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IMPACT OF LEAN CONSTRUCTION IMPLEMENTATION ON CONSTRUCTION BUILDING PROJECTS

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Abstract

Enhancing efficiency, minimizing waste, and improving project productivity are key objectives in Lean Construction. This study explores the impact of Lean Construction implementation at PT PP by examining the correlation between Planned Percentage Complete (PPC) in the Last Planner System (LPS) and project performance, including productivity and cost efficiency. The research employs a descriptive statistical analysis method, with data collected through a self-assessment survey and an evaluation of the correlation between PPC and key project management factors. The results indicate that LPS implementation significantly enhances productivity, with a positive correlation between PPC values and project efficiency. Furthermore, waste analysis reveals that Waiting, Defect, and Overproduction are construction projects' most dominant waste categories. This study also identifies that Lookahead Planning within LPS is crucial in reducing constraints, positively impacting project timeliness and cost control. Consequently, the findings provide deeper insights into Lean Construction implementation and offer strategic recommendations for companies to sustainably enhance efficiency and project performance.

Keywords: Lean Construction, Last Planner System, Planned Percentage Complete, Waste Management, Productivity

Introduction

Lean Construction is a strategy adapted from the principles of Lean Manufacturing, aimed at improving efficiency and reducing waste in construction projects (Binh, 2013; Maradzano et al., 2019). This concept emphasizes the importance of continuous improvement and customer satisfaction, which is reflected in process optimization, collaboration among teams, and the use of practical management tools to enhance project performance in terms of time, quality, and cost (Binh, 2013; Garcés & Peña, 2023; Maradzano et al., 2019; Pancholi & Devkar, 2023). In this context, the implementation of the Last Planner System (LPS) becomes key to optimizing project planning and execution, which in turn can improve productivity and reduce time and costs (El Samad et al., 2017; Pancholi & Devkar, 2023). Research by Bajjou & Chafi, (2018) and Pancholi & Devkar (2023) indicates that by adopting the LPS method, construction projects can achieve better outcomes, including waste reduction and increased efficiency. Therefore, the construction industry needs to explore and apply Lean principles continuously.

Although many studies demonstrate the potential of Lean Construction in improving project outcomes, there remains a gap in understanding how specific metrics, such as Percent Planned Complete (PPC), contribute to overall project performance (Bajjou & Chafi, 2018; El Samad et al., 2017). This gap includes a lack of empirical analysis linking PPC values with project completion duration and cost control (Bajjou & Chafi, 2018; Bharadhwaaj, 2022). Previous research has shown that while Lean Construction principles have been implemented, a deeper understanding of the relationship between the metrics and project performance is still needed (Bajjou & Chafi, 2018; Samad et al., 2017). Thus, focusing on the right metrics can help formulate better strategies to enhance project performance in the future.

This study focuses on the correlation between PPC outcomes in implementing LPS and project performance at PT PP. By analyzing data from projects implementing LPS, this research aims to identify how improvements in PPC values contribute to productivity and cost efficiency. This study will provide insights into the effectiveness of Lean Construction implementation and assist in formulating better strategies to enhance project performance in the future. Consequently, the results of this research are expected to contribute significantly to the understanding and application of Lean Construction.

Literature Review

Lean Construction

Lean construction is a systematic approach that emphasizes continuous improvement and customer satisfaction in construction projects (A C et al., 2023; Bajjou & Chafi, 2018; Kalubovila & Kawmudi, 2023). Koskela and Howell define Lean Construction as a method for designing production systems (Maradzano et al., 2019) that is effective in minimizing waste, enhancing efficiency and productivity while maximizing value (A C et al., 2023; Bajjou & Chafi, 2018; Kalubovila & Kawmudi, 2023). By applying Lean principles, construction projects can achieve better outcomes, including reduced time and costs and improved quality (Zelenko & Maxwell, 2024 ; Garcés & Peña, 2023).

Productivity is a measure of how effectively work is completed and how efficiently resources are utilized, referring to the relationship between the results achieved (output) and the total resources used in the production process (input) (Bharadhwaaj, 2022; Indrayani, 2012; Mats, 1992). Various factors can influence productivity in construction projects, including project management, team involvement, and the use of technology (Bajjou & Chafi, 2018; Samad et al., 2017). Productivity is a crucial factor in the construction industry as it affects project success, cost efficiency, and overall performance, necessitating a deep understanding of the factors that influence productivity (Bajjou & Chafi, 2018; Samad et al., 2017). Implementing Lean Construction not only focuses on waste reduction but also seeks to enhance productivity more systematically, thereby creating significant added value for all stakeholders in construction projects (Assaf et al., 2024 ; Amaral et al., 2024).

Last Planner System (LPS)

The Last Planner System (LPS) is a method designed to improve planning and reduce unpredictabilit y in project workflows by involving all parties (Pancholi & Devkar, 2023). LPS focuses on reducing variability and increasing reliability in project workflows through better collaboration and communication among project teams, thereby addressing the inefficiencies that often occur (Daniel et al., 2018; Kalubovila & Kawmudi, 2023). This process transforms work that "should" be done into work that "can" be done and then into work that has been "completed" (El Samad et al., 2017). By using LPS, project teams can identify and address issues before they become more significant obstacles, which reduces project time and costs (Brioso et al., 2024 ; Fireman et al., 2024).

The implementation of LPS consistently yields positive results in various construction projects. Research by Pancholi & Devkar (2023) ndicates that projects utilizing LPS tend to have higher completion rates and fewer delays than projects that do not use LPS. Ballard (2000) emphasizes the importance of the role of the "Last Planner," such as foremen, ineffective production planning to ensure the accuracy of work definitions, the timeliness of work orders, and the feasibility of activities(Lappalainen et al., 2023). LPS has five application process methods, including Master Scheduling, Phase Scheduling (Pull Planning), Look Ahead Planning, Weekly Work Planning (El Samad et al., 2017; Pourrahimian et al., 2023), and Percentage Planned Complete (PPC) (Kalubovila & Kawmudi, 2023).

LPS also fosters a collaborative culture among all project stakeholders, including contractors, subcontractors, and project owners, allowing them to share information and resources more effectively (Power et al., 2021; C. I. Lagos et al., 2022). By involving all parties in the planning process, LPS creates a shared responsibility for project outcomes, making each team member feel more engaged and motivated to achieve common goals (Ivina & Olsson, 2020). This not only enhances transparency in communication but also accelerates decision-making and minimizes the risk of errors that could disrupt workflow (Asadian & Leicht, 2022 ; Sharma & Trivedi, 2021). The application of LPS focuses not only on the technical aspects of planning but also on developing strong interpersonal relationships within the team, ultimately contributing to the project's overall success (Kassab et al., 2020).

Planned Percentage Complete (PPC)

Percent Planned Complete (PPC) is a metric used in the Last Planner System (LPS) to measure the extent to which planned work is actually completed within a specific period (El Samad et al., 2017; Lappalainen et al., 2023; Pancholi & Devkar, 2023). PPC assesses workflow reliability, productivity, and project progress by calculating the ratio of completed planned work to the total planned work (Antonini et al., 2023; Lappalainen et al., 2023). It provides a clear picture of the effectiveness of project planning and execution, as well as helping project teams identify areas that require improvement (Daniel et al., 2018). Consistent planning and monitoring of PPC can lead to increased productivity and performance, with a minimum of 70% of planned work being completed on time (Torre et al., 2021).

The application of PPC within LPS has been shown to improve project outcomes significantly. This is evidenced by Witte et al., (2022), who found that high PPC levels are directly related to better project performance, including cost control and completion time. This aligns with the research of Erazo-Rondinel et al., (2020) and C. Lagos et al., (2020), which suggests that increasing PPC values during LPS implementation can reduce variability and enhance project schedule performance. These findings underscore the practical implications of PPC in driving project success through structured planning and execution.

To understand the impact of Lean Construction implementation, mainly through the application of the Last Planner System (LPS), on construction project performance at PT PP, this study will address the following questions: (1) What is the relationship between Percent Planned Complete (PPC) values and project productivity in the implementation of LPS? (2) To what extent does the increase in PPC values contribute to cost efficiency and project completion time? (3) What types of waste are most encountered in construction projects, and how can Lean Construction strategies be used to reduce this waste? (4) How does constraint management affect project performance and PPC?

By answering these questions, this research aims to provide deeper insights into the effectiveness of Lean Construction in enhancing project performance and offer practical recommendations for better implementation in the future.

Research Methods

This research method uses a quantitative descriptive approach to assess the impact of Lean Construction implementation on construction projects. Data were collected through self-assessment surveys and correlation analysis of Planned Percentage Complete (PPC) in the Last Planner System (LPS) and project performance. Primary data were obtained from questionnaires distributed to 56 respondents who were representatives of a total of 7 BUMN contractors, while secondary data came from project reports and academic literature. In addition, the observation method was also used to examine the implementation of LPS directly at the project site.

Data analysis was carried out using descriptive analysis to describe the characteristics of Lean Construction implementation, Pearson correlation analysis to test the relationship between PPC and project productivity, and Lookahead Planning evaluation to assess the effectiveness of constraint management. Furthermore, linear regression was applied to determine the effect of PPC on project efficiency in more depth. Instrument validity was measured using factor analysis to ensure that the questionnaire measures the appropriate construct, while reliability was tested with the Cronbach's alpha coefficient, with a value above 0.7 as an indicator of good internal consistency. Through this method, the study aims to provide comprehensive insight into the effectiveness of Lean Construction as well as strategic recommendations to improve the efficiency and productivity of construction projects.

Research Results and Discussion

In lean construction, there are several important parameters, namely waste, familiarity, and value creation (A C et al., 2023; Bajjou & Chafi, 2018; Kalubovila & Kawmudi, 2023). Waste in construction projects refers to any form of activity that does not add value to the final product . Focusing on waste reduction is very important because it can increase productivity and cost efficiency. In this study, identifying the most common types of waste, such as waiting time, defects, and overproduction, is crucial to understanding the challenges faced by the project team. By reducing waste, projects can be completed faster and at a lower cost, in line with the principles of Lean Construction which emphasize efficiency.

Furthermore, the familiarity of the project team with the principles of Lean Construction greatly influences the success of the implementation of this method. Good knowledge of Lean Construction allows team members to apply relevant techniques, such as the Last Planner System (LPS) and waste identification, effectively (Pancholi & Devkar, 2023). In this study, evaluating the level of understanding and application of Lean Construction among project team members is important to assess their readiness and ability to manage the project better.

Finally, value creation is the main goal of every construction project. In the context of Lean Construction, value creation is not only about cost reduction, but also about quality improvement and customer satisfaction. By implementing Lean principles, projects can produce better and faster outputs, which in turn increases value for all stakeholders. This study emphasizes the importance of innovation and value engineering as methods to improve project efficiency and effectiveness, thus contributing positively to the final outcome (A C et al., 2023). By focusing on these parameters, this study aims to provide deeper insights into the effectiveness of Lean Construction implementation and offer strategic recommendations to improve the performance of construction projects in the future.

LCI Self-Assessment

An evaluation of the impact of PT PP's implementation of Lean Construction was conducted through a series of self-assessment questions submitted to project team representatives.

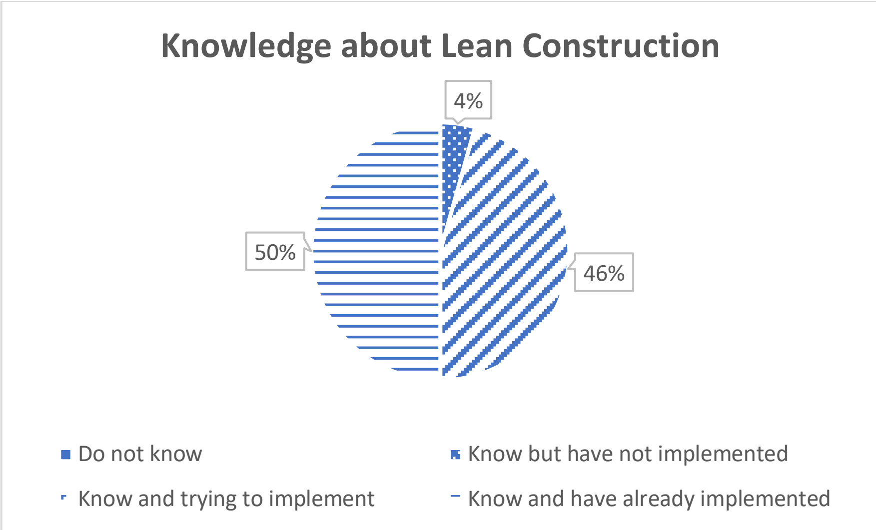

Figure 1. Knowledge about Lean Construction

The first question pertains to the question concerns the project team's knowledge of Lean Construction. The results indicate that most respondents have a good understanding of Lean Construction. Twenty-three respondents stated that they have implemented Lean Construction., while 21 reported having attempted to apply it. Only two respondents were aware of Lean Construction but had not yet implemented it, and there were no respondents who were completely unaware of the concept. This suggests that knowledge and awareness of Lean Construction at PT PP are on the high level.

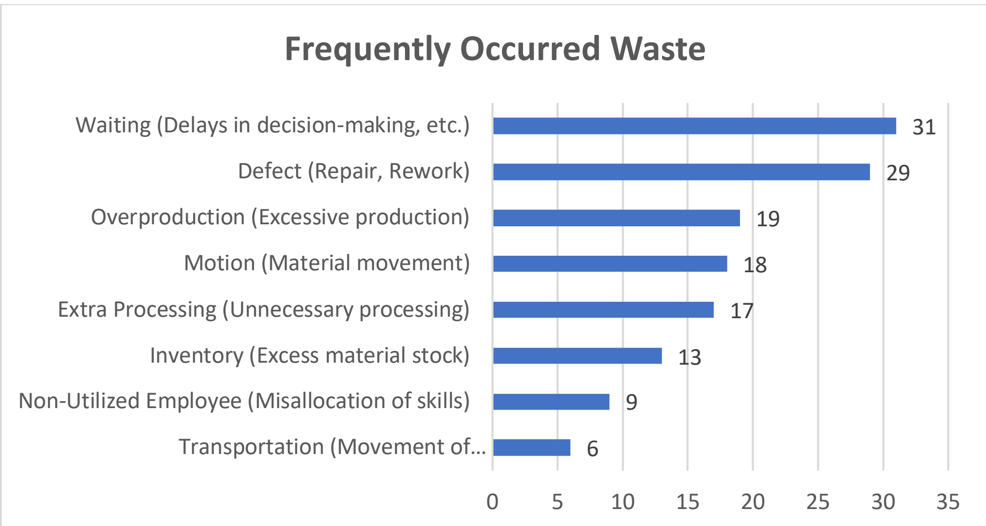

Figure 2. Frequently Occurred Waste

The second question focuses on identifying the types of waste that frequently occurred in projects. The results indicate that the most common waste category is Waiting, with 31 responses. High waiting times indicate that construction workers often spend time in a state of waiting, whether for decisions, information, the arrival of materials, or the arrival of workers (Sacks et al., 2017). This is often caused by a lack of coordination among the various parties involved in the project. High waiting times not only hinder productivity but can also lead to delays in project completion, negatively impacting time and costs (Bajjou & Chafi, 2018; Zighan & Abualqumboz, 2021).

Following Waiting, Defect is the second highest type of waste, indicating that quality issues remain a significant concern. Identifying 29 responses in this category indicates to a lack of quality standards, inadequate worker training, and unsuitable materials, which necessitate repairs or rework. Defects not only increase project costs but also slow overall project progress, contradicting the goals of Lean Construction to achieve efficiency (Darmawan & Susetyo, 2025; Kalubovila & Kawmudi, 2023). The third highest type of waste is Overproduction, with 19 responses. Overproduction can result from accumulating unused materials, contributing to waste and increased costs. Inefficient planning, such as ordering too much concrete or excessive use of steel, can produce more materials than necessary to avoid shortages (Kurniawan et al., 2024). Pressure from management to meet production targets can also drive poor decision-making regarding production quantities (Ayalew et al., 2018; Sacks et al., 2017). Inefficient work habits and a lack of training also contribute to Overproduction, where untrained workers may not understand the project's limitations or needs, leading them to produce more than required.

Motion, Inventory, and Extra Processing categories are also present, albeit with lower response counts. These results highlight the importance of reducing waste to improve project efficiency and productivity. Companies must implement Lean Construction principles more effectively, including better planning, enhanced communication, and worker training.

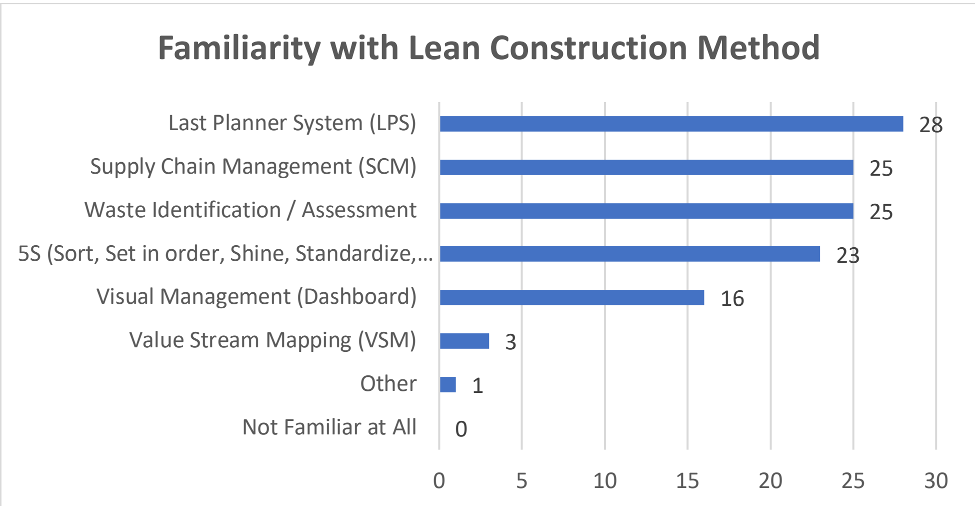

Figure 3. Familiarity with Lean Construction Method

The third question explores the methods that are commonly used in the implementation of Lean Construction. The results indicate that the Last Planner System (LPS), Waste Identification, Supply Chain Management (SCM), and 5R received high scores, while Value Stream Mapping (VSM) received very low scores. The high results for LPS and Waste Identification are attributed to the fact that these two methods have become mandatory in projects through a directive requiring their use. LPS, which focuses on planning and collaboration, helps project teams manage schedules more effectively and reduce time waste, while Waste Identification allows teams to systematically identify and eliminate existing waste (Amado, 2022).

Supply Chain Management also received many responses because PT PP has a dedicated division responsible for its management, demonstrating the company's commitment to optimizing the supply chain and reducing costs (Kalubovila & Kawmudi, 2023; Gao et al., 2023). Additionally, 5R, managed by the QHSE division, focuses on maintaining a clean and organized work environment, enhancing operational efficiency.

On the other hand, the low usage of Value Stream Mapping (VSM), which received only three responses, stems from its highly analytical and complex nature. Project personnel often have limited time and resources to implement this method effectively, leading them to favour more practical and straightforward approaches that can be readily applied in their daily work. Therefore, it is recommended that this method be implemented by a central team rather than by field personnel. This approach would allow the central team to manage and apply VSM effectively. Consequently, the central team can provide the necessary guidance and support to project personnel, enabling them to focus on executing their daily tasks without being burdened by complex analyses.

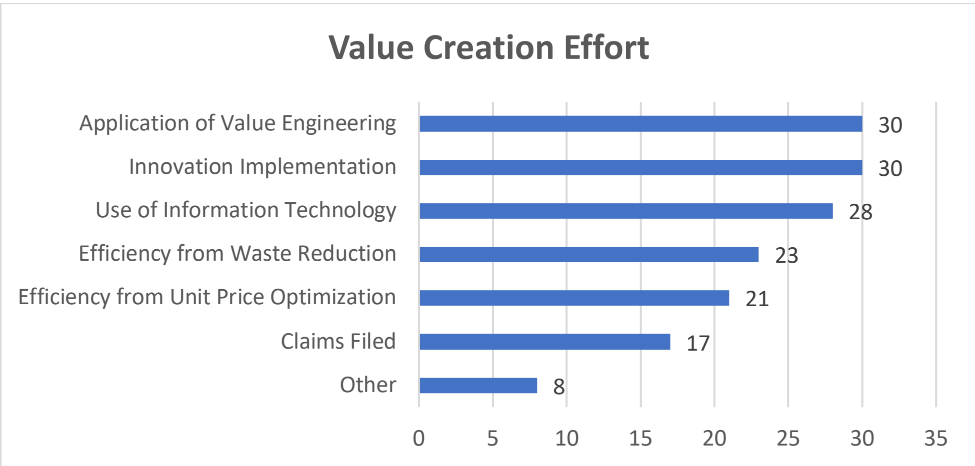

Figure 4. Value Creation Effort

The fourth question inquiries about the project's value-creation efforts. The results indicate that several methods received positive responses. Implementing Innovation and applying Value Engineering each garnered 30 responses, demonstrating that both efforts are considered highly important for enhancing project efficiency and effectiveness. Innovation allows teams to discover better ways to complete tasks, while Value Engineering focuses on cost reduction without compromising quality, aligning with Lean Construction principles to maximize value (A C et al., 2023).

Information Technology and efficiency resulting from waste reduction received 28 and 23 responses, respectively, as both significantly contribute to improving efficiency and effectiveness in construction projects. Using Information Technology (IT) in construction projects enables more efficient data and information management, enhancing communication, collaboration, and faster decision-making (Indrayani, 2012). Meanwhile, efficiency resulting from waste reduction indicates that project teams have successfully identified and minimized waste in the construction process, which is at the core of Lean Construction principles. By reducing waste, projects can save costs, improve the final output quality, and accelerate completion times (Aisyah et al., 2023). These two aspects support each other in value creation and efficiency in construction projects.

On the other hand, cost efficiency resulting from competitive unit pricing, with 21 responses, indicates that project teams also pay attention to cost aspects in their value-creation efforts. However, claims received only 17 responses, suggesting that despite efforts for value creation, there are still challenges in managing claims that arise during the project. This highlights the need for further attention in risk management and problem resolution that may occur during project execution.

Overall, the results of this self-assessment indicate that the knowledge and implementation of Lean Construction at PT PP are progressing very well. Project teams demonstrate a deep understanding of Lean Construction concepts and awareness of the types of waste present and the methods that can be applied to enhance efficiency. The efforts to create value are also clear. These findings provide a positive outlook on applying Lean Construction at PT PP. They can serve as a foundation for further development in construction project management practices in the future.

Correlation of LPS to Productivity

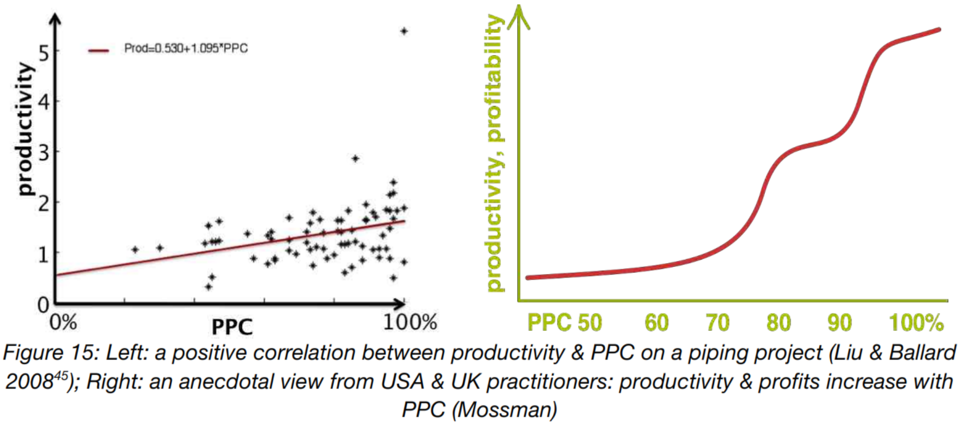

Figure 5. Correlation between Productivity & PPC Value

In theory, the higher the PPC value, the greater the potential to increase productivity, which is defined as revenue per person-hour in a project (Samad et al., 2017).

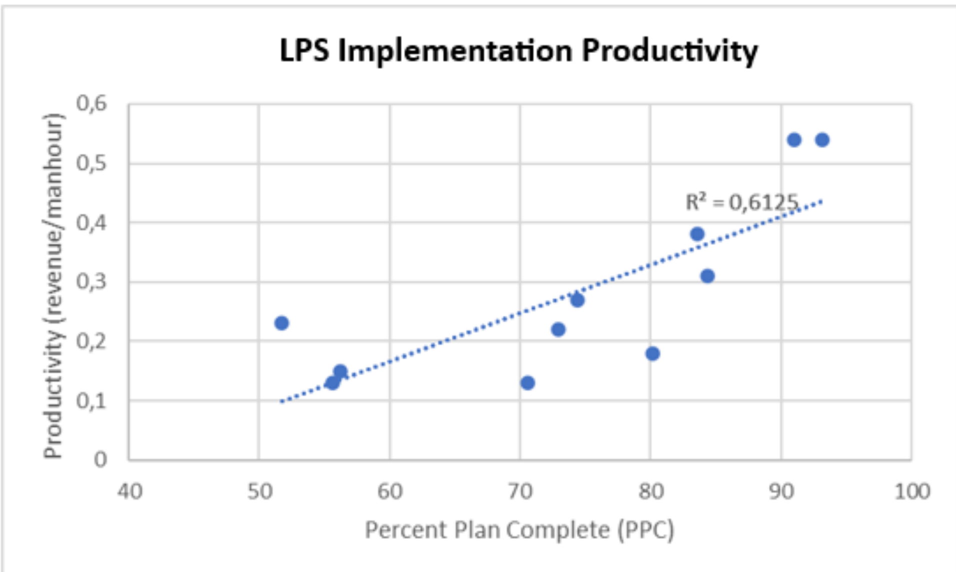

Figure 6. LPS Implementation Productivity

Eleven projects owned by PT PP were randomly selected to assess their PPC values. The results indicate a positive trend between PPC and productivity in implementing LPS. An R^2 value of 0.6125 demonstrates a significant relationship between the two variables, where an increase in PPC can potentially enhance project productivity. This aligns with the theory that PPC can serve as a practical project performance indicator to measure the amount of planned work completed (Lappalainen et al., 2023).

Although there is a positive correlation between PPC and productivity, other factors may also influence productivity. Therefore, additional analysis is needed to understand other underlying aspects of this relationship. Furthermore, the observed relationship is moderate because the data used only comes from completed projects.

The Influence of Lookahead Planning on Commitment Performance

The relationship between Planned Percentage Complete (PPC) and Percent Constraint Closed (PCC) is critical to understanding project performance and workflow. PPC measures the percentage of plans completed within a given period, while PCC measures how many constraints have been resolved before the work is executed.

Table 1. Correlation between PPC & PCC

Month	Average PPC	Average PCC	R^2	Gradient
1	78	53%	0,6378	Positive
2	85	51%	0,6317	Positive
3	85	58%	0,6006	Positive
4	75	50%	0,6212	Positive
5	86	61%	0,6148	Positive

A five-months study revealed a correlation between PPC and PCC, indicating that the greater the project's ability to reduce constraints (PCC), the better the project performance (PPC). This aligns with Lean Construction and the Last Planner System (LPS) principles.

In the first month, the average PPC was 78%, while the PCC was 53%. In the following months, although PCC fluctuated, PPC generally increased or remained stable, particularly during the months with higher PCC. This suggests that effective constraint management is crucial for maintaining a high level of PPC. The final month showed a PCC of 61% and an increase in PPC to 86%. This increase in PPC demonstrates that when constraints are managed well, planning effectiveness can improve, leading to enhanced project performance.

The high R^2 values ranging from 0.6006 to 0.6378 also indicate a moderate correlation between PPC and PCC. By reducing existing constraints, project teams can focus more on executing planned work, thereby improving task completion in a timely manner. Therefore, if PCC is managed effectively and constraints are addressed, PPC is likely to increase, creating a positive cycle in project management (El Samad et al., 2017; Pourrahimian et al., 2023).

Correlation of LPS Implementation to Time and Cost

A well-implemented LPS will influence improvements in the acceleration of progress targets and reductions in project costs with moderate correlation.

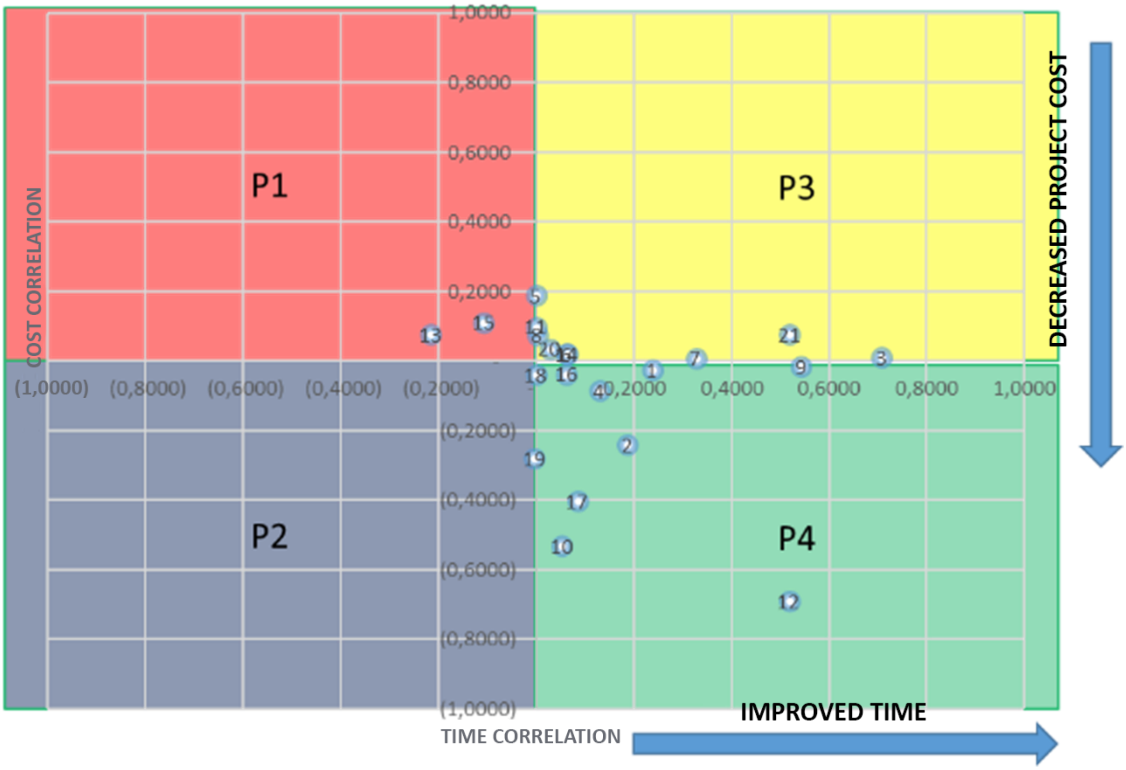

Figure 7. LPS Implementation to Time & Cost Quadrant

P1 = time does not improve – project costs rise (14%)
P2 = time does not improve – project costs go down (10%)
P3 = time improves – project costs increase (43%)
P4 = time improves – project costs decrease (32%)

In quadrant P1, time does not improve, but project costs increase, accounting for 14% of the data. This indicates that despite collaborative efforts, the results are inadequate, and costs remain high. Research shows that unplanned or ineffective collaboration can increase costs without significant time improvements.

Quadrant P2 indicates that project costs decrease while time does not improve, which encompasses 10% of the cases. This suggests that although the project is not completed faster, significant cost savings exist.

Quadrant P3 shows that increased time corresponds with decreased costs, reflecting an optimal condition where the project can be completed efficiently. Data in this quadrant indicate that 43% of the cases fall into this category. Quadrant P4 illustrates that time improves and project costs decrease, accounting for 32% of the data. This indicates that effective collaboration can yield very positive results, where projects are completed faster and at a lower cost.

This correlation shows that effectiveness in project management significantly influences the outcomes, where planned and structured collaboration can prevent the waste of both time and costs. This research demonstrates that project success relies on managing time and costs separately and on the quality of interactions and communication among project teams.

LPS Evaluation Based on Constraint and Variance

The Last Planner System (LPS) is an important framework for improving project management, especially in evaluating and reducing constraints and variances (Gupta & Devkar, 2023; Power et al., 2023). LPS provides a framework for continuous monitoring and evaluation

(Lappalainen et al., 2022). Analysing constraints and variances in Lean Construction provides a deep understanding of the underlying causes of project delays and inefficiencies.

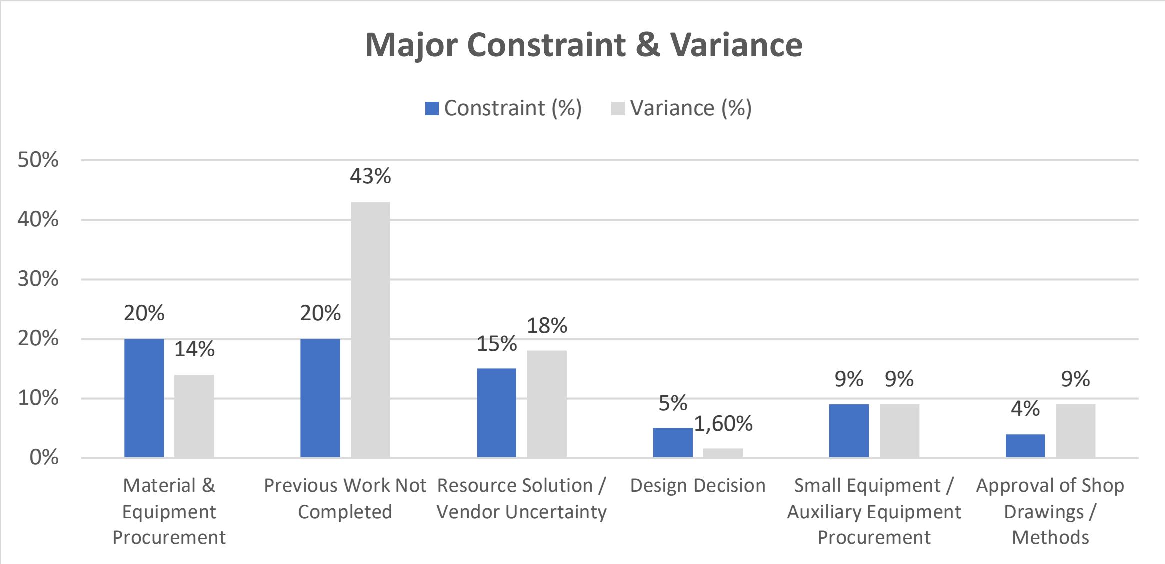

Figure 8. Major Constraint & Variance

A sample was taken to identify significant constraints and the variance causing project delays across several construction projects, yielding data as illustrated in the accompanying figure. In the procurement process for materials and equipment, a constraint of 20% and a variance of 14% were observed. The high constraint figure indicates that 20% of the work is hindered by issues related to the procurement of materials and equipment. Delays in procurement can arise from various factors, such as delays in the ordering process, logistical issues, financial problems, or unexpected price fluctuations. The variance of 14% suggests that despite having a procurement plan, the reality shows significant discrepancies, which can lead to delays in the execution of work dependent on those materials. This aligns with research by Elshaboury et al. (2021), which highlights that financial issues and poor supply chain management are often causes of delays in construction projects.

The constraint for unfinished work is also 20% but with a much higher variance of 43%. The high variance indicates that unfinished tasks can cause delays in subsequent activities, potentially resulting in additional costs and wasted time. This finding is consistent with García-Nieves et al. (2018), who emphasize the importance of efficient scheduling and resource management to prevent such obstacles in construction projects. Therefore, it is crucial to improve planning and ensure that each stage of work is completed on time.

A constraint of 15% and a variance of 18% related to subcontractor/foreman involvement indicate that discrepancies in the execution of work by subcontractors can lead to delays. A lack of coordination and communication among subcontractors can significantly cause delays and issues in project execution. Thus, enhancing communication and collaboration among all parties involved is essential.

Design decisions, which have a constraint of 14% and a variance of 5%, indicate that while design decisions are not the most significant risk factor, they still play a role in project delays. Delays in design approvals can lead to rework and additional costs. However, the relatively low variance (5%) suggests that the impact of these design issues is not as severe as that of other problems, making their effects appear more manageable. This aligns with research by Kamal et al. (2022), which shows that delays in the design approval process can affect project schedules, but if managed well, their impact can be minimized.

A constraint of 9% and a variance of 2% in the procurement of light equipment/tools does not significantly contribute to project delays. This indicates that the procurement process in this area is relatively smooth and does not disrupt the project's overall progress. However, it remains important to ensure that equipment procurement does not become a hindrance in the future. Efficient scheduling and resource allocation can mitigate potential delays.

The approval of shop drawings/methods, with a constraint of 8% and a variance of 9%, indicates that while this is a smaller issue, delays in the approval process for shop drawings and methods can still contribute to project delays. If not addressed properly, delays in this approval process can have a more significant impact on the project schedule.

This analysis demonstrates that effective risk management is crucial in addressing existing constraints and variances. By identifying and managing risks effectively, project performance can be improved, and the likelihood of future delays can be reduced. With structured data on constraints and variances, regular evaluations can be conducted to ensure that the project remains on track and necessary adjustments are made.

Conclusion

The application of Lean Construction principles has significantly impacted the efficiency and effectiveness of construction projects. The self-assessment evaluation revealed that the project team's knowledge and awareness of Lean Construction are quite high, with the majority of respondents having implemented or attempted to apply the method. This indicates that the company has a strong foundation for broader implementation of Lean Construction.

Identifying common types of waste in projects, such as Waiting, Defects, and Production, highlights the challenges still faced by project teams. The high levels of waste indicate the need for further efforts to reduce waste and improve productivity. Methods such as the Last Planner System (LPS) and Waste Identification have proven effective in managing projects and reducing waste. However, there are still challenges in implementing other methods like Value Stream Mapping (VSM).

The results of the correlation analysis between Planned Percentage Complete (PPC) and productivity show a significant relationship, where an increase in PPC can potentially enhance project productivity. The relationship between PPC and PCC indicates that effective constraint management is crucial for maintaining high PPC levels, contributing to better project performance. The correlation between the application of LPS and time and cost shows that planned and structured collaboration can prevent waste of both time and costs.

The analysis of constraints and variance underscores the importance of effective risk management in addressing existing obstacles and the need for better planning to ensure that each stage of work is completed on time.

Overall, these findings provide a positive view of the implementation of Lean Construction at PT PP and demonstrate that with effective management, the company can improve efficiency, reduce waste, and create added value in construction projects. The implications of this study for the wider construction industry suggest that the implementation of Lean Construction principles can be key to enhancing the competitiveness of companies in facing existing challenges. By identifying and reducing waste, companies can not only save costs but also improve customer satisfaction through more timely and high-quality project completion. For further development, it is recommended that the company continue to enhance training and communication between teams and apply more analytical methods, such as Value Stream Mapping (VSM), with support from the central team. Thus, PT PP can continue to adapt and innovate in construction project management practices in the future while making a positive contribution to the development of the construction industry as a whole.

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