rp. 167.588
		Total				Rp. 811.288

Data Processing Using the Craft Method

CRAFT is a repair method. This method seeks the optimum design by gradually improving the layout. CRAFT evaluates the layout by swapping workstation locations.

Determination of the Distance of Material Movement Between Work Stations

Determination of the distance between work stations in the Snack Food Industry using Euclidean distance. Euclidean distance is the distance measured between one station center and another station center.

TABLE XVI. DETERMINATION OF COORDINATE POINT VALUES FOR EACH WORK STATION

Work Station	Coordinate Value	
	X	Y
A	1,5	1,6
B	6,99	9,61
C	7,65	4,32
D	6,1	7,29
E	1,35	5,56
F	1,08	9,03

The euclidean distance formula is as follows.

$$dij = \sqrt{[(Xi - Xj)^2 + (Yi - Yj)^2]} \qquad (3)$$

Example of calculation from Station A (1.5;1.6) to Station B (6.99;9.61)

$dij = \sqrt{[(Xi - Xj)^2 + (Yi - Yj)^2]}$

A-B $= \sqrt{[(1,5 - 6,99)^2 + (1,6 - 9,61)^2]}$

A-B $= \sqrt{[(-5,49)^2 + (-8,01)^2]}$

A-B $= \sqrt{[30,1401 + 64,1601]}$

A-B $= 3,07$

The following table calculates the distance using the Euclidean distance formula.

TABLE XVII. CALCULATION OF MATERIAL MOVEMENT DISTANCE BETWEEN WORK STATIONS

From		To		Distance (m)
Work Station	Code	Work Station	Code	
Raw Material Warehouse	A	Oven	B	3,07
Oven	B	Frying	C	5,33
Frying	C	Cutting	D	3,35
Cutting	D	Packaging	E	5,06
Packaging	E	Gluing	F	3,48

Determination of the Total Distance of Material Movement Between Work Stations

The total distance of material movement is obtained from the distance x frequency. Determining the frequency of moving material needs to consider the average production per month and also the capacity to move material. The following table shows the results of calculating the total distance of

TABLE XVIII. TOTAL DISTANCE OF MATERIAL MOVEMENT BETWEEN WORK STATIONS

From		To		Distance (m)	Frequency	Total Distance/Month
Work Station	Code	Work Station	Code			
Raw Material Warehouse	A	Oven	B	3,07	125	383,75
Oven	B	Frying	C	5,33	125	666,25
Frying	C	Cutting	D	3,35	125	418,75
Cutting	D	Packaging	E	5,06	125	632,5
Packaging	E	Gluing	F	3,48	125	435

Determination of the From to Chart Matrix

The determination of the From to Chart matrix is by inputting the total distance between work stations. The following table From to Chart the moment of distance in the Barokah Jaya Snack Industry.

TABLE XIX. FROM TO CHART THE MOMENT OF DISTANCE IN THE BAROKAH JAYA SNACK INDUSTRY

From to	From to Chart					
	A	B	C	D	E	F
A		383,75				
B			666,25			
C				418,75		
D					632,5	
E						435
F						

Furthermore, the From to Chart data obtained will be used as input for calculations using the CRAFT method. Input is done manually with the help of Microsoft Excel. After inputting, the resulting layout design will appear, along with the results of the layout design from the input using the CRAFT method.

Figure 4. Initial layout of CRAFT calculation results

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Department	Color	Area-require	Area-defined	x-centroid	y-centroid	Sequence
Gudang Bahan Baku	1	13	13	1,42307687	2,19230771	1
Oven	2	10	10	1,5	6	2
Penggorengan	3	2	2	1,5	8	3
Pemotongan	4	5	5	3,5	8,5	4
Packaging	5	14	14	4,42857122	5,64285707	5
Perekatan	6	9	9	4,5	1,83333337	6

Figure 5. Layout legend of CRAFT calculation results

Calculation of the Coordinate Points of the Craft Method Iteration Results

The coordinate values of each work station can be seen in the following table.

TABLE XX. COORDINATE VALUE OF EACH WORK STATION LAYOUT RESULTS OF THE CRAFT METHOD

Work Station	Coordinate Value	
	X	Y
A	1,42	2,19
B	1,5	6
C	1,5	8
D	3,5	8,5
E	4,43	5,64
F	4,5	1,83

Calculation of Distance Between Work Stations with the Craft Method

To calculate the distance between work stations, the rectilinear distance formula is used. The results of calculating the overall distance between stations for the iteration layout using the CRAFT method can be seen in the following table.

TABLE XXI. CALCULATION OF TOTAL DISTANCE BETWEEN WORK STATIONS CRAFT METHOD CALCULATION RESULTS

	A	B	C	D	E	F
A		3,88				
B	3,88		2			
C		2		2,5		
D			2,5		1,93	
E				1,93		3,74
F					3,74	

Calculation of Total Moments of Material Movement with the Craft Method

Calculation of the total moment of movement as a result of iterations using the CRAFT method at each work station in the Barokah Jaya Snack Industry can be seen in the following table.

TABLE XXII. CALCULATION OF THE TOTAL MOMENT OF MATERIAL MOVEMENT CRAFT METHOD CALCULATION RESULTS

No	Starting Station	Destination Station	Movement Frequency (times)	Station Distance	Displacement Moment (meter/month)
1	A	B	125	3,88	485
2	B	C	125	2	250
3	C	D	125	2,5	313
4	D	E	125	1,9	241,1
5	E	F	125	3,74	467,3
	Total				1755,8

Calculation of the Total Cost of Material Handling with the Craft Method

Calculation of the total cost of material handling results of iterations using the CRAFT method at each work station in the Barokah Jaya Snack Industry can be seen in the following table.

TABLE XXIII. TOTAL COST OF MATERIAL HANDLING RESULT OF CRAFT METHOD ITERATION

No	Starting Station	Destination Station	Movement Frequency (times)	Station Distance (m)	OMH (Rp/m)	Total OMH (Rp/m)
1	A	B	125	3,88	410	Rp. 198.850
2	B	C	125	2	410	Rp. 102.500
3	C	D	125	2,5	410	Rp. 128.125
4	D	E	125	1,93	410	Rp. 98.839
5	E	F	125	3,74	410	Rp. 191.577
	Total					Rp. 719.892

ANALYSIS AND DISCUSSION

Analysis

Elaboration on Analysis of Layout Design Results using the CORELAP and CRAFT methods. Comparison of layout design is done by comparing the total moment of displacement and the total cost of material handling as a reference. The total initial layout moments and the initial total material handling costs are compared with the total material handling moments and total costs resulting from the CORELAP and CRAFT methods. Based on these two methods, the total displacement moment that produces the largest correction value and the smallest total material handling cost is selected as the proposed improvement layout.

In the initial conditions, the Barokah Jaya Snack Industry layout has a total displacement moment of 3,635.75 meters/month. Meanwhile, the total cost of material handling (OMH) in the initial layout is Rp. 1,498,038/month. In the results of the layout design using the CORELAP method for the Barokah Jaya Snack Industry, the total moment of displacement is 1,978.75 meters/month and the total material handling cost is Rp. 811,288/month. In the results of the layout design using the CRAFT method for the Barokah Jaya Snack Industry, the total moment of displacement is 1,755.8 meters/month and the total material handling cost is Rp. 719,892/month.

Discussion

From the results of the analysis of the moment of material movement using the CORELAP method and the CRAFT method, the next step is to select the best layout that will be used as a proposed layout design for the Barokah Jaya Snack Industry. The following table compares the results of layout calculations using the CORELAP method and the CRAFT method.

TABLE XXIV. COMPARISON OF LAYOUT RESULTS

No.	Layout Design Results	Total Moment of Displacement (meters/month)	Total OMH (Rp/month)	Efficiency (%)	Cost Savings (Rp/month)
1	CORELAP Method	1978,75	811.288	45,88	686,750
2	CRAFT Method	1755,8	719.892	51,98	778.146

From the table above it is found that the best layout is an alternative layout using the CRAFT method which has the smallest total material handling moments and total material handling costs of 1755.8 meters/month and Rp. 719,892/month. When compared with the initial layout at the Barokah Jaya Snack Industry, the layout design using the CRAFT method increases material flow efficiency by 51.98% and material transfer cost savings of Rp. 778,146/month.

CONCLUSION

1. The total moment of movement in the Barokah Jaya Snack Industry in the current initial layout is 3,635.75 meters/month.
2. The Material Handling Cost (OMH) for the Barokah Jaya Snack Industry in the current initial layout is Rp. 1,498,038/month.
3. The total moment of movement in the Barokah Jaya Snack Industry, the design using the CORELAP method is 1,978.75 meters/month, and the design using the CRAFT method is 1,755.8 meters/month.
4. Cost of Material Handling (OMH) design using the CORELAP method of Rp. 811,288/month and the design using the CRAFT method is Rp. 719,892/month.
5. The layout resulting from the CORELAP method provides a material flow efficiency of 45.88% against the initial layout and the layout resulting from the CRAFT method provides a material flow efficiency of 51.98%.
6. The selected layout recommendation has a smaller total material displacement moment than the initial layout and the smallest among the other alternative layouts. The selected layout is the layout designed using the CRAFT method, which is 1,755.8 meters/month increasing the efficiency of material flow by 51.98% and saving material transfer costs of Rp. 778,146/month.

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