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Analysis of Time Reduction Using the Lean Construction Method in the Construction Project of the Syifaul Qulub Islamic Boarding School in Surabaya

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Abstract
This research aims to reduce costs and time waste in the construction of the *Syifaul Qulub* Islamic Boarding School Surabaya by applying a Lean Construction approach. Using questionnaires and Lean tools such as value stream mapping, process activity mapping, and root cause analysis—including Pareto and fishbone diagrams—the study identifies and quantifies sources of inefficiency. The main contributor to waste is waiting time, accounting for 41.8% of critical waste and causing a 33-day project delay. Other significant factors include delayed material and equipment deliveries, material handling difficulties, lost or damaged equipment, disorganized work techniques, and unauthorized worker breaks. Overall, the waste ratio across 35 construction tasks is 21%, with the breakdown as follows: waiting (41.8%), unnecessary motion (13.7%), transportation (12.2%), material defects (11%), inventory storage (10.9%), overproduction (6.8%), and non-SOP-compliant processes (3.6%). The findings highlight the importance of timely logistics, effective material management, and adherence to standard operating procedures to minimize waste and improve project efficiency in building construction.
Keywords: *Lean Construction, Waste, added value, critical waste, Fishbone diagram*

INTRODUCTION

The concept of lean construction is gaining attention in Indonesia thanks to its potential to improve sustainability and efficiency in project implementation. Research by Bigwanto et al. (2024) highlights various factors and variables that influence the implementation of Lean Construction in government projects in the country, while emphasizing its role in sustainable practices. On the other hand, Adhi & Muslim (2023) emphasized the low intention of contractors in Indonesia to adopt Lean Construction concepts and tools, showing the need for strategies involving various stakeholders to improve sustainable construction practices. In addition, the focus on Lean theory and techniques in the context of post-disaster housing reconstruction in Indonesia also shows the application of Lean models that are relevant to local conditions. Irfandi et al. (2022) identified the key factors that support and hinder the implementation of Lean Construction in major projects in Indonesia, providing valuable insights into the challenges and opportunities that exist in the construction industry in the country.

In the context of the construction of the Distance Learning Program Unit building of the Open University of Surabaya phase II, it is important to conduct an audit of cost and time performance. The use of the earned value method offers a comprehensive approach to evaluating project performance, by making a careful comparison between actual costs and schedules as well as pre-estimated costs (Witjaksana & TJendani, 2023). Currently, the construction industry has begun to adopt and learn from the innovative system produced by the manufacturing industry, namely Lean Production, which in the construction world is known as Lean Construction. Lean Construction is the application of a new production philosophy in the construction sector (Koskela et al., 2019). The Lean concept, which was originally developed in developed countries such as in Toyota manufacturing in the automotive industry, aims to increase value and minimize waste in the construction process.

Risk is an integral part of any construction project. Any planner in charge of the project needs to be aware of the risks that may arise during the implementation of the project. Risk itself is uncertainty that can have a positive or negative impact on the achievement of project objectives. Certain factors trigger the emergence of risks, and the consequences of these risks will affect the implementation of the project.

In practice, construction planners must simultaneously analyze variability and resource allocation issues. It is important to evaluate how schedule adjustments can affect the duration of the project as well as the efficiency of resource use. By optimizing resources, we can increase productivity and reduce risks related to project schedules and costs. Therefore, a system is needed that can manage the workflow of the work process in order to achieve project efficiency. In this context, the principles of Lean Construction are highly recommended to be applied to construction projects.

In construction, the Lean Construction method is applied in a variety of ways, especially in planning and coordination. Sleek construction encourages careful planning and effective coordination between teams to minimize waste of time and resources. In lean construction, material management applies the principles of punctuality and completeness to ensure that materials are available when needed and minimize material overstorage.

Deep *Lean Construction*, quality management emphasizes error prevention and continuous improvement to improve project quality and reduce rework. Collaboration and involvement in *Lean Construction* Encourage collaboration between teams and the active participation of all stakeholders to improve decision-making and more effective problem-solving. Increasing awareness of sustainability, the public is increasingly aware of the environmental impact of the construction industry, this is what drives the demand for buildings that are more energy-efficient, more environmentally friendly, and use environmentally friendly materials. Lean construction can help achieve these sustainability goals by implementing strategies such as designing energy-efficient buildings, using sustainable materials, and reducing construction waste.

High construction material prices and inflation have led to a surge in construction costs, which in turn results in project delays and budget overruns. In the face of these challenges, *Lean Construction* emerged as a solution to control project costs by reducing waste, increasing efficiency, and optimizing the use of resources. On the other hand, the construction industry also faces a shortage of skilled labor, which can have an impact on project delays and the quality of work. Lean Construction has the potential to address this problem by improving worker training and development, creating a positive work environment, and attracting new talent to the sector.

The demand for high-quality buildings is increasing, with society demanding higher standards and stricter quality control. In the face of these demands, Lean Construction is an effective solution. By implementing strategies such as careful quality control, in-depth material testing, and detailed documentation, Lean Construction is able to help achieve the expected quality standards. In addition, the construction industry is beginning to adopt advanced technologies such as Building Information Modeling (BIM), 3D printing, and robotics to improve efficiency and productivity. Lean Construction plays an important role in effectively integrating these new technologies, so that the expected benefits can be maximized.

Increased focus on occupational safety and health is becoming increasingly important, especially in the construction industry. The safety and welfare of workers must always be a top priority. In this regard, *Lean Construction* offers effective solutions to improve workplace safety through the implementation of strategies such as hazard identification, risk control, and comprehensive safety training programs. On the other hand, modular construction has gained rapid popularity thanks to several benefits it offers, such as shorter construction times, waste reduction, and better-quality control. *Lean Construction* plays an important role in optimizing modular construction processes by implementing strategies that include careful planning, coordination between teams, and efficient material management. However, the challenge of collaboration remains a key issue in the construction industry, involving a wide range of stakeholders with diverse interests. *Lean Construction* can overcome these constraints by improving collaboration and communication through strategies such as joint planning, structured workflow arrangements, and effective use of communication platforms.

The COVID-19 pandemic has had a significant impact on the construction industry, causing supply chain disruptions, project delays, and new safety protocols. Lean Construction can help you adapt to these new challenges by implementing strategies such as material procurement risk management, strict safety procedures, and cleaning and sanitation programs. Increased focus on diversity and inclusion: The construction industry has long lacked diversity and inclusion. The construction industry can help promote diversity and inclusion by implementing strategies such as equality and diversity awareness training. Lean construction is a method that aims to minimize waste and maximize the value of a construction project. It is about the application of Lean Manufacturing principles in the construction sector. Several studies have highlighted the benefits and challenges associated with implementing Lean construction practices. Lean construction has been implemented in many projects, which means that during the planning period, the project minimizes waste effectively and efficiently (Allo & Bhaskara, 2022). Further, Babalola et al. (2019) emphasize the importance of lean construction methods such as virtual design and construction, prefabrication, and timely construction to improve environmental sustainability. No Further, Meng et al. (2023) found that lean construction with supply chain collaboration, especially when it comes to long-term collaboration, is more effective than lean construction alone.

Implementing simple building practices is not without challenges. Sarhan et al. (2017) identified barriers in the implementation of lean construction practices in the Kingdom of Saudi Arabia, including issues related to labor productivity, coordination, and communication. Similarly, Gao & Low (2014) report on the fundamental factors that hinder the implementation of lean construction in China's construction industry, such as culture, organization, and provisioning. In addition, the integration of Building Information Modeling (BIM) with Lean construction has been explored as a means to visualize product aspects and processes of construction projects in accordance with lean construction principles by Sacks et al. (2010) page 11. This integration has proven its ability to improve the efficiency of lean construction, as well as improve overall design and performance. In short, lean construction has great potential to improve the performance and sustainability of construction projects. However, to successfully implement this method, there are various obstacles that need to be overcome, which require a collaborative approach.

In addition, Anggraini & Wahyudi (2022) conducted a case study on the application of Lean Construction in construction projects in Indonesia, with a main focus on eliminating waste and obstacles faced in the implementation of this method. These studies collectively highlight the importance of Lean Construction in Indonesia, as well as discuss the potential for more sustainable and efficient construction practices. They also identify the specific challenges faced as well as factors that can support the success of the project in the local context. Overall, research on Lean Construction in Indonesia shows an increased interest in applying these principles in order to improve construction practices and address existing sustainability issues.

The problem that is the focus of this research is how to identify and minimize waste, both in terms of cost and time, related to Detail Engineering Design. It is very important to ensure that construction activities run cost-efficiently and time-effectively, so that projects can be completed on time and budgeted costs can be accurately known. To address the waste that occurs in this project, the Lean Construction method is considered very appropriate, as it is a continuous process that aims to eliminate waste. Lean Construction also prioritizes consumer needs, focuses attention on the flow of information and materials, and strives to achieve perfection in construction implementation.

This study aims to analyze the reduction of time waste in the construction project of the Syifaul Qulub Islamic Boarding School in Surabaya, which is located in a densely populated area with limited access. By applying a lean construction approach, this study focuses on finding efficient solutions in the management of constructioan projects, especially in the face of geographical challenges and accessibility limitations. It is hoped that this approach can identify and minimize activities that do not provide added value, so as to be able to increase time efficiency in project implementation.

METHOD

This study adopts a quantitative approach (Creswell & Creswell, 2017). The research subjects included all workers and project implementers, with the following criteria: field workers who have at least high school/equivalent education and work experience in the construction sector for at least three years (8 people), project implementers with at least D3 education in civil engineering (1 person), and project managers who have a S1 degree in civil engineering or architecture (1 person). In this study, the population studied included all workers and project implementers, while the sample was determined by the purposive sampling method, which ensured the representativeness of the respondents in accordance with the research objectives.

This research was carried out at the location of the construction project of the Syifaul Qulub Islamic Boarding School located on Jl. Kedungdoro Gang Pondok Number 29, Surabaya, taking place during November 2024, while the construction process is ongoing. Data collection was carried out through questionnaires designed based on the Value Stream Analysis Tool (VALSAT), as well as through interviews, field observations, and project documentation. The questionnaire covers various categories of waste, including defective materials, lead times, overproduction, inappropriate processing, over transportation, unnecessary inventory, and inefficient movement. Each category of waste is given a weight on a scale of 1 to 5, where a score of 1 indicates the absence of waste, while a score of 5 reflects a very high level of waste.

The data analysis process is carried out in several structured stages. First, we identified the activities that trigger waste using the VALSAT approach. Next, we weighted different types of waste based on the average respondent score. Then, we compiled the Value Stream Mapping to categorize activities into three groups: Value Added (VA), Necessary but Non-Value Added (NNVA), and Non-Value Added (NVA) activities. After that, an in-depth analysis of waste was carried out using fishbone diagrams to find the root cause and formulate solutions through an evaluation matrix. To ensure the accuracy of the measurements, we also test the validity and reliability of the questionnaires used. By applying this method, it is hoped that we can identify the factors that cause waste as well as provide practical improvement recommendations that can improve the efficiency of construction projects through the application of lean construction principles.

RESULTS AND DISCUSSION

Research Findings

Waste Identification

To identify waste, we need to first weight, as explained in the previous chapter in Table 1., regarding the weighting score value based on the VALSAT method. Furthermore, through the data from the questionnaire that has been distributed, the results of the analysis are obtained that show the weight of waste in each activity, as follows:

Table 1. Recap of Questionnaire Waste of each activity

No.	Categories of Waste	Respondents										Total
		1	2	3	4	5	6	7	8	9	10	
A	***Defect***											***91***
A1	***Defects in the Material***											***71***
1	Are Defects Found in Iron Material Ø10?	1	1	1	1	1	1	1	1	2	1	11
2	Are Defects Found in Iron Material Ø12?	1	1	1	1	1	1	1	1	1	1	10

Table 2. Recap of Waste Questionnaire of each Advanced activity

No.	Categories of Waste	Respondents										Total
		1	2	3	4	5	6	7	8	9	10	
3	Are Defects Found in Iron Material Ø16?	1	1	1	1	1	1	1	1	1	1	10
4	Are Defects Found in D22 Iron Material?	1	1	1	1	1	1	1	1	1	1	10
5	Are Defects Found in the H Beam 250 GG Steel Material?	1	1	1	1	1	1	1	1	1	1	10
6	Are Defects Found in the H Beam 300 GG Steel Material?	1	1	1	1	1	1	1	1	1	1	10
7	Are there any defects found in the material of the 5/8 steel anchor?	1	1	1	1	1	1	1	1	1	1	10
A2	***Defects in the Prebiation of Steel Structures***											20

8	Is a Defect Found On Joint Welding?	1	1	1	1	1	1	1	1	1	1	10
9	Is there a Defect in the Bolt Nut Hole?	1	1	1	1	1	1	1	1	1	1	10

Source: Processed Researcher, 2024

With the same approach, weighting results are obtained for each activity that occurs. The results include various types of waste, such as waiting, unnecessary motion, excessive transportation, unnecessary inventory, over production, and work that is not in accordance with procedures (Inappropriate Processing).

It is known that the highest and lowest rankings of each type of waste. The following is an analysis of waste that occurs based on the highest to lowest Waste ranking from the results of the analysis of 7 wastes.

1. *Waiting*: A type of wastage in the form of waiting is one of the most common categories in projects. This waste can involve machinery, labor, and information. In this project, wastage waiting is the biggest problem, mainly due to the delay in materials reaching the site, which interferes with the smooth running of the work. In addition, there are also other factors that inhibit it, such as waiting for work instructions, the arrival of equipment, and appliance repairs. However, of all these factors, the one that has the most significant impact in the analysis of waiting waste is the delay in the labor coming to the project site.
2. *Unnecessary Motion:* One of the biggest forms of waste in the workplace is when workers spend time with unproductive activities, such as smoking, relaxing, or returning late from breaks. In addition, a lack of effectiveness at work, such as slow completion of tasks, also contributes to this waste of time.
3. *Excessive Transportation:* This type of waste occurs due to the process of moving, both human and material, which leads to waste of time, energy, and costs. Considering that the location of this project is in a densely populated area, the transfer of materials must be done manually, so it takes a long time and requires a lot of effort.
4. *Defects:* This type of waste can be defects in materials ordered from suppliers, but also defects in the construction process on site.
5. *Unnecessary Inventory:* This type of waste occurs in the form of excessive inventory levels and misordering of materials, which results in unused materials.
6. *Over Production:* In this project, the waste due to *overproduction* is reflected in the accumulation of tools and materials on the job site. Often, piles of materials such as sand and concrete iron are found that have not been used in the construction process. This kind of waste is also caused by the implementation of work that exceeds the instructions that have been set.
7. *Inappropriate Processing:* This type of waste can occur through several ways, such as the use of tools or machines that are not in accordance with

their capacity and capabilities in the work process. In addition, the inconsistency between standard work procedures and their application in the field also contributes. Significant differences in working methods between operators in the construction area are also another contributing factor.

Value Stream Analysis Tool (VALSAT)

The next step is to choose a value stream mapping tool by utilizing the Value Stream Analysis Tool (VALSAT). In VALSAT, there are seven tools that will be used to analyze different types of waste. The conformity determination process is carried out by multiplying the average score of each type of waste with the Value Stream Mapping conformity matrix contained in Table 4. The Value Stream Mapping that has the highest total score based on the VALSAT results will be selected to provide detailed identification of waste. This selection is based on the fact that the Value Stream Mapping tool with the highest value is most accurate at identifying waste in the value stream.

Table 3. VALSAT Results Recapitulation

Waste / Structure	Process Activity Mapping	Supply Chain Response Matrix	Product Variety Funnel	Quality Filter Mapping	Demand Amplification Mapping	Decision Point Analysis	Physical Structure
Waiting	H 311.4	H 311.4	L 34.6		M 103.8	M 103.8	
Unnecessary Motion	H 101.7	L 11.3					
Excessive Transportation	H 90.9						L 10.1
Defect	L 9.1			H 89.1			
Unnecessary Inventory	M 27	H 81	M 27		H 81	M 27	L 9
Over Production	L 7	M 21	L 7		M 21	M 21	
Inappropriate Processing	H 36		M 12	L 4		L 4	
Total	**583.1**	**424.7**	**73.6**	**100.1**	**205.8**	**155.8**	**19.1**

Source: Processed Researcher, 2024

Information:
- H (High Correlation): Multiplier factor = 9
- M (Medium Correlation): Multiplier factor = 3
- L (Low Correlation): Multiplier factor = 1

Based on table 4. It can be known that *Tools* The selected with the highest score are *Process Activity Mapping* with a total of 583.1. The next process will be created *detailed mapping* from *Process Activity Mapping (PAM).*

Process Activity Mapping (PAM)

Process Activity Mapping serves to map all activities in detail with the aim of eliminating waste. Through Activity Mapping, we can see the physical flow, information, and time required for each activity, including the distance traveled at each stage of production. Furthermore, these activities are identified and grouped into five categories: operations, transportation, inspections, delays (*Delay*), and storage. Among these categories, operations and inspections are value-added activities, while transportation and storage are considered important but do not provide added value. Delays are activities that should be avoided because they do not provide added value at all. The collected data is then processed into activity mapping processes to support further analysis.

Information:
The blue mark in the table is the activity that occurs from the production process flow.

- KINDERGARTEN : Workforce
- O : Operation VA : *Value Added*
- T : Transportation NVA : *Non-Value Added*
- I : Inspection NNVA : *Necessary Non-Value Added*
- S : Storge
- D : Delay

From the table above, activities that have added value (VA), activities that do not have added value but are still needed (NNVA), and activities that do not have added value (NVA) are then grouped.

The time for the entire construction work process from the foundation to the dome is 200 days, with a total of 35 activities where there are 25 operations, 2 transportation, 1 inspection, 1 storage, and 6 delays in all activities.

The calculation of value-added activities (VA) took 152 days (76%), while non-value-added activities (NVA) took 33 days (17%), and activities that did not have added value but were needed (NNVA) took 15 days (8%).

Analysis and Interpretation of Results

The analysis is carried out based on the data that has been collected and processed. The three tools selected in the value stream mapping include process stream mapping, supply chain response matrix, and demand amplification mapping. Through this evaluation, we will provide recommendations for improvement taken from the root cause analysis of every waste that occurs.

Analysis of Plumbing in Whole Stream Construction Projects

The first step to identifying waste in a project is to perform Big Picture Mapping (BPM), which depicts the entire flow of the project. Through this picture, we can determine which areas have the potential to experience waste. BPM shows that engineering and construction activities take a total of 200 days, which is an accumulation of the operating time of the two activities. However, the project also indicates that the total time for construction, from planning to execution, is 200 days. This shows that no time is allocated for other activities that are included in non-value-added activities in the field of engineering and construction, so the schedule becomes very tight and the implementation must be carried out in parallel. These activities have the potential to cause delays in project completion. The initial plan was to schedule the project to be completed in the third week of February 2025. However, in reality, the schedule had to be pushed back and is expected to be completed only in the fourth week of March 2025. To prevent similar things from happening in the future, it's important to assess the engineer's manpower needs with the ideal time required to complete deliverables. In addition, it is necessary to create a clear Standard Operating Procedure (SOP), along with detailed scheduling of the preparation and review of engineering documents, as well as the qualifications and specifications of the engineers needed.

Waste Analysis Based on VALSAT

The analysis carried out based on VALSAT is limited to the aspects handled by the contractor, namely the Engineering and Construction sections. From the table available, it can be seen that the tool that obtained the highest score was Process Activity Mapping, with a total score of 583.1. Next, a more detailed mapping of Process Activity Mapping (PAM) will be made.

Waste Analysis Based on Process Activity Mapping (PAM)

Process activity mapping will provide a clear picture of the physical flow, information, and time required for each activity, including the distance traveled at each stage of production. Furthermore, this activity will identify five categories of activities, namely operation, transportation, inspection, delay, and storage. Among these categories, operations and inspections are activities that provide added value. Meanwhile, transportation and storage are important activities but do not add value. On the other hand, procrastination is an activity that should be avoided, because it is classified as an activity that does not add value. The data that has been collected will then be processed into a mapping of process activities.

Based on table 9. the calculation of value-added activities (VA) with a time of 152 days (76%), while non-value-added activities (NVA) are 33 days (17%), and activities that do not have added value but are needed (NNVA) are 15 days (8%).

The results showed that non-value *added* (*NVA*) activities have a large percentage second after *Value Added (VA)* of 17%, so it must be reduced to be able to shorten the cycle time so that it can also reduce delays.

Root Cause of Waste

Root Cause Analysis (RCA) is a structured evaluation method to identify root causes (*root cause*) an unexpected event and the measures necessary to prevent the recurrence of the unexpected event (*undesirable outcome*). To create a *root cause analysis*, can be done using 5 *Why*. The following is an analysis of the root causes of the occurrence *Waste Waiting* in the construction project of the Syifaul Qulub Islamic boarding school in Surabaya.

Based on the analysis of waste factors with the *Root Cause Analysis* It is concluded that the root causes of the occurrence of waste that have a dominant impact on cost losses are:

1. Waiting for the arrival of concrete iron materials.
2. Waiting for additional workers and masons to come.
3. Waiting for the steel structure fabrication material to arrive
4. Waiting for additional workers and steelworkers to arrive
5. Waiting for the dome material to come.

Table 4. RCA *Waste Waiting*

Yes	Types of Waste	(5 *Why*) Five Critical Questions Related to the Causes of Why Waste Can Occur?				
		Why1	*Why2*	*Why3*	*Why4*	*Why5*
1	*Waiting*	Why does the ironing work only start after waiting for the materials to arrive?	Why does the concrete casting work only start after waiting for workers to come?	Why does the work of a new steel structure start after waiting for the material to arrive?	Why does the work of a new steel structure start after waiting for the steelworkers to come?	Why does the dome work only start after waiting for the materials to arrive?

Source: Processed researcher, 2024

Table 5. RCA *Waste Waiting* Extension

Yes	Types of Waste	(5 *Why*) Five Critical Questions Related to the Causes of Why Waste Can Occur?				
Root Cause Analysis		Because the logistics staff are not careful in buying materials	Because foremen are not careful in calculating the needs of workers	Because the logistics staff are not careful in buying materials	Because foremen are not careful in calculating the needs of workers	Because the logistics staff are not careful in buying materials

Source: Processed researcher, 2024

Fishbone Analysis Diagram of Waste Factors

To identify the root cause of critical waste, researchers use the cause-and-effect diagram method (Fishbone). This approach is carried out by analyzing the various factors that contribute to the problem, which are divided into five categories: human, machine, work environment, materials, and work methods. In this context, the Fishbone Diagram is used to describe the factors that cause waste waiting in the construction project of the Syifaul Qulub Islamic Boarding School in Surabaya.

Skip *Fishbone* Diagram *Waste waiting,* so 5 factors are known, namely humans, machines, work environment, materials and work methods,

1. Human
   Delays in the arrival of workers at the project site and the number of workers who work lazy (not following the work process) are the causes of critical losses that can affect time and cost.
2. Milieu
   Less than ideal job site conditions, with many piles of materials scattered, as well as storage locations that are not centralized and far from the work area, are factors that can cause significant waste. All of this has the potential to negatively impact project time and cost.
3. Machine
   The delay in the arrival of the jackdrill tool slows down the dismantling process, while in casting work, time delays occur due to waiting for the repair of the milling machine. This can be categorized as a significant cause of waste, potentially impacting project time and cost.
4. Method
   Manual disassembly methods often take longer than planned, which can lead to significant waste. This situation has an impact on the overall time efficiency and cost of the project.
5. Material
   The delay in the delivery of materials is caused by the lack of precision of the logistics part in meeting the needs of materials. This is one of the main factors that leads to significant waste, which in turn can have an effect on project time and cost.

Solutions to Overcome Waste

In this study, several *Tools* in analyzing the evaluation of the waste of the construction project of the Syifaul Qulub Islamic boarding school Surabaya. *Tools* The evaluation matrix is used.

Table 6. Formulation If Then

Yes	If	Then	When
1	Damaged Materials	Buying good quality materials	At the time of implementation
		Provide a special warehouse where materials are stored	At the time of implementation
2	Materials arrive late	Perform other work using materials already in the project	At the time of implementation
		Speed up work when materials have arrived	At the time of implementation
3	Concrete Mixer *Machine* is late coming	Doing other work that does not use *a Concrete Mixer machine*	At the time of implementation

Yes	If	Then	When
		Speed up work when the *Concrete Mixer* machine has arrived	At the time of implementation
4	Difficulties in moving materials	Material storage is placed close to the job site	At the time of implementation
		Cleaning the work floor by disposing of the waste material at the time of implementation	

Source: Processed researcher, 2024

Table 7. Formulation If Then Advanced

Yes	If	Then	When
5	Lost Equipment	Buying new equipment	At the time of implementation
		Provide a special place to store the tools	At the time of implementation
6	Damaged Equipment	Use the equipment carefully	At the time of implementation
		Maintaining Equipment Regularly	At the time of implementation
7	Advantages of buying materials	Resell leftover materials that are still good	After the Implementation
		Saving good materials until the next project	After the Implementation
8	Less thorough work techniques	Conduct training for field workers	Before Implementation
9	Workers take breaks during working hours	Implementation of sanctions and reprimands by company leaders	At the time of implementation

Source: Processed Researcher, 2024

The Evaluation Matrix is used to identify the causes of waste and provide recommendations that need to be implemented to minimize waste that occurs in the construction project of the Syifaul Qulub Islamic Boarding School in Surabaya. The weight score is obtained from the results of the weight factor with the ranking value, where the weight of the factor and ranking are taken from direct observation of conditions in the field, using a scale of 1 to 10. With this method, the score weight value is generated to determine which improvements will be implemented, so as to reduce waste on each activity that has been mapped in the activity mapping process.

Table 8. Damaged Material Evaluation Matrix

Criterion	Weight factor	Alternative Solutions			
		Buying good quality materials		Provide a dedicated warehouse for material storage	
		Ranking	Weight score	Ranking	Weight score
(1)	(2)	(3)	(4) (2X3)	(5)	(6) (2X5)
Cost	6	9	54	8	48
Time	6	7	42	8	48
Impact on risk	6	5	30	6	36

Criterion	Weight factor	Alternative Solutions			
		Buying good quality materials		Provide a dedicated warehouse for material storage	
		Ranking	Weight score	Ranking	Weight score
Risk	6	9	54	9	54
Total			180		186
GO/NOT GO		***NOT GO***		***GO***	

Source: Processed researcher, 2024

Based on the evaluation matrix of damaged materials above, the solution to overcome *waste defect* The project is to provide a special warehouse for material storage.

Table 9. Material Evaluation Matrix Late Arrival

Criterion	Weight factor	Alternative Solutions			
		Perform other work using materials already in the project		Speed up work when materials have arrived	
		Ranking	Weight score	Ranking	Weight score
(1)	(2)	(3)	(4) (2X3)	(5)	(6) (2X5)
Cost	8	9	72	7	56
Time	8	8	64	6	48
Impact on risk	8	7	56	8	64

Source: Processed researcher, 2024

Table 10. Material Evaluation Matrix Late Arrival Continued

Criterion	Weight factor	Alternative Solutions			
		Perform other work using materials already in the project		Speed up work when materials have arrived	
		Ranking	Weight score	Ranking	Weight score
Risk	8	9	72	7	56
Total			264		224
GO/NOT GO		***GO***		***NOT GO***	

Source: Processed researcher, 2024

Based on the material evaluation matrix late coming up above, the solution to overcome *Waste Waiting* In the project, it is to do other work using materials that are already at the project site.

Table 11. Evaluation matrix of Concrete Mixer Machine late arrival

Criterion	Weight factor	Alternative Solutions			
		Doing other work that does not use a Concrete Mixer machine		Speed up work when the Concrete Mixer machine has arrived	
		Ranking	Weight score	Ranking	Weight score
(1)	(2)	(3)	(4) (2X3)	(5)	(6) (2X5)
Cost	8	7	56	5	40
Time	8	6	48	4	32
Impact on risk	8	8	64	6	48
Risk	8	8	64	6	48

Criterion	Weight factor	Alternative Solutions			
		Doing other work that does not use a Concrete Mixer machine		Speed up work when the Concrete Mixer machine has arrived	
		Ranking	Weight score	Ranking	Weight score
Total			232		168
GO/NOT GO		***GO***		***NOT GO***	

Source: Processed researcher, 2024

Based on the machine evaluation matrix *Concrete Mixer* Coming on top late then the solution to overcome *Waste Waiting* on the project is to do other work that does not use the machine *Concrete Mixer*.

Table 12. Difficulty Evaluation Matrix in Material Removal

Criterion	Weight factor	Alternative Solutions			
		Material storage is placed close to the job site		Cleaning the work floor by disposing of the waste material	
		Ranking	Weight score	Ranking	Weight score
(1)	(2)	(3)	(4) (2X3)	(5)	(6) (2X5)
Cost	7	6	42	5	35
Time	7	6	42	4	28
Impact on risk	7	7	49	5	35
Risk	7	7	49	3	21
Total			182		119
GO/NOT GO		***GO***		***NOT GO***	

Source: Processed researcher, 2024

Based on the evaluation matrix of difficulties in moving materials above, the solution to overcome *Motion* and *Waste Transportation* In the project, the material storage is placed close to the work site.

CONCLUSION

Based on the results of data processing and analysis, the construction project of the *Syifaul Qulub* Islamic Boarding School Surabaya experienced significant time and cost waste, mainly due to delays in the delivery of key materials such as reinforced concrete, steel structures, and domes, as well as delays in the addition of labor such as masons and steelworkers. Root cause analysis using Root Cause Analysis (RCA) and Detailed Process Activity Mapping identified several main contributing factors, including damaged materials, delays in the arrival of materials and machinery such as concrete mixers, difficulties in moving materials, loss or damage of equipment, excess material purchases, less thorough work techniques, and worker breaks that did not comply with the schedule. The percentage of activities categorized as waste (non-value-added activities) reached 21% of the total 35 jobs analyzed, with the largest category of waste being Waiting (41.8%), followed by Unnecessary Motion (13.7%), Excessive Transportation (12.2%), Defect (11%), Unnecessary Inventory (10.9%), Over Production (6.8%), and

Inappropriate Processing (3.6%). The dominance of waste in the Waiting category indicates that one of the main challenges of the project is time waste, which significantly affects overall efficiency. The application of the Lean Construction method is expected to form the basis for effective solutions to reduce waste and improve project efficiency in the future; for future research, it is recommended to evaluate the continuous implementation of lean solutions and to examine the integration of digital technologies to monitor and minimize waste in real time.

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