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Understanding the Effect of Non-Value-Adding Activities On Construction Project Cost: Main Effects and Causal Relations

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Abstract

In the construction sector, cost overruns are still an ongoing issue, especially in developing nations like Malaysia. Physical waste receives a lot of attention, but process-related inefficiencies, particularly Non-Value-Adding Activities (NVAAs), have a significant but sometimes disregarded effect on project costs. This study focused on the eight categories of NVAAs: overproduction, waiting time, non-utilized talent, inventory, motion, transportation, and additional processing. This study determines the extent to which NVAAs effect construction costs and the root causes of these inefficiencies. A mixed-methods strategy was used in this study, which included questionnaire surveys, semi-structured interviews, and diagramming. According to the study, the most important NVAAs causing construction cost overruns are defects and waiting times. Industry stakeholders rated defects as having the highest severity. Moreover, it has been discovered that low tender price methods, poor planning, and bad procurement practices are frequently the causes of these significant NVAAs. The results emphasize how urgently improved planning, awareness, and stakeholder collaboration are needed to improve cost performance through the removal of NVAAs from building processes.

Keywords: Defect, Waiting Time, Root Causes, Causal Diagram

1. Introduction

Even though the construction sector plays a critical role in economic growth and development, it continues to face persistent inefficiencies and frequent cost overruns. In Malaysia, such issues are especially pronounced many construction projects exceed their intended budgets, undermining both public and private sector objectives. While the reduction of physical waste (e.g., excess materials or debris) has been widely studied and addressed, process-related inefficiencies often classified as Non-Value-Adding Activities (NVAAs) remain poorly understood and under-researched.

Although several studies have explored individual types of NVAAs, such as making-do (Koskela, 2000a), excessive inspection (Rahman et al., 2012), and long walking distances (Tersine, 2004), there remains a scarcity of comprehensive, updated research, particularly in the construction context. Much of the existing literature is outdated or fragmented, and very few recent empirical studies systematically explore the root causes of these non-physical wastes. This highlights a critical gap in current knowledge and underscores the need for targeted research.

Inspired by lean thinking from the manufacturing sector, pioneers such as Ohno (1988) and Liker (2004) have long emphasized the need to eliminate waste to improve system performance. In line with this, the lean construction movement has adapted these principles to the construction industry. Referring to Klosova and Kozlovská (2021), the most common categories of NVAAs include waiting, motion, transportation, defects, overproduction, overprocessing, inventory, and making do. Measuring the frequency of these activities on-site allows project teams to identify inefficiencies and adopt best practices to reduce them.

According to Shou et al. (2020), NVAAs in construction are any activities that consume resources but add no value to the client. Alarmingly, research suggests that only 5% of construction time is dedicated to value-adding activities, while the remaining 95% is spent on non-value-adding work (Dara, Raut, et al., 2024). This includes common forms of waste such as defects, rework, idle time, and excessive movement—all of which increase project costs and extend timelines.

Emuze (2013) highlights that many of these wasteful activities go unnoticed, as they are embedded in routine construction workflows and mistakenly considered essential. Similarly, Yuniarto (2012) identified persistent issues like poor procurement practices, unrealistic tendering, and limited early stakeholder involvement as major contributors to NVAAs. However, despite these insights, the underlying drivers of non-physical waste remain insufficiently studied in Malaysia, leaving a critical gap in local industry knowledge.

The concept of the "seven wastes," or *muda*, was first introduced by Ohno (1988) in the manufacturing industry as a core element of the Toyota Production System, forming the foundation of lean manufacturing. These seven types of waste; defects, overproduction, waiting, transportation, inventory, motion, and extra processing have been widely used to evaluate system performance, identify inefficiencies, and drive continuous improvement (Formoso et al., 2017). Over time, this framework has been adapted and applied in construction research (e.g., Ogunbiyi et al., 2013; Gustafsson & Marzec, 2007; Felipe et al., 2012) to better understand and address process-related inefficiencies in construction projects. Recognizing the critical role of human resources, later researchers such as Sarhan & Fox (2012) and Liker & Meier (2006) proposed the inclusion of non-utilised talent as an eighth category.

Applying the same idea of waste in manufacturing to the construction industry, this study focusses on eight major NVAAs categories, known collectively as DOWNTIME: Defects, Overproduction, Waiting, Non-utilised Talent, Transportation, Inventory, Motion, and Extra-processing. The objectives are to understand how NVAAs contribute to rising construction costs and explore the root causes behind these inefficiencies. By identifying and addressing these issues at their source, the overall cost performance of construction projects can be significantly improved.

2. Research Method

2.1 Research Design

A combination of quantitative data from structured questionnaires with qualitative input from semi-structured interviews used to achieve the objectives of this research. This mix allowed for both a broad overview of how widespread NVAAs is, and a more detailed look at why they occur. The semi-structured interviews were particularly useful for digging deeper into specific issues, as they gave the researcher the flexibility to guide conversations and explore cause-and-effect links. When trying to understand complex problems and the perspectives of those involved, qualitative methods are especially valuable. They provide a more holistic view and help uncover insights that might be missed with numbers alone. For example, by letting participants share their ideas and experiences in their own words, interviews can reveal the underlying reasons of issues. This strategy can highlight contextual elements and underlying problems that quantitative approaches might miss (Ramakrishnan & Krupskyi, 2024).

Question 1:	*Why did the robot stop?*
Answer	The circuit is overloaded, causing a fuse to blow.
Question 2:	*Why is the circuit overloaded? Answer:*
Answer	There was insufficient lubrication on the bearings, so they locked up.
Question 3:	*Why was there insufficient lubrication on the bearings?*
Answer	The oil pump on the robot is not circulating sufficient oil.
Question 4:	*Why is the pump not circulating sufficient oil? Answer:*
Answer	The pump intake is clogged with metal shavings.
Question 5:	*Why is the intake clogged with metal shavings?*
Answer	Because there is no filter on the pump.

Figure 1. Example of the 5-Why Technique (Ohno, 1988)

Ohno (1988) first proposed the 5-Why Technique, which is illustrated in Figure 1 above. During the interview phase, this organized approach, called the 5-Why Analysis, was used as a Root Cause Analysis (RCA) tool to go beyond the problems' immediate symptoms and find their underlying causes. The method is generally considered to be successful despite its simplicity (Lee, 2012; Leino & Helfenstein, 2008; Sauder, 2007). Scholars like Tezel (2007) and Gao and Low (2013b) have emphasized that asking "why" repeatedly helps one grasp the underlying problems more thoroughly. While Liker (2004) and Hanid (2014) noted that addressing these fundamental problems is the only way to achieve sustained improvements, Ohno (1988) emphasized the significance of uncovering hidden root causes. In the given situation, Ohno showed that it was only after determining the underlying reason using this repeated questioning approach that the proper remedy, fitting a filter on the pump, was made clear.

2.2 Participants

A total of 375 questionnaires were distributed randomly via postal mail across Malaysia to clients, consultants, and contractors involved in construction projects. The inclusion of diverse stakeholder groups ensured a balanced representation and provided a holistic view of industry perceptions regarding NVAAs.

For the qualitative phase, 12 experienced professionals were purposively selected based on their roles in project management, cost control, and construction planning. The group consisted of eight consultants, two clients, and two contractors, each possessing between 10 to 29 years of industry experience. Their insights were critical for identifying root causes of inefficiencies in construction workflows.

Among the twelve interviewees, eight were from consultancy firms, two represented client organisations, and the remaining two were from contractor organisations. These participants were selected for their ability to provide rich, experience-based insights relevant to the study's objectives.

2.3 Procedure

The structured questionnaire focused on eight categories of NVAAs, which were defects, overproduction, waiting time, non-utilised talent, transportation, inventory, motion and extra-processing (DOWNTIME). The level of effect towards the construction cost with the identified Non-Value-Adding Activities (NVAAs) was assessed using a 5-point Likert scale. Respondents rated each activity from "no effect" (1) to "major effect" (5), allowing for the evaluation of how significantly each NVAA contributes to cost implications. The use of the 5-point Likert scale not only helps validate whether construction practitioners in Malaysia share similar perceptions with their international counterparts but also provides insights into their level of knowledge, understanding, and awareness regarding NVAAs.

The semi-structured interview protocol was developed after analysing the survey results. The process was conducted in several structured phases:

a. A standard list of interview questions and themes was prepared after analysing data from a prior questionnaire study.
b. A 5-Why schedule was developed and used in every interview to probe underlying causes.
c. Potential respondents were identified, contacted, and scheduled for interviews.
d. Each session began with an explanation of the study objectives, interview purpose, and format
e. The 5-Why method and the use of forms to record responses were explained clearly.
f. Permission to record the interview using an audio device was requested (only if approved by the respondent).
g. Interviews began with participant background, then explored defect and waiting time issues.
h. Initial questions focused on types of NVAAs, followed by a series of “why” questions.
i. Although five iterations of “why” are standard, more or fewer could be used depending on response depth.
j. Interview flow was flexible, with probing based on respondent answers.
k. The 5-Why method was repeated for each NVAA category (defects and waiting time).
l. Sessions were limited to 30 minutes per topic to maintain focus and efficiency.
m. Responses were handwritten during the session using a pre-designed schedule form.
n. Notes were later transcribed and formatted uniformly.
o. Finally, three experts from different stakeholder backgrounds (client, contractor, consultant) validated the collected data.

2.4 Data Analysis

To address the two objectives of this study, data were collected using both questionnaires and semi-structured interviews. The quantitative data obtained from the questionnaires were analysed using descriptive statistics to provide an overview of the respondents’ perceptions and to support specific research inquiries. Mean scores were calculated to represent the central tendency and average responses, offering a general view of the data in line with the recommendation of Sekaran (2003). Additionally, following Emuze (2011), ordinal data from the Likert scale were not treated as interval data; instead, appropriate ranking and hierarchy were applied to maintain the descriptive integrity of the results. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS).

Moreover, semi-structured interviews were analysed using the 5-Why Technique and causal diagramming. Interview data were manually recorded in a matrix table and analysed qualitatively, following the three-step procedure proposed by Miles and Huberman (1994) and Saunders et al. (2009): data reduction, data display, and conclusion drawing. This process involved condensing long statements into summaries, categorising themes using established literature, and developing theoretical insights.

To better understand how the root causes of inefficiencies are connected, a causal diagram was created using Vensim software. This diagram helped map out the relationships between key variables, such as underlying issues, process bottlenecks, and factors driving inefficiencies. By visualizing these connections, the researcher could see how different elements of the system interact and where targeted improvements could be made. When combined with the 5-Why Analysis, the causal diagram offered a clear and structured way to explore how and why NVAAs lead to increased project costs, directly supporting the study’s objectives.

In this research, the causal chain reflects a sequence of events where one issue leads to another, highlighting how inefficiencies emerge and spread across a construction project. Data gathered through the 5-Why Analysis were translated into visual models to illustrate these cause-and-effect links, making it easier to see the bigger picture and understand how specific problems escalate.

As shown in Figure 2, different types of causal links were mapped based on the classification by Rosslenbroich (2001) as cited in Milatos (2010). Types (a) to (c) represent linear relationships, while Type (d) forms a feedback loop. For example, Type (a) involves a chain reaction where one effect becomes the cause of another. Type (b) occurs when multiple causes lead to a single effect, and Type (c) shows how one cause can trigger multiple outcomes. In contrast, Type (d) loops back on itself, showing how a system's output can eventually influence its input again (Machin, 2014; Han & Lee, 2007).

In these diagrams, two key elements are nodes and arrows. Nodes represent variables or conditions observed in the real construction context, while arrows depict the direction and nature of influence from one variable to another (Sapiri et al., 2015). In this study, the nodes include root causes, bottleneck causes, underlying causes, and their resulting effects, as visualized in Figure 3.

Root causes are shown as nodes with arrows flowing out but none flowing indicating their role as originating factors. Bottleneck causes are identified by multiple arrows pointing in, signifying convergence from multiple root conditions. Underlying causes are those that support or aggravate the primary causes but are not direct origins. Eden and Ackermann (1992) introduced the concepts of "head" nodes (no outgoing arrows) and "tail" nodes (no incoming arrows), where addressing a tail node can offer the most leverage in solving systemic problems.

The use of a causal diagram in this study enables construction professionals, particularly in Malaysia, to better understand the chain of root causes that lead to cost-related inefficiencies caused by NVAAs. By visualising these interdependencies, stakeholders are better equipped to plan, prioritise, and implement effective countermeasures to control and reduce unnecessary project costs.

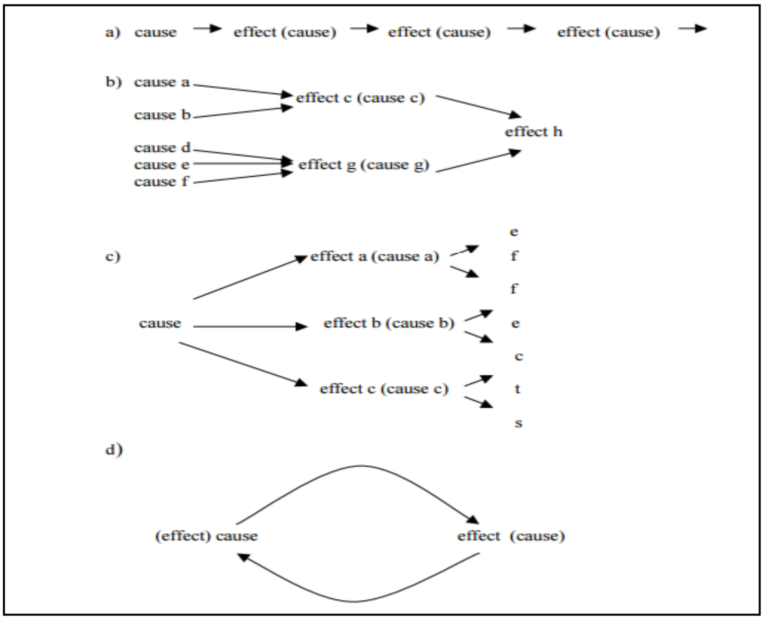

Figure 2. Causal Connection (Milatos, 2010)

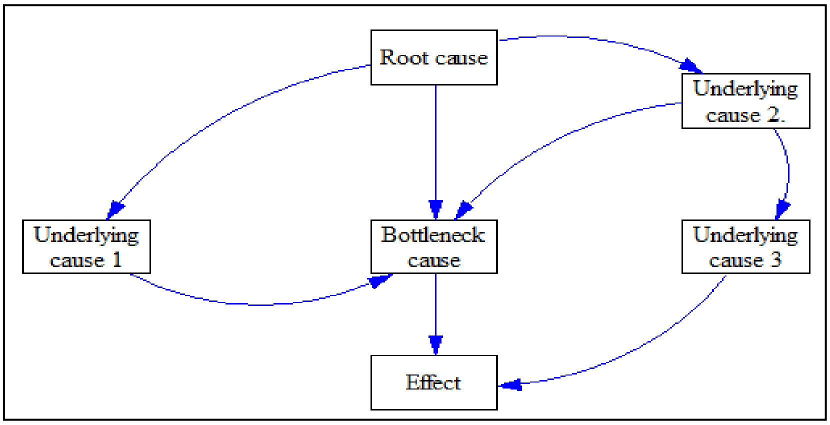

Figure 3: Elements in the Causal Diagram

3. Results and Discussion

3.1 Objective 1: To assess the extent to which Non-Value Adding Activities (NVAAs) contribute to escalating construction costs.

A structured survey was conducted among three main categories of stakeholders in the construction industry which were clients, consultants, and contractors, to evaluate the perceived impact of various Non-Value Adding Activities (NVAAs) on project costs. The objective was to quantify the extent to which each NVAA contributes to cost escalations, based on collective industry experience and professional judgment.

The results in Table 1 clearly indicate that defects are perceived as the most significant contributor to increased project costs. The findings of this study, which revealed that defects registered the highest mean score of 4.26 with 50% of respondents indicating a major effect and 33% indicating a moderate effect are consistent with existing literature. For instance, Senaratne and Wijesiri (2008) reported a comparable mean score of approximately 4.28 for defects in the Sri Lankan construction industry, with 96% of respondents identifying them as a frequent and impactful form of waste. These defects, including poor workmanship, design errors, and rework, are widely acknowledged as critical cost drivers due to their association with quality-related deficiencies throughout the construction process.

Likewise, waiting time in this study was rated with a mean score of 4.14, and 78.3% of respondents perceived it as having either a moderate or major impact. This finding aligns with multiple studies that consistently rank waiting as a top source of non-value-adding activities (NVAAs), often resulting from inefficient communication, delayed approvals, and material shortages, which in turn lead to costly idle labor and delayed project milestones (Koshkin et al., 2020; Senaratne & Wijesiri, 2008).

Furthermore, overproduction, which scored a mean of 4.01 in this study with 32.1% rating it as major and 44.3% as moderate, also reflects global observations. Although some studies, such as those conducted in Kazakhstan and Singapore, reported lower observed frequency or criticality for overproduction, they still acknowledged its negative implications—particularly when arising from misaligned planning or poor coordination, resulting in unnecessary use of resources, increased storage costs, and potential rework (Koshkin et al., 2020). Collectively, these findings reinforce that defects, waiting time, and overproduction are persistent and costly inefficiencies across diverse construction contexts.

Table 1. The Effect of the NVAAs towards the Cost

Categories	Percentage (%)					Mean Score
	No effect	Minor effect	Neutral	Moderate effect	Major effect	
The effect of the defects on construction costs	0.9	4.7	11.3	33	50	4.26
The effect of overproduction on construction costs	0.9	5.7	17	44.3	32.1	4.01
The effect of the waiting time on construction costs	0.9	0.9	19.8	39.6	38.7	4.14
The effect of the non-utilized talent on construction costs	2.8	9.4	31.1	41.5	15.1	3.57
The effect of transportation on construction costs	0	5.7	20.8	48.1	25.5	3.93
The effect of the inventory on construction costs	0.9	7.5	28.3	42.5	20.8	3.75
The effect of the motion on construction costs	1.9	6.6	35.8	40.6	14.2	3.59
The effect of the extra process on construction costs	1.9	2.8	21.7	49.1	24.5	3.92
Average (%)	**4.54**	**5.41**	**23.23**	**42.34**	**27.62**	

On the other hand, activities such as non-utilized talent (mean = 3.57), motion (mean = 3.59), and inventory (mean = 3.75) were perceived as having a relatively lower though still moderate impact on cost. These forms of inefficiency, while not as directly visible as defects or delays, still contribute to cumulative losses through underused human resources, unproductive movement, and excess material holding.

The analysis shows a general consensus across the respondents, where the average mean score across all NVAA categories falls between 3.57 and 4.26, suggesting that all eight categories of waste are perceived as moderately to highly impactful on construction costs. Very few respondents rated any NVAA as having no effect (between 0% and 2.8%), reinforcing the broad acknowledgment of their relevance in cost management.

These insights are crucial for prioritizing interventions. Emphasis should be placed on improving quality management systems to reduce defects, streamlining processes to minimize waiting times, and refining planning mechanisms to avoid overproduction. Together, these improvements can substantially mitigate the hidden and visible costs caused by NVAAs.

3.2 Objective 2: To investigate the root causes of inefficiencies associated with these NVAAs.

The findings from interviews and qualitative coding (including 5-Why Analysis) revealed two dominant forms of NVAAs in construction projects are defects and waiting time. The research uncovered a network of systemic, procedural, and human-related factors that contribute to these inefficiencies throughout the project lifecycle.

Defects were identified as the most prominent NVAA during both the pre-construction and construction phases. In the pre-construction phase, two main types of defects were found: designs that did not meet user needs and drawing discrepancies, with the former mentioned by half of the respondents. During the construction phase, frequently cited defects included defective work, uncompleted work, non-compliance with specifications, poor quality of jointing and fixing, variation work, failed testing, rework, damaged materials, and materials not complying with specifications. Among these, defective work was the most common, caused by factors such as poor workmanship, inadequate inspection, use of low-quality materials, rushing, design errors, and delayed document revisions.

Uncompleted work was linked to missing items in the bill of quantities, lack of supervision, and lack of motivation. Damaged materials were attributed to weather exposure, poor handling, long storage, and transportation issues, while materials not meeting specifications resulted from supplier issues and cost-saving measures. Importantly, the study emphasized that defects are not limited to the contractor's activities but can also stem from design and planning failures by consultants, reinforcing the idea that construction defects span all phases and involve multiple stakeholders.

Figures 4 illustrate the occurrences of defects during the construction process, as represented through causal diagrams.

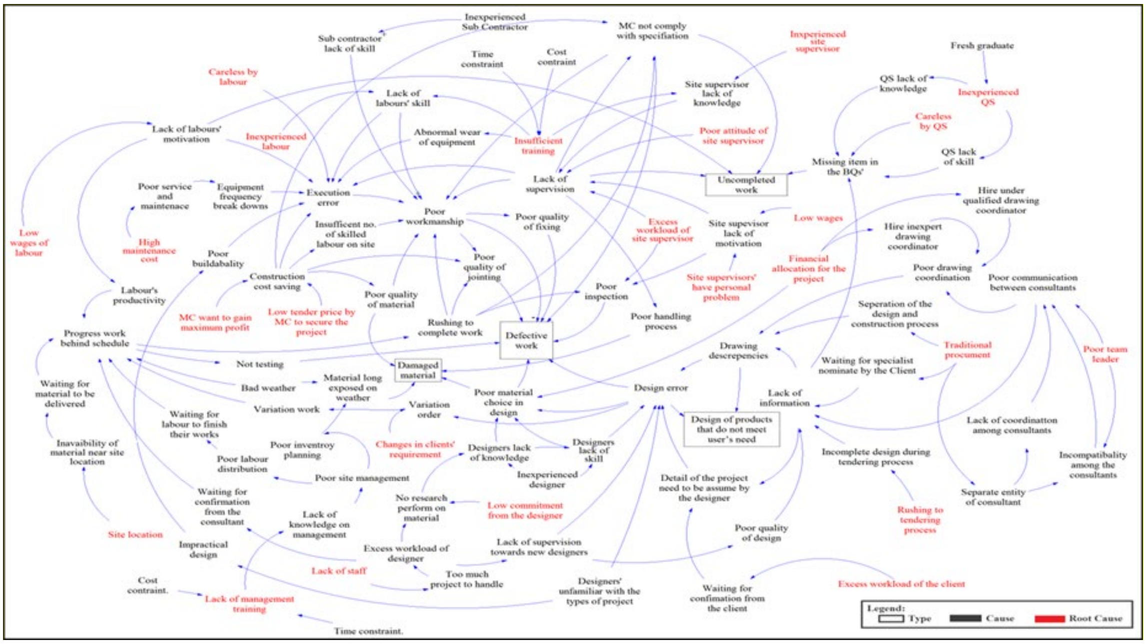

Figure 4. The Incidences of Defects during Construction Process

The most commonly reported issues included: defective work, uncompleted work, designs not meeting client requirements, and damaged materials. At the root of these defects were several interrelated factors. A key cause was inexperienced labour and site supervisors, many of whom were fresh graduates with insufficient exposure to field conditions. The lack of comprehensive training programs and mentorship further compounded their inability to meet performance expectations.

Additionally, traditional procurement practices particularly in public sector projects were found to fragmentcommunication between consultants, clients, and contractors. This disconnect led to delayed document submissions, drawing discrepancies, and inefficient coordination during critical project phases. Cost-driven decisions also played a major role. Contractors operating under low bidding strategies often made compromises on quality, opting for substandard materials and less skilled labour to reduce expenses. This approach directly contributed to rework, material failures, and non-compliance with specifications.

Other contributing factors included excessive workloads among consultants and supervisors, which led to insufficient oversight, late design revisions, and delayed approvals. Poor site management, inadequate supervision, and low motivation among workers (caused by low wages or unclear career pathways) were also prevalent. Behavioral issues such as carelessness, lack of accountability, and weak leadership structures further degraded construction quality. These findings suggest that defects in construction projects are not isolated incidents, but manifestations of deep-rooted challenges within the procurement, training, and management ecosystems.

Waiting time was another significant inefficiency highlighted in the study, especially during the construction phase. This aligns closely with global construction research. For instance, Sambasivan and Soon (2007) confirmed that in the Malaysian context, improper planning and scheduling often led to material procurement delays, which in turn caused significant project hold-ups. Similarly, studies in Pakistan and Egypt ranked financing difficulties and delayed payments as critical contributors to material shortages and project delays (El-Razek et al., 2008; Haseeb et al., 2011). In Indonesia, failure to calculate material needs accurately, material shortages, and late material arrivals were key delay drivers in construction projects (Durdyev & Hosseini, 2020)

The instances of waiting time during the construction process found in this study are depicted using causal diagrams in Figure 5. Participants reported numerous forms of delay, including waiting for materials, specialist nomination, client approvals, variation orders, consultant responses, and even labour availability. Each of these waiting types was mapped through 5-Why Analysis to reveal deeper structural and procedural issues.

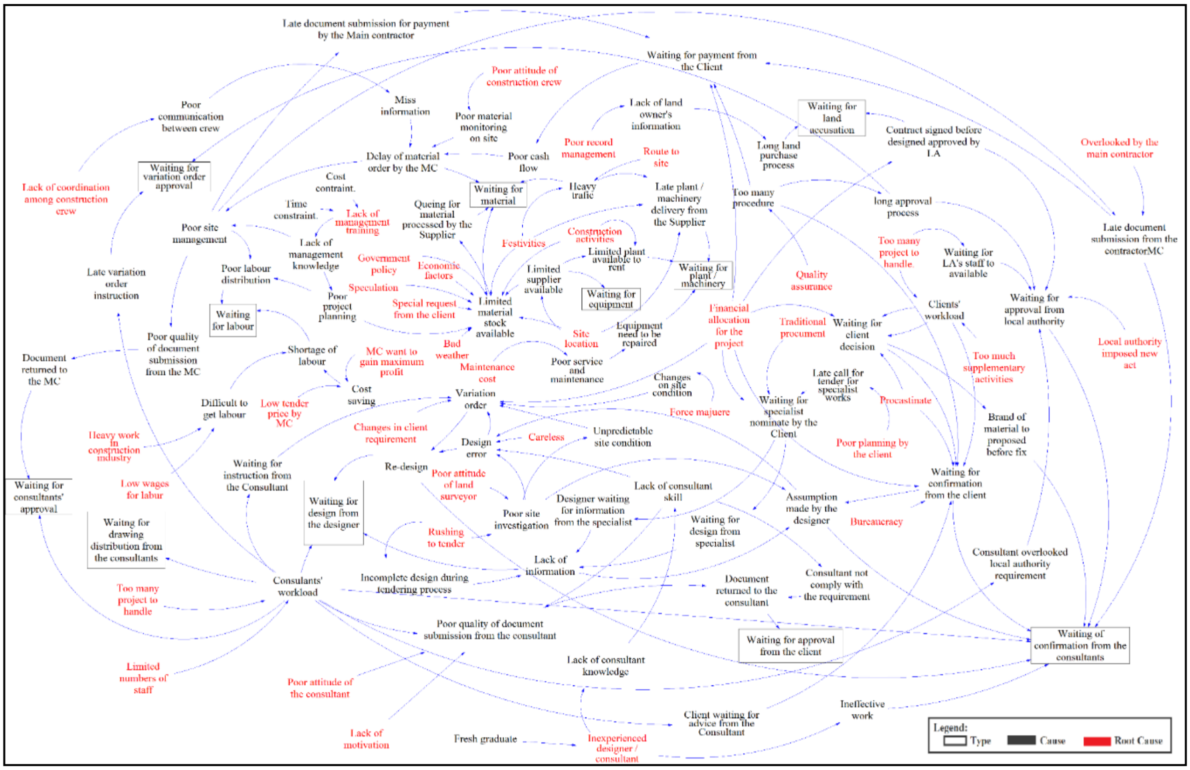

Figure 5. The Incidences of Waiting Time during Construction Process

One of the primary causes of waiting time was the delay in material delivery, often due to poor planning, insufficient supplier stock, and cash flow issues that delayed contractor payments. The traditional procurement approach again emerged as a core issue, especially in cases involving late specialist appointments or fragmented consultant coordination. Moreover, too many bureaucratic procedures, particularly in public sector projects, caused significant lags in the approval of variation orders, design changes, and payment processing.

The study also revealed that financial constraints and workload imbalances among consultants and clients contributed to prolonged response times. Consultants, often managing multiple projects simultaneously, struggled to issue timely feedback, while clients especially in government agencies faced internal delays due to rigid administrative hierarchies. Procrastination in decision-making, compounded by unclear delegation of authority, further slowed project momentum.

In addition, force majeure elements such as bad weather, unforeseen site conditions, and shifting regulatory requirements added unpredictability to project timelines. Poor labour distribution, low availability of machinery or equipment, and site access issues (e.g., land acquisition delays) were also frequently cited. The findings make it evident that waiting time is not just the result of isolated delays, but a systemic inefficiency rooted in poor planning, lack of coordination, limited resource availability, and inflexible processes.

4. Conclusion

The effects of Non-Value Adding Activities (NVAAs) on construction projects were examined in this study, with a focus on the way they affect costs and cause inefficiencies. Defects and waiting times were consistently identified as the most detrimental types of NVAAs affecting project outcomes and budgets through a combination of survey responses and interviews. According to survey data, more than 80% of respondents rated defects' impact as moderate to major, making them the primary cause of cost overruns. Not far behind were waiting times and overproduction, both of which were connected to problems including rework, delays, idle labor, and inadequate coordination. Even less evident inefficiencies, such as unnecessary movement, excess inventory, and not utilized talent, were nevertheless thought to have a significant impact on rising expenses, demonstrating that waste in every way adds up.

The interviews provided insight into the real root cause of these issues. Defects were frequently linked to more general problems including inexperienced workers, inadequate oversight, antiquated procurement procedures, and cost-cutting that resulted in subpar quality. Conversely, waiting times were frequently brought on by sluggish approvals, excessive bureaucracy, misunderstandings, and financial setbacks that delayed the delivery of materials, consultant input, or variation orders. One recurring theme was the disjointed nature of project roles, particularly in conventional procurement approaches, which resulted in delays, unclear accountability, and poor coordination. Poor site management, low employee morale, overworked employees, and inadequate training for new team members were among the other frequent issues.

According to the study's findings, Non-Value Adding Activities (NVAAs) have a significant impact on the structural, managerial, and procedural facets of building projects and are not only small operational problems. Addressing these inefficiencies requires a thorough strategy that goes beyond band-aid solutions. This entails adopting data-informed decision-making, enhancing staff training and development, enhancing communication channels, and changing procurement procedures. The construction sector may significantly improve cost efficiency, expedite project delivery, and improve overall project performance by tackling the root issues, especially those associated with faults and waiting times.

Declaration of Conflicting Interests

All authors declare that they have no conflicts of interest.

Author Contributions

Conceptualisation, Haryati Binti Ismail. Methodology, Haryati Binti Ismail. Validation, W. Mohd Haniff Bin W. Mohd Shaupil. Analysis, Haryati Binti Ismail, W. Mohd Haniff Bin W. Mohd Shaupil. Investigation, Haryati Binti Ismail, Nor Asma Binti Mamat, W. Mohd Haniff Bin W. Mohd Shaupil. Resources, Haryati Binti Ismail, Nor Asma Binti Mamat. Data Curation, Nor Asma Binti Mamat. Writing-Draft Preparation, Haryati Binti Ismail. Writing-Review & Editing, Nor Asma Binti Mamat, W. Mohd Haniff Bin W. Mohd Shaupil. Visualisation, Haryati Binti Ismail. Supervision, Haryati Binti Ismail. Project Administration, Nor Asma Binti Mamat. Funding Acquisition, Haryati Binti Ismail, Nor Asma Binti Mamat, W. Mohd Haniff Bin W. Mohd Shaupil. All authors have reviewed and approved the final version of the manuscript for publication.

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