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Facility Layout Redesign to Improve Material Handling Efficiency in Colored Stone Production at PT Tatalogam Lestari

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Abstract

Facility layout efficiency and material handling are important for improving manufacturing performance. An inappropriate layout can increase material travel distance, movement frequency, and Material Handling Cost (MHC). This study aims to redesign the facility layout for the colored stone production process at PT Tatalogam Lestari and evaluate its impact o?n material travel distance and MHC. A quantitative approach was applied using field observations, interviews, facility measurements, and material movement data. The redesign employed the Activity Relationship Chart (ARC), Total Closeness Rating (TCR), and Blocplan methods, while material travel distance was calculated using the rectilinear distance approach. The results show that the proposed layout reduced material travel distance from 30,019.18 to 27,057.64 meters/day, a reduction of 2,961.54 meters/day or 9.87%. MHC decreased from IDR 1,395,846.49 to IDR 1,155,276.42/day, generating savings of IDR 240,570.07/day or 17.23%. The proposed layout improves material handling efficiency and operational cost performance.

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1. Introduction

Increasing competition in the manufacturing industry requires companies to improve operational efficiency and productivity through optimal resource management. Production efficiency is not only determined by the ability to achieve production targets but also by the effectiveness of managing production facilities, workspaces, materials, labor, and material movement activities. One important aspect supporting operational efficiency is facility layout. An inappropriate facility layout can create unnecessary material movements, increase travel distances, and ultimately contribute to higher operating costs.

Facility layout represents the physical arrangement of production facilities, storage areas, equipment, and workspaces to support the continuity of production processes and material flow. An effective layout can reduce material travel distance, improve material flow, optimize space utilization, and minimize non-value-added activities. Muslim and Ilmaniati (2018) demonstrated that facility layout improvement can optimize material travel distance and reduce material handling costs. Adiasa et al. (2020) also found that facility layout redesign using a systematic approach could improve the arrangement of production facilities and support more efficient material flow. These findings indicate that facility layout is not merely a spatial arrangement problem but also an operational decision that directly affects production efficiency.

Material handling is closely related to facility layout because material movement occurs between production facilities throughout the manufacturing process. Material travel distance and movement frequency are important factors influencing material handling efficiency and operational costs. Daya et al. (2022) showed that facility layout redesign using Blocplan could provide alternative arrangements to improve facility positioning and material flow. Similarly, Gunanti et al. (2021) demonstrated that computerized layout approaches could be used to optimize facility arrangements based on relationships among production areas. These studies reinforce the importance of considering material flow and facility relationships when developing an improved layout.

The relationship among facilities can be analyzed using the Activity Relationship Chart (ARC), which identifies the required degree of proximity between facilities based on process relationships and operational requirements. The resulting relationships can subsequently be quantified using the Total Closeness Rating (TCR) to determine facility placement priorities. Hadi et al. (2024) applied ARC and TCR to evaluate facility layout strategies and demonstrated that proximity relationships can support more systematic facility placement. Supriyadi et al. (2025) also applied ARC and TCR in facility layout design and found that these methods could be used to identify relationships among production areas as a basis for improving facility arrangements.

In addition to ARC and TCR, Blocplan can be used to generate alternative facility layouts based on the relationships among facilities. Khofifah and Suhartini (2021) combined systematic layout planning and Blocplan to redesign production facilities with the objective of minimizing material handling costs. Saffanah et al. (2023) similarly applied SLP and Blocplan to develop alternative production floor layouts and improve material flow. These findings indicate that the integration of analytical facility relationship methods with computerized layout approaches can provide a more systematic basis for facility layout redesign. However, previous studies have generally focused on different manufacturing objects and production characteristics, while the simultaneous evaluation of facility proximity, material travel distance, and material handling costs in colored stone production remains limited.

PT Tatalogam Lestari is a manufacturing company operating in the infrastructure sector, producing products including metal roofing and lightweight steel. One supporting process for metal roofing with natural stone coating is colored stone production. This process consists of raw material receiving and unloading, stone aggregate storage, screening, temporary storage, coloring, and colored stone storage before the material is transferred to the subsequent production process. Based on observations of the colored stone production area, several facility layout problems were identified, including material accumulation, unorganized material storage, facility positions that do not fully correspond to the production flow, and repeated material movement activities. These conditions potentially increase material travel distance and movement frequency and consequently affect Material Handling Cost (MHC).

Under the existing layout, the total material travel distance reaches 30,019.18 meters/day, while MHC amounts to IDR 1,395,846.49/day. These conditions indicate that there is considerable potential for improving operational efficiency through facility layout redesign. The research gap addressed in this study is therefore the need for an integrated evaluation that not only determines facility proximity relationships and generates alternative layouts but also quantitatively measures the resulting changes in material travel distance and MHC in the colored stone production process. The contribution of this study lies in integrating ARC and TCR for facility relationship analysis, Blocplan for developing alternative layouts, and quantitative evaluation of material travel distance and MHC to assess the effectiveness of the proposed layout.

Therefore, this study aims to redesign the facility layout of the colored stone production process at PT Tatalogam Lestari by integrating the ARC, TCR, and Blocplan methods and to evaluate the effectiveness of the proposed layout based on changes in material travel distance and Material Handling Cost compared with the existing layout.

2. Research Method

This study employed a quantitative research approach with a case study design to evaluate and redesign the facility layout in the colored stone production process at PT Tatalogam Lestari. The study was conducted in the colored stone production area of PT Tatalogam Lestari, Cibitung, Bekasi Regency, West Java, from August 2025 to February 2026. The research focused on the facilities involved in the material flow of the colored stone production process, from raw material receiving and unloading to intermediate product storage.

The study used both primary and secondary data. Primary data were collected through direct observation of the production process and material handling activities, interviews with personnel involved in the production process, measurements of facility dimensions and locations, observation of material flow patterns, measurement of material travel distances, and recording of material movement frequencies. Secondary data were obtained from company records and relevant literature concerning facility layout, material handling, Activity Relationship Chart (ARC), Total Closeness Rating (TCR), Blocplan, and Material Handling Cost (MHC).

The main variables examined in this study were facility layout, material travel distance, material movement frequency, and Material Handling Cost (MHC)**.** Facility layout was operationally defined as the physical arrangement and relative positioning of production facilities involved in the colored stone production process. Material travel distance was defined as the distance traveled by materials between facilities during each material movement activity. Material movement frequency represented the number of material movements occurring between facilities during the observation period. MHC represented the cost incurred from material handling activities, which was determined by material travel distance, movement frequency, and the applicable material handling cost per unit distance.

The research procedure began with an assessment of the existing facility layout and material flow**.** This assessment included the identification of facility locations, production sequences, inter-facility relationships, material travel distances, and material movement frequencies. The results were used to identify material handling activities that contributed substantially to the total travel distance and MHC.

The Activity Relationship Chart (ARC) was then applied to determine the required degree of closeness among facilities based on material flow, process sequence, activity interactions, and operational requirements. The proximity relationships were classified into six categories : **A** (Absolutely Necessary), **E** (Especially Important), **I** (Important), **O** (Ordinary Closeness), **U** (Unimportant), and **X** (Undesirable)**.** The ARC results provided the qualitative basis for determining the required proximity relationships among facilities.

The ARC results were subsequently quantified using the Total Closeness Rating (TCR) to determine facility placement priorities. TCR represents the cumulative closeness relationship of a facility with other facilities. It was calculated using the following equation :

$$TCR_i = \sum R_{ij}$$

where TCR_i is the Total Closeness Rating of facility , and R_{ij} represents the closeness relationship value between facility i and facility j . Facilities with higher TCR values were given greater priority for placement near facilities with strong operational relationships.

Based on the ARC and TCR results, alternative facility layouts were developed using Blocplan. The proposed layouts were assessed by considering facility proximity relationships, material flow patterns, total material travel distance, and MHC. The alternative providing the most favorable performance across these criteria was selected as the proposed facility layout.

Material travel distance was calculated using the rectilinear distance method, which is appropriate for material movement along horizontal and vertical paths within the production area. The distance between facilities and was calculated using :

$$d_{ij} = | x_i - x_j | + | y_i - y_j |$$

where d_{ij} represents the distance between facilities i and j, x_i and x_j represent their horizontal coordinates, and and represent their vertical coordinates. Total material travel distance was determined by multiplying the distance of each movement by its corresponding material movement frequency.

The economic performance of the proposed layout was evaluated using Material Handling Cost (MHC). MHC was calculated based on the material handling cost per unit distance, material travel distance, and movement frequency, as follows :

$$MHC = MHC/meter \times Distance \times Movement\ Frequency$$

This calculation represents the cost associated with material handling activities, including the use of material handling equipment and labor involved in material movement.

Finally, the effectiveness of the proposed layout was evaluated by comparing the existing and proposed layouts based on total material travel distance and MHC. The percentage improvement was calculated using :

$$Efficiency\ (\%) = \frac{Existing\ Value - Proposed\ Value}{Existing\ Value} \times 100\%$$

A positive efficiency value indicates an improvement in performance relative to the existing layout. The proposed layout was therefore evaluated not only from a facility arrangement perspective but also from operational and cost-efficiency perspectives.

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3. Results and Discucion

Results

The assessment of the existing facility layout identified several conditions affecting material flow in the colored stone production process. The existing arrangement did not fully correspond to the production sequence and material flow. Several facilities with strong process relationships were positioned relatively far apart, while material accumulation and storage conditions resulted in repeated material movements.

A total of 12 major material movement activities were identified under the existing layout, resulting in a total material travel distance of 30,019.18 meters/day. The material movements contributing substantially to the total distance included the movement from the unloading area to the stone aggregate storage area and the movement of stone aggregate to the screening machines.

The facility proximity relationships were then analyzed using the Activity Relationship Chart (ARC). The analysis classified the relationships among facilities into six proximity categories : **A** (Absolutely Necessary), **E** (Especially Important), **I** (Important), **O** (Ordinary Closeness), **U** (Unimportant), and **X** (Undesirable). The resulting ARC was used to identify the required degree of proximity among facilities based on production sequence, material flow, activity interactions, and operational requirements.

The ARC results were quantified using the Total Closeness Rating (TCR). The TCR values provided facility placement priorities based on the cumulative proximity relationships among facilities. Facilities with higher TCR values were prioritized for placement near facilities with stronger operational relationships.

Based on the ARC and TCR results, alternative facility layouts were generated using Blocplan. The proposed layout included repositioning the screening machines to better correspond with the production sequence and material flow. The proposed arrangement also reduced repeated material movement patterns and improved the continuity of material flow.

The performance of the proposed layout was evaluated based on total material travel distance. The comparison between the existing and proposed layouts is presented in Table 1.

Table 1. Comparison of Material Travel Distance

Parameter	Existing Layout	Proposed Layout	Reduction	Efficiency
Total material travel distance	30,019.18 m/day	27,057.64 m/day	2,961.54 m/day	9.87%

As shown in Table 1, the proposed layout reduced total material travel distance from 30,019.18 meters/day to 27,057.64 meters/day. The reduction amounted to 2,961.54 meters/day, corresponding to an efficiency improvement of 9.87%.

The economic performance of the proposed layout was subsequently evaluated using Material Handling Cost (MHC). The results are presented in Table 2.

Table 2. Comparison of Material Handling Cost

Parameter	Existing Layout	Proposed Layout	Cost Saving	Efficiency
Material Handling Cost	IDR 1,395,846.49/day	IDR 1,155,276.42/day	IDR 240,570.07/day	17.23%

As presented in Table 2, MHC decreased from IDR 1,395,846.49/day to IDR 1,155,276.42/day. The resulting cost saving was IDR 240,570.07/day, equivalent to an efficiency improvement of 17.23%.

Based on an assumption of 24 working days per month, the potential monthly cost saving is calculated as follows :

IDR 240,570.07 × 24 = IDR 5,773,681.68/month

Thus, the estimated potential cost saving is approximately IDR 5.77 million per month.

Discussion

The results demonstrate that the existing facility layout created opportunities for improvement because the spatial arrangement did not fully correspond to the sequence of production activities and material flow. The presence of repeated material movements and relatively large distances between facilities with strong process relationships contributed to the overall material handling burden.

The ARC analysis provides a qualitative basis for determining the required proximity among facilities. Facilities that have direct process relationships require closer positioning to support continuous material flow. This finding is consistent with Supriyadi et al. (2025), who demonstrated that ARC can be used to identify proximity relationships among production areas and support facility layout development. In the present study, the ARC results indicate that facility positioning should be determined based on operational relationships rather than physical space considerations alone.

The application of TCR further strengthened the facility positioning analysis by converting qualitative proximity relationships into quantitative priorities. A higher TCR value indicates stronger overall relationships between a facility and other facilities. Consequently, TCR can reduce subjectivity in determining which facilities should receive greater priority during layout development. This approach is relevant to facility layout decision-making because the placement of facilities must consider their interactions with multiple activities rather than their relationship with only one adjacent facility.

The use of Blocplan subsequently translated the ARC and TCR results into an alternative spatial arrangement. The repositioning of the screening machines represents an important improvement because the machines have direct relationships with material processing activities before and after screening. Aligning the position of these facilities with the production sequence can reduce unnecessary movement and improve material flow continuity.

The reduction in material travel distance from 30,019.18 to 27,057.64 meters/day represents an efficiency improvement of 9.87%**.** This finding indicates that facility layout redesign can improve material flow by reducing unnecessary travel. The result supports the general principle of facility planning that facilities with strong material and process relationships should be positioned closer together. It also reinforces previous findings that systematic facility layout approaches can reduce material movement and improve production flow.

More importantly, the proposed layout produced a 17.23% reduction in MHC, which is greater than the 9.87% reduction in material travel distance. This difference indicates that material handling cost is influenced not only by distance but also by movement frequency and the associated handling cost**.** Therefore, the economic impact of a layout improvement depends on which material movement activities are reduced.

The relationship can be represented conceptually as:

This finding has an important implication for Industrial Engineering practice. A facility layout should not be evaluated solely based on the shortest average travel distance. Material movement activities with high frequencies may provide greater opportunities for cost reduction even when their individual travel distances are not the longest.

From an Industrial Engineering perspective, the integration of ARC, TCR, and Blocplan provides a systematic framework for redesigning facility layouts. ARC identifies qualitative proximity requirements, TCR establishes facility priorities, and Blocplan develops spatial alternatives. The resulting reduction in material travel distance demonstrates that the integrated approach can support improvements in material flow efficiency.

From an Industrial Management perspective, the reduction in MHC demonstrates that facility layout decisions have direct implications for operational cost management. The estimated potential saving of approximately IDR 5.77 million per month indicates that facility layout improvement can become part of a broader operational cost-reduction strategy. However, this value should be interpreted as a potential saving based on the assumed 24 working days per month rather than as a realized financial saving.

The findings also provide a managerial implication regarding periodic facility layout evaluation. Layout performance should be reassessed when production volume, product characteristics, demand patterns, machine capacity, material movement frequency, or production space requirements change. Such changes can alter material flow patterns and consequently affect the effectiveness of an existing layout.

The contribution of this study lies in the integration of facility proximity analysis using ARC and TCR, layout development using Blocplan, and quantitative evaluation using material travel distance and MHC in the colored stone production process. The results demonstrate that facility layout redesign can simultaneously provide operational and economic improvements. Therefore, the proposed approach can serve as a practical decision-support framework for facility layout improvement in manufacturing environments with intensive material handling activities.

4. Conclusions and Suggestions

Conclusion

This study demonstrates that the existing facility layout in the colored stone production process at PT Tatalogam Lestari has opportunities for improvement, particularly in terms of material travel distance and Material Handling Cost (MHC). The integration of the Activity Relationship Chart (ARC), Total Closeness Rating (TCR), and Blocplan methods resulted in a proposed facility layout that better reflects the relationships among activities and the material flow sequence. The proposed layout reduced total material travel distance from 30,019.18 meters/day to 27,057.64 meters/day, representing a reduction of 2,961.54 meters/day or 9.87%. In addition, MHC decreased from IDR 1,395,846.49/day to IDR 1,155,276.42/day, resulting in a potential cost saving of IDR 240,570.07/day or 17.23%. These findings indicate that facility layout redesign can provide both operational and economic benefits by reducing unnecessary material movement and associated handling costs. The contribution of this study lies in the integration of qualitative facility relationship analysis and quantitative material handling performance evaluation, providing a practical decision-support approach for facility layout improvement in manufacturing operations. From a practical perspective, the proposed layout can support more efficient material flow and cost management. However, the study is limited to the evaluation of material travel distance and MHC and does not assess implementation-related factors such as investment requirements, material transfer time, production capacity, or labor productivity.

Suggestion

Further research is recommended to evaluate the proposed facility layout using broader operational and economic indicators. Future studies may incorporate material transfer time, production cycle time, labor productivity, space utilization, production capacity, equipment utilization, and investment requirements to provide a more comprehensive assessment of layout implementation. Simulation-based evaluation may also be considered to examine the performance of the proposed layout under different production volumes and material flow conditions. In addition, the proposed layout should be periodically reevaluated when changes occur in production volume, product characteristics, machine capacity, demand patterns, or production requirements. These extensions would provide stronger evidence regarding the long-term operational and economic feasibility of the proposed facility layout.

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