LAYOUT EVALUATION AT PT JUYOMI SINAR LABUAN USING THE SYSTEMATIC LAYOUT PLANNING METHOD

Nur'Asia[1]
Universitas Tadulako, Palu, Indonesia
nurasia2708@gmail.com

Sulaeman Miru[2]
Universitas Tadulako, Palu, Indonesia
sulaemanmiru@untad.ac.id

Umar Syarifuddin[3]
Universitas Tadulako, Palu, Indonesia
umarsyarif@untad.ac.id

Fatlina Zainuddin[4]
Universitas Tadulako, Palu, Indonesia
fatlina.z@gmail.com

Syamsuddin[5]
Universitas Tadulako, Palu, Indonesia
syamsuddinsyam@untad.ac.id

Abstract

This study aims to evaluate and improve the facility layout performance at PT Juyomi Sinar Labuan using the Systematic Layout Planning (SLP) method in a heavy-equipment-based stone crusher industry. The research employs a quantitative case study approach supported by qualitative analysis through field observations, material flow measurements, cycle time analysis, production capacity evaluation, and interviews with relevant personnel. The results indicate that the existing layout, although functionally aligned with the production sequence, still experiences inefficiencies due to suboptimal material flow configuration. This condition is reflected in a total Load Distance of 302 meters and a material handling cycle time of 5.05 minutes. The primary source of inefficiency is the recirculation flow between the 2 Deck Screen and the Kun Crusher, which creates a backtracking pattern and increases material movement distance. The application of SLP produces an improved layout by optimizing activity relationships and material flow paths without major relocation of production facilities. The proposed layout reduces the Load Distance from 302 meters to 278 meters and decreases cycle time from 5.05 minutes to 4.65 minutes, representing improvements of approximately 8% and 7.9%, respectively. These findings demonstrate that optimizing critical material flow paths can improve operational efficiency and workflow integration in open-space heavy-equipment industries. This study contributes to the limited application of SLP in stone crusher operations by adapting layout optimization principles to environments characterized by large-scale material handling and equipment mobility. Further research should incorporate simulation and economic analysis to validate long-term operational impacts.

Keywords: Facility Layout, Systematic Layout Planning (SLP), Load Distance, Material Handling, Production Efficiency

INTRODUCTION

Facility layout is a fundamental component of production systems because it determines the efficiency of material movement, utilization of production resources, occupational safety, and overall operational performance. An effective layout arrangement can reduce unnecessary movement, minimize process delays, optimize resource utilization, and support a more stable production flow. In contrast, inappropriate facility configurations may generate excessive material handling activities, bottlenecks, higher operational costs, and increased safety risks (Apple, 1977; Tompkins et al., 2010). Therefore, facility layout is not merely a spatial arrangement problem but also a strategic decision that influences productivity and industrial competitiveness.

One of the most widely adopted approaches for facility layout design is the Systematic Layout Planning (SLP) method introduced by Muther (1994). SLP provides a structured framework for designing or improving facility arrangements by analyzing activity relationships, material flow patterns, space requirements, and alternative layout configurations. Previous studies have demonstrated the effectiveness of SLP in improving production efficiency. For example, Kumar and Naga Malleswari (2022) reported that SLP implementation improved facility arrangement and material flow efficiency, while other studies found that SLP-based redesign could reduce material movement distances, handling costs, and production time (Kholidasari et al., 2022; Kholifah & Suhartini, 2021; Santoso et al., 2022).

However, existing studies on SLP have predominantly focused on conventional indoor manufacturing environments, such as food processing, furniture, metal industries, and small-medium enterprises. In these industries, production activities generally occur within controlled spaces, with relatively stable working surfaces, fixed material handling systems, and predictable movement patterns. Consequently, layout optimization is often evaluated based on workstation proximity, machine arrangement, and internal material flow efficiency. For instance, Siahaan and Oktiarso (2019) and Ernita et al. (2023) demonstrated the effectiveness of SLP in improving indoor production layouts by reorganizing workstations and reducing unnecessary movement. However, these approaches cannot be directly generalized to heavy-equipment-based industries because operational constraints, equipment mobility, environmental conditions, and safety considerations differ substantially.

The stone crusher industry represents a unique production environment characterized by open-space operations, large-scale material handling, uneven terrain conditions, and continuous interaction between heavy equipment and material flow systems. Unlike indoor manufacturing facilities where movement is mainly performed by conveyors, workers, or small handling equipment, stone crusher operations involve excavators, loaders, crushers, screens, and transportation routes with significant operational constraints. Therefore, layout optimization in this sector requires not only minimizing distance but also ensuring safe equipment movement, reducing fuel consumption, preventing traffic conflicts, and maintaining continuous production flow. Previous research by Agustin and Widarwati (2019) demonstrated that SLP could improve efficiency in crushing plant operations; however, studies applying SLP in open-space heavy-equipment industries remain relatively limited compared with indoor manufacturing sectors. This indicates a research gap regarding how SLP principles can be adapted to production environments where mobility, safety, and spatial constraints are dominant factors.

PT Juyomi Sinar Labuan, a stone processing company located in Central Sulawesi, represents a relevant case for investigating this issue. Although the existing production layout is functionally arranged according to the production sequence, preliminary evaluation indicates that operational efficiency has not yet reached an optimal level. Quantitative analysis shows that the existing layout produces a total Load Distance of 302 meters and a material handling cycle time of 5.05 minutes per production cycle. These conditions are primarily influenced by inefficient material movement patterns, particularly the recirculation flow between the 2 Deck Screen and the Kun Crusher, which creates a backtracking movement pattern and increases material travel distance. Furthermore, production capacity utilization is only approximately 58–70% of theoretical capacity, indicating that the current production system still has potential inefficiencies requiring improvement.

These conditions demonstrate that the problem faced by PT Juyomi Sinar Labuan is not primarily caused by insufficient production equipment or limited operational space, but rather by the mismatch between activity relationships and the existing spatial configuration. The Activity Relationship Chart analysis also indicates that several production units have high interaction requirements but are not optimally positioned, resulting in longer material movement distances and increased cycle time. In heavy-equipment-based industries, such inefficiencies may lead to greater fuel consumption, longer equipment operating hours, higher maintenance requirements, and increased safety risks.

Therefore, a systematic evaluation of the existing facility layout is required using a measurable and industry-relevant approach. The application of the Systematic Layout Planning method in this research is expected to identify weaknesses in the current layout configuration and develop improvement alternatives that consider material flow efficiency, operational feasibility, and safety requirements. Unlike previous SLP studies that primarily address indoor manufacturing environments, this research contributes by examining the applicability of SLP principles within an open-space stone crusher industry where heavy equipment mobility and continuous material flow represent dominant operational challenges. The findings are expected to provide both theoretical contributions to the development of facility layout studies and practical recommendations for improving operational performance in heavy-equipment-based industries.

REVIEW OF LITERATURE

Facility layout is a strategic element in production systems because it determines how resources, equipment, materials, and human activities are organized to achieve operational objectives. In operations management, production performance is commonly evaluated through two complementary concepts: efficiency and effectiveness. Efficiency refers to the ability of an organization to minimize resource consumption while producing a desired output, including reductions in time, energy, cost, and space utilization (Herjanto, 2015). Meanwhile, effectiveness refers to the extent to which organizational objectives are achieved through appropriate processes and outcomes (Robbins & Coulter, 2012). Although these concepts are frequently discussed separately, facility layout optimization requires both perspectives simultaneously because a layout that minimizes movement distance may not necessarily support production targets, safety requirements, or operational flexibility. Drucker (1993) emphasized that efficiency without effectiveness may result in resource optimization without achieving organizational goals, while effectiveness without efficiency may generate unnecessary resource consumption.

Within facility layout studies, efficiency is generally measured using quantitative indicators such as material movement distance, cycle time, material handling cost, and equipment utilization. Heizer and Render (2017) argued that layout decisions directly influence productivity and production costs because unnecessary movement and inefficient spatial arrangements increase non-value-added activities. However, previous studies have mainly evaluated efficiency from an internal manufacturing perspective, where production activities occur within controlled environments. For example, Siahaan and Oktiarso (2019) focused on redesigning an indoor production floor layout by minimizing material movement distance, while Ernita et al. (2023) integrated SLP with 5S principles to improve workplace organization and efficiency. These studies successfully demonstrated that layout improvement can reduce unnecessary movement; however, their approaches were developed for industries with relatively stable working environments and limited interaction with heavy mobile equipment.

Different operational characteristics are found in heavy-equipment-based industries, particularly stone crusher operations. Unlike conventional manufacturing systems where material movement is commonly performed through fixed conveyors or manual handling systems, stone crusher facilities involve large-scale equipment such as crushers, screens, loaders, and transportation routes operating in open areas. Consequently, layout optimization cannot only consider distance minimization but must also address equipment mobility, terrain conditions, fuel consumption, traffic safety, and continuous material availability. This distinction indicates that findings from indoor manufacturing studies cannot be directly generalized to heavy-equipment industries because the relationship between spatial arrangement and operational performance is influenced by different environmental constraints.

Facility layout design is therefore not only concerned with arranging physical facilities but also managing the interaction between material flow, equipment movement, and human safety. Apple (1977) stated that an effective layout should consider several fundamental principles, including integration between activities, minimum movement distance, smooth flow patterns, efficient space utilization, and flexibility. However, the implementation of these principles may vary depending on industrial characteristics. Product-based layouts are generally suitable for industries with standardized sequential production processes, while process-based layouts provide flexibility for products with varying processing requirements (Stevenson, 2011). In stone crusher operations, the production sequence tends to follow a product-based flow from raw material receiving to crushing, screening, and stockpiling. Nevertheless, the requirement for equipment mobility and material variation creates characteristics that differ from conventional product-based manufacturing systems.

The Systematic Layout Planning (SLP) method developed by Muther (1994) provides a structured approach for addressing these layout challenges by integrating activity relationships, material flow analysis, space requirements, and alternative layout evaluation. Unlike simple distance-based approaches, SLP considers both quantitative and qualitative relationships between facilities through tools such as Activity Relationship Charts (ARC), flow diagrams, and space analysis. This characteristic makes SLP potentially suitable for complex production environments where operational relationships cannot be determined solely from physical distance.

Previous empirical studies have confirmed the effectiveness of SLP in improving facility performance, but their applicability varies depending on industrial context. Kholidasari et al. (2022) demonstrated that SLP reduced material movement distance in small and medium enterprises, while Kholifah and Suhartini (2021) showed that combining SLP with BLOCPLAN reduced material handling costs in garment production. Santoso et al. (2022) and Wahyudi et al. (2024) further confirmed that SLP could improve production flow and reduce operational inefficiencies. However, these studies primarily focused on indoor manufacturing environments where facility boundaries, equipment positions, and movement patterns were relatively controllable.

In contrast, research related to heavy-equipment industries remains limited. Agustin and Widarwati (2019) applied SLP in a crushing plant environment and found that layout improvement significantly reduced material movement intensity. This study provides evidence that SLP can be applied beyond conventional manufacturing; however, the analysis primarily emphasized movement efficiency and did not extensively integrate other operational considerations such as occupational safety, equipment interaction, and open-space operational constraints. Therefore, further research is required to develop a more comprehensive evaluation framework for stone crusher industries by integrating efficiency, effectiveness, material flow, and safety aspects.

Material flow represents the central mechanism connecting facility layout decisions with operational performance. According to Tompkins et al. (2010), effective material flow planning requires consideration of movement direction, frequency, volume, and transportation method. Poorly designed flow patterns may create unnecessary movement, backtracking, increased energy consumption, and longer production cycles. In heavy-equipment industries, these impacts become more significant because every additional movement directly affects fuel usage, equipment operating hours, and maintenance requirements. Therefore, optimizing material flow is not only an efficiency issue but also an important factor affecting long-term operational sustainability.

Furthermore, occupational safety and ergonomics represent important considerations in heavy-equipment-based layouts. Unlike indoor manufacturing systems, stone crusher operations involve direct interaction between workers and large moving equipment, creating risks related to visibility limitations, equipment routes, dust exposure, and accidental collisions. Kroemer and Grandjean (1997) emphasized that ergonomic considerations should be incorporated into workplace design to minimize physical risks and improve operational reliability. Therefore, an optimized layout should not only shorten material movement distance but also ensure safe separation between equipment movement paths and human activities.

Based on the reviewed literature, a conceptual relationship can be established in which facility layout acts as the primary factor influencing material flow characteristics. Improved material flow contributes to higher efficiency through reduced distance, shorter cycle time, and lower resource consumption. At the same time, effective layout configuration supports production objectives by improving workflow continuity and operational reliability. In heavy-equipment industries, these relationships must be strengthened by incorporating safety and ergonomic considerations because operational performance cannot be separated from workplace risk management. Within this framework, Systematic Layout Planning functions as an analytical approach that integrates activity relationships, material flow, spatial requirements, and safety considerations to develop improved facility configurations.

Therefore, this research positions SLP not merely as a layout redesign tool but as an integrated evaluation framework for analyzing the relationship between spatial configuration, material movement, operational efficiency, effectiveness, and occupational safety. The existing research gap lies in the limited application of integrated SLP analysis within open-space heavy-equipment industries, particularly stone crusher operations. This study addresses this gap by evaluating the existing layout of PT Juyomi Sinar Labuan and developing improvement alternatives based on measurable operational indicators while considering the specific characteristics of heavy-equipment-based production systems.

RESEARCH METHOD

This study employs a quantitative case study approach supported by qualitative analysis to evaluate and improve the facility layout at PT Juyomi Sinar Labuan. The selection of this research design is based on the characteristics of the research objectives, which require both measurable evaluation of layout performance and contextual understanding of operational conditions. The quantitative approach is used to objectively measure facility layout efficiency through numerical indicators, including material movement distance, Load Distance (LD), material handling cycle time, heavy equipment movement frequency, and comparison between actual and theoretical production capacity. These quantitative indicators provide empirical evidence regarding the level of inefficiency within the existing facility layout. However, numerical measurements alone are insufficient to explain the operational factors causing layout inefficiencies. Therefore, qualitative analysis is incorporated to identify contextual factors influencing production performance, including workflow constraints, equipment interaction patterns, operational difficulties, and occupational safety considerations. The integration of quantitative and qualitative approaches allows this research to identify the magnitude of layout problems through numerical analysis while simultaneously explaining the operational causes and feasibility of improvement alternatives through field-based observations and interviews.

The case study approach was selected because this research examines a specific operational phenomenon within its real industrial context, namely the facility layout system of PT Juyomi Sinar Labuan. According to Yin (2018), case studies are appropriate for investigating contemporary phenomena where the relationship between the observed problem and its surrounding environment cannot be separated. In this research, facility layout performance is strongly influenced by the characteristics of the stone crusher industry, including open-space production activities, heavy equipment mobility, large-volume material handling, and continuous production flow. Therefore, an in-depth case study approach provides an appropriate methodological framework for understanding existing layout conditions and developing improvement recommendations that are aligned with the operational characteristics of heavy-equipment-based industries.

The research was conducted at PT Juyomi Sinar Labuan, located in Donggala Regency, Central Sulawesi. The company was selected as the research object because it operates a stone processing facility with sequential crushing and screening activities supported by heavy equipment. These characteristics represent the operational challenges of open-space production systems, where facility arrangement influences material movement efficiency, equipment utilization, production continuity, and occupational safety. The research was conducted for three months, from September to November 2025, covering the stages of preliminary observation, data collection, facility layout evaluation, SLP analysis, and assessment of proposed layout alternatives.

The data used in this study consist of quantitative and qualitative data obtained from primary and secondary sources. Quantitative data include facility-to-facility distances, material movement frequency, travel time between production processes, heavy equipment movement patterns, and comparisons between actual and theoretical production capacity. These data were collected through direct field measurements, production records, and company documentation. Meanwhile, qualitative data consist of information related to workflow conditions, operational constraints, achievement of production targets, and occupational safety aspects. Qualitative data were obtained through direct observation and semi-structured interviews with personnel who have direct involvement in production activities. The combination of these data sources enables triangulation between measured operational performance and actual field conditions, thereby increasing the reliability of research findings.

The population of this research includes all production facilities and operational activities within the PT Juyomi Sinar Labuan production area, consisting of the raw material receiving area, crusher units, screening units, heavy equipment movement routes, and final product storage areas. The selection of research participants was conducted using purposive sampling, considering their relevance and experience related to facility layout and production operations. The participants consisted of the production manager, field supervisor, and heavy equipment operators because these individuals possess direct knowledge regarding production flow, equipment movement, operational constraints, and safety conditions within the existing layout. Their perspectives were used to complement quantitative measurements and provide a deeper understanding of layout effectiveness.

Data collection was conducted through direct observation, quantitative measurement, interviews, and documentation studies. Field observations were performed to identify existing material flow patterns, equipment movement routes, interaction between production facilities, and potential bottleneck areas within the production system. Observation activities were supported by field notes, layout documentation, and material flow mapping to ensure that operational conditions were accurately represented. Quantitative measurements were conducted by recording the distance and travel time of material movement between production facilities based on actual operational routes. Distance measurements were obtained by measuring the existing conveyor paths and equipment movement routes, while travel time measurements were conducted by observing the duration required for material transfer between consecutive production stages. The measurements were performed during normal production activities to minimize the influence of temporary operational variations, and the collected data were subsequently used as input for Load Distance and material handling cycle time calculations.

Semi-structured interviews were conducted with selected participants to obtain contextual information regarding the effectiveness of the existing layout. The interview process focused on identifying operational problems related to material movement, equipment accessibility, workflow limitations, safety concerns, and possible improvement alternatives. The interview results were compared with quantitative findings to determine whether the measured inefficiencies reflected actual operational problems experienced by workers and management. In addition, secondary data were collected from company documents, including existing facility layout drawings, monthly production reports, production capacity records, material flow documentation, and standard operating procedures. These documents were used to validate field observations and support the analysis of production performance.

The data analysis process was conducted using the Systematic Layout Planning (SLP) method developed by Muther (1994) as the primary analytical framework. The SLP approach was selected because it provides a systematic procedure for evaluating facility relationships, material flow patterns, space requirements, and alternative layout configurations. The analysis began with an evaluation of the existing layout through Activity Relationship Chart (ARC) analysis to determine the level of relationship between production facilities. Subsequently, material flow analysis was conducted using flow diagrams and from-to charts to identify inefficient movement patterns, excessive travel distances, and potential backtracking activities. Space requirement analysis was also performed to determine whether operational area limitations influenced layout performance.

The efficiency of the existing layout was quantitatively evaluated using Load Distance (LD) analysis and material handling cycle time calculations. Load Distance was calculated by multiplying the frequency of material movement between facilities by the distance between those facilities, while cycle time was calculated based on the total time required for one complete material movement cycle. In addition to quantitative evaluation, qualitative analysis was conducted to assess layout effectiveness based on workflow continuity, operational constraints, and occupational safety considerations identified from observations and interviews. Material flow visualization using spaghetti diagrams was also applied to identify movement patterns, unnecessary routes, and potential bottleneck locations.

Based on the integrated results of quantitative and qualitative analyses, alternative facility layouts were developed by considering activity relationships, material flow efficiency, space requirements, equipment mobility, and occupational safety aspects. The proposed layouts were then evaluated using the same quantitative indicators applied to the existing layout to determine the level of performance improvement. Through this methodological approach, the research provides layout recommendations that are not only supported by measurable efficiency improvements but also applicable to the operational realities of heavy-equipment-based production environments.

RESULTS AND DISCUSSION

Distance Between Facilities and Material Flow Patterns

Based on field measurements, the existing facility layout at PT Juyomi Sinar Labuan shows variations in the distances between production units, ranging from approximately 25 meters to 48 meters. The measurements were conducted along the actual conveyor paths to accurately represent real material transfer conditions.

Table 1.
Distance Between Facilities (Summary)

No	Facility	Main Function	Distance to Facility Next (m)
1	Tunnel	Reception material standard	45
2	1 Deck Screen	Filtering beginning	25
3	Jaw Crusher 1	Primary destruction	25
4	Jaw Crusher 2	Destruction advanced	37
5	2 Deck Screen	Filtering product beginning	37
6	Kun Crusher	Destruction advanced	37 (recirculation)
7	3 Deck Screen	Filtering end	48
8	Stockpile	Storage product end	–

In general, the material flow pattern can be classified into two types: linear flow, representing the main production process, and recirculation flow, which returns material from the Kun Crusher to the 2 Deck Screen. The presence of this recirculation path increases the complexity of material flow and contributes to longer movement distances within the production cycle.

Load Distance (LD) Analysis

Following the analysis of facility distances and material flow patterns, a quantitative evaluation is conducted using Load Distance (LD) analysis to measure the efficiency of the existing layout. This analysis provides a numerical representation of material movement within the production system. Load Distance (LD) is calculated as the product of the frequency of material movement between facilities (Fij) and the corresponding distance (Dij). The calculation results are presented in Table 2.

Table 2.
Load Distance

From	To (To)	Frequency (Fij)	Distance (Dij) (m)	Moment (Mij = Fij × Dij)
Tunnel	1 Deck Screen	1	45	45
1 Deck Screen	Jaw Crusher 1	1	25	25
Jaw Crusher 1	Jaw Crusher 2	1	25	25

From	To (To)	Frequency (Fij)	Distance (Dij) (m)	Moment (Mij = Fij × Dij)
Jaw Crusher 2	2 Deck Screen	1	37	37
2 Deck Screen	Kun Crusher	1	37	37
Kun Crusher	2 Deck Screen	1	37	37
2 Deck Screen	3 Deck Screen	1	48	48
3 Deck Screen	Stockpile	1	48	48
Total Load Distance				**302**

The results show that the total Load Distance is 302 meters, indicating that materials travel a relatively long distance within a single production cycle. This finding is consistent with the previously identified material flow pattern, particularly the presence of a recirculation path that increases movement distance. The extended travel distance suggests inefficiencies in the existing layout, especially in supporting optimal material flow and operational efficiency.

Material Handling Cycle Time

Following the Load Distance (LD) analysis, the material handling cycle time is evaluated to measure the total time required for material transfer within one production cycle. This analysis provides a temporal perspective of layout efficiency and complements the distance-based evaluation.

Table 3.
Material Handling Cycle Time

No	Track Material Transfer	Existing Distance (m)	Transfer Time (minutes)
1	Tunnel to 1 Deck Screen	45	0.75
2	1 Deck Screen to Jaw Crusher	25	0.42
3	Jaw Crusher 1 to Jaw Crusher 2	25	0.42
4	Jaw Crusher 2 to 2 Deck Screen	37	0.62
5	2 Deck Screen to Kun Crusher	37	0.62
6	Kun Crusher to 2 Deck Screen (recirculation)	37	0.62
7	2 Deck Screen to 3 Deck Screen	48	0.80
8	3 Deck Screen to Stockpile	48	0.80
Total Cycle Time (Existing CT)			**5.05 minutes**

The results show that the total material handling cycle time is 5.05 minutes, indicating a relatively high accumulation of processing time within a single production cycle. This condition is primarily influenced by the recirculation path and the relatively long conveyor distances. As a result, production capacity utilization has not yet reached its optimal level, operating at approximately 58%–70% of theoretical capacity.

Activity Relationship Chart (ARC)

To further analyze the relationship between production units, an Activity Relationship Chart (ARC) is developed to identify the required level of proximity between facilities based on process interactions.

Table 4.
Activity Relationship Chart (ARC)

From / To	1 *Tunnel*	2 1DS	3 Jaw 1	4 Jaw 2	5 2DS	6 Kun	7 3DS	8 *Stockpiles*
1 *Tunnel*	-	A	U	U	X	X	X	X
2 1 *Deck Screen*	A	-	A	U	U	X	X	X
3 *Jaw Crusher* 1	U	A	-	A	U	U	X	X
4 *Jaw Crusher* 2	U	U	A	-	A	U	X	X
5 2 *Deck Screen*	X	U	U	A	-	A	A	U
6 *Kun Crusher*	X	X	U	U	A	-	U	X
7 3 *Deck Screen*	X	X	X	X	A	U	-	A
8 *Stockpiles*	X	X	X	X	U	X	A	-

The ARC results show a dominance of "A" (Absolutely Necessary) relationships among key production facilities, indicating a high level of interdependence between process units. This confirms that the production system follows a linear and sequential flow with strong spatial interaction requirements. However, these proximity relationships are not fully reflected in the existing layout, particularly in the recirculation path between the 2 Deck Screen and the Kun Crusher. This mismatch between required proximity and actual facility distances contributes to increased material movement distance and cycle time. Therefore, layout efficiency is strongly influenced by how well spatial configuration aligns with activity relationships.

Analysis Space Requirements

Following the evaluation of activity relationships and material flow, a space requirements analysis is conducted to determine whether spatial capacity constrains layout optimization. This analysis evaluates the adequacy of existing space to accommodate production activities and potential layout improvements.

Table 5.
Analysis Space Requirements

No	Facility	Main Function	Machine Area (m²)	Operational Allowance (%)	Additional Area (m²)	Total Space Requirements (m²)
1	Tunnel	Reception material standard	30	30%	9	39
2	1 Deck Screen	Filtering beginning	40	30%	12	52
3	Jaw Crusher 1	Primary destruction	35	30%	10.5	45.5

Vol. 9. No. 2 (2026)
Page: 16784-16802

4	Jaw Crusher 2	Destruction advanced	35	30%	10.5	45.5
5	2 Deck Screen	Filtering product beginning	45	30%	13.5	58.5
6	Kun Crusher	Destruction continued (recirculation)	40	30%	12	52
7	3 Deck Screen	Filtering end	45	30%	13.5	58.5
8	Stockpile	Accumulation product end	10,000	20%	2,000	12,000
9	Mining Road	Material & tool movement	5,000	20%	1,000	6,000
	TOTAL		15,270		3,080	18,350

The results indicate that the existing space capacity is sufficient and does not constitute a constraint in layout optimization. The total required area is adequately accommodated within the available space, suggesting that spatial limitations are not the primary source of inefficiency. This finding confirms that the main issue in the existing layout lies not in space availability, but in the configuration of material flow paths. Despite sufficient space capacity, suboptimal arrangement of facilities and inefficient routing—particularly in the recirculation path—contribute significantly to increased material movement distance and cycle time.

Following the space requirements analysis, which confirms that spatial capacity is not a limiting factor, the proposed layout is developed by focusing on optimizing material flow configuration rather than expanding or relocating facilities. This approach emphasizes improving spatial arrangement within existing structural constraints, particularly in a heavy-equipment-based production environment.

The proposed layout is designed without relocating major production units, ensuring practical feasibility and minimal operational disruption. The primary improvement targets the recirculation path between the 2 Deck Screen and the Kun Crusher, which has been identified as the main source of inefficiency in the existing layout. In the current configuration, this path forms a backtracking pattern that increases material movement distance and cycle time. In the proposed layout, the path is restructured into a shorter and more direct route, thereby reducing unnecessary material movement.

This transformation is consistent with the principles of Systematic Layout Planning (SLP), particularly the alignment between activity relationships and spatial proximity. The ARC analysis previously demonstrated that several facility relationships are classified as Absolutely Necessary, indicating the need for close physical positioning. By translating these relationship priorities into spatial configuration, the proposed layout achieves a more compact and integrated arrangement.

This approach is also supported by previous research (Erdiansyah & Szs, 2024), which highlights that converting qualitative closeness relationships into spatial clustering enables more efficient facility grouping and reduces unnecessary material movement. Their findings confirm that systematic alignment between activity relationships and physical layout significantly improves material handling efficiency and workflow integration. The resulting proposed layout is illustrated in Figure 1, which shows a more streamlined and structured material flow compared to the existing configuration.

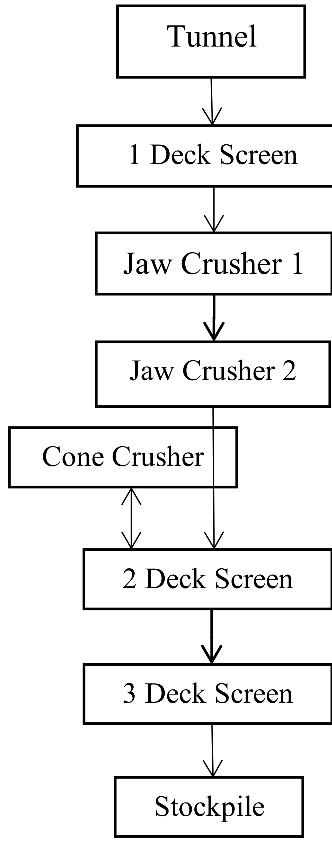

Figure 1.
Proposed Facility Layout

Figure 1 illustrates the proposed facility layout, which presents a more compact and progressively linear arrangement of production units. Facilities with high interaction intensity are positioned in closer proximity, resulting in a more streamlined material flow. The improvement is particularly evident in the recirculation segment between the 2 Deck Screen and the Kun Crusher, where the material flow path is restructured into a shorter and more direct route, reducing unnecessary backtracking.

To quantitatively evaluate the effectiveness of the proposed layout, Load Distance (LD) analysis is performed. The results are presented in Table 6.

Table 6.
Load Distance Analysis of the Proposed Facility Layout

From	To	Frequency (*Fij*)	Proposed Distance (Dij) (m)	Moment (Mij = *Fij* × Dij)
Tunnel	1 *Deck Screen*	1	45	45
1 *Deck Screen*	*Jaw Crusher* 1	1	25	25

Jaw Crusher 1	*Jaw Crusher* 2	1	25	25
Jaw Crusher 2	2 *Deck Screen*	1	37	37
2 *Deck Screen*	*Kun Crusher*	1	25	25
Kun Crusher	2 *Deck Screen*	1	25	25
2 *Deck Screen*	3 *Deck Screen*	1	48	48
3 *Deck Screen*	*Stockpile*	1	48	48
Total				**278 m**

Based on Table 6, the Load Distance (LD) analysis of the proposed facility layout is conducted to evaluate the efficiency of material movement after optimizing the material flow paths within the production system. The LD value is calculated as the product of the frequency of material movement (Fij) and the distance between facilities (Dij). A lower LD value indicates a more efficient layout in supporting material flow. The results indicate that the total Load Distance in the proposed layout is 278 meters, compared to 302 meters in the existing layout, representing a reduction of 24 meters (approximately ±8%). This reduction confirms an improvement in material handling efficiency without requiring major relocation of production units.

The most significant improvement is observed in the recirculation path between the 2 Deck Screen and the Kun Crusher. In the existing layout, this path forms a relatively long backtracking flow, which increases the total travel distance of materials. In the proposed layout, the distance is reduced through conveyor path optimization and route simplification, while maintaining the original positions of the main facilities. This adjustment becomes the primary contributor to the reduction in LD. Meanwhile, the distances between facilities along the main production flow remain largely unchanged due to constraints related to permanent structures and operational space requirements. This finding suggests that efficiency improvement does not necessarily require major layout restructuring but can be effectively achieved by optimizing critical paths that contribute significantly to material handling loads.

Overall, the LD analysis demonstrates that the proposed layout provides a more efficient and streamlined material flow. The reduction in movement distance contributes to improved material handling performance and supports better operational efficiency at PT Juyomi Sinar Labuan without requiring permanent structural modifications.

To further validate these improvements from a temporal perspective, the material handling cycle time (CT) is analyzed for the proposed layout. The results are presented in Table 7.

Tabel 7.
Material Handling Cycle Time of Proposed Layout

No	Stages of Migration	Distance (m)	Time (minute)
1	*Tunnel* → 1 Deck Screen	45	0,75
2	1 *Deck Screen* → Jaw Crusher	25	0,42
3	Jaw Crusher 1 → Jaw Crusher 2	25	0,42
4	Jaw Crusher 2 → 2 Deck Screen	37	0,62
5	2 *Deck Screen* → *Kun Crusher*	25	0,42
6	*Kun Crusher* → 2 *Deck Screen*	25	0,42

	(Resirkulasi)		
7	2 *Deck Screen* → 3 Deck Screen	48	0,80
8	3 *Deck Screen* → *Stockpile*	48	0,80
	Total Waktu Siklus (CT)	**278 m**	**4,65 menit**

Based on Table 7, the material handling cycle time (CT) in the proposed layout is 4.65 minutes, compared to 5.05 minutes in the existing layout, indicating a reduction of 0.40 minutes (approximately 7.9%). This result reflects an improvement in material handling efficiency following the application of the Systematic Layout Planning (SLP) method. This reduction in cycle time is consistent with the decrease in total Load Distance (LD), which declined from 302 meters to 278 meters. The improvement is achieved through optimization of material flow paths and enhanced proximity between facilities without requiring relocation of major production units. This indicates that the improvement is primarily operational rather than structural. The most significant improvement is observed in the recirculation path between the 2 Deck Screen and the Kun Crusher. In the existing layout, this path forms a relatively long backtracking flow, increasing material travel time. In the proposed layout, the recirculation distance is reduced through path simplification and improved flow alignment, resulting in a more efficient production cycle. Overall, the reduction in cycle time indicates a more integrated and efficient production flow. The improved coordination of material movement enhances operational performance without requiring permanent layout modifications. This finding confirms that SLP-based layout optimization is effective and applicable in stone crusher industries with structural limitations.

The evaluation of the existing facility layout at PT Juyomi Sinar Labuan demonstrates that the production system is functionally capable of maintaining the sequential crushing and screening process. However, functional continuity does not necessarily indicate optimal operational performance. The quantitative analysis reveals that the existing layout generates a total Load Distance (LD) of 302 meters and a material handling cycle time of 5.05 minutes per production cycle. These values indicate that although the production sequence is correctly arranged, the spatial configuration between facilities does not fully support efficient material movement. The primary contributor to this inefficiency is the recirculation flow between the 2 Deck Screen and the Kun Crusher, which creates a backtracking pattern. In a heavy-equipment-based production environment, repeated material movement does not only increase travel distance but also contributes to higher equipment operating hours, greater energy consumption, and potential increases in maintenance requirements.

The proposed layout developed through the Systematic Layout Planning (SLP) approach reduces the total Load Distance from 302 meters to 278 meters, representing a reduction of 24 meters or approximately 8%. Although this reduction may appear moderate, its operational significance should be considered within the context of continuous production activities. In stone crusher operations, material movement occurs repeatedly throughout the production cycle, meaning that a reduction in distance on each cycle accumulates into significant operational savings over long production periods. Shorter movement routes reduce unnecessary conveyor travel, minimize recirculation activities, and improve the utilization of material handling resources. Therefore, the improvement is not solely reflected in distance reduction but also indicates a more efficient movement pattern that can support better production stability.

The reduction in material handling cycle time from 5.05 minutes to 4.65 minutes further confirms the operational impact of layout improvement. The 0.40-minute reduction per cycle represents approximately a 7.9% improvement in material transfer time. While this study does not directly simulate the effect on annual production output or operating cost reduction, the improvement indicates potential benefits in reducing non-value-added movement activities. In a continuous processing industry, shorter cycle time provides opportunities for increased equipment availability, reduced waiting periods between production stages, and improved synchronization between crushing and screening units. Consequently, the proposed layout has the potential to support higher production efficiency, although the exact effect on throughput and profitability requires further validation using production simulation or long-term operational data.

The ARC analysis provides further explanation regarding the source of inefficiency in the existing layout. The dominance of “A” (Absolutely Necessary) relationships among major production units indicates that several facilities require close physical proximity due to strong process dependencies. However, these relationship requirements are not fully represented in the existing spatial arrangement, particularly between the 2 Deck Screen and the Kun Crusher. This finding demonstrates that the problem is not related to incorrect production sequencing or insufficient operational space but rather to the mismatch between activity relationships and physical configuration. In other words, the existing system achieves process continuity but sacrifices movement efficiency due to suboptimal spatial alignment.

The space requirement analysis also provides important implications regarding the feasibility of layout improvement. The results indicate that available operational space is sufficient and does not represent a limiting factor in redesigning the facility arrangement. Therefore, the main improvement opportunity lies in optimizing existing material flow routes rather than expanding production areas or relocating major equipment. This finding is particularly relevant for heavy-equipment industries, where large-scale structural modifications often require significant investment and may disrupt production activities. The proposed improvement demonstrates that targeted optimization of critical movement paths can generate efficiency gains without requiring major capital expenditure.

The effectiveness of the proposed layout is further reflected in the transformation of the material flow pattern. The existing layout contains a backtracking movement between the 2 Deck Screen and the Kun Crusher, which increases complexity and creates unnecessary material circulation. Through SLP-based improvement, this route is shortened and converted into a more direct flow pattern. This adjustment follows the fundamental principle of facility planning, where facilities with high interaction intensity should be positioned closer together to minimize unnecessary movement. Therefore, the proposed layout improves not only quantitative efficiency indicators but also the overall logical structure of the production flow.

However, the validation of the proposed layout in this study remains limited to analytical evaluation based on LD and cycle time calculations. The proposed configuration has not yet been tested through physical implementation, production simulation, or long-term operational trials. Therefore, the reported improvements should be interpreted as potential performance improvements rather than confirmed operational outcomes. To strengthen validation, further studies may incorporate discrete-event simulation, digital modeling, or pilot implementation to examine layout performance under different operational scenarios, such as increased production demand, equipment downtime, maintenance activities, and variations in material flow volume.

Despite this limitation, the proposed layout provides a theoretically and operationally reasonable improvement because it is derived from measured production conditions, actual material flow patterns, and facility relationship analysis. Additional validation through expert assessment was conducted by considering operational feasibility, equipment accessibility, and minimal disruption to existing production activities. The fact that the proposed layout does not require relocation of major production units increases its practical applicability for industrial implementation. Therefore, the contribution of this research lies not only in reducing movement distance and cycle time but also in demonstrating how SLP can be adapted as a decision-making framework for optimizing open-space heavy-equipment production systems.

Overall, the findings demonstrate that facility layout optimization using the SLP method can improve both efficiency and effectiveness of stone crusher operations. The study confirms that a production system may maintain process continuity while still experiencing spatial inefficiencies. By aligning activity relationships with physical arrangement, the proposed layout creates a more integrated material flow, reduces unnecessary movement, and provides a feasible improvement alternative under existing operational constraints. Future research incorporating simulation-based validation and economic analysis is recommended to quantify the long-term impact of layout improvements on production capacity, operational costs, and equipment utilization.

CONCLUSION

Based on the research results, the production facility layout at PT Juyomi Sinar Labuan is functionally capable of supporting the production process from initial material reception to final stockpile. However, in terms of efficiency and effectiveness, a mismatch is identified between activity proximity and the actual distances between facilities. This is reflected in the Load Distance value of 302 meters and a material handling cycle time of 5.05 minutes in the existing layout. The primary source of inefficiency is the recirculation path between the 2 Deck Screen and the Kun Crusher, which forms a backtracking flow and increases material travel distance.

The implementation of the Systematic Layout Planning (SLP) method results in a more compact and structured layout without requiring relocation of major production units. The proposed layout reduces the Load Distance to 278 meters and the cycle time to 4.65 minutes, indicating improvements of approximately 8% and 7.9%, respectively. These findings demonstrate that optimizing material flow configuration can effectively improve operational efficiency while enhancing the integration of production flow.

Based on these findings, it is recommended that the company implement the proposed layout gradually to maintain operational stability. An incremental approach is considered appropriate, as the improvements focus on optimizing material flow paths without requiring major structural changes. Furthermore, future research is suggested to incorporate more comprehensive analyses, such as material handling cost evaluation, downtime analysis, and production system simulation to assess the impact of layout improvements in greater depth. The use of algorithm-based optimization methods or industrial software may also be considered as comparative approaches to support more adaptive and data-driven layout improvements.

REFERENCES

Agustin, A. S., & Widarwati, E. (2019). *Layout Using Systematic Layout Planning (Slp) In Pt Kasomalang Crushing Plant (Kcp) Subang*.

Apple, J. M. (1977). *Plant Layout and Material Handling* (3rd Edition). John Wiley & Sons.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4 ed.). SAGE Publications.

Drucker, P. F. (1993). *Management: Tasks, Responsibilities, Practices*. HarperCollins.

Ernita, T., Mesra, T., & Febrina, W. (2023). *Penerapan Metode Systematic Layout Planning dan 5S dalam Perancangan Ulang Pabrik Roti Almeera Bakery*. *18*.

Heizer, J., & Render, B. (2017). *Operations Management* (12th ed). Pearson Education.

Herjanto, E. (2015). *Manajemen Operasi* (3 ed.). Grasindo.

Kholidasari, I., Sridewi Syahri, Y., & Sundari, S. (2022). Penerapan Metode Systematic Layout Planning Untuk Meminimasi Jarak Perpindahan Material Pada Ukm X. *Industrika: Jurnal Ilmiah Teknik Industri*, *7*(1). https://doi.org/10.37090/indstrk.v7i1.943

Kholifah, U., & Suhartini. (2021). Perancangan Ulang Tata Letak Fasilitas Produksi dengan Metode Systematic Layout Planning dan BLOCPLAN untuk Meminimasi Biaya Material Handling pada UD. Sofi Garmen. *Journal of Research and Technology*, *7*(2). https://doi.org/10.55732/jrt.v7i2.556

Kroemer, K. H. E., & Grandjean, E. (1997). *Fitting the Task to the Human: A Textbook of Occupational Ergonomics* (5th ed.). Taylor & Francis.

Kumar, V., & Naga Malleswari, V. (2022). Improvement of facility layout design using Systematic Layout Planning methodology. *Journal of Physics: Conference Series*, *2312*(1), 012089. https://doi.org/10.1088/1742-6596/2312/1/012089

Moleong, L. J. (2017). *Metodologi Penelitian Kualitatif*. Remaja Rosdakarya.

Muther, R. (1994). *Systematic Layout Planning* (2nd ed). Cahners Books.

Robbins, S. P., & Coulter, M. (2012). *Management* (11th ed). Pearson.

Santoso, D., Pradipto, M., & Setiowati, R. (2022). Usulan Layout Lantai Produksi Industri Mebel Menggunakan Systematic Layout Planning dan Simulasi. *Jurnal Optimasi Teknik Industri (JOTI)*, *4*(1), 7. https://doi.org/10.30998/joti.v4i1.11644

Siahaan, R. C., & Oktiarso, T. (2019). Perancangan Tata Letak Lantai Produksi Baru dengan Metode Systematic Layout Planning. *Journal of Integrated System*, *1*(2), 161–179. https://doi.org/10.28932/jis.v1i2.1201

Stevenson, W. J. (2011). *Operations Management* (11th ed.). McGraw-Hill Education.

Tompkins, J. A., White, J. A., Bozer, Y. M., & Tanchoco, J. A. (2010). *Facilities Planning* (4th ed.). Wiley.

Wahyudi, R., Garamba, R. R. N., & Nugraha, A. T. N. (2024). Evaluasi Tata Letak Fasilitas Menggunakan Metode Systematic Layout Planning di PT Lambang Jaya. *JOURNAL*

OF INDUSTRIAL AND MANUFACTURE ENGINEERING, *8*(1), 66–77. https://doi.org/10.31289/jime.v8i1.10618

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6 ed.). SAGE Publications.