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Research Paper

Application of Lean Construction in The Structural Work of the Arumaya Office Building Project

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ABSTRACT: *This study aims to evaluate the implementation of lean construction, identify the causes of waste, and analyze its impact on time performance in the structural work of the Arumaya Office Building project in Jakarta. Lean construction focuses on reducing waste and increasing added value in the construction process. However, the project faced several challenges, such as design revisions, limited storage space, and technical obstacles that contributed to waste.The method used is exploratory with a quantitative approach. Data were collected through interviews and questionnaires, then analyzed descriptively to identify the most dominant waste factors.*

The results show that lean construction has been implemented, although improvements are still needed. The most frequent type of waste is defects caused by a lack of coordination. The greatest impact on project delays comes from damaged materials due to poor maintenance. These findings provide a strategic foundation for improving the implementation of lean construction in future projects

KEYWORDS: *Lean Construction, Lean construction Tools, Waste, Time Performance*

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I. INTRODUCTION

In the highly competitive construction industry, it is essential to innovate and improve to achieve performance and targets. Delivering the best service to clients is critical for building and sustaining confidence in the company's credibility. Among the methods employed to improve company performance and attain targets is the adoption of Lean Construction. This management approach, commonly referred to as lean construction, represents a fundamental endeavor within the construction industry aimed at maximizing value and efficiency, concurrently and effectively mitigating various forms of waste (both tangible and intangible) inherent in construction activities.

Construction projects are undertaken based on thorough planning, leveraging diverse resources such as labor, capital, materials, and equipment. Paradoxically, even with each work phase meticulously detailed and non-repetitive, waste frequently emerges as an inherent risk throughout the construction process. A project is exposed to significant risk, thus its success is highly contingent upon the effective management of five pivotal factors, referred to as the 5Ms: Manpower, Machinery, Material, Money, and Method (Mudzakir, Setiawan, Wibowo, & Khasani, 2017).

On construction project sites, while waste is frequently identified primarily as material waste, its actual scope extends far beyond that. Waste can also be associated with a multitude of other activities, as articulated by Womack & Jones (1996)

The Arumaya Office Building is being erected on a 25,000 m2 site, featuring 23 stories and 4 basements, with a projected construction period of 24 months. The work scope encompasses structural, architectural, and plumbing components. The structural work is anticipated to be completed within approximately 16 months. Throughout the project's execution, challenges such as project drawing revisions, suboptimal storage area utilization, and various on-site technical hurdles have been detected. Collectively, these factors contribute to waste generation and possess the potential to exert significant adverse effects on the project. Therefore, this research will investigate the application of lean construction to address these issues, ensuring its alignment with lean construction tools and mitigating inefficiencies that lead to waste.

The objectives of this research are as follows:

a. To assess the extent of lean construction implementation in the project.
b. To identify the types of waste occurring in The Arumaya Office Building construction project.
c. To map the impact of waste on the time performance of The Arumaya Office Building project.

This study aims to substantially improve readers' knowledge of waste causes and their impact on the structural performance of The Arumaya Office Building project. It is also expected to offer insights into lean construction implementation within this project. For the company, this research will contribute significantly by providing comprehensive information on waste triggers and identifying the most impactful types of waste. The findings will further serve as a strategic basis for optimizing future lean construction tool deployment

II. LITERATURE REVIEW

2.1 Lean Construction

Lean construction is a philosophy rooted in manufacturing concepts. Thoengsal (2023) explains that in this context, the philosophy focuses on efforts to organize and refine construction processes, with the ultimate goal of achieving profit and meeting customer needs. Lean Construction, or 'ramping construction,' is an approach first introduced by Lauri J. Koskela of VTT Building and Transport, Finland, in 1992. This approach aims to enhance the performance of the construction sector by adapting Lean Production principles that have been successfully applied in the manufacturing industry (Thoengsal, 2023).

2.1.1 Lean Construction Tools

Lean construction is currently still in its early stages of development. Tools like the Last Planner have been field-tested and refined over the past decade. However, tools such as Visualization, daily meetings, and 5S have not been extensively tested, and concrete procedures for their implementation are still being developed.

2.2 Waste in Building Construction Projects

Within construction projects, waste is frequently categorized as non-value adding costs. This denotes the inefficient consumption of resources, including materials, time, and labor, stemming from activities that necessitate either direct or indirect expenditure, yet fail to contribute additional value to the end product for construction service users (Formosa, M.ASCE, Cesare, & Isatto, 2002)

According to Womack & Jones (1996), there are eight categories of waste commonly encountered in the execution of construction projects, as shown in the following table:

Table 1 Eight Types of Waste in Construction Projects

Waste	Construction Project
Defects	The building structure, materials, and properties that are still needed have been damaged, resulting in repairs or rework.
Overproduction	Overproduction that exceeds actual needs.
Waiting	Waiting for materials.
	Waiting for equipment to be repaired.
	Weather conditions that do not support activities.
	Waiting for instructions from the site supervisor.
Overprocessing	Equipment or work procedures that do not comply with established standards.
Motion	Unproductive or unnecessary movement of workers and equipment.
Transportation	Transportation of materials and equipment that does not add value but incurs costs.
Inventory	Supplying materials in excess of actual needs.
Design of goods of service is not satisfactory	Building design that does not meet customer requirements.

Source : (Womack & Jones, 1996))

2.3 Value Stream Analysis Tools

Developed by Hines & Rich (1997), Value Stream Analysis Tools (VALSAT) serve as a method to enhance comprehension of value streams. This approach is specifically engineered to bolster efforts in mitigating waste within the value stream. VALSAT is employed to ascertain the significance level of each distinct type of waste. Subsequent to this assessment, the selection of appropriate improvement tools is facilitated by an evaluation matrix (Situmeang, Afifuddin, & Rani, 2020)

III. RESEARCH METHOD

3.1 Types of Research

In light of the background, problem statement, and objectives outlined in this study, the research type is categorized as exploratory. This investigation seeks to identify the application of lean construction, pinpoint the root causes of waste encountered, and ascertain the influence of waste on the time performance of The Arumaya Office Building – Jakarta construction project.

3.2 Research Process

The study commences with problem identification, leading to the formulation of research questions. Addressing these questions necessitates data acquisition from The Arumaya Office Building project.

Data collection for this research primarily involves questionnaires to ascertain the types of waste and their influence on project performance. Conversely, information regarding lean construction implementation is gathered via interviews.

The interview data, focusing on the application of lean construction tools within The Arumaya Office Building project, will be descriptively analyzed. Subsequently, the questionnaire data will undergo processing using Microsoft Excel, followed by descriptive statistical analysis.

3.3 Data Collection Stage

In order to acquire the requisite data, this study will utilize a combination of interviews and questionnaires. Interviews shall be employed to collect information pertaining to the application of lean construction, whereas questionnaires will function to elicit direct data from informants (research respondents) for the purpose of identifying waste-generating factors and mapping their repercussions on the performance of The Arumaya Office Building – Jakarta construction project. The aforementioned respondents will be members of The Arumaya Office Building – Jakarta construction project team.

3.4 Data Processing

Descriptive statistics are employed for the analysis of data acquired from respondents, albeit without the intention of formulating universally applicable conclusions. The procedural steps involved in conducting descriptive statistics are as follows:

1. Each variable has been assigned an answer score, from which the mean value is subsequently computed.
2. Subsequently, the percentage values derived from the questionnaire will be calculated using frequency distribution.
3. To gain insight into the factors contributing to waste and their influence on project time performance, questionnaire data will be analyzed utilizing mean values and percentages, then presented in tabular and diagrammatic formats. This presentation will be structured according to the highest mean value ranking."

3.5 Data Analysis

Data analysis is conducted using descriptive methodology. The data, having been previously validated for reliability and validity, is subsequently configured to derive rankings for waste factors influencing variables and to prioritize waste-causing factors. Following this, the researcher will proceed to describe the findings from interviews concerning the implementation of lean construction.

IV. RESULT AND DISCUSSION

4.1 Responden Profile

This study employs a dual approach for data collection, namely interviews and questionnaires. Interviews are intended to acquire comprehensive information concerning the implementation of lean construction tools within the project, whereas questionnaires are designed to ascertain the contributing factors of waste and to map their ramifications on project performance. The interview process was carried out with the Deputy Project Manager of The Arumaya Office. Concurrently, this questionnaire will be disseminated to the project team, comprising 10 respondents.

Table 2 Responden Profile

No	Age	Frequency
1	< 30 Years	3
2	31 - 40 Years	6
3	41 - 50 Years	-
4	> 50 Years	1

No	Gender	Frequency
1	Man	8
2	Women	2

No	Work Experience	Frequency
1	< 5 Years	2
2	5 - 10 Years	4
3	> 10 Years	4

No	Job Title	Frequency
1	Deputy Project Manager	1
2	Project Planning & Engineering Manager	1
3	Project Operation Manager	1
4	Quality Control	1
5	Site Engineer	2
6	Staff	3
7	Other	1

4.2 Implementation of Lean Construction

a. Last Planner System

The contractor has established a master schedule, which has subsequently undergone revisions, resulting in Master Schedule Revision 2. This revised master schedule now serves as the primary reference for project execution. In response to project delays, the contractor has devised a 'catch up plan' or acceleration schedule, supplemented by structural schematics.

Furthermore, the contractor has developed a six-week lookahead plan, referenced against the master schedule. This 6-week plan is utilized for monitoring work progress over the specified period. As an improvement to this process, the contractor has implemented micro planning for all work items, detailing the time allocation for each stage of work. The scheduling team is responsible for weekly updates to this schedule. A weekly work plan is also generated by the contractor to track work accomplishment on a weekly basis. The 'percent plan complete' metric is employed to assess the attainment of planned targets. Schedule updates and overall progress are disseminated daily via WhatsApp groups and updated weekly on the information board

b. Increased Visualization

The contractor establishes an information board that displays the organizational structure, planned schedule, performance objectives, safety signage, and Personal Protective Equipment (PPE) requirements for the site.

c. Daily Huddle Meeting

The contractor sets a regular meeting schedule with both subcontractors and foremen. Meetings with subcontractors are held every Monday, while meetings with foremen take place every Wednesday. These meetings are routinely conducted on-site.

In addition, a daily morning briefing is held to review progress updates and the work schedule. A weekly project team meeting is also conducted to discuss planned schedules, weekly progress, current issues, and updates on weekly targets.

d. First-Run Studies

There was an adjustment to the installation method of the safety screen and safety blue net. Initially, the plan was to install the safety blue net two floors below the safety screen. However, due to a request from the owner, the safety blue net was installed directly below the safety screen. Several method adjustments were made in terms of safety.

There is ongoing monitoring and inspection related to work procedures. The BIM process did not run smoothly, as the BIM modeler was not present on the project site.

e. 5R Process

The contractor has implemented the 5S principles in the office. Project waste is also reused or repurposed. For example, plywood waste is used to create safety signs, and scrap metal sheets are turned into hazardous waste disposal containers.

Figure 1 Reuse of Plywood and Zinc Waste

Source : (Project Data ,2025)

f. Fail-safe for Quality and Safety

The contractor bears the responsibility for executing a comprehensive set of inspections, encompassing the verification of material quality intended for use, the assessment of safety parameters concerning equipment and work methodologies, and an evaluation of environmental conditions.

Figure 2 Environmental Inspection

Source : (Project Data ,2025)

In addition, the contractor performs examinations of personnel and operators, which include fatigue and Romberg tests for those working at elevated heights, alongside daily health check-ups for all workers and operators

Figure 3 Worker and operator inspection

Source : (Project Data ,2025)

4.3 Validity and Reliability Test

Table 3 Validity Test of the Survey of Waste Causes

Types Of Waste	Indicator	R Count	R tabel	Remarks
Defect	1. Fisik Bangunan, material dan properti yang masih dibutuhkan mengalami kerusakan sehingga menyebabkan repair atau rework	0.781	0.632	Valid
	2. Kurangnya tenaga kerja	0.718	0.632	Valid
	3. Penyimpanan material yang buruk	0.758	0.632	Valid
	4. Koordinasi dengan pihak-pihak terkait	0.685	0.632	Valid
	5. Menggunakan metode konstruksi yang kurang tepat	0.740	0.632	Valid
Overproduction	6. Produksi berlebihan yang melebihi kebutuhan	0.774	0.632	Valid
	7. Kehilangan material di lokasi kerja	0.714	0.632	Valid
	8. Tidak ada pengendalian produksi	0.651	0.632	Valid
Waiting	9. Adanya waktu menunggu material, peralatan dan pekerja datang	0.656	0.632	Valid
	10. Menunggu peralatan diperbaiki	0.661	0.632	Valid
	11. Cuaca tidak mendukung untuk melakukan aktivitas	0.821	0.632	Valid
	12. Menunggu instruksi dari pimpinan lapangan	0.677	0.632	Valid
Overprocessing	13. Peralatan atau prosedur pekerjaan yang tidak sesuai dengan standar yang telah ditetapkan	0.739	0.632	Valid
	14. Maintenance peralatan yang kurang baik	0.774	0.632	Valid
	15. Kurangnya pengawasan	0.929	0.632	Valid
Motion	16. Pergerakan pekerja dan peralatan yang tidak produktif atau tidak perlu	0.838	0.632	Valid
	17. Tata lokasi kerja yang tidak sesuai	0.847	0.632	Valid
Transportation	18. Perpindahan material dan peralatan yang tidak memberikan nilai tambah tapi memerlukan biaya	0.732	0.632	Valid
	19. Mobilisasi tenaga kerja terlalu jauh	0.689	0.632	Valid
Inventory	20. Menyediakan material yang lebih dari kebutuhan	0.882	0.632	Valid
	21. Material rusak karena kurangnya perawatan	0.851	0.632	Valid
Design of goods of service is not satisfactory	22. Desain bangunan yang tidak sesuai dengan permintaan pelanggan	0.715	0.632	Valid

Table 4 Validity Test of Waste Impact Mapping on Time Performance

Types Of Waste	Indicator	R Count	R tabel	Remarks
Defect	1. Repair atau rework dikarenakan kerusakan pada fisik bangunan dan material	0.834	0.632	Valid
	2. Banyak material yang tidak bisa dipakai	0.784	0.632	Valid
Overproduction	3. Produksi berlebihan yang melebihi kebutuhan, menyebabkan material menumpuk	0.754	0.632	Valid
	4. Kurangnya pengawasan mengakibatkan kehilangan material di lokasi kerja	0.684	0.632	Valid
Waiting	5. Keterlambatan material, peralatan dan pekerja datang	0.700	0.632	Valid
	6. Menunggu peralatan diperbaiki	0.733	0.632	Valid
	7. Waktu bekerja terganggu karena cuaca buruk	0.689	0.632	Valid
Overprocessing	8. Penggunaan alat dan material yang melebihi spesifikasi	0.728	0.632	Valid
	9. Hasil pekerjaan mandor tidak sesuai spesifikasi	0.816	0.632	Valid
Motion	10. Kapasitas produksi tidak tercapai	0.860	0.632	Valid
	11. Arah pergerakan pekerja dan alat tidak sesuai memperlambat waktu pergerakan	0.648	0.632	Valid
Transportation	12.Pergerakan material dan peralatan yang tidak perlu memperlambat progres pekerjaan	0.836	0.632	Valid
	13. Mobilisasi tenaga kerja terlalu jauh memperlambat waktu mulai kerja	0.730	0.632	Valid
Inventory	14. Penumpukan material di gudang penyimpanan	0.807	0.632	Valid
	15. Material rusak karena kurangnya perawatan	0.772	0.632	Valid
Design of goods of service is not satisfactory	16. Pekerjaan ulang karena ketidaksesuaian desain	0.721	0.632	Valid

Based on the results of the validity test that has been conducted, all questions related to the causes of waste were found to be valid, and all questions regarding the mapping of waste impacts affecting time performance were also found to be valid. Therefore, the data analysis process can proceed to the next stage.

Table 5 Reliability Test Results

Variabel	Reference Value	Cronbach Alpha	Conclusion
Survey of Waste Causes	0.70	0.963	Reliabel
Waste Impact Mapping on Time Performance	0.70	0.943	Reliabel

Based on the results of the reliability test, which show a Cronbach's Alpha value above 0.7, it can be concluded that the questionnaire has an adequate level of reliability and can therefore be used for further analysis.

4.4 Result of Waste Causes

Based on the following table, the highest-ranked cause of waste is identified as defect waste, with the source being lack of coordination with relevant parties. In second place is the waiting type of waste, caused by unfavorable weather conditions that hinder field activities. The third rank is occupied by overproduction waste, which results from a lack of control over the production process. The fourth position is taken by defect waste, sourced from a shortage of labor. In fifth place, defect waste is again identified, this time caused by damage to physical elements of buildings, materials, or other necessary properties, leading to the need for repairs or rework. The twentieth rank is occupied by overproduction waste, caused by producing more than what is needed. Meanwhile, in the twenty-first rank, waiting waste arises due to equipment repair waiting time. Finally, the twenty-second rank shows overprocessing waste, resulting from inadequate equipment maintenance.

Table 6 Percentage and Ranking of Waste Cause Classification

Types Of Waste	Indicator	Mean	Presentase	Ranking
Defect	4. Koordinasi dengan pihak-pihak terkait	3.70	74%	1
Waiting	11. Cuaca tidak mendukung untuk melakukan aktivitas	3.40	68%	2
Overproduction	8. Tidak ada pengendalian produksi	3.20	64%	3
Defect	2. Kurangnya tenaga kerja	3.10	62%	4
Defect	1. Fisik Bangunan, material dan properti yang masih dibutuhkan mengalami kerusakan sehingga menyebabkan *repair* atau *rework*	3.00	60%	5
Defect	3. Penyimpanan material yang buruk	3.00	60%	6
Waiting	9. Adanya waktu menunggu material, peralatan dan pekerja datang	3.00	60%	7
Inventory	21. Material rusak karena kurangnya perawatan	2.80	56%	8
Waiting	12. Menunggu instruksi dari pimpinan lapangan	2.70	54%	9
Overprocessing	15. Kurangnya pengawasan	2.60	52%	10
Motion	17. Tata lokasi kerja yang tidak sesuai	2.50	50%	11
Inventory	20. Menyediakan material yang lebih dari kebutuhan	2.50	50%	12
Overproduction	7. Kehilangan material di lokasi kerja	2.40	48%	13
Design of goods of service is not satisfactory	22. Desain bangunan yang tidak sesuai dengan permintaan pelanggan	2.40	48%	14
Defect	5. Menggunakan metode konstruksi yang kurang tepat	2.30	46%	15
Motion	16. Pergerakan pekerja dan peralatan yang tidak produktif atau tidak perlu	2.30	46%	16
Transportation	18. Perpindahan material dan peralatan yang tidak memberikan nilai tambah tapi memerlukan biaya	2.20	44%	17
Transportation	19. Mobilisasi tenaga kerja terlalu jauh	2.20	44%	18
Overprocessing	13. Peralatan atau prosedur pekerjaan yang tidak sesuai dengan standar yang telah ditetapkan	2.10	42%	19
Overproduction	6. Produksi berlebihan yang melebihi kebutuhan	2.00	40%	20
Waiting	10. Menunggu peralatan diperbaiki	2.00	40%	21
Overprocessing	14. Maintenance peralatan yang kurang baik	2.00	40%	22

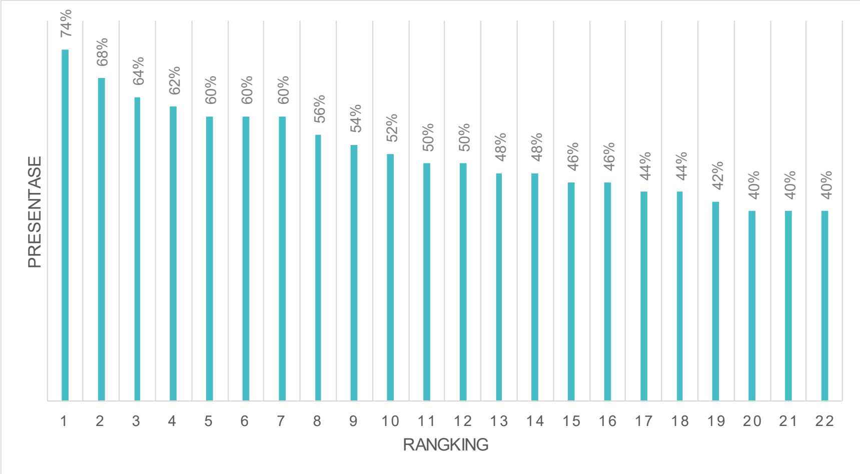

Figure 4 Graph of Mean Percentage of Waste Cause Classification

4.5 Result of Waste Impact Mapping on Time Performance

Based on the following table, the highest-ranked waste impact affecting time performance is inventory waste, with the impact being damaged materials due to lack of maintenance. The second rank is defect waste, with the impact of a large amount of unusable materials. The third rank is transportation waste, which impacts performance through unnecessary movement of materials and equipment that slows down work progress. The fourth rank is again defect waste, with the impact being repairs or rework due to damage to building structures and materials. In fifth place is overproduction waste, caused by excessive production beyond actual needs, resulting in material buildup. In eleventh place, waiting waste occurs due to delays in the arrival of materials, equipment, and labor. Twelfth place shows motion waste, which impacts the inability to reach production capacity. Next, in thirteenth place, transportation waste is caused by excessive distance in labor mobilization, which slows down the start of work. The fourteenth rank highlights waste due to unsatisfactory design of goods or services, leading to rework caused by design discrepancies. In fifteenth place, overprocessing waste emerges from the use of tools and materials exceeding the required specifications. Finally, the sixteenth rank records motion waste resulting from inefficient movement of workers and equipment, which slows down the transfer process.

Table 7 Percentage and Ranking of Waste Impact Mapping on Time Performance

Types Of Waste	Indicator	Mean	Presentase	Ranking
Inventory	15. Material rusak karena kurangnya perawatan	4.20	84%	1
Defect	2. Banyak material yang tidak bisa dipakai	3.70	74%	2
Transportation	12.Pergerakan material dan peralatan yang tidak perlu memperlambat progres pekerjaan	3.70	74%	3
Defect	1. Repair atau rework dikarenakan kerusakan pada fisik bangunan dan material	3.60	72%	4
Overproduction	3. Produksi berlebihan yang melebihi kebutuhan, menyebabkan material menumpuk	3.60	72%	5
Inventory	14. Penumpukan material di gudang penyimpanan	3.60	72%	6
Overproduction	4. Kurangnya pengawasan mengakibatkan kehilangan material di lokasi kerja	3.50	70%	7
Waiting	7. Waktu bekerja terganggu karena cuaca buruk	3.50	70%	8
Overprocessing	9. Hasil pekerjaan mandor tidak sesuai spesifikasi	3.50	70%	9
Waiting	6. Menunggu peralatan diperbaiki	3.40	68%	10
Waiting	5. Keterlambatan material, peralatan dan pekerja datang	3.30	66%	11
Motion	10. Kapasitas produksi tidak tercapai	3.30	66%	12
Transportation	13. Mobilisasi tenaga kerja terlalu jauh memperlambat waktu mulai kerja	3.20	64%	13
Design of goods of service is not satisfactory	16. Pekerjaan ulang karena ketidaksesuaian desain	3.20	64%	14
Overprocessing	8. Penggunaan alat dan material yang melebihi spesifikasi	3.10	62%	15
Motion	11. Arah pergerakan pekerja dan alat tidak sesuai memperlambat waktu pergerakan	3.10	62%	16

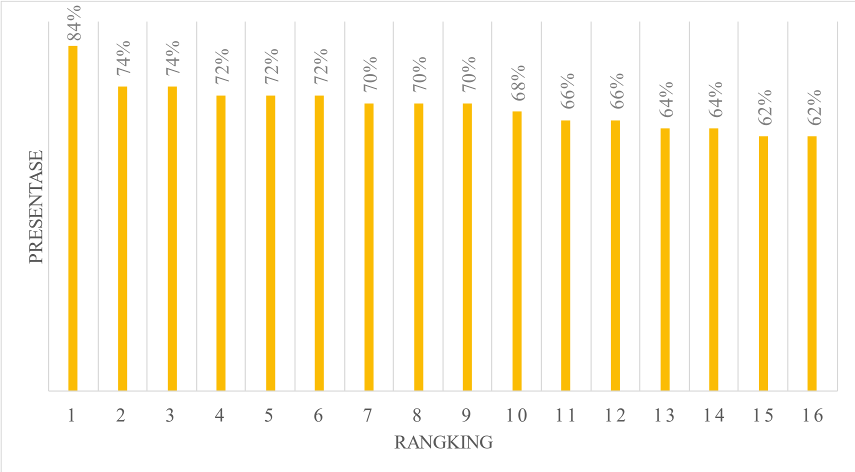

Figure 5 Graph of Mean Percentage of Waste Impact Classification Affecting Time Performance

4.6 Value Stream Analysis Tools

Table 8 Summary of Highest Scores in the Assessment of 8 Types of Waste.

No	Waste Classification	Questionnaire Assessment Scores.
1	Defect	4
2	Overproduction	4
3	Waiting	4
4	Overprocessing	3
5	Motion	3
6	Transportation	2
7	Inventory	4
8	Design of goods of service is not satisfactory	3
Total Nilai		**27**

To determine the ranking for selecting a waste analysis tool, calculations will be conducted by combining the waste data with the Value Stream Analysis Tool (VALSAT) framework.

Table 9 VALSAT Calculation Results for 8 Wastes.

Waste / Structure	**Bobot VALSAT**						
	Proses Activity Mapping	***Supply Chain Respons Matrix***	***Production Variety Funnel***	***Quality Filler Mapping***	***Demand Amplification Mapping***	***Decision Point Analysis***	**Physical Structure**
Defects	4			36			
Overproduction	4	12		4	12	12	
Waiting	36	36	4		12	12	
Overprocessing	27		9	3		3	
Motion	27	3					
Transportation	18						2
Inventory	12	36	12		36	12	4
Design	3	3	9	3	27	9	27
Total	**131**	**90**	**34**	**46**	**87**	**48**	**33**
Rangking	**1**	**2**	**6**	**5**	**3**	**4**	**7**

The recap data above will then be entered into the Value Stream Analysis Tools (VALSAT) matrix. From the table, the highest rank is held by the Process Activity Mapping with a total score of 131. The second rank is the Supply Chain Response Matrix with a score of 90, followed by Demand Amplification Mapping in third place with a score of 87. The fourth rank is Decision Point Analysis with a score of 48, the fifth is Quality Filler Mapping with a score of 46, the sixth is Production Variety Funnel with a score of 34, and the seventh and final rank is Physical Structure with a score of 33.

V. CONCLUSION

The implementation of lean construction tools in the Arumaya Office building project is running well. Lean construction tools such as the Last Planner System, increased visualization, the 5R process, and fail-safe measures for Quality and Safety have been applied and are being monitored. Additionally, the contractor has made improvements to the Last Planner System by creating micro-planning.

However, two tools need improvement: First-Run Studies and Daily Huddle Meetings. The BIM process progress in First-Run Studies needs to be updated. Regarding Daily Huddle Meetings, based on the waste cause analysis, coordination with relevant parties ranks as the primary cause of waste. Actions must be taken to reduce this waste cause.

The analysis shows that the most frequent type of waste in the structural work of the building project is defect waste, indicated by a lack of coordination with relevant parties. Meanwhile, the least frequent waste type in the project is overprocessing waste, indicated by inadequate equipment maintenance.

Based on the impact analysis, the waste that most significantly affects time performance is inventory waste, caused by damaged materials due to lack of maintenance. Conversely, the waste with the least impact on time performance is motion waste, caused by improper movement directions of workers and equipment, which slows down movement time.

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