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INTEGRATED PROJECT CONTROL STRATEGY IN HIGH-COMPLEXITY HOSPITAL CONSTRUCTION: A CASE STUDY OF HARAPAN KITA HOSPITAL PROJECT

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ABSTRACT

High-rise hospital construction projects require strict integration of technical coordination, cost control, quality assurance, and occupational safety management due to their complexity and regulatory requirements. However, empirical case-based studies examining how integrated construction control systems are implemented in Indonesian healthcare infrastructure projects remain limited. This study aims to analyze the implementation of integrated construction control mechanisms across Engineering, Quantity Surveying (QS), Quality Control (QC), and Health, Safety, and Environment (HSE) divisions in the Harapan Kita–Tokushukai Hospital Project, Jakarta. A qualitative case study approach was adopted, involving document analysis, field observation, and structured technical review of project control practices. The findings indicate that structured production planning (Last Planner System), systematic quality inspection protocols, progressive cost mapping, and safety monitoring contribute significantly to schedule reliability, cost transparency, and quality compliance. The study provides practical and theoretical contributions to construction management literature by demonstrating how cross-divisional coordination strengthens project control performance in high-complexity healthcare infrastructure.

Keywords: construction management, hospital project, project control, quality management, safety management, case study

Introduction

Healthcare infrastructure projects are widely recognized as among the most complex categories of construction due to strict regulatory requirements, high-performance building systems, advanced mechanical-electrical integration, and uninterrupted operational demands {Formatting Citation}. In high-rise hospital developments, the coordination of structural works, medical facility requirements, infection-control standards, and safety compliance significantly increases managerial complexity. Effective project control systems therefore become critical to maintaining schedule reliability, cost certainty, quality compliance, and occupational safety performance [3].

Project control theory emphasizes the integration of time, cost, and quality monitoring as interdependent management functions rather than isolated control instruments [4]. Meanwhile, Lean Construction theory, particularly the Last Planner System (LPS), has demonstrated effectiveness in improving workflow reliability and reducing variability in construction production systems [5]. Recent empirical studies confirm that lean-based planning enhances schedule predictability and collaborative coordination in complex building projects [6]. However, much of this literature focuses primarily on production planning performance, with limited integration into cost management, quality assurance, and safety governance systems.

Similarly, research on cost control and quantity surveying highlights the importance of accurate progress measurement and earned value management in ensuring financial transparency [7], [8]. Advances in digital construction, particularly Building Information Modeling (BIM) 5D integration, have further strengthened cost-performance alignment [9], [10]. Nevertheless, empirical case studies examining how QS practices interact dynamically with engineering planning systems and inspection-based quality control mechanisms in hospital projects remain scarce.

Quality management literature in construction emphasizes systematic inspection, material traceability, and continuous improvement principles derived from Total Quality Management [11]. Recent studies indicate that digital quality tracking significantly reduces rework and enhances compliance in high-rise projects [12], [13]. At the same time, safety management research underscores proactive risk identification and structured reporting systems as determinants of accident reduction (ISO, 2018). However, these domains production planning, cost management, quality control, and safety governance are frequently examined independently rather than as an integrated control ecosystem.

In the context of healthcare construction in emerging economies, scholarly evidence remains particularly limited. While global best practices advocate integrated digital project delivery and cross-functional coordination [13], [15], there is insufficient empirical documentation of how these principles are operationalized within Indonesian hospital megaprojects. This indicates a critical research gap: the absence of structured case-based analysis that explains how Engineering, Quantity Surveying (QS), Quality Control (QC), and Health, Safety, and Environment (HSE) divisions function collectively as an integrated performance control system in a high-rise hospital construction project.

Accordingly, this study addresses the following research question: *How does the implementation of integrated construction control systems across Engineering, Quantity Surveying, Quality Control, and Health, Safety, and Environment divisions contribute to performance reliability in a high-rise hospital construction project?* Project performance is operationalized through four measurable dimensions: schedule reliability, cost transparency, quality compliance, and safety performance.

Theoretically, this research contributes in three ways. First, it extends Lean Construction theory by empirically demonstrating how the Last Planner System can be integrated beyond workflow reliability into cost reconciliation, inspection compliance, and safety monitoring mechanisms [16], [17]. Second, it reinforces multidimensional project control theory by illustrating the systemic interdependence of time, cost, quality, and safety management functions [18]. Third, it enriches comparative construction management scholarship by providing contextualized empirical evidence from a high-complexity hospital project in Indonesia, thereby contributing to global discourse on infrastructure delivery in emerging economies.

Objectives

This research aims to achieve the following measurable objectives:

1. Evaluate the efficacy of digital modeling (Cubicost TRB) in reducing rebar configuration discrepancies between design revisions.
2. Analyze the impact of the Last Planner System (LPS) on short-term production reliability and constraint identification.
3. Assess the correlation between physical progress mapping (QS) and quality verification (QC) in ensuring administrative and technical transparency.
4. Determine the role of integrated HSE protocols in mitigating high-risk construction activities in a dense urban environment.

Methods

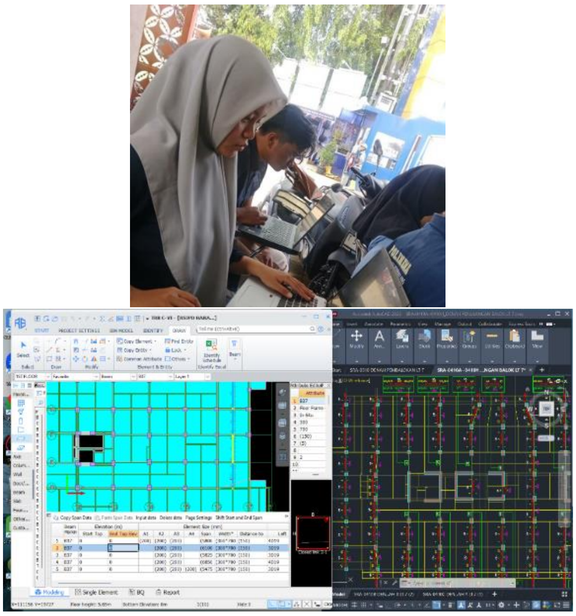
This study employs a qualitative descriptive case study methodology. Data was gathered through a 16-week longitudinal observation period at the Harapan Kita – Tokushukai Hospital project site in West Jakarta.

1. Data Collection: Methods included direct field observation of structural works (rebar, formwork, and casting), document analysis of shop drawings and technical specifications, and active participation in technical coordination meetings.
2. Analysis: The study utilized a comparative analysis approach, benchmarking field observations against industry "best practices" such as Lean Construction principles and Indonesian National Standards (SNI) for structural concrete and steel.

Results

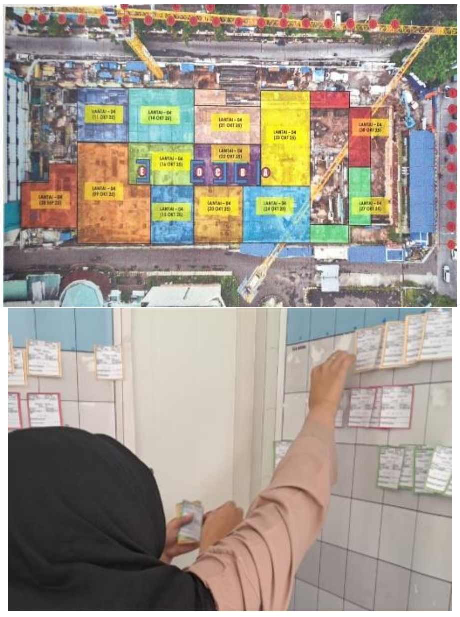
1. Engineering Division

The implementation of construction control within the Engineering division primarily focused on design validation, reinforcement modeling, and production planning coordination. The systematic review of shop drawing revisions enabled early identification of potential discrepancies between structural design updates and field execution requirements. Through reinforcement modeling and cross-checking processes, technical inconsistencies were minimized before on-site implementation. Furthermore, the adoption of the Last Planner System (LPS) strengthened short-term production planning by identifying constraints, resource readiness, and task sequencing prior to execution. This structured planning approach enhanced workflow reliability and reduced the likelihood of schedule disruptions.



Picture 1. Reinforcement modeling activities in Cubicost TRB software

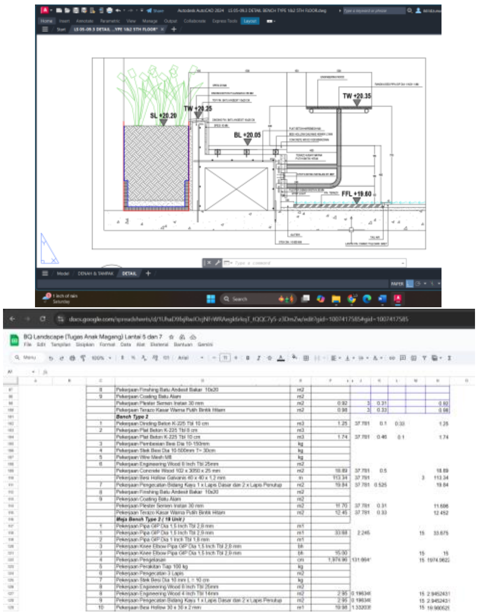
Beyond technical validation, the Engineering division played a central role in facilitating coordination across other divisions. Outputs from planning activities were utilized by the Quantity Surveying division for quantity verification and by the Quality Control division for inspection readiness scheduling. This interdependency demonstrates that engineering planning functions extended beyond technical design review and acted as a coordination backbone for integrated project control. As a result, schedule predictability improved, and execution phases were supported by clearer operational guidance.



Picture 2. LPS (Last Planner System) creation

2. Quantity Surveyor (QS) Division

Within the Quantity Surveying division, construction control was implemented through systematic volume calculation, reconciliation of as-built quantities, and progress-based financial reporting. By comparing shop drawing quantities with actual field conditions, discrepancies were identified and addressed before affecting payment claims or cost projections. Weekly progress mapping enabled the alignment of physical progress with financial performance indicators, thereby strengthening cost transparency and reporting accuracy. This approach minimized inconsistencies between administrative documentation and on-site execution.



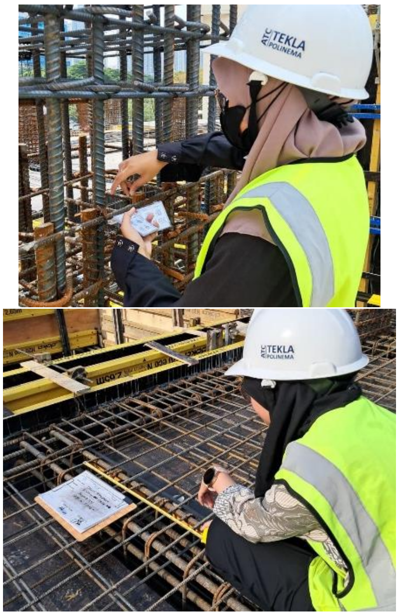
Picture 3. Landscape volume calculation work

In addition, the QS division's integration with engineering planning outputs enhanced the reliability of cost control mechanisms. Design changes identified by the Engineering division were quantitatively evaluated to assess their financial implications, ensuring informed decision-making. This coordination reduced the risk of cost overruns caused by unmonitored variation orders. The findings indicate that cost control in this project functioned not merely as financial record-keeping but as an active performance monitoring instrument integrated within the broader construction control system.

Picture 4. Weekly structural work mapping

3. Quality Control (QC) Division

The Quality Control division implemented structured inspection mechanisms to ensure compliance with technical specifications prior to structural execution. Pre-casting inspections, reinforcement checklists, and tagging systems were systematically applied to verify conformity between installed work and approved drawings. Concrete test result recapitulation and material documentation further supported compliance verification. These procedures reduced the potential for structural defects and minimized the risk of rework, which could otherwise impact both schedule and cost performance.

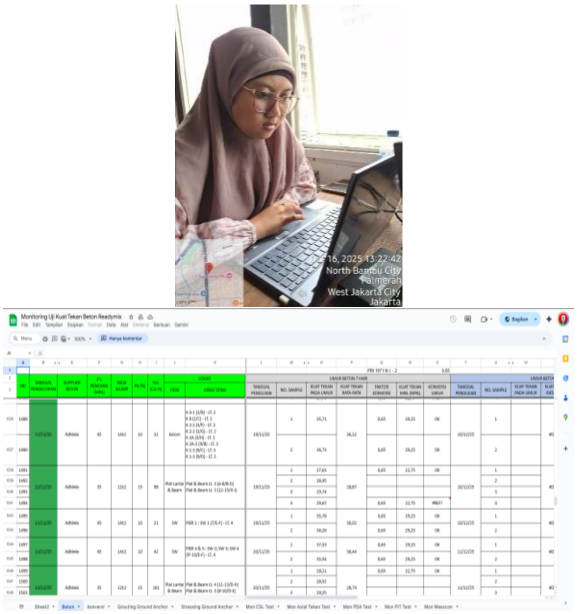


(a)

(b)

Picture 5. (a) column detail tagging; (b) beam reinforcement checking

Moreover, documentation and traceability practices strengthened quality governance across the project lifecycle. Inspection outcomes were recorded and communicated across divisions, ensuring that only verified work proceeded to subsequent stages. The integration of quality inspection schedules with engineering planning and QS progress tracking demonstrates that quality assurance was embedded within operational workflows rather than treated as an isolated function. Consequently, quality control contributed directly to overall project reliability and performance stability.



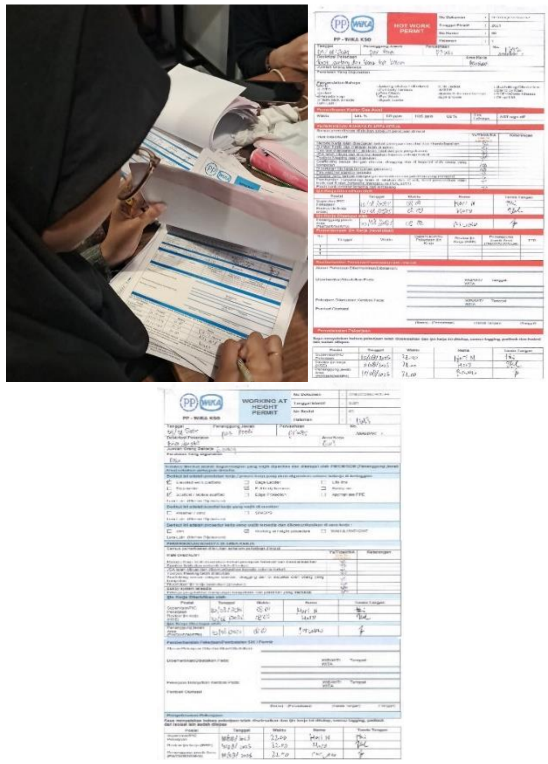
Picture 6. concrete evaluation recap

4. Healt, Safety, and Environment (HSE) Division
Construction control within the HSE division emphasized proactive risk management and compliance monitoring. Routine toolbox meetings, safety talks, and hazard identification activities enhanced workers' awareness of potential risks in daily operations. The implementation of structured work permit systems (Surat Izin Bekerja) ensured that high-risk activities were formally reviewed and authorized prior to execution. These mechanisms supported preventive safety governance and reduced exposure to workplace incidents.

(a)

Picture 7. (a) Safety Talk on Thursday; (b) Toolbox Meeting Every Morning

Furthermore, unsafe condition reporting and corrective action follow-ups strengthened the project's safety feedback loop. Safety monitoring was integrated with engineering scheduling and QC inspection planning to ensure that operational activities complied with established safety standards. This integration demonstrates that safety management was embedded within the broader construction control framework rather than functioning as a parallel supervisory process. As a result, safety performance contributed to sustaining uninterrupted workflow and overall project continuity.



Picture 8. Work Permit Processing

Discussion

The findings indicate that the implementation of integrated construction control systems in the Harapan Kita–Tokushukai Hospital Project functions as a coordinated multidimensional management mechanism rather than as separate operational activities. The interaction between Engineering, Quantity Surveying (QS), Quality Control (QC), and Health, Safety, and Environment (HSE) divisions demonstrates that schedule reliability, cost transparency, quality compliance, and safety performance are interdependent dimensions of project control. The adoption of the Last Planner System (LPS) strengthened workflow predictability and constraint management, supporting Lean Construction theory that emphasizes variability reduction and collaborative planning [19]. Importantly, this planning system also influenced downstream processes, including cost reconciliation and inspection readiness, illustrating systemic cross-divisional integration.
From a financial and quality management perspective, systematic quantity reconciliation and structured inspection protocols enhanced both budget control and defect prevention. The alignment between physical progress measurement and financial reporting supports project control theory, which highlights the importance of synchronized monitoring of time and cost performance [20]. Furthermore, the structured inspection checklists and material testing documentation reflect Total Quality Management principles and contribute to minimizing rework risks [21]. Although these mechanisms were operationally effective, digital

integration—such as BIM-based real-time monitoring—remains partially implemented compared to international best practices [23].

In terms of safety governance, proactive practices such as toolbox meetings, work permit systems, and unsafe condition reporting demonstrate alignment with structured occupational safety frameworks [22]. Safety management was embedded within operational workflows rather than treated as an isolated administrative function, reinforcing the systemic nature of integrated project control. Overall, the case study confirms that cross-divisional integration enhances performance stability in complex hospital construction projects; however, further advancement toward digitally integrated control platforms would strengthen predictive capacity and real-time decision-making efficiency.

Conclusions

This study demonstrates that integrated construction control systems significantly contribute to performance reliability in high-rise hospital construction projects. Cross-divisional coordination enhances schedule predictability, cost transparency, quality compliance, and safety performance.

The Harapan Kita–Tokushukai Hospital Project illustrates how structured production planning, systematic inspection procedures, and proactive safety management can be effectively integrated within a complex healthcare infrastructure project. Future research should explore digital transformation and multi-case comparative analysis to strengthen generalizability.

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