



Analysis of the Application of Lean Construction Methods in a Number of Contractors in West Java Region

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ABSTRACT

This study aims to explore the application of Lean Construction methods to reduce waste in construction projects in West Java. Inefficiencies often arise from seven types of waste: waiting, inventory, motion, overproduction, inappropriate processing, transportation, and defects. Data were collected through a quantitative approach, by distributing questionnaires to construction experts in the West Java region. Data analysis utilized a Likert Scale to determine the intensity level of each waste category. From 14 respondents, the two highest waste categories were Waiting (weather disturbances) and Transportation (the distance of suppliers to the project site). Root cause analysis was conducted using the 5 Why method with experienced respondents. The main issues identified were poor planning, inefficient logistics, and improper supplier selection.

INTRODUCTION

The construction sector plays a major role in national infrastructure development, affecting economic growth and quality of life. Unfortunately, construction projects are often plagued by waste, which prevents projects from running efficiently and effectively. This waste can take many forms, from long waiting times, materials that accumulate unused, wasteful transportation, to having to rework due to defects (Harsa et al., 2024). In reality in the field, this waste often goes unnoticed by project implementers, even though the consequences are fatal, detrimental in terms of cost, time, and quality of results.

The concept of Lean Construction emerged as a modern management perspective that seeks to cut waste and add value at every step of the project. This concept is adapted from Lean Manufacturing and has been widely applied in global projects, especially in an effort to improve workflow and create maximum value for project owners (Aslam et al., 2020). Although this method has been widely adopted in various countries, its application in Indonesia, especially in West Java, is still relatively limited and not fully structured (Angguningtyas & Beatrix, 2024).

The main questions we aim to answer in this study are: (1) What are the most dominant categories of wastage in construction projects in West Java? and (2) What are the root causes of the wastage? In short, our main hypothesis is that there are patterns of wastage that stand out the most, and these patterns can be discovered and explained in depth using Lean Construction methods. This study aims to find out what categories of wastage are most prevalent in West Java construction projects and uncover their root causes using a combination of quantitative and qualitative methods, so that we can provide appropriate recommendations in improving project efficiency through a more targeted implementation of lean construction.

LITERATURE REVIEW

Lean Construction is a construction project management approach adapted from the concepts of Lean Manufacturing and Toyota Production System. The goal is to maximize value by minimizing waste throughout the project process. The concept emphasizes eliminating non-value added activities, streamlining work flow, and strengthening project team collaboration.

There have been several previous studies that show that Lean methods are indeed effective in reducing waste. For example, Setiono, Rifai, and Wibawa (2024) found that waste such as product defects and improper processes are often the cause of large losses on projects. Meanwhile, Bhaskara, Ginting, and Masagala (2022) found that waste occurs due to project delays and material overages.

The Likert scale is one of the data processing methods that serves to measure data in the form of the results of thoughts, perceptions, and behavior of individuals or groups related to social issues (Sugiyono, 2020). This scale allows efficient measurement of subjective phenomena and provides more nuanced data with a choice of assessment indicators from very positive to negative. In this

study, an odd scale (1-5) was used to measure the level of intensity of the Likert scale.

Table 1. Likert scale indicators

Indicator	Score
Very Often Occurs (SST)	5
Often Occurs (ST)	4
Never Happens (PT)	3
Rarely Occurs (JT)	2
Not Occurring (TT)	1

The Pareto principle states that about 80% of problems are caused by 20% of the main causes. Pareto analysis is used to identify and prioritize the most dominant waste in construction projects, so that corrective actions can be more effective. Waste categories are organized by average value in descending order to show the highest contribution to waste, then the percentage contribution and accumulated percentage are calculated. Categories that fall within the cumulative percentage of 20%-40% are considered as the top priority for improvement.

Root Cause Analysis (RCA) is a method for finding the true source of a problem, rather than just addressing symptoms. In construction, RCA helps understand why problems occur and prevent them from recurring, for example looking for the root cause of material failure instead of just fixing it. The process involves data collection, analysis with techniques such as 5 Why or Fishbone diagrams, and development of appropriate solutions. The advantages of RCA are cost savings, project smoothness, and continuous quality improvement. RCA also encourages cross-functional team collaboration to identify problems systemically.

The majority of these studies are limited to quantitative methods and have not included exploratory methods to explore root cause analysis, such as the 5 Why method. Therefore, this study brings something new scientifically because it combines quantitative and qualitative methods to analyze how Lean Construction is implemented. Not only mapping the dominant waste categories based on Likert scale, but also exploring the root cause of the highest waste using Root Cause Analysis (5 Why) method. In addition, this research focuses on the West Java region as the study location, which until now has been minimally used as a research object in the context of local lean construction.

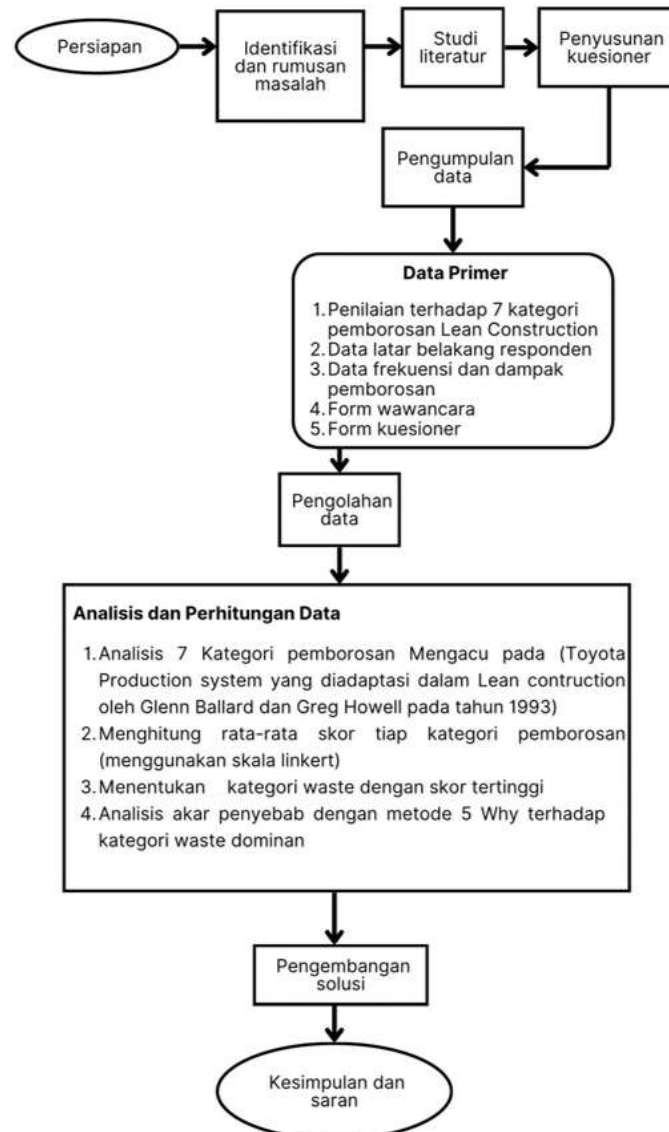


Figure 1. Research framework

METHODOLOGY

This research uses the questionnaire analysis method with the support of the interview method to identify and analyze waste in construction projects in the West Java region. We chose the construction project area in West Java as the research location, considering that this area is actively developing and has many types of project implementers.

Data was collected by distributing questionnaires to 14 respondents, all of whom had experience in construction projects. The questionnaire instrument was structured based on the seven categories of waste in Lean Construction, namely: waiting, inventory, motion, overproduction, inappropriate processing, transportation, and defects. Respondents were asked to rate 28 statements representing each waste category using a Likert Scale in excel software.

Table 2. Questionnaire Form

Category	Waste Variable	TT	JT	PT	ST	SST
Waiting (Waiting for Work Orders, Drawings, Materials, and Field Conditions)	1. Waiting for delays and changes regarding design updates and related materials. 2. Delays in materials and other needs to support the work. 3. Weather conditions that are not easy to predict. 4. Erratic schedule and design.					
Unnecessary Inventory	1. Erratic planning and scheduling 2. Delay in material arrival at site 3. Materials that exceed the capacity of storage space 4. Damaged materials due to lack of maintenance					
Unnecessary Motion	1. Inadequate field conditions 2. Lack of material storage so that it is necessary to move the material repeatedly to the location closest to the workmanship process 3. Changeable way of working 4. Unstable worker ability					
Over Production	1. The type of material is not in accordance with specifications or requirements 2. Lack of storage space for materials that require a special place 3. No control over production and materials 4. Frequent design changes					
Inappropriate Processing	1. Inappropriate work tools 2. Inappropriate work method 3. Lack of supervision and teamwork between personnel resources 4. Mismatch in the type of material ordered					
Transportation	1. Inappropriate material delivery schedule 2. Inadequate work location 3. The location of the orderer with the supplier is too far away					

Defect	4. Delivery delays due to inaccurate price information submitted by the supplier 4.
	1. The process is not in accordance with the design
	2. Lack of labor in accordance with the field of workmanship
	3. Material standards used are not in accordance with design specifications
	4. Material storage is not in the right place

The data obtained was then processed using the Pareto diagram analysis method to determine the total number of points for each waste factor in each category. The factor with the highest value in each category is considered to represent the most dominant type of waste.

In addition, to dig deeper into the root causes of the highest waste, further analysis was carried out using the Root Cause Analysis method (5 Why method) on experienced respondents. The 5 Why analysis was conducted in the form of interviews to explore the multiple causes of the highest waste factors in the Waiting and transportation categories. The results of the interviews were then compiled in tabular form per respondent and used as the basis for developing suggestions and strategies for improving project efficiency.

RESEARCH RESULTS

Based on Pareto analysis Vital Few are the first two categories of waste that account for >80% of the cumulative impact, if summed up Waiting and Transportation contribute more than 20% to the total waste that occurs is referred to as Vital Few which means a little but fatal and the remaining 80% can be referred to as Trivial Many or Many but trivial. So, improvement interventions and Lean Construction strategies should be prioritized on these 2 categories that are considered Vital Few 20% contributors to total waste.

Table 3. Pareto Principle Results

Waste Category	Average Value	Percentage Value	Accumulation	Description
Waiting	41	16,45%	16,45%	Vital Few
Transportation	37,25	14,94%	31,39%	Vital Few
Inventory	35,25	14,14%	45,54%	Trivial
Defect	35	14,04%	59,58%	Many
Motion	34,25	13,74%	73,32%	Trivial
Overproduction	34	13,64%	86,96%	Many
				Trivial

Inappropriate processing	32,5	13,04%	100,00%	Many Trivial Many
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Table 4. Prioritization of vital few

Rating	Waste Category	Contribution Percentage	Description
1	Waiting	16,45%	Vital few
2	Transportation	14,94%	Vital few

For specifics, it can be seen in table 5 the highest statement factor of the 2 waste categories.

Table 5. Highest Statement Factors

Waste Category	Dominant Statement Factor	Points
Waiting	Weather disturbances that cause delays in work	41
Transportation	Supplier and project site are too far away	39

The Waiting category is the most dominant, driven by the factor "weather disturbances that cause delays in work" which obtained the highest score of 41 points. This phenomenon shows the weakness of the weather risk anticipation system in project scheduling. The absence of weather mitigation SOPs and lack of use of forecast data are the main causes, as also confirmed by respondents in the 5 Why analysis.

In the Transportation category, the factor "supplier and project location are too far away" ranked the highest with 39 points. The root causes found from the interviews show that supplier selection is often based solely on price, without considering logistics efficiency, there is no database of local suppliers, and a delivery location-based evaluation system has not been implemented.

Scientifically, this finding suggests that the root of waste in construction projects comes not only from the technical work process, but from systemic weaknesses in decision-making, logistics planning, and external risk mitigation. This is consistent with the research results of Zhang et al. (2021) and Kulkarni et al. (2022) who confirmed that Root Cause Analysis can uncover managerial problems that are hidden and often overlooked in surface analysis.

These results also support the hypothesis that there are categories of waste that are more dominant and have a significant influence on project inefficiency. In addition, the 5 Why method proved effective for uncovering the underlying causes of waste, enriching the quantitative results with more contextualized field narratives.

DISCUSSION

This research was conducted on construction projects in the West Java region involving 14 respondents consisting of professional practitioners in the construction field. This research aims to identify the most dominant category of waste based on the Lean Construction approach. The research procedure was

carried out by distributing questionnaires containing statements related to seven categories of waste in construction projects. Each respondent was asked to give an assessment based on a Likert Scale.

Processing of questionnaire data was carried out using Microsoft Excel software to calculate the total score and average value of each category of waste. The recapitulation results show that there are two main categories that most dominate the contribution to waste in construction projects in West Java, namely Waiting and Transportation. Details of the results of the calculation of respondents' quantitative data can be seen in Table 1.

Table 6. Respondent Questionnaire Results

Respondent Code	Waiting				Unnecessary Inventory				Unnecessary Motion				Over Production			
	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
R1	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
R2	3	3	3	2	2	3	3	1	2	1	1	3	1	1	2	3
R3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
R4	4	1	2	2	2	2	5	2	1	2	2	2	2	2	2	2
R5	4	4	4	3	4	3	4	3	2	3	4	4	3	3	4	3
R6	2	2	3	3	2	2	3	2	3	2	3	2	2	2	2	3
R7	4	4	5	4	4	3	3	4	2	3	2	2	3	2	2	4
R8	2	4	3	1	1	2	1	3	3	1	1	3	1	3	2	2
R9	3	3	4	4	4	3	3	3	4	3	3	3	3	3	4	3
R10	4	5	3	4	3	3	4	4	5	3	4	4	4	3	4	3
R11	4	2	4	2	2	2	2	2	3	2	1	2	2	2	2	2
R12	3	3	3	2	2	1	1	2	2	1	2	2	2	3	2	3
R13	3	3	4	2	2	3	3	2	2	3	3	3	3	2	3	4
R14	1	2	3	2	2	2	3	2	3	2	3	1	2	1	1	2
R14	1	1	3	2	1	2	1	1	2	2	1	2	1	1	1	2
Total	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3	3
	1	0	7	6	4	4	9	4	7	1	3	6	2	1	4	9
Average	41				35.25				34.25				34			

Respondent Code	Inappropriate Processing				Transportation				Defect			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
R1	2	3	3	1	2	3	3	3	3	3	2	2
R2	3	3	3	3	3	4	3	3	3	3	3	3
R3	2	2	2	2	2	2	2	2	2	2	2	2
R4	2	2	4	3	3	3	4	3	3	4	3	2
R5	1	1	2	2	2	2	1	2	3	2	2	3
R6	2	3	3	2	2	3	3	3	3	3	3	4
R7	3	1	1	1	1	2	3	3	2	1	1	1
R8	3	3	4	3	3	4	4	3	3	4	3	3
R9	4	4	4	4	4	3	4	4	3	4	4	4
R10	1	2	2	1	2	3	3	2	2	2	2	2

R11	2	2	3	3	3	4	4	4	2	1	1	2
R12	3	3	2	3	3	3	3	3	3	3	3	3
R13	1	2	1	1	2	2	1	1	2	1	2	1
R14	2	2	2	1	2	1	1	1	2	3	2	3
Total	31	33	36	30	34	39	39	37	36	36	33	35
Average	32.5				37.25				35			

Description:

S: statement

R: respondent

Since the purpose of the research is to see the highest measurement value, the analysis is carried out through the following steps:

1. Summation of Variable Values

- Each variable (R1 to R14) is calculated for its total value based on the questionnaire responses. S is a statement of each variable

2. Grouping by Waste Category

- Variables are classified into 7 Lean Construction waste categories.
- Example: Variables 1 - 4 belong to the waiting category, variables 5 - 8 to other categories, etc.

3. Calculation of Average Category Value

- The total variable value of each statement is summed up, then divided by the number of variables.

4. Calculation example

- After summing up the value of the waiting variable is:

$$S1 = 41$$

$$S2 = 40$$

$$S3 = 47$$

$$S4 = 36$$

- Furthermore, to obtain the total value of the Waiting category, the four total values are summed up

$$\text{Total Waiting category} = 41 + 40 + 47 + 36 = 164 \text{ (1)}$$

- To find out the average value per variable, the total is divided by the number of items (4 category statements):

$$\text{Average per category waiting} = 41 \text{ (2)} = \frac{164}{4}$$

$$\text{Waiting percentage} = \frac{41}{249} \times 100\% = 16.45\% \text{ (3)}$$

Perform similar steps for all waste categories, so as to obtain overall total and average value data.

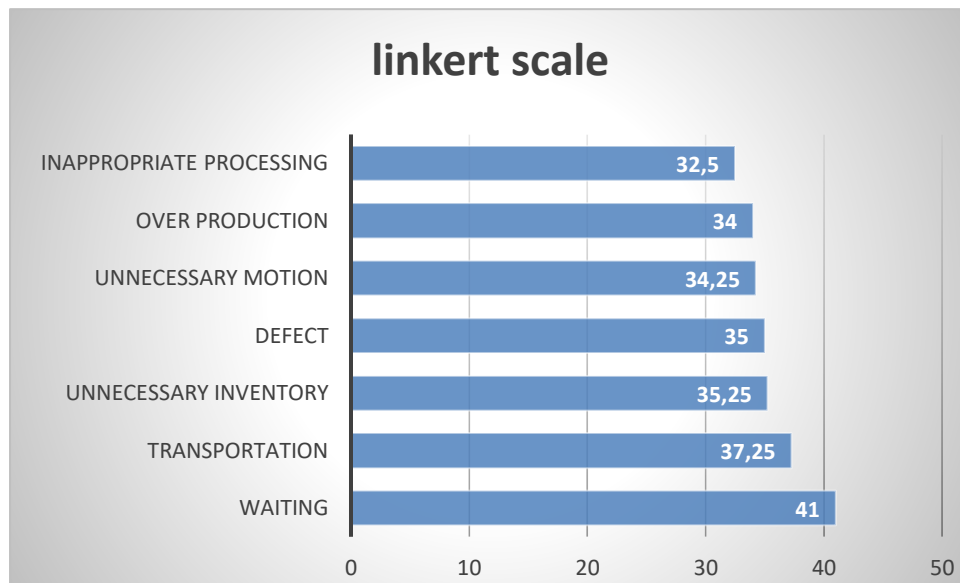


Figure 2. Likert Scale Result Graph

The Pareto Principle section states that about 80% of problems are caused by 20% of the main causes, so the identification of the most dominant waste is very important for the effectiveness of corrective actions. The following steps in preparing a Pareto diagram using excel *software* are explained as follows:

1. Using average data from each waste category
7 categories of waste have been obtained from the Likert scale method. Here is the average value:

2. Sort the values from highest to lowest

Waste categories are arranged based on the average value in descending order to show the highest contribution to waste.

3. Calculating the percentage contribution of each category to the overall total

The total of all category scores was summed up first, then each category was calculated with the percentage formula:

$$\text{Percentage} \times 100\% = \frac{\text{Nilai Kategori}}{\text{Total Seluruh Nilai}}$$

4. Calculating the accumulated percentage

After that, the cumulative percentage of the categories that have been sorted from largest to smallest is calculated.

5. Determining priority limits

Pareto diagram is a logic approach from the early stages of the process of improving a situation depicted in the form of a histogram known as the concept of vital few and the trivial many to get the main cause (Topayung & Kawulur, 2022).

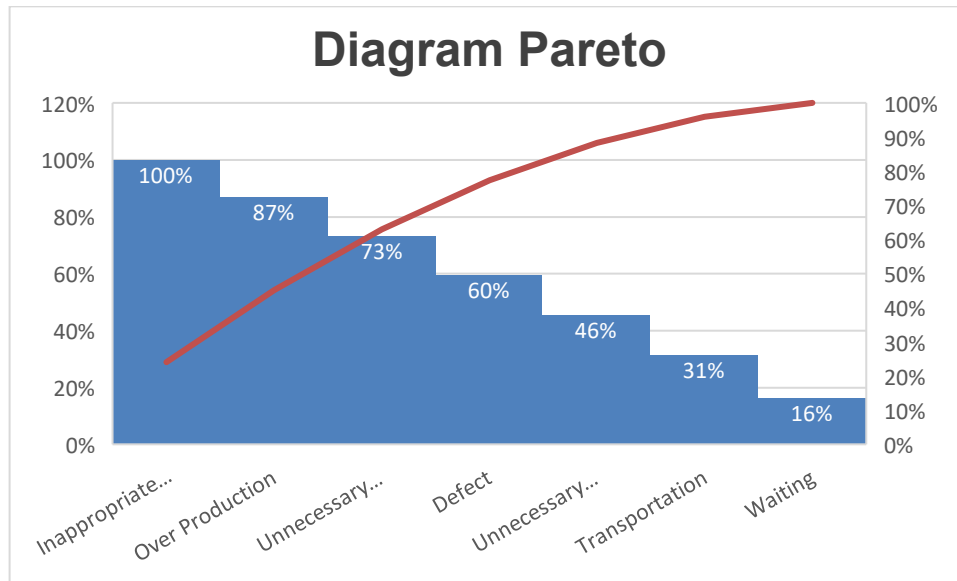


Figure 3. Pareto Diagram Graph

Finding the root cause of the problem using the 5 Whys method
From table 5, it can be concluded that the statement factor of the seven waste categories must prioritize the waiting and transportation categories, so to find the root cause can use the 5 ways method as follows:

Table 7. Method 5 whys Waiting Factor - Weather Disruption

Respondent Code	Why 1	Why 2	Why 3	Why 4	Why 5
R1	Scheduling does not consider seasonality	No forecast data used	There is no weather prediction system in the work schedule	The company does not allocate weather forecasting technology	
R2	Workers cannot work when it rains	No protection in the work area	Management does not prioritize light weather mitigation	Assumption that weather is a factor that cannot be controlled	
R3	No alternative schedule when it rains	Planners did not use annual weather data	Because it is not required in the project SOP	Planning procedures have not touched weather mitigation	No consultation with environmental experts or BMKG

Table 8. Method 5 whys Transportation factor - Supplier location too far away

Respondent Code	Why 1	Why 2	Why 3	Why 4	Why 5
R1	Fixed supplier location from head office	Company policy does not consider location	The company is not flexible in supplier selection	There is no procurement autonomy at the project level	Organizational structure is too centralized
R2	No local suppliers selected	No local supplier database	No logistics survey conducted at the beginning of the project		
R3	Supplier selected from out of town	Because the price is cheaper	Procurement team only considers cost	No logistics efficiency analysis	There is no supplier selection evaluation standard

CONCLUSIONS AND RECOMMENDATIONS

This study found that the main wastes in construction projects in the West Java region are the two most dominant waste categories, namely

1. Waiting
2. Transportation.

From the results of the root cause analysis using the 5 Whys method, the root causes were found and the following solutions were also obtained:

1. Root cause of weather-related delays
 - Utilization of weather forecast data (BMKG)
 - Rescheduling outdoor work
 - Implementation of weather mitigation SOP
 - Project team training
 - Provision of physical protection in the work area
 - Increased work safety
2. Waste of transportation due to long distance of suppliers
 - Compilation of local supplier database
 - Autonomy of supplier selection by the project team
 - Application of the total cost of ownership (TCO) method
 - Revision of supplier evaluation standards
 - Improved supply chain efficiency and resilience

ADVANCED RESEARCH

This study has several limitations that need to be acknowledged. First, the study's focus was limited to the analysis of seven main waste categories in Lean Construction, thus not yet covering other categories such as Underutilized Talent which may also contribute to project inefficiencies. Second, the number of respondents involved in primary data collection was 14 people, which may limit the generalizability of the findings to the entire population of construction projects in Indonesia. Third, the research location was focused on construction projects in the West Java region, so the results obtained may not fully represent conditions in other areas. Lastly, this research had limited resources, including research funds, which affected the scope and depth of data exploration beyond the established parameters. As a continuation of this research, it is recommended to expand the study by adding an analysis of the eighth category of waste, namely Underutilized Talent, in order to obtain a more comprehensive picture of potential inefficiencies in construction projects in Indonesia.

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