

Andraiko, H., and Munthe, T. A. (2026) Exploring the Use of 4D BIM and the Last Planner System® with Parametric Design Tools in Lean Construction and Control Learning Settings. *Lean Construction Journal* 2026 pp 199-224  
<https://doi.org/10.60164/ngnfebmbq> (Submitted 03Sep2025; Accepted 02Jun2026) [www.leanconstructionjournal.org](http://www.leanconstructionjournal.org)

# Enhancing Project Quality by Implementing Lean Construction and Building Information Modelling Techniques

Heru Andraiko<sup>1</sup> and Agyana Tua Munthe<sup>2</sup>

## Abstract

**Research Question:** What are the results of implementing the integration of Lean Construction and Building Information Modeling methods to improve quality performance?

**Purpose:** To analyze the results of implementing the integration of Lean Construction and Building Information Modeling methods in improving quality performance.

**Research Method:** We used observation and interview methods on the PGRI Semarang University apartment project. Work quality was assessed using the QPASS (Quality Product Assessment) measuring tool.

**Findings:** The qualitative analysis revealed that the integration of Lean Construction with BIM 5D can enhance project quality performance, increasing the QPASS value by up to 90%.

**Limitations:** We limited this research to high-rise construction projects. Project quality was assessed using the QPASS measurement tool. Several Lean Construction and BIM tools were selected, and the benefits of integrating the two methods were analyzed.

**Implications:** By integrating building information modeling and Lean Construction methods, project managers can maintain project quality in accordance with the established quality plan.

**Value for practitioners:** Construction professionals in Indonesia can leverage these findings to enhance quality performance in building construction projects.

**Keywords:** Quality Performance, Integration, Lean Construction, BIM, Construction.

**Paper type:** Case Study.

---

<sup>1</sup>Mercu Buana University, Jakarta, Indonesia, [andraiko@mercubuana.ac.id](mailto:andraiko@mercubuana.ac.id) corresponding author.

<sup>2</sup> Mercu Buana University, Jakarta, Indonesia, [Agyanata\\_tua@mercubuana.ac.id](mailto:Agyanata_tua@mercubuana.ac.id).



## Introduction

The construction industry is essential to the economic development of any country. The many failures in achieving effective quality performance in construction projects contribute to the development of the industry (Michalski et al. 2021). Indonesia's construction development has also been plagued by several quality performance failures over the past decade. The 2018 failure of the Becakayu Toll Road Project, caused by inappropriate work methods and a lack of oversight in implementing safety and quality standards, has provided valuable lessons for the Indonesian construction industry (JNP CNN Indonesia 2018). Quality performance standards are crucial in construction project implementation, as evidenced by the 2021 Jakarta-Bandung High-Speed Train accident, which was caused by inadequate work safety procedures and a lack of technical supervision during heavy equipment operation (JNP CNN Indonesia 2021).

Several projects currently under construction have also been found to exhibit quality defects. This is the case with the Suncity apartment building in Sidoarjo. Cracks occurred during construction. The cracks were in the floor slab structure. The crack pattern spread across every floor slab in the 32-story building. The crack distribution pattern can be seen in the following image.

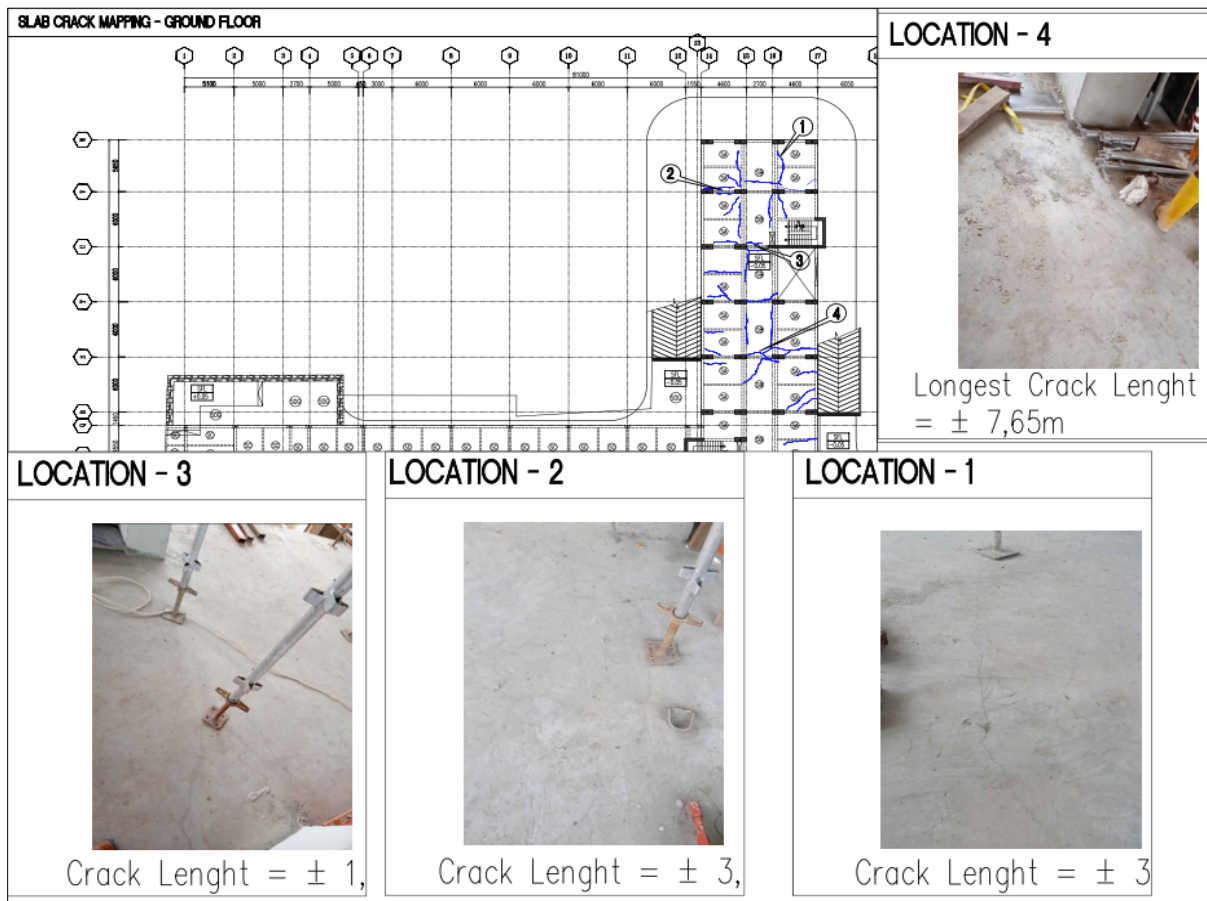
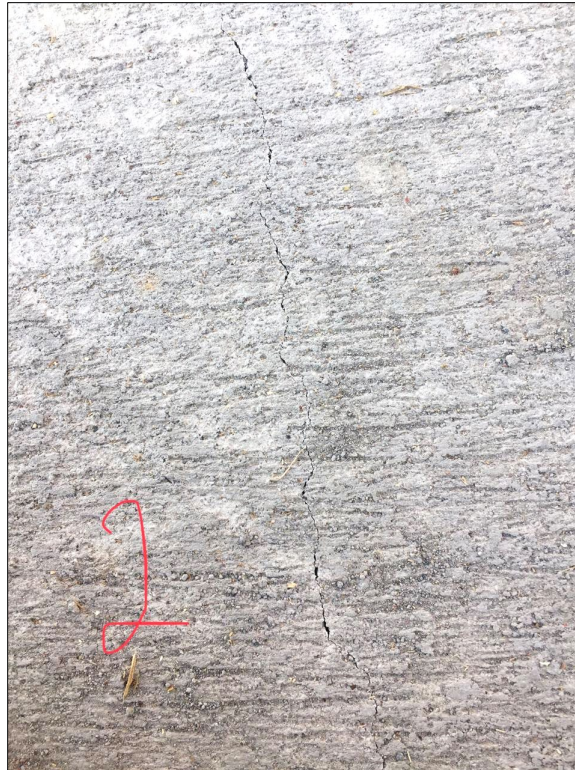


Figure 1: Plate crack distribution mapping



**Figure 2: Floor plate cracks**

In the two images above, the shape and pattern of cracks extending almost across the entire floor slab are visible. The possible causes of the damage are thought to be a combination of factors. These include a lack of supervision and quality control, inadequate design and planning, and the use of low-quality materials. This damage occurred during the planning, implementation, and supervision stages (Karatas & Budak 2023).

Improving the quality of construction projects by significantly reducing clashes during the construction phase is a challenge that must be addressed. One way to improve the quality of construction projects is through the use of Building Information Modeling (BIM) and the implementation of Lean Construction. BIM and Lean Construction are two approaches that have significant potential to reduce error factors, which can increase risks related to time, cost, and quality performance (Pérez et al., 2024). In a building renovation project in Aceh, the integration of Lean Construction and BIM methods improved time performance by 32.57% (Andraiko & Dwiyanto 2023).

Building Information Modeling (BIM) is one of the methodologies that has shown tremendous benefits in reducing delays and optimizing costs in building projects (Pérez et al. 2024). Many previous studies have shown the application of building information modeling (BIM) can help with construction quality inspection in the project construction process (Luo et al. 2022). Using BIM to handle project activities can help make important construction decisions faster and improve teamwork among different fields, which may lower risks linked to design and planning mistakes (Yanda et al. 2019).

Furthermore, BIM is widely used as a digital representation today. This feature is reinforced by the Regulation of the Minister of Public Works and Public Housing Number 22/PRT/M/2018, which mandates the use of BIM in construction development in Indonesia (Murdiyanto & Susetyo, 2024). The regulation states that the implementation of Building Information Modeling (BIM) aligns with Indonesian regulatory mandates. Article 15 of this regulation mandates BIM implementation for state-owned buildings that meet certain criteria, such as having a floor area exceeding 2,000 m<sup>2</sup> or more than two stories. By adopting this digital workflow, projects can ensure compliance with national technical standards for building reliability and efficient information management, which is the core of integrating Lean-BIM practices (Regulation Of The Minister Of Public Works And Public Housing No. 22/PRT/M/2018, 2018).

Meanwhile, Lean Construction is best understood as a socio-technical production system. It represents a production management philosophy that integrates social elements (people and culture) with technical components (methods and tools) to improve workflow and create value, going beyond waste reduction programs (Mossman 2018). This socio-technical perspective emphasizes the need to achieve reliable workflows across construction operations in order for Lean Construction to succeed. This approach focuses not only on reducing waste (*muda*) but also on reducing variability (*mura*) and overload (*muri*). A system enables individuals within the organization to anticipate and adapt to risks (Schafer et al., 2008). In this study, Lean Construction is specifically defined as a work management system that can minimize material waste due to rework, minimize work time, and optimize labor to produce maximum value in the construction project process (Karatas & Budak 2023). The application of the concepts and principles of Lean Construction methods has the potential to accelerate the process, especially when integrated with digital systems, such as the use of BIM tools (Ibarra et al. 2022). The integration of Lean Construction with BIM increases schedule flexibility and visualization of project conditions by facilitating better real-time communication regarding product information and construction processes (Chen et al. 2019).

Although the foundational Lean Construction literature largely focuses on workflow reliability and production control, a critical gap remains in understanding how these workflows, when combined, directly impact quality outcomes on the project site. This paper addresses this gap by positioning the Lean-BIM framework not simply as a tool to expedite work, but as an integrated socio-technical mechanism designed to proactively minimize structural and architectural defects. By shifting the focus to the final quality outcomes of the work, verified through a structured protocol (QPASS), this study provides a crucial empirical bridge connecting theoretical Lean workflows with actual quality outcomes on the project site.

This study also focuses on analyzing quality performance through the integration of Lean Construction methods and BIM implementation. The impact of Lean Construction methods on project quality and the effectiveness of Building Information Modeling (BIM) implementation have dominated the existing literature. This study will examine how Lean Construction methods can be applied to BIM software to improve project quality performance.

Based on the above, this study makes three key contributions to the knowledge of Lean Construction. First, it establishes a direct empirical relationship demonstrating that an integrated Lean-BIM approach improves quality performance as measured by the QPASS framework. Second, this study details the operationalization of socio-technical production control, specifically through Last Planner System® (LPS®) routines coordinated with BIM as a digital coordination tool. Finally, this study presents a practical and reproducible framework for practitioners to adopt to stabilize quality governance in high-rise construction projects in emerging markets.

## Research Methodology

This study uses two integrated methods. Lean Construction is the primary choice for improving quality performance. Building Information Modeling software is used to strengthen the implementation of Lean Construction. The results of this integration will be assessed using the Quality Product Assessment (QPASS) method. The research framework is illustrated in the following figure.

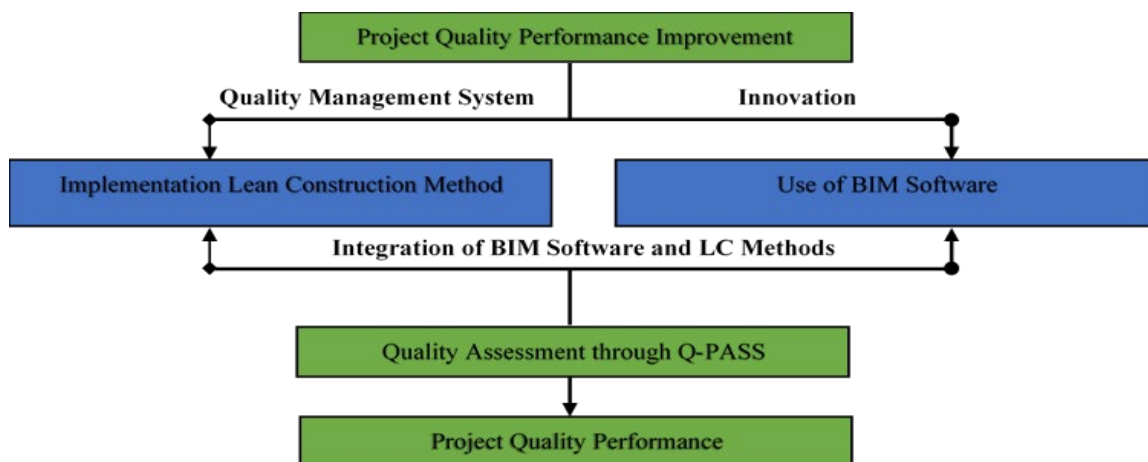


Figure 3: Research framework

The image above shows a research flow plan using two integrated methods. The results of the integration of these two methods will be assessed for quality using the QPASS method. QPASS is a method used by a government-owned construction company in Indonesia to measure the quality performance of ongoing projects. QPASS measures quality by conducting field inspections, evaluating structural, architectural, mechanical, electrical, and plumbing (samep) works, and assessing how consistently the quality management system is implemented, including the 5Rs (Ringkas, Rapi, Resik, Rawat, Rajin)<sup>3</sup> and occupational safety

- 2 Ringkas: Remove all unnecessary items from the work area, keeping only what is truly needed.  
Rapi: Arrange necessary items in accessible and easy-to-find places (use labels/markers)

and health. QPASS differentiates among structural, architectural, mechanical, electrical, and plumbing (samep) works. Structural work is assessed during the process, while architectural, mechanical, electrical, and plumbing works are assessed after completion. The QPASS assessment produces a score that is used to measure the level of compliance with established quality standards. The QPASS assessment steps can be seen in the following figure.

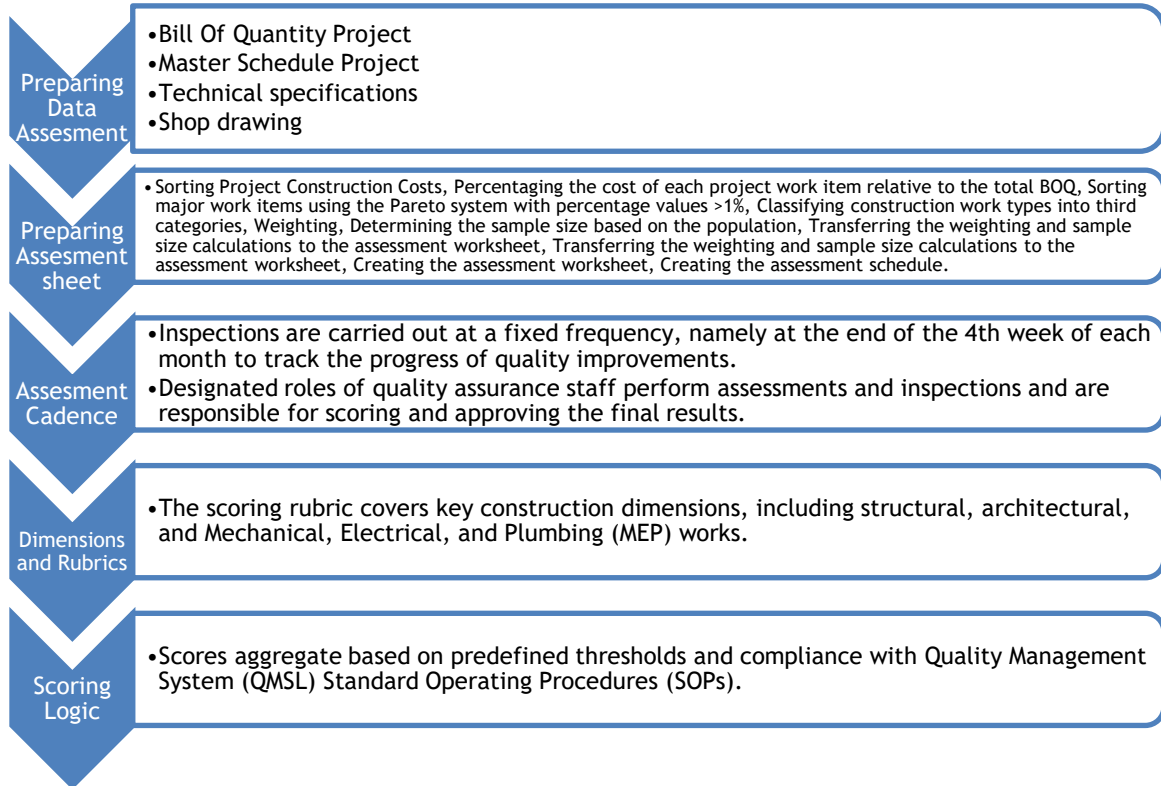


Figure 4: QPASS assessment steps

To objectively measure project quality, this study used QPASS as the primary governance metric, as illustrated above. The documents required for a QPASS assessment are the Bill of Quantities for weighting, the master project schedule for the assessment schedule, the technical specifications for the assessment sheet, and the shop drawings for sample distribution. After obtaining these documents, a monthly assessment sheet is completed, beginning with ranking the project costs and developing an assessment schedule plan based on the master schedule. Assessments were conducted monthly by the Quality Assurance (QA) team and supervised by the Site Engineer to ensure impartial scoring. The inspection process begins by evaluating the project's products and identifying met and unmet requirements. The average scores from all inspected samples are summed to obtain a final inspection score. After

Resik: Regularly clean the work area and equipment to keep them free of dust, dirt, and trash.

Rawat: Continuously maintain a tidy and clean condition.

Rajin: Make the 5Rs a habit and a disciplined work culture.

completing the inspection score sheet, the results are transferred to a summary sheet. To determine the total score for the assessed work categories, enter the assessment scores for the work evaluated during the month, calculate the progress weights for each work item in each category, and then multiply the assessment scores by the progress weights. This process is repeated at the end of each month for each remaining work item until a final QPASS score is achieved, indicating 100% project completion. The final QPASS score is determined by multiplying the actual score by the proportion of progress completed and approved by the project manager, the person responsible for the project. This activity is carried out in the fourth week of each month.

Meanwhile, BIM integration utilizes Revit and Navisworks software, which serves as an error-prevention mechanism. A structured workflow ensures accountability and problem resolution. The site engineer coordinates the BIM integration process. The personnel involved serve as BIM engineers. The following image illustrates the work sequence.

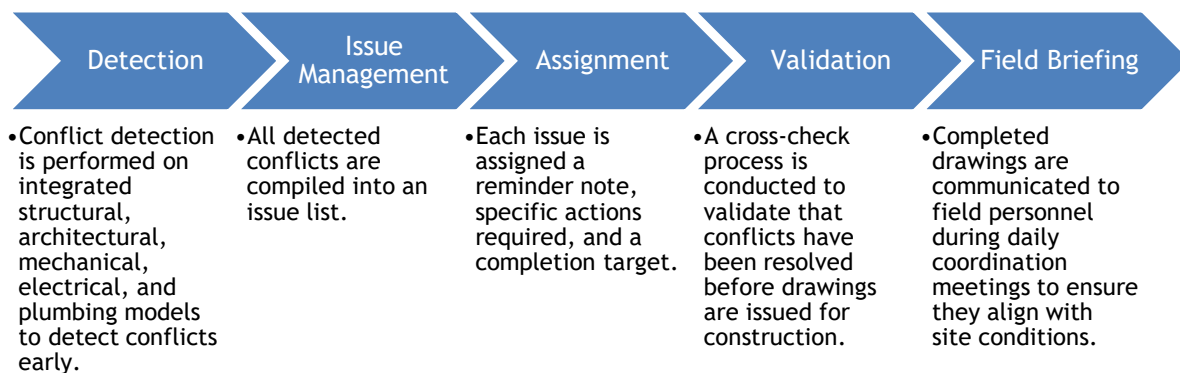


Figure 5: Workflow BIM process

The socio-technical aspect of the intervention is managed through Last Planner System® (LPS®) routines. These include daily huddles, toolbox meetings, and safety patrols aimed at stabilizing execution and fostering a commitment-based culture. Deviations from the plan are analyzed using 5-Whys notes to ensure continuous learning and root-cause removal.

The data collection techniques used in this study to obtain all the necessary data are direct observation in the field and interviews with the contractor and owner through face-to-face meetings and question-and-answer sessions to collect data for analysis. This research using the direct observation method in the field was conducted on the PT. Wijaya Karya Pracetak Gedung project, which is a subsidiary of the Indonesian government-owned construction company. The interview subjects in this study were personnel holding the positions of head of the engineering section and project manager, who are directly involved in enhancing quality performance for the PGRI Semarang University flats project.

## Result

The project began after the owner issued a work order on March 23, 2019. During the first three months of construction, site conditions faced numerous challenges, particularly

quality issues. The standard casting of column structures resulted in a product unacceptable to the owner, as shown in the following image.



Figure 6: Column casting results



Figure 7: Quality defects in column casting

Figures 6 and 7 demonstrate the appearance of quality defects following the casting of the columns. This is due to the lack of coordination in the field so that the planned quality is not in accordance with the expectations of the quality produced. The deviation from the Standard Operating Procedure results in suboptimal quality production. The following image shows the ironing process that is not in accordance with the applicable work instructions.



Figure 8: Iron installation before casting

The figure above shows that a concrete blanket is mandatory in the ironing process before casting. However, the necessary procedures were not followed in the field at the beginning of the project. The study identified a variety of causes. These include the absence of information on the relevant Standard Operating Procedure, poor field coordination, and unqualified field staff. The following figure shows an example of a standard operating procedure that must be communicated to the field.

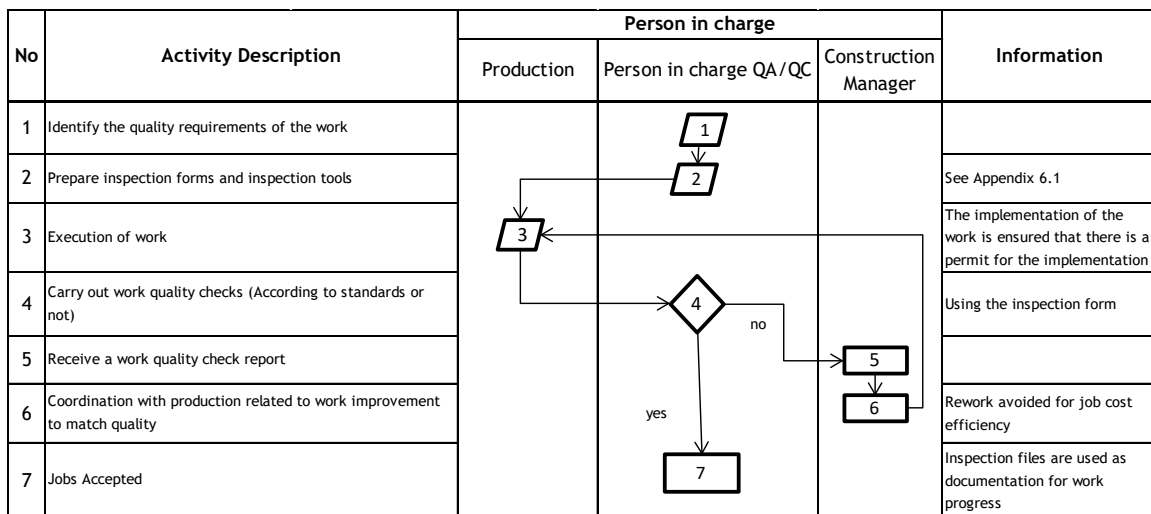


Figure 9: Job inspection flowchart

The existing Standard Operation Procedure regulated the execution of each work item. However, the field personnel never implemented these standard operating procedures. Quality measurements obtained from the QPASS tool indicated scores that were significantly below the established quality standards. The following are the QPASS scores resulting from the



The figure above shows the correlation between the implementation of Lean-BIM interventions and improved quality performance. Following a baseline assessment of 59.17% in March 2019, Lean-BIM interventions were implemented in April 2019. These interventions, which included daily meetings and weekly work planning, coincided with the initial stabilization of the QPASS score at 49.54%. Furthermore, the BIM Conflict Detection workflow became fully effective in May 2019, allowing the team to resolve conflicts between architectural plans and structural and MEP drawings prior to field execution. This proactive error elimination contributed to rapid field improvement, with scores surpassing the 60% threshold in June 2019. Maintaining field coordination through Lean-BIM implementation, followed by precise shop drawings through the use of BIM software, was critical to sustaining this upward trend.

## Discussion

Considering the above conditions, the following steps need to be taken to integrate Lean Construction and 5D methods, along with the tools and parameters used.

### Last Planner System® (LPS®)

The Last Planner System® is the most fundamental tool in the implementation of Lean Construction. This tool also greatly affects the quality obtained. LPS® is a collaborative production planning and control system. In this project, LPS® involves the foreman, field personnel, and all vendors involved as the "final planner." The integration of LPS® with BIM software makes coordination related to work directional and has a very significant role in improving quality. One of the applications of this LPS® method is by implementing a daily huddle meeting. Through this activity, the project management team coordinates between disciplines before carrying out activities in the field. The daily huddle meeting also involves all project staff, workers, squad heads, and foremen. This activity consisted of safety talk, a toolbox meeting, and safety patrol. Safety talk activities are not only held in the morning. On some occasions it is also held at night. The following picture can be seen of safety talk activities at night and in the morning:



Figure 11: Safety talk at night



**Figure 12: Safety morning talk**

This activity plays a crucial role in the day-to-day operations of the project. Project management conveys all information regarding the quality of work to be achieved, any obstacles encountered in the field, and other work-related directives. This activity enables effective communication between field workers and project management. After the safety talk session, the agenda progresses to a toolbox meeting, as detailed below:



**Figure 13: Toolbox meeting**

Only staff representatives, management, and foremen from the project were at the toolbox meeting shown above. This meeting aimed to deliberate on all the construction activities scheduled for that day. The focus of this session was to review the achieved quality targets and determine the necessary corrective measures. The next agenda item after the Toolbox Meeting is completed is for project management to conduct a field inspection regarding the achievement of quality targets, progress, and other issues related to field challenges. The picture below illustrates the meeting:



**Figure 14: Safety patrol**

This field inspection activity is known as safety patrol. The project manager always leads this activity. This activity is carried out at least once a month. The purpose of holding this safety patrol activity is to see firsthand the real conditions in the field. All problems related to quality, progress, and other non-technical problems encountered will always be followed up to find solutions. This activity aims to detect the risk of quality defects caused by miscoordination among divisions.

### Building Information Modelling

The role of BIM tools in this activity is significant. BIM tools provide material for field reviews and discussions. The BIM software used is Autodesk Revit and Navisworks. The following are the resulting planning drawings to facilitate implementation in the field.

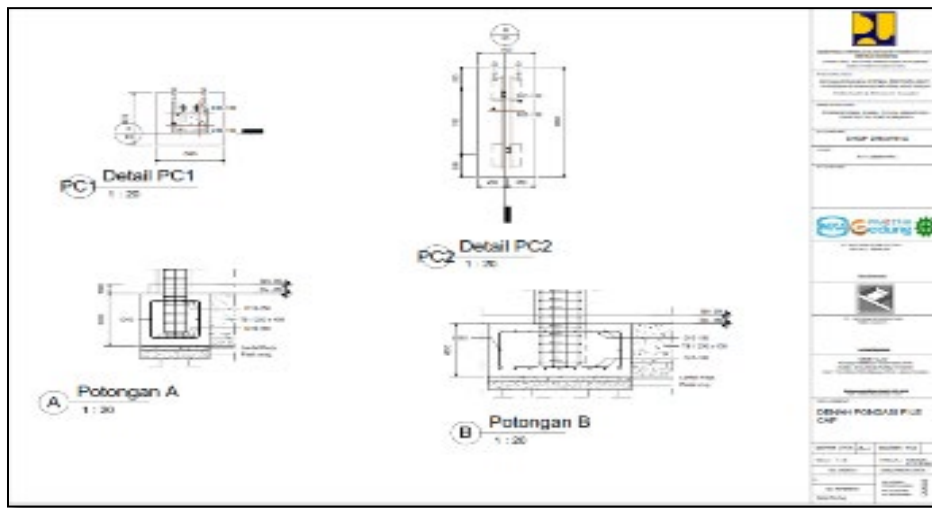


Figure 15: Shop drawing pilecap

Rebar Schedule PC.1														
Host Category	Mark	Bar Diameter	A	B	C	D	E	F	G	SCFD/PC Bar Length	Qty	Image	Reinforcement Volume	Barrel (kg)
Structural Foundation	c1	16 mm	0.00 mm	424.00 mm	446.00 mm	424.00 mm	0.00 mm	0.00 mm	0.00 mm	1200.00 mm	0		1206.53 cm³	0.707
Structural Foundation	c1	16 mm	0.00 mm	433.00 mm	446.00 mm	433.00 mm	0.00 mm	0.00 mm	0.00 mm	1200.00 mm	0		1206.54 cm³	0.689
Structural Foundation	c1	13 mm	0.00 mm	425.00 mm	430.00 mm	425.00 mm	0.00 mm	0.00 mm	0.00 mm	1200.00 mm	0		916.30 cm³	6.406
Structural Foundation	c1	13 mm	0.00 mm	412.00 mm	430.00 mm	412.00 mm	0.00 mm	0.00 mm	0.00 mm	1200.00 mm	0		796.39 cm³	6.202
Structural Foundation	c1	16 mm	114.30 mm	405.00 mm	410.00 mm	410.00 mm	405.00 mm	0.00 mm	114.30 mm	1700.00 mm	1		130.87 cm³	1.087
Structural Foundation	0												53.294	33.208
Grand total: 0														
Rebar Schedule PC.2														
Host Category	Mark	Bar Diameter	A	B	C	D	E	F	G	SCFD/PC Bar Length	Qty	Image	Reinforcement Volume	Barrel (kg)
Structural Foundation	c2	16 mm	0.00 mm	425.00 mm	524.00 mm	425.00 mm	0.00 mm	0.00 mm	0.00 mm	1110.00 mm	0		2008.61 cm³	15.766
Structural Foundation	c2	16 mm	0.00 mm	405.00 mm	524.00 mm	405.00 mm	0.00 mm	0.00 mm	0.00 mm	1650.00 mm	4		1471.77 cm³	11.353
Structural Foundation	c2	13 mm	0.00 mm	425.00 mm	524.00 mm	425.00 mm	0.00 mm	0.00 mm	0.00 mm	1110.00 mm	0		1337.86 cm³	10.263
Structural Foundation	c2	13 mm	0.00 mm	412.00 mm	524.00 mm	412.00 mm	0.00 mm	0.00 mm	0.00 mm	1640.00 mm	4		976.31 cm³	7.669
Structural Foundation	c2	13 mm	114.30 mm	295.00 mm	1052.00 mm	320.00 mm	1046.50 mm	0.00 mm	114.30 mm	2500.00 mm	1		271.45 cm³	2.217
Structural Foundation	0												48.410	48.410
Grand total: 0														

Figure 16: Barbending schedule

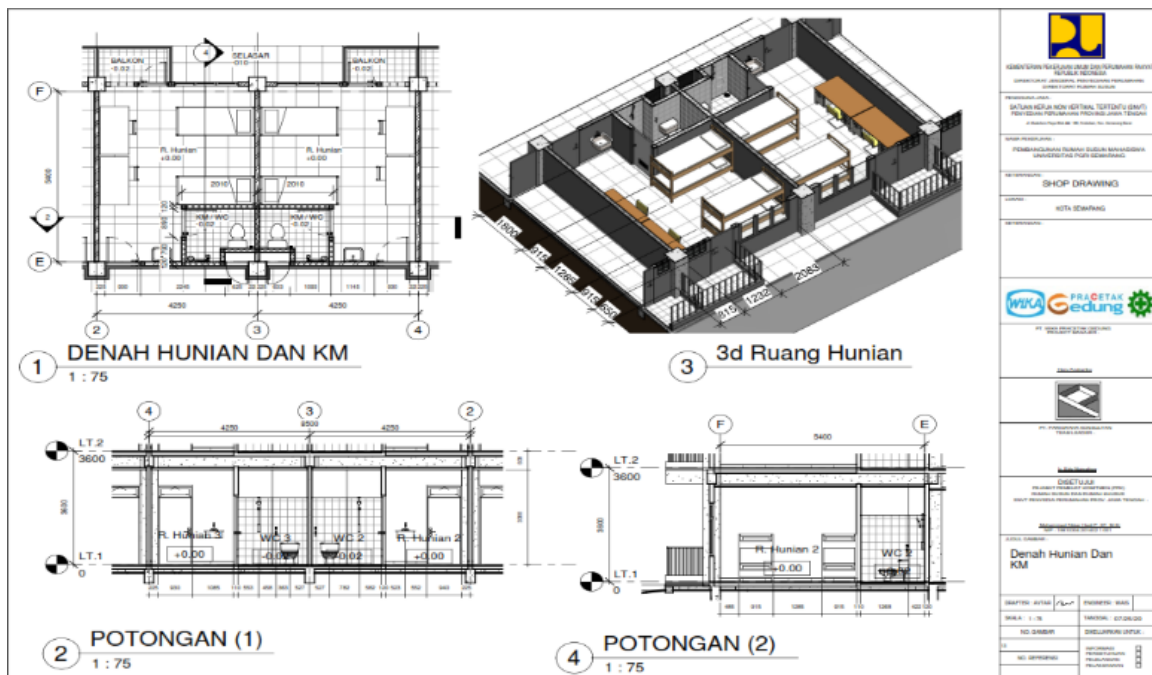


Figure 17: Shop drawing architecture

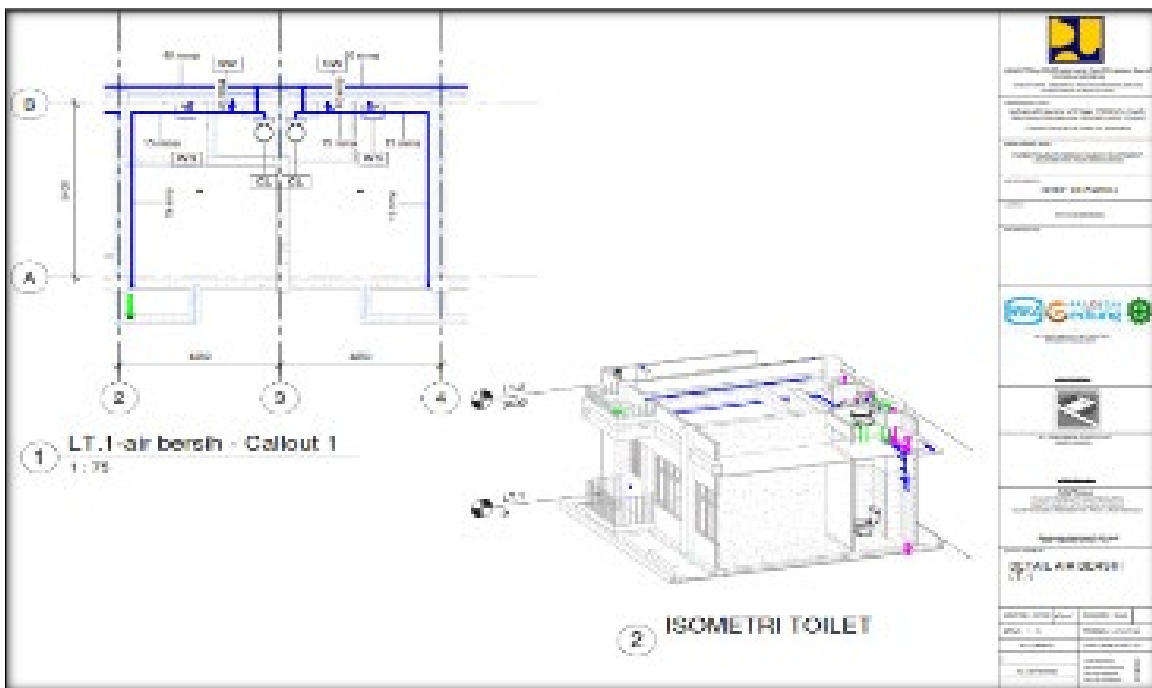


Figure 18: Shop drawing MEP

The drawings above are working drawings created using BIM software. These drawings have undergone an error reduction process during the interdisciplinary superimposition. This is because they have undergone clash detection in Navisworks software. The planning process

has addressed all potential field errors that could lead to quality defects. The following image demonstrates the clash detection process in Navisworks.

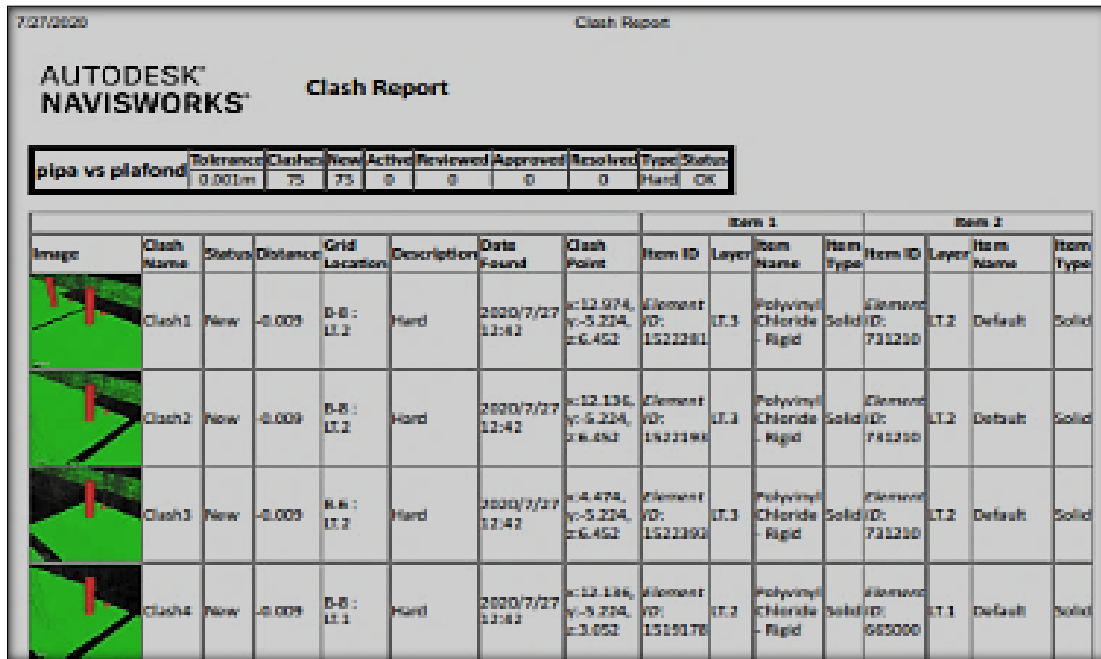


Figure 19: Clash detection

The image above shows several conflicts detected in the project planning drawings. Conflicts between structural, architectural, and MEP (Mechanical, Electrical, and Plumbing) drawings significantly impact the smooth progress of fieldwork. By using BIM software during the planning phase and applying Lean Construction methods during implementation and supervision, project management can anticipate future errors and improve project quality by eliminating rework during construction. The BIM workflow significantly reduces errors in later stages by resolving conflicts during the design phase. The systematic detection and resolution of physical conflicts across various disciplines quantitatively demonstrates the effectiveness of BIM integration. The results can be seen in the table below.

Table 2: Clash detection results

Month	Phase	Clashes Detected	Clashes Resolved (Pre-Construction)	Resolution Rate (%)
May'19	Structural & MEP Core	184	156	84.80%
July'19	Typical Floor MEP	92	88	95.60%
September'19	Finishing & Interior	28	28	100%

The systematic detection and resolution of physical conflicts across multiple disciplines quantitatively validated the effectiveness of BIM integration. During the initial BIM implementation phase in May 2019 (Month 3), the conflict detection process identified a total of 184 major conflicts, primarily between structural elements and Mechanical, Electrical, and

Plumbing (MEP) systems. BIM-based coordination meetings digitally resolved 156 of these conflicts (84.8%) prior to construction on the affected works. By September 2019 (Month 7), as coordination routines matured, the number of new conflicts detected dropped to 28, all of which were resolved prior to implementation. Proactive conflict resolution significantly minimized interdisciplinary clashes and reduced rework. This reduction in rework was a key driver behind the sharp increase in QPASS scores, demonstrating that digital coordination serves as a critical prerequisite for stable quality governance.

### Continuous Improvement

Continuous improvement, also known as Kaizen, is a core philosophy of Lean. It's not just a tool but a culture of continually finding ways to improve. This method uses an approach where all team members, from project managers to workers, are empowered to identify inefficiencies and problems and then suggest small, continuous improvements. This method begins to be implemented in the third month of a project. The first step is to focus on the root cause.

When a quality defect occurs, the project team doesn't just fix it. They use techniques like the "5 Whys," which involves asking "why" five times to identify the root cause of the problem and then designing solutions to prevent it from recurring. This is implemented through a company standard called "Deviation Notes—Corrective and Preventive Action Requests." The Deviation Log is a procedure for identifying critical deviations in a product/process, which require root cause analysis and corrective action. A deviation is a situation where the actual condition does not meet the standard. The following figure is the implementation of Deviation Notes—Corrective and Preventive Action Requests carried out by the project team to improve quality so that it can meet the set targets.



Figure 20: Corrective action

This project also documented methods that will become new standards for all teams to follow. These guidelines will serve as best practice for future quality improvement. Standards for architectural work to improve project quality have been established, as illustrated in the image below.

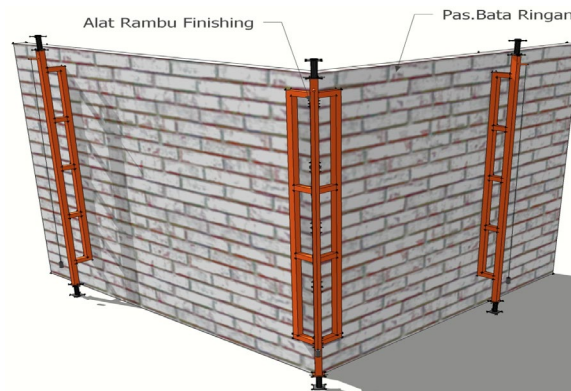


Figure 21: Finishing aid innovation

The image above shows the project team's wall installation method using a tool called a finishing signage tool. This tool help ensure the wall is installed straight and achieves the desired quality. The following image illustrates the implementation of the planned work method.



Figure 22: Finishing installation process

Empowering workers in quality assurance and implementing the 5R concept also play a crucial role in continuous improvement efforts. Fieldwork is supervised by all project staff, from supervisors and engineers to the safety officer team. They all help monitor the quality of the work process. The following image shows the concrete floor slab casting process supervised by a safety officer.



Figure 23: Preparation by safety team

## Error Prevention

Error prevention is a proactive approach to designing processes so that mistakes are not possible. This method is applied through the issuance of Process Work Instructions and Inspection Work Instructions. The publication of this guide aims to prevent defects from the source. By providing guidelines for each task, this document ensures the maintenance of work quality during the construction period.

After implementing the Lean Construction method integrated with the use of BIM tools on the project, changes in work quality were seen. The Engineering Team, acting as quality assessors, started evaluating the products and outcomes of the completed work. Handovers were carried out every month until routine handovers were implemented. The parameters for assessing work quality used the Quality Management System Level (QMSL) SOP issued by the company. Meanwhile, the assessment tool used was the Quality Product Assessment (QPASS). The following image illustrates the QPASS assessment process:



Figure 24: QPASS column structure



Figure 25: Precast beam dimension checking



Figure 26: Half slab module check

Figures above are part of the quality check. The assessment will be poured into the QPASS paper form, as shown below:

Q-PASS ASSESSMENT SUMMARY												
SEMARANG PGRI UNIVERSITY FLAT HOUSING PROJECT												
UP TO MONTH: JANUARY 2020												
ELEMENT	Number of samples	Number of samples taken	Number of items assessed	Number of items received	WEIGHT			DATA ASSESSMENT			Percentage Accepted	POINTS
					( % )			a	b	c	( a/b )	(a/bxc)
					(a)	(1)	sesuai progress	(3)	(4)	(5)	(3) / (4)	(6)=(3)/(4)x(5)
1. Pekerjaan Struktur					100%							
FORM WORK/ BEGESTING/ PRECAST	120	95	714	700	21%	21%	700	714	21%	98.04%	20.6%	
REBAR	120	88	704	680	26%	26%	680	704	26%	96.59%	25.1%	
FINISH CONCRTE	120	72	917	646	31%	31%	646	917	31%	70.45%	21.8%	
CONCRETE QUALITY	300	53	53	52	11%	11%	52	53	11%	98.11%	10.8%	
STEEL REINFORCEMENT QUALITY	104	33	33	31	11%	11%	31	33	11%	93.94%	10.3%	
<i>Sub Total Structural Work</i>					100.00%	100.00%						88.7%

Figure 27: Quality level measurement

The above figure shows that the QPASS calculation for structural work has reached 88%. This figure has increased quite significantly from before. From March 2019 to May 2019, the achievement of QPASS scores was below 50%. The graph below illustrates the increase in QPASS scores.

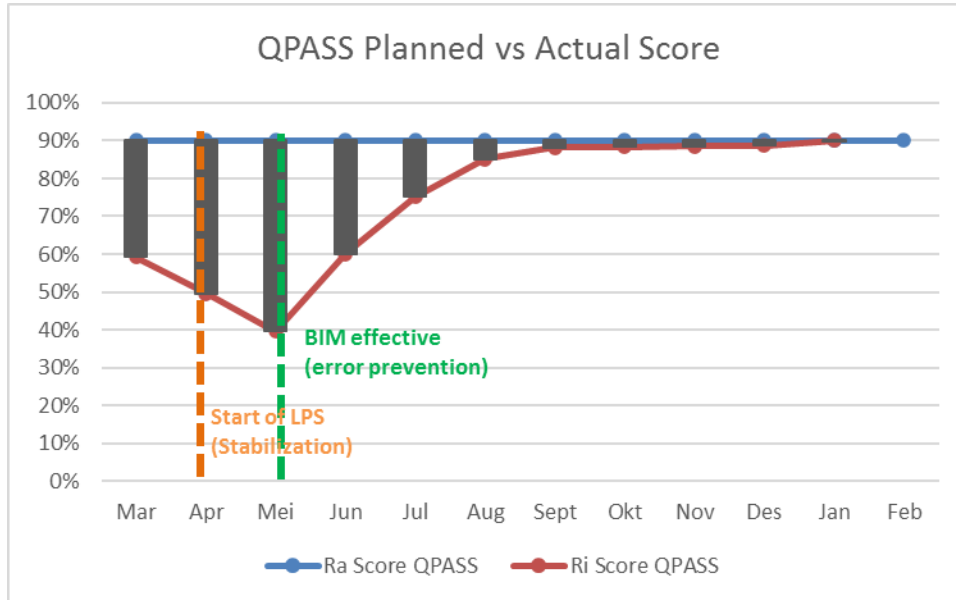


Figure 28: QPASS score increase chart

The graph above shows the increase in the QPASS score starting in June 2019. In that month, the project management team began implementing Lean Construction methods in the field. Consistency in implementing these methods is key to successfully improving project quality. When Lean Construction methods are integrated with BIM software, the quality improvement is significant. As seen in January 2020, the QPASS score reached 90%, as planned. From the results of quality performance measurements using the QPASS tool, it can be concluded that the integration of Lean Construction methods with Building Information Modeling (BIM) significantly improved quality performance on the PGRI Semarang University Apartment Construction project. The QPASS score was below 50% in the first three months, but within eight months, it improved and reached 90%, as originally planned. Meanwhile, the recommendation based on this research is that the implementation of Lean Construction methods integrated with BIM can be a requirement for construction projects in Indonesia.

## Conclusion

This study demonstrates that the integration of Lean Construction practices and Building Information Modeling (BIM) techniques significantly impacts the quality of a high-rise construction project. Through the implementation of a quality improvement package consisting of Last Planner System® routines for coordination, Standard Operating Procedure enforcement for process stability, and BIM-based clash detection for early error prevention, the project achieved a credible improvement in its QPASS score. In just eight months, the

project's score went up from 48% to 93%. Combining socio-technical production control with digital coordination worked well to cut down on rework and make project execution more stable.

While the results are promising, several limitations of this study should be noted. The study's focus on a single high-rise project in Semarang restricts the applicability of its findings to other project types. The study also lacked multiple project controls for comparison, making it difficult to infer the impact of the Lean-BIM intervention from external factors. Further Research Suggestions To strengthen the validity of these findings, the Lean-BIM integration method should be repeated in various project sites with different characteristics to validate its broader effectiveness. Additionally, simple statistical tests should be applied to measure the significance of the relationship between specific interventions and quality score improvements. Creating a real-time monitoring dashboard for BIM clash resolution and QPASS scores will also help professionals in the field get into the habit of making improvements on their own.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

## Reference

- Andraiko, H., & Dwiyanto, P. (2023). Integration of Lean Construction Methods and 4D BIM in the Lhokseumawe Aceh Government Building Renovation Project to Improve Time Performance. *JURNAL TEKNIK SIPIL*, 12(1), 1-8. <https://doi.org/10.24815/jts.v12i1.27538>
- Chen, L., Wu, Q., & Xie, X. (2019). Research and Application of BIM-based Specification-compliant Field Quality Management for Lean Construction. *IOP Conference Series: Earth and Environmental Science*, 267(5). <https://doi.org/10.1088/1755-1315/267/5/052059>
- Ibarra, J. F. V., Isatto, E. L., Formoso, C. T., & Viana, D. D. (2022). BIM+Lean for integrating production and quality control at the construction site. *Ambiente Construido*, 22(2), 7-25. <https://doi.org/10.1590/s1678-86212022000200591>
- JNP CNN Indonesia. (2018). Chronology of the Becakayu Toll Road Girder Collapse, Injuring 7 People. *CNN Indonesia*, 6-7. <https://www.cnnindonesia.com/nasional/20180220073527-20-277337/kronologi-ambruknya-tiang-girder-tol-becakayu-lukai-7-orang>
- JNP CNN Indonesia. (2021). *Kecelakaan Proyek Kereta Cepat Jakarta - Bandung*. CNN Indonesia.
- Karatas, I., & Budak, A. (2023). Investigating the impact of lean-BIM synergy on labor productivity in the construction execution phase. *Journal of Engineering Research (Kuwait)*, 11(4), 322-333. <https://doi.org/10.1016/j.jer.2023.10.021>
- Luo, H., Lin, L., Chen, K., Antwi-Afari, M. F., & Chen, L. (2022). Digital technology for quality management in construction: A review and future research directions. *Developments in the Built Environment*, 12(August), 100087. <https://doi.org/10.1016/j.dibe.2022.100087>



- Michalski, A., Glodzinski, E., & Bode, K. (2021). Lean construction management techniques and BIM technology - Systematic literature review. *Procedia Computer Science*, 196, 1036-1043. <https://doi.org/10.1016/j.procs.2021.12.107>
- Mossman, A. (2018). WHAT IS LEAN CONSTRUCTION: ANOTHER LOOK - 2018. *Proc. 26th Annual Conference of the International Group for Lean Construction (IGLC)*, 1240-1250. <https://doi.org/10.24928/2018/0309>
- Murdiyanto, E., & Susetyo, B. (2024). Driving and Inhibiting Factors for the Implementation of 3D Building Information Modeling (BIM) in Construction Management Consultants (CMC). *Rekayasa Sipil*, 13(1), 58-64.
- Pérez, Y., Ávila, J., & Sánchez, O. (2024). Influence of BIM and Lean on mitigating delay factors in building projects. *Results in Engineering*, 22(November 2023). <https://doi.org/10.1016/j.rineng.2024.102236>
- Schafer, D., Abdelhamid, T. S., Mitropoulos, P., & Howell, G. A. (2008). Resilience Engineering : a New Paradigm for Safety in Lean. *Proceedings of IGLC16: 16th Annual Conference of the International Group for Lean Construction*, 723-734.
- Regulation Of The Minister Of Public Works And Public Housing No. 22/PRT/M/2018, Pub. L. No. 22/PRT/M/2018, 1 (2018). <https://peraturan.bpk.go.id/Details/159730/permen-pupr-no-22prtm2018-tahun-2018>
- Yanda, G., Amin, M., & Soehari, T. D. (2019). Investment, returns, and risk of building information modeling (BIM) implementation in Indonesia's construction project. *International Journal of Engineering and Advanced Technology*, 9(1), 5159-5166. <https://doi.org/10.35940/ijeat.A1806.109119>

## Appendix

### 1 Daily Huddle Meeting Agenda (Last Planner System® Routine)

The purpose of this agenda is to align daily commitments and ensure adherence to SOPs.

- Review Yesterday's Commitments: Verify which tasks have been completed and which have not.
- Identify Obstacles: Discuss any obstacles hindering today's work.
- Plan Today: Assign new tasks based on the collision detection-free drawings.
- SOP & Safety Briefing: A brief reminder of the key points in the work instructions (SOP).
- Commitment Signing: Close the meeting with a commitment from each foreman or crew leader.

#### DAILY MEETING

No	Main Topic	Problem Description	Follow-up Plan	Target	Status		Pic
					Open	Closed	
<b>A</b>	<b>Management</b>						
1	Progress	Progress R1 covid effect Week 11	Finishing meeting room 1. Carpet Tile	continue	v		sofyan
		Ra : 9,98%	2. Window coverings	continue	v		zaldi + bela
		Ri : 10,72%	3. Box downlight	continue	v		sofyan
		Dev ; 0,74%	4. Rest area behind the container	continue	v		anas
2	Meeting Schedule	1. Internal Meeting	Every Tuesday	continue	v		all team
		2. Special production meeting	Every Saturday	continue	v		anas cs
		3. External Meeting	Every Monday	continue	v		wawan
4	Potensial Problem	1. Vendor payment	Bill coordination group	10 juni 2019	v		bela
		2. Work path	Immediately according to the site plan	13 juni 2019	v		sofyan
		3. Expenditure of piling equipment	Week 11 must be out	continue	v		wawan
		4. Dropping operational	40 million / 2 weeks	continue	v		heru + bela
<b>B</b>	<b>Finance / General</b>						
1	Uniform and shoes	Looking for a supplier immediately	Personil Data	Week 11	v		zaldi
2	Id card	Waiting Uniform	Personil Data			v	sofyan + zaldi
<b>C</b>	<b>Production</b>						
		5 R	Field Coordination	continue			
<b>D</b>	<b>ENGINEERING</b>						
1	Quality Control	Continue in the field	Coordination with production	continue	v		avtar/wais
2	QA	QA form will be processed immediately	Coordination with QA sun city	continue	v		wais
3	MEP	Coordination with Mr. Udin	Coordination with pak budianto	continue	v		heru
<b>E</b>	<b>Procurement</b>						
	acquisition		Ceramic Material	continue	v		indra + wawan
			plafond Material ( subcont )	continue	v		indra + wawan
			Mortar Material	continue	v		indra + wawan
			Sanitair Material	continue	v		indra + wawan
			Hebel Material	continue	v		indra + wawan
			Roof + light steel (subcont)	continue	v		indra + wawan
			Railing ( Subcont )	continue	v		indra + wawan
			Paint ( subcont )	continue	v		indra + wawan
			Aluminum window doors (subcon)			v	indra + wawan

No	Main Topic	Problem Description	Follow-up Plan	Target	Status		Pic	
					Open	Closed		
F	Commercial	MCO	Close soon	9 juni 2019	√		wawan + wais + heru	
		RKP	Immediately close each function	continue	√		all team	
		Kelengkapan penerapan denda pada mandor	1. Sertificate K3 SR	continue	√		wawan + sofyan	
			2. Photo of the incident	continue	√			
			3. Receipt issued	continue	√			
4. Minutes of foreman's approval	continue		√					
		5. Number of workers using APD	continue	√				
G	SHE	Jumlah Tenaga kerja	- Fc. KTP labor	continue		√	Sofyan	
			- ID Card labour+ staff	continue	√		Sofyan	
			- APD	continue		√	Sofyan	
		Sampah Proyek			√		Sofyan	
		Rambu Proyek	Laminating	17 juni 2019	√		Sofyan	
				Saffety morning ( kamis pagi )		√		Sofyan
		Dokumentasi ( foto )	Once a week (SHE photos + videos)	continue	√		Sofyan	
		Rujukan Rumah Sakit	Staff dan Worker	12 juni 2019	√		Sofyan + zaldi	

Approved by,



Heru Andraiko  
Project Manager

Notulen,



Farid Fernando  
Document Control

Figure 29: Daily huddle meeting

## 2 Quality Inspection Checklist

This checklist is used to ensure quality expectations are clear for all parties in the field.

Table 3: Quality inspection checklist

Item No	Inspection Point (SOP Reference)	Criteria	Result (Pass/Fail)
1	Rebar Placement	Accordance with BIM-generated shop drawings.	
2	Formwork Verticality	Tolerance within $\pm X$ mm as per QMSL SOP.	
3	Cleanliness	No debris inside the formwork before casting.	
4	Clash Verification	All MEP sleeves installed as per Navisworks coordination	
5	Concrete Slump	Meets technical specifications.	




<b>Checklist for Reinforcement</b>			
<b>Project</b>	: UPGRIS FLAT	<b>Doc. No.</b>	: QA/CL-REN/
<b>Client</b>	: Ministry of Public Housing	<b>Project Location</b>	: Semarang
<b>SITE</b>		<b>LOCATION</b>	
UPGRIS PROJECT		SEMARANG, MIDDLE JAVA	
		<b>DATE</b>	
		September 2, 2019	
		<b>YES</b>	<b>NO</b>
		<b>NA</b>	
1	Structural Drg. No. and date as per which reinforcement checked. Bar Bending Schedule Prepared?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2	Connecting of bars to existing dowels to be checked for alignment. OK?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
3	Placing of Bar diameter, number, spacing match with the Construction Schedule?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
4	Lap Length, Position of lap, OK?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
5	Cleanliness of shuttering and Bars OK?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
6	Chairs provided?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
7	Cover for reinforcement ok?	<input checked="" type="checkbox"/>	<input type="checkbox"/>
8	Provision of cover blocks/ preparation of cover blocks	<input checked="" type="checkbox"/>	<input type="checkbox"/>
9	Maintaining records and getting approval for additional reinforcement not shown	<input checked="" type="checkbox"/>	<input type="checkbox"/>
10	To check the construction joint for proper concrete bonding before placing reinforcement	<input checked="" type="checkbox"/>	<input type="checkbox"/>
11	Laying of bars of required dia. As per requirement	<input checked="" type="checkbox"/>	<input type="checkbox"/>
12	Check for Test Reports for steel and approved brand or not	<input checked="" type="checkbox"/>	<input type="checkbox"/>
13	Check colour coding for identification	<input checked="" type="checkbox"/>	<input type="checkbox"/>
14	Check for proper binding (double strand/ quality of binding wire of 18 SWG)	<input checked="" type="checkbox"/>	<input type="checkbox"/>
15	Check for any rework or alteration	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<b>Remarks of Quality Assurance Engineer:</b>			
<b>Signature</b>	<b>Date</b>	<b>Remarks/ Comments</b>	
Checked By: 	9/1/2019		
Approved By: 	9/2/2019		

Figure 30: Iron work table checklist

### 3 Sample Project Quality Dashboard

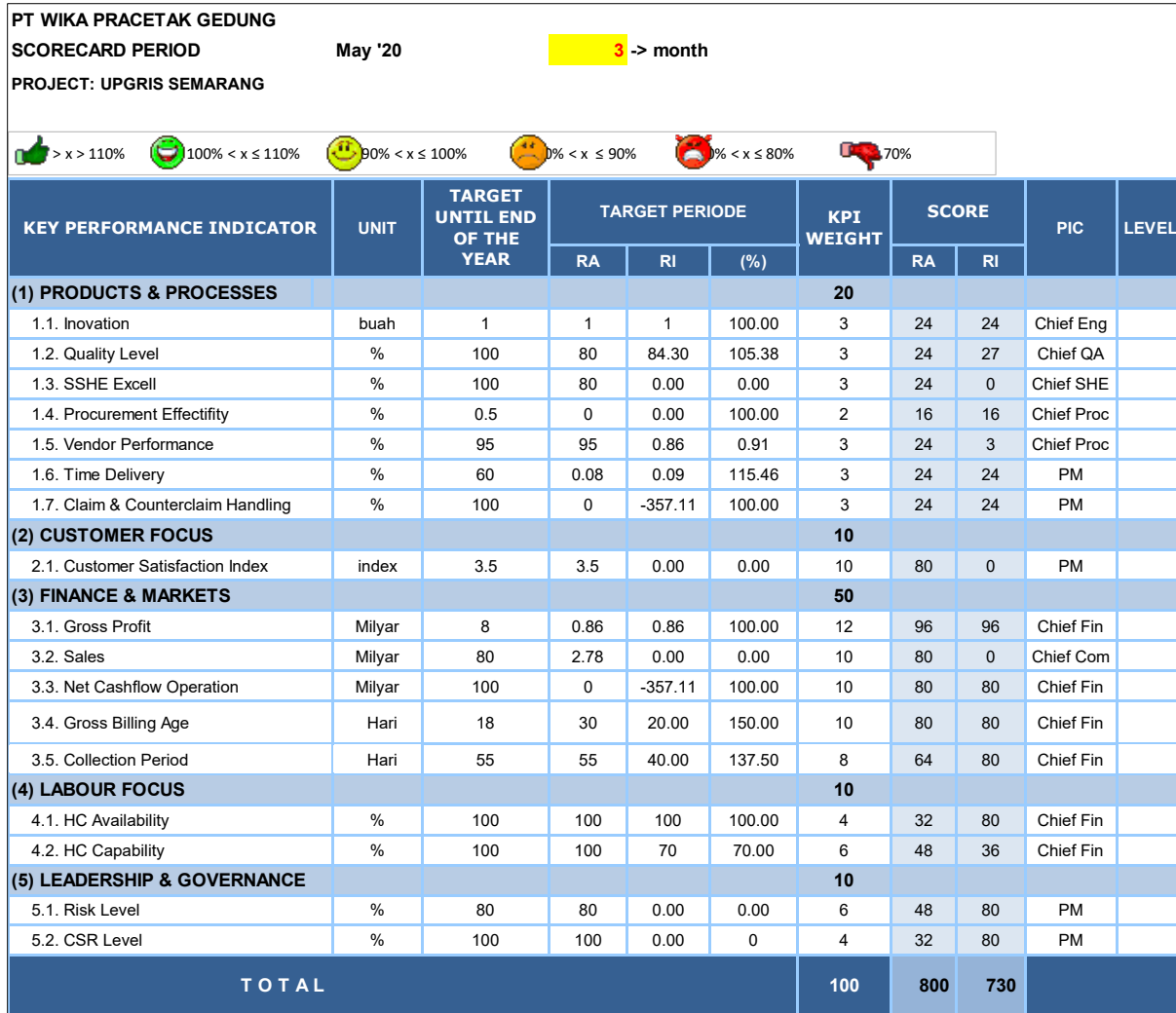


Figure 31: Project monitoring dashboard