Fajarwanto, A., Saputra, R. A., Sentosa, G. A., Azzaqy, A. U., Widyastuti, A. R., Winfried, A., Wachid, N., Nugroho, D., Aditriananda, A., & Mardiansyah, B. (2025). Implementation Of Progress Monitoring Dashboard Based on Last Planner System on Pavement Work: A Case Study of Bayung Lencir – Tempino Section 3 Toll Road Construction, In O. Seppänen, L. Koskela, & K. Murata (Eds.), *Proceedings of the 33rd Annual Conference of the International Group for Lean Construction* (IGLC33) (pp. 529–539). https://doi.org/10.24928/2025/0246

IMPLEMENTATION OF PROGRESS MONITORING DASHBOARD BASED ON LAST PLANNER SYSTEM ON PAVEMENT WORK: A CASE STUDY OF BAYUNG LENCIR – TEMPINO SECTION 3 TOLL ROAD CONSTRUCTION

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ABSTRACT

The integration of digital progress monitoring tools in construction enhances workflow transparency and real-time decision-making. This study evaluates the application of a collaborative digital dashboard in the Bayung Lencir–Tempino Section 3 Toll Road project, focusing on its alignment with the Last Planner System (LPS). Using a case study approach and Fishbone Diagram analysis, key limitations in progress tracking, constraint management, and stakeholder collaboration were identified. While the dashboard improved milestone tracking and data transparency, challenges remained in manual data entry inconsistencies and identifying and addressing constraints before they impact the progress.

Findings highlight the need for predictive tracking, structured commitment planning, and automated constraint removal to enhance LPS integration. Recommendations include improving dashboard automation, embedding structured feedback loops, and integrating predictive analytics to support continuous improvement in Lean-based infrastructure projects. This study contributes to Lean Construction knowledge by demonstrating how digital monitoring systems can better support LPS implementation, leading to more effective planning, execution, and resource management.

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KEYWORDS

Road Construction, Project Management, Last Planner System, Progress Monitoring Dashboard, Respect for People.

INTRODUCTION

The Trans-Sumatera Toll Road, spanning 2,800 kilometers, has been under development since 2016 to enhance mobility and economic growth in Sumatera Island. One of its key segments, Bayung Lencir – Tempino Section 3, covering 15 kilometers, connects Jambi Province and South Sumatra Province. PT Hutama Karya (Persero), as the main contractor, commenced construction in May 2023 and successfully completed it in September 2024. However, due to its classification as a national strategic project, the construction timeline was accelerated from 20 to 17 months, increasing the risk of workflow variability, coordination issues, and inefficient resource management. This schedule compression required real-time progress monitoring to ensure project control and timely decision-making.

Traditional monitoring methods, such as paper-based reporting and weekly inspections, were inadequate for tracking daily progress, leading to reactive decision-making and limited visibility into workflow constraints. By March 2024 (Month 11), the project was 4% behind schedule, which worsened to 5% by April 2024 (Month 12) despite mitigation efforts. To address this, the project introduced a digital progress monitoring dashboard to enhance workflow visibility and data accessibility. Digital dashboards have been widely recognized as an effective tool for Lean Construction (Conte et al., 2022; McHugh et al., 2023), yet their structured integration with the Last Planner System (LPS) remains an area of further investigation.

The LPS framework provides a structured approach to improving workflow predictability and stakeholder coordination (Ballard & Tommelein, 2021). While the dashboard improved progress tracking, it lacked key LPS components such as structured lookahead planning, commitment tracking, and continuous learning mechanisms. Without these elements, it functioned more as a reporting tool rather than a proactive Lean Construction management system.

This study evaluates the implementation of a digital progress monitoring dashboard within the LPS framework, analyzing its effectiveness in enhancing real-time tracking, collaborative decision-making, and constraint identification. By comparing the dashboard's functionalities against LPS principles, this research provides recommendations for optimizing digital monitoring tools in Lean Construction, ensuring their alignment with structured planning methodologies and continuous improvement practices.

LITERATURE REVIEW

The Last Planner System (LPS), developed by Ballard and Howell in the early 1990s, has been widely adopted in construction management to enhance workflow reliability and minimize process variability. In the context of pavement works for road projects, the integration of digital tools has become crucial for optimizing LPS implementation. These tools offer real-time data visualization, enabling project managers to track Percent Plan Complete (PPC), monitor constraint removal, and detect workflow deviations. For instance, McHugh et al. (2023) highlighted that digital tools supporting LPS can positively influence participant behaviors by improving transparency and understanding among project stakeholders.

Recent studies have emphasized the role of digital solutions in supporting LPS. Conte et al. (2022) explored the use of digital Visual Management (VM) tools for LPS implementation, finding that these tools enhance collaboration and information flow among project stakeholders.

Similarly, Bellaver et al. (2022) demonstrated that integrating lookahead planning with digital tools enhances scalability and planning reliability in multi-site lean implementations.

The adoption of LPS has also been explored beyond traditional construction tasks, including its application in design management. Hamzeh et al. (2008) examined how LPS can be integrated into design phases, demonstrating that planning reliability significantly improved when applied to upstream project processes. Similarly, Hamzeh (2012) emphasized continuous learning and team collaboration as critical factors in LPS adoption, highlighting that effective communication between project teams can further enhance workflow efficiency. In commissioning and qualification processes, Power, Sinnott, and Mullin (2021) found that LPS implementation led to better coordination and reduced rework, further reinforcing its value in broader construction applications.

In pavement works, where sequential tasks require precise coordination, integrating LPS with location-based planning has been shown to enhance workflow reliability (Formoso et al., 2022). Additionally, logistics planning within LPS improves resource allocation and efficiency in highway projects (Antonini et al., 2023), while LPS implementation in transportation projects has led to better schedule adherence and reduced workflow variability (Al Heet, 2020).

While previous studies have explored LPS in various construction domains, limited research has examined the role of digital dashboards in enhancing real-time progress monitoring and constraint removal in pavement works. This study seeks to bridge this gap by evaluating how digital progress monitoring tools improve workflow reliability and planning predictability within LPS frameworks.

RESEARCH METHODOLOGY

This study adopts a case study approach to evaluate the effectiveness of a digital progress monitoring dashboard within the Last Planner System (LPS) framework in the Bayung Lencir – Tempino Section 3 Toll Road project. The objective is to assess how the dashboard supports real-time progress tracking, workflow reliability, and Lean Construction principles, while identifying its limitations and areas for improvement. The methodology includes data collection, root cause analysis, dashboard evaluation, and recommendations, ensuring a structured examination of its integration with LPS framework.

The data collection process was conducted from March to August 2024, using project reports, direct observations, and stakeholder interviews. Progress deviation reports provided insights into schedule adherence, while daily field updates through the dashboard helped track workflow consistency and bottlenecks. Interviews with site managers, supervisors, and field workers captured feedback on the dashboard's usability, decision-making support, and coordination impact.

To identify factors contributing to schedule deviations, a Fishbone Diagram analysis was conducted, examining planning constraints, resource allocation, progress tracking inconsistencies, and stakeholder coordination challenges. The findings determined whether a lack of real-time data visibility was a root cause of project delays or if other factors, such as material shortages or workforce inefficiencies, had a greater impact.

The dashboard evaluation focused on its alignment with LPS framework, including milestone planning, lookahead planning, commitment tracking, constraint removal, and continuous improvement. The study assessed whether the dashboard enabled project teams to identify and resolve constraints proactively, enhance task predictability, and integrate structured feedback loops for process optimization. A comparison with Lean principles highlighted areas where the system supported Lean workflows and where improvements were needed.

Recommendations for improvement included enhancing constraint identification, incorporating automated alerts and predictive tracking, and refining the dashboard's user

interface to improve accessibility and minimize data input errors. These enhancements will help transition dashboards from passive reporting tools to proactive workflow management solutions, ensuring greater LPS alignment and improved Lean Construction implementation.

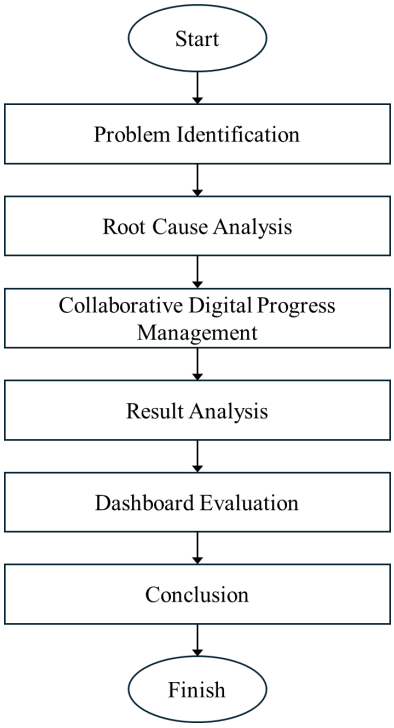

Figure 1: Research Methodology

INITIAL PROBLEM IDENTIFICATION

During the construction of the Bayung Lencir–Tempino Section 3 Toll Road project, significant challenges in progress monitoring and schedule adherence were encountered, particularly in the first quarter of 2024. By March 2024 (Month 11), the project was already 4% behind schedule, and despite efforts to optimize productivity through extended work hours in both structural and pavement work, the delay increased to 5% by April 2024 (Month 12). This raised concerns regarding the effectiveness of the existing progress tracking methods, which were heavily reliant on manual reporting and periodic inspections.

The Engineering team primarily monitored project progress using weekly joint inspections and daily paper-based reports from field supervisors. However, this approach had significant limitations, including the risk of misplaced documents, errors due to illegible handwriting, and delayed data entry, leading to inaccurate volume calculations. Additionally, the weekly joint inspections relied on visual assessments, which, while useful for surface-level tracking, lacked the precision required for real-time decision-making. As a result, project stakeholders only received progress updates once a week, which limited their ability to identify workflow deviations and implement timely corrective measures.

Another critical issue was that weekly and monthly progress reports only provided aggregate volume-based progress tracking, without detailing specific work items that were lagging or identifying areas where productivity could be improved. The lack of granular, real-time data made it difficult to pinpoint bottlenecks, coordinate resource allocation effectively, and align project activities with Lean Construction principles. This highlighted the need for a more structured, data-driven progress monitoring approach that could enhance workflow visibility, stakeholder coordination, and proactive decision-making.

ROOT CAUSE ANALYSIS USING FISH BONE DIAGRAM

The Fishbone Diagram analysis (Figure 2) identified multiple factors contributing to delays in pavement work, with progress monitoring inefficiencies emerging as the most significant issue. Further validation through project data analysis and stakeholder discussions confirmed that the primary challenge was a lack of accurate, real-time information among stakeholders, leading to delayed constraint identification and reactive decision-making. This issue was classified as a measurement problem, as progress reports were prepared weekly by the main contractor despite the involvement of field workers, supervisors, subcontractors, and site managers. The delay in reporting limited the project team's ability to conduct effective Lookahead Planning and remove constraints in a timely manner.

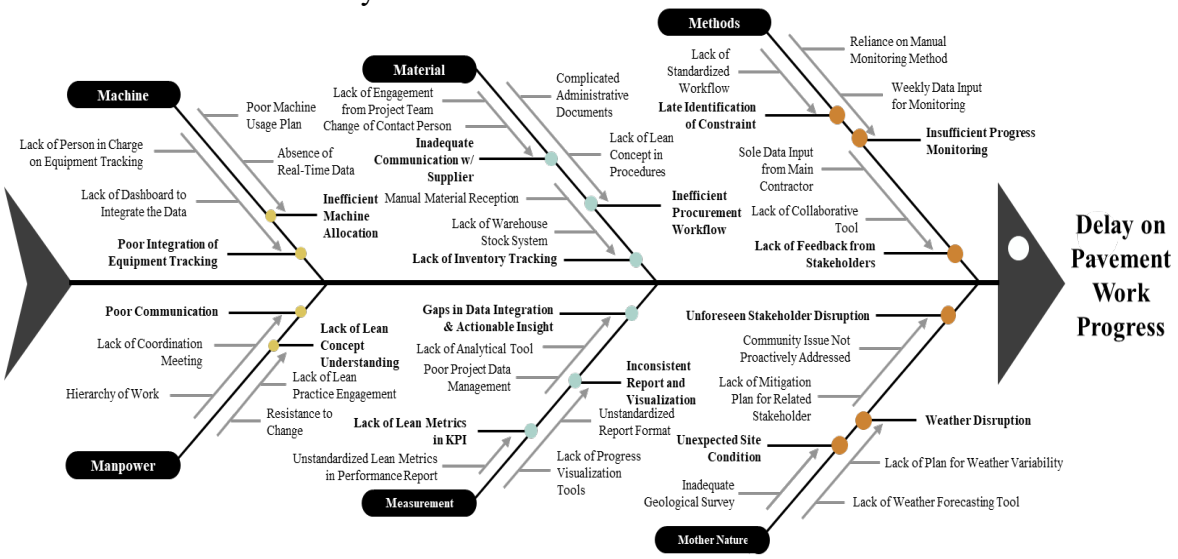

Figure 2: Fishbone Diagram

A key finding was that weekly progress updates were insufficient for effective decision-making, as they relied on manual inspections and paper-based reporting, increasing risks of misplaced documents, misinterpretation of handwritten data, and incomplete reporting. Additionally, progress was measured in volume-based aggregates, which failed to highlight bottlenecks in specific activities and did not support proactive constraint management. Without real-time visibility into ongoing activities, stakeholders struggled with resource allocation, workforce adjustments, and timely corrective actions.

To address these challenges, the project team engaged in collaborative discussions with on-site stakeholders and implemented a real-time digital progress monitoring system using Google Sheets. This allowed field workers to input daily updates, which were then reviewed and approved by supervisors before being integrated into the overall project dashboard. This transition enhanced workflow transparency and accountability, ensuring all stakeholders had access to current project data.

COLLABORATIVE DIGITAL PROGRESS MONITORING

The discussions between project stakeholders resulted in the need for a dashboard to monitor daily progress and provide informative data that could be updated daily in a user-friendly interface. This requirement emerged due to differences in academic background and age gaps among field supervisors, surveyors, and daily workers. To enhance collaboration, discussions were conducted with subcontractors and vendors, incorporating the Last Planner System to enable them to directly create and evaluate work plans based on remaining tasks and weekly achievements. This approach fostered a more realistic schedule while reinforcing the "Respect for People" principle. To ensure effective implementation, the Engineering team first

established a visual representation of the project's current progress, allowing stakeholders to identify workflow bottlenecks and performance gaps.

A key finding from the discussions was the importance of accurately tracking pavement work, which involved the construction of six layers, each requiring specific quality standards. The subgrade layer had a 6% California Bearing Ratio (CBR) and underwent density, CBR, and proof-rolling tests using a loaded dump truck to ensure uniformity. Above this, a Separator Layer of selected material (15% CBR, 15 cm thick) was placed, followed by a Drainage Layer/Aggregate Foundation Layer of the same thickness. Before rigid pavement casting, a 10 cm Lean Concrete layer (10 MPa) was installed. The final Rigid Pavement layer (30 cm, 4.5 MPa) was only cast once the Lean Concrete had cured properly

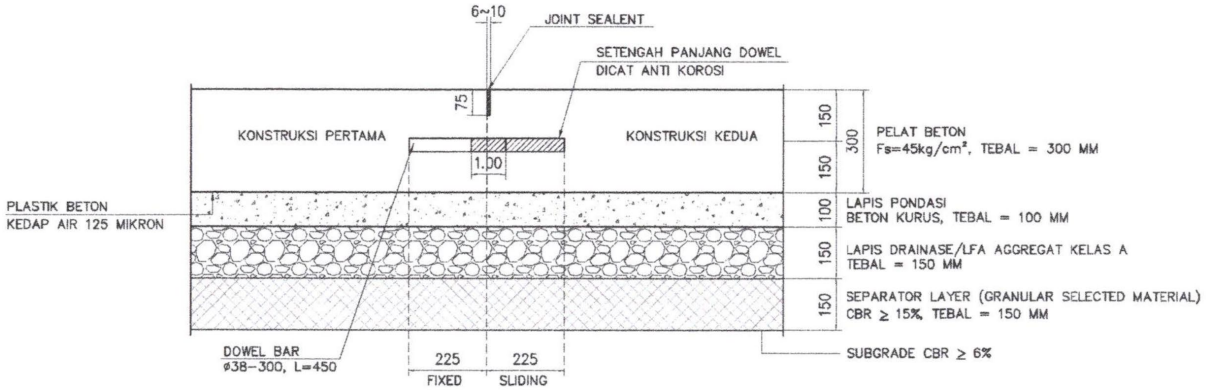

Figure 3: Pavement Layer Design

Initially, weekly reports measured pavement progress in cubic meters, but this method failed to highlight localized productivity issues. To improve workflow tracking and decision-making, the project team transitioned to length-based progress tracking, which provided a clearer representation of completed sections and gaps in each pavement layer. The dashboard visualized the progress of each pavement layer across the entire 13.242-kilometer stretch of the toll road, ensuring greater accuracy in identifying delays and optimizing resource allocation.

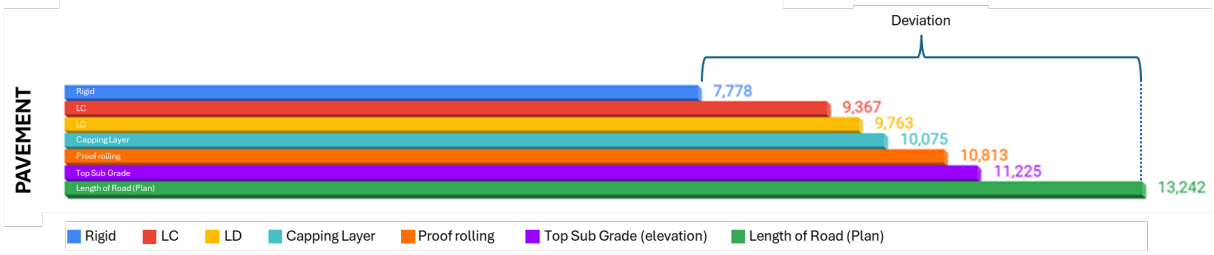

Figure 4: Pavement Progress Chart

When the charts were presented to the Project Manager, the manager immediately set up a meeting with project stakeholders, including supervisors, surveyors, quantity engineers, operation managers, engineering managers, procurement managers, as well as subcontractors and vendors. As part of the Last Planner System, they collaboratively analyzed the root cause of the issue and worked together to find practical solutions. The analysis found that Rigid Pavement casting was constrained by limited work hours, as casting could only be performed at night to maintain proper curing temperatures. The dashboard enabled the team to quantify the productivity gap, showing that each Slipform Concrete Paver was achieving an average of 200 m³ per day, which was insufficient to close the 1.5-kilometer gap within the planned timeline. To address these challenges, discussions were also held with subcontractors and vendors as part of the Last Planner System to collaboratively find solutions and ensure all stakeholders were aligned in resolving the productivity issue. By the end of the meeting, the stakeholders concluded that they urgently needed to mobilize more Slipform Concrete Pavers along with a set of workers to enhance the productivity of Rigid Pavement.

While the decision was made to mobilize additional Slipform Concrete Pavers, the dashboard later revealed another critical issue—the mobilization process itself introduced a three-week delay due to logistical challenges. This insight underscored the importance of lookahead planning and constraint identification.

To maximize adoption, the dashboard was designed with a simplified, intuitive data entry system where field teams only needed to input the completion date of each pavement section in a structured format. This minimized the risk of data input errors and reduced resistance to adoption, aligning with Lean Construction's Respect for People principle, which emphasizes empowering field workers to contribute effectively to project success. By enabling real-time collaboration and transparent data sharing, the dashboard not only improved progress monitoring but also facilitated proactive decision-making, helping stakeholders adjust workflows dynamically to meet project deadlines.

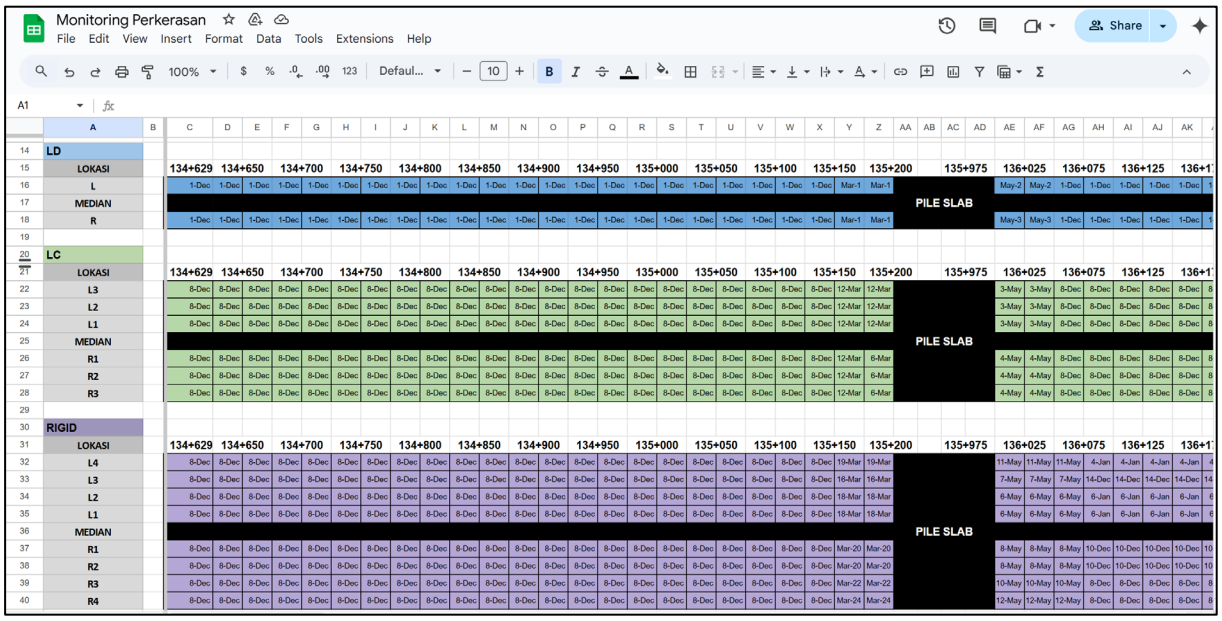

Figure 5: Data Collecting Platform

RESULT ANALYSIS

The implementation of the collaborative digital progress monitoring dashboard led to significant improvements in workflow transparency, real-time tracking, and stakeholder coordination. By July 2024 (Month 14), the gap between Rigid Pavement and Lean Concrete progress had visibly narrowed, as reflected in the updated pavement progress chart. The dashboard's real-time data entry allowed for earlier detection of workflow bottlenecks, enabling proactive decision-making and resource allocation to address constraints.

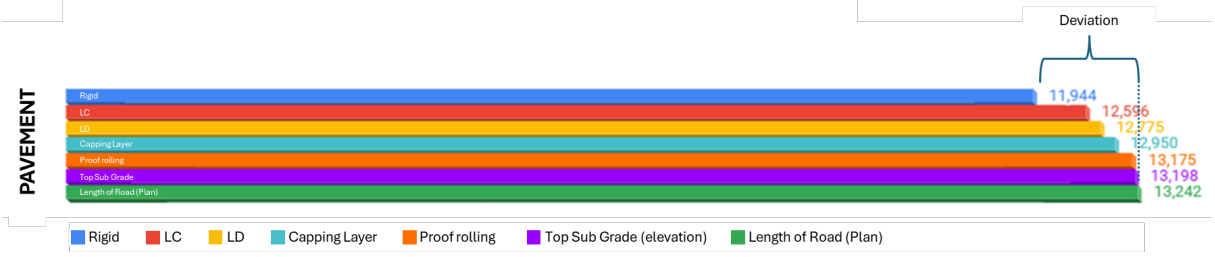

Figure 6: Pavement Progress Chart in July 2024

A major benefit of the dashboard was its ability to replace inefficient paper-based reporting, which often led to delayed or inaccurate progress updates. By providing live project data to site managers and company executives, the system eliminated lag time in decision-making, allowing for faster response to deviations and improved adherence to Lean Construction

principles, particularly workflow reliability and continuous improvement (McHugh et al., 2023). Additionally, the dashboard's flexibility enabled its use beyond pavement tracking, making it applicable for structural work, resource allocation, and logistics planning. This adaptability ensured that the system functioned as a scalable project management tool rather than a single-purpose monitoring platform.

By August 2024 (Month 16), the project successfully met its revised schedule, demonstrating the effectiveness of integrating digital monitoring tools within LPS workflows. The ability to track progress in real time, identify constraints, and adjust work plans dynamically contributed to improved project efficiency and on-time delivery. Moving forward, enhancements such as automated constraint tracking and predictive analytics could further align the dashboard with LPS, ensuring that constraint management and continuous learning are embedded into project execution strategies.

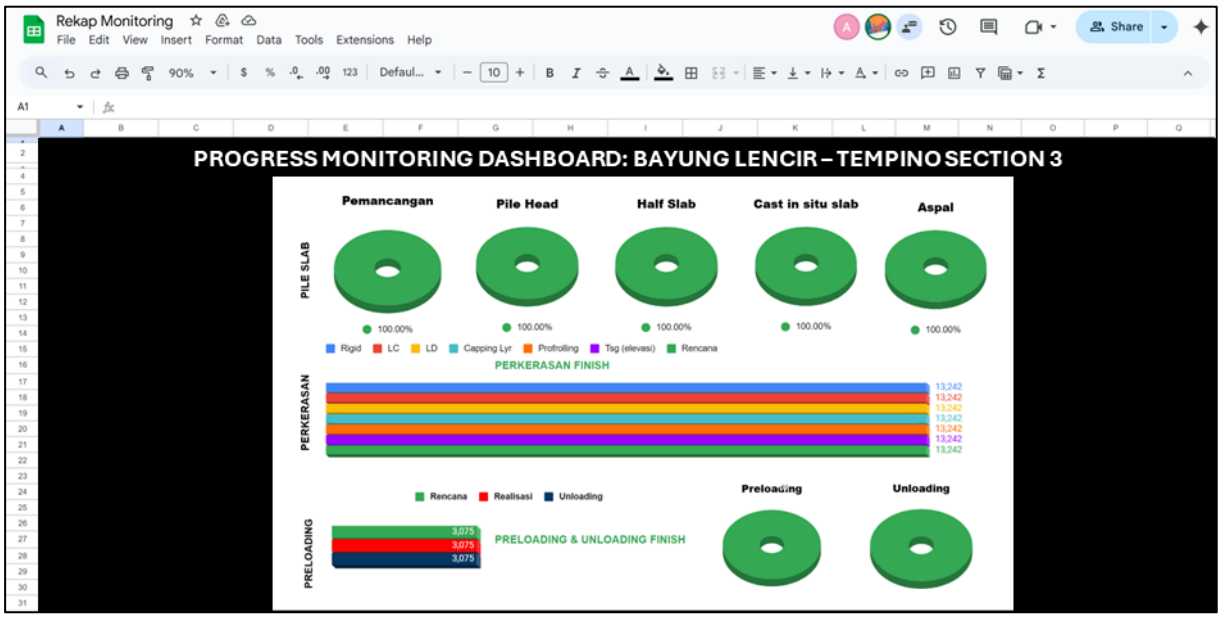

Figure 7: Progress Monitoring Dashboard of Bayung Lencir – Tempino Section 3 Toll Road Project

DASHBOARD EVALUATION BASED ON LAST PLANNER SYSTEM (LPS) FRAMEWORK

The collaborative digital progress monitoring dashboard was evaluated primarily through the Last Planner System (LPS) framework, which includes Milestone Planning, Lookahead Planning, Commitment Planning, Constraint Removal, and Learning & Continuous Improvement. While not initially designed as a strict LPS tool, the dashboard indirectly supported key Lean Construction principles such as transparency, collaboration, workflow reliability, and continuous improvement. The evaluation below identifies how the dashboard aligns with LPS, its limitations, and recommendations for enhancing its role in LPS-driven project management

Table 1. Evaluation of Collaborative Digital Project Monitoring Dashboard Features Based on Last Planner System Framework

LPS Framework	Current Dashboard Capability	Challenges Identified	Lean Principles	Recommended Improvement	Expected Impact
Milestone Planning	Tracks overall project progress and pavement layer completion with real-time updates.	Manual data entry errors and missing updates reduced accuracy, affecting decision-making.	Transparency & Workflow Reliability	Implement automated validation and real-time synchronization to ensure data accuracy and milestone reliability.	Reduces reporting inconsistencies, ensuring clear milestone tracking and better decision-making.
Lookahead Planning	Provides real-time monitoring but lacks predictive analytics for identifying potential workflow constraints in advance.	Constraint tracking is reactive, relying on field input rather than predictive indicators.	Proactive Planning & Constraint Management	Develop predictive analytics and automated alerts for identifying material shortages, weather impacts, and logistical constraints early.	Enhances workflow predictability and ensures constraint management is proactive, not reactive.
Commitment Planning	Enables daily updates from field teams, making short-term planning visible to all stakeholders.	Lacks a validation mechanism to ensure planned tasks align with resource availability and site conditions.	Collaboration & Commitment Reliability	Introduce weekly work commitment validation tools that compare planned vs. actual progress and highlight deviations.	Improves task predictability and accountability, ensuring work commitments are realistic and achievable.
Constraint Removal	Helps identify workflow gaps but lacks real-time constraint logging and automated issue escalation.	Issues were only identified after they caused delays, rather than being addressed preemptively.	Waste Reduction & Continuous Flow	Integrate automated constraint tracking and develop a real-time issue escalation system within the dashboard.	Minimizes workflow disruptions, ensuring teams address constraints before they impact project execution.
Learning & Continuous Improvement	Stores historical progress data but does not systematically capture lessons learned or process inefficiencies.	Lacks a structured feedback mechanism for documenting causes of delays and best practices.	Kaizen & Process Standardization	Implement a lessons-learned module where teams can log workflow challenges, solutions, and improvement insights.	Strengthens continuous learning, allowing future projects to benefit from past experiences and enhance Lean Construction workflows.

CONCLUSION

The evaluation of the progress monitoring dashboard within the Last Planner System (LPS) framework highlights the crucial role of last planners (field workers) in structured progress tracking. Their direct involvement improves work plan feasibility, reporting accuracy, and real-time constraint identification, enabling better decision-making and workflow reliability. By shifting from weekly manual updates to real-time digital monitoring, the project enhanced Lookahead Planning and constraint resolution, reducing delays and inefficiencies.

However, the study identifies limitations in the current implementation, emphasizing the need for a more proactive approach to constraint removal and predictive tracking. Adopting LPS from the planning phase—including structured Lookahead Planning, commitment tracking, and automated alerts—can minimize disruptions and improve resource allocation. Additionally, the study contributes to Lean Construction knowledge by demonstrating how digital dashboards enhance LPS workflows, reinforcing continuous improvement and collaborative decision-making.

A critical improvement area is the inclusion of structured feedback loops to capture lessons learned and refine planning methodologies. Future implementations should focus on automated validation and AI-driven constraint detection to further optimize real-time tracking and resource planning.

By transforming digital progress monitoring systems into proactive, Lean-based management tools, projects can enhance efficiency, predictability, and adaptability. Future research should focus on scaling these solutions across various construction sectors while integrating machine learning and IoT-based automation to improve real-time constraint detection and continuous process improvement.

ACKNOWLEDGEMENTS

The authors would like to express their deepest gratitude to the entire project team of the Bayung Lencir – Tempino Section 3 Toll Road for their support in providing access to valuable project data and insights that made this study possible. Special appreciation is extended to the Engineering and Operations team of the Civil Construction Division for fostering culture of continuous improvement, collaboration, and transparency, which served as a critical foundation for the implementation and evaluation of the progress monitoring dashboard. The analysis and interpretations presented in this paper are those of the authors.

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