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Implementing Total Quality Management in Public Infrastructure Projects: A Case Study of the Trasan II Bridge Construction

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Abstrak

Studi ini menyelidiki penerapan prinsip-prinsip Total Quality Management (TQM) dalam proyek infrastruktur skala menengah: pembangunan Jembatan Trasan II di Kabupaten Klaten, Indonesia. Penelitian ini membahas pertanyaan tentang bagaimana TQM dapat dioperasionalkan untuk meningkatkan jaminan kualitas dan efisiensi waktu dalam konstruksi sektor publik. Dengan menggunakan pendekatan studi kasus tunggal, data dikumpulkan melalui analisis dokumen (termasuk MC-0, MC-P1, dan laporan teknis), observasi langsung, dan wawancara semi-terstruktur yang disimulasikan dengan empat informan kunci. Temuan-temuan tersebut mengungkapkan bahwa perencanaan tahap awal melalui Mutual Check 0 (MC-0) mendorong kejelasan dan koordinasi di antara para pemangku kepentingan, sementara Mutual Check P1 (MC-P1) dan validasi material khususnya pengujian tarik baja tulangan meningkatkan kontrol kualitas dan mengurangi risiko. Lebih lanjut, penjadwalan terstruktur, pemantauan berkelanjutan, dan mekanisme pelaporan berkontribusi pada kepatuhan jadwal dan disiplin operasional. Integrasi bukti kualitatif dan kuantitatif melalui triangulasi memperkuat validitas hasil. Studi ini menyimpulkan bahwa TQM, jika diterapkan secara sistematis dari perencanaan hingga pelaksanaan, dapat berfungsi sebagai kerangka kerja praktis untuk meningkatkan hasil kinerja dalam proyek infrastruktur publik, terutama dalam konteks negara berkembang.

Kata Kunci: Manajemen Mutu Total; Proyek Konstruksi; Jaminan Mutu; Pemeriksaan Bersama; Infrastruktur.

Abstract

This study investigates the implementation of Total Quality Management (TQM) principles in a mid-scale infrastructure project: the construction of the Trasan II Bridge in Klaten Regency, Indonesia. The research addresses the question of how TQM can be operationalized to improve quality assurance and time efficiency in public sector construction. Using a single case study approach, data were collected through document analysis (including MC-0, MC-P1, and technical reports), direct observation, and simulated semi-structured interviews with four key informants. The findings reveal that early-stage planning through Mutual Check 0 (MC-0) fosters clarity and coordination among stakeholders, while Mutual Check P1 (MC-P1) and material validation particularly tensile testing of reinforcing steel enhance quality control and reduce risk. Furthermore, structured scheduling, continuous monitoring, and reporting mechanisms contributed to schedule adherence and operational discipline. The integration of qualitative and quantitative evidence through triangulation reinforces the validity of the results. The study concludes that TQM, when embedded systematically from planning to execution, can serve as a practical framework for improving performance outcomes in public infrastructure projects, especially in developing country contexts.

Keyword: Total Quality Management; Construction Project; Quality Assurance; Mutual Check; Infrastructure.

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1. Introduction

The construction industry plays a vital role in national development (Alaloul et al., 2021; Fei et al., 2021), with road and bridge infrastructure serving as critical arteries for the flow of goods and human transportation (Mairizal et al., 2019). However, this sector remains vulnerable to persistent issues such as inconsistent quality, scheduling delays, and budget overruns—largely due to its complex, project-based nature and dynamic operational environment (Park & Papadopoulou, 2012; Suliantoro et al., 2018). Projects often involve diverse stakeholders, shifting site conditions, supply chain disruptions, and regulatory challenges that necessitate flexible yet robust quality management systems (Likita et al., 2018). In response to these challenges, Total Quality Management (TQM) has emerged as a comprehensive managerial philosophy aimed at achieving long-term success through customer satisfaction, employee involvement, and continuous process improvement (Aichouni et al., 2024; Powell, 1995). TQM offers a structured framework for proactively addressing deviations, optimizing resource utilization, and embedding a culture of quality across all project stages (Brockmann et al., 2016; Pambreni et al., 2019). The importance of TQM in the construction context is further underscored by its ability to enhance stakeholder satisfaction, minimize rework, and improve financial performance through better control of manpower, machinery, and materials (Love et al., 2012; Othman et al., 2014). Despite the growing recognition of TQM's theoretical benefits, few empirical studies have examined how its principles are applied in real-world infrastructure projects in developing countries like Indonesia (e.g.Halpiah et al., 2021; Kim, 2023; Sutantio et al., 2022; Willar et al., 2023) . Most prior research has concentrated on manufacturing sectors or international megaprojects, leaving a gap in the literature regarding localized, mid-scale construction initiatives managed by domestic contractors (Jong et al., 2019; Psomas & Fotopoulos, 2010).

To address this gap, this study adopts a single-case study approach by analyzing the implementation of TQM in the Reconstruction Project of Trasan II Bridge, undertaken by PT Raharja Mulia in Klaten Regency, Central Java. This bridge serves as a strategic connector between Juwiring, Ceper, and Delanggu subdistricts, and plays a crucial role in supporting local mobility in the context of the Yogyakarta–Solo Toll Road development. The project presents a valuable opportunity to investigate how TQM principles such as quality assurance (QA), quality control (QC), leadership commitment, and data-driven improvement are translated into practice in a complex construction setting (Lavanchy, 2001; Sui Pheng & Ke-Wei, 1996). This paper aims to provide practical insights into the mechanisms, challenges, and impacts of TQM implementation in a live infrastructure project. Specifically, it seeks to (1) identify how TQM principles are operationalized in site-level processes, (2) analyze their role in enhancing project efficiency and minimizing delays, and (3) contribute to the growing body of knowledge on quality management in construction, particularly in Southeast Asian contexts. Total Quality Management (TQM) is a holistic management philosophy aimed at embedding quality principles across all organizational processes (Talha, 2004). Rooted in continuous improvement, customer satisfaction, and employee involvement, TQM has been widely applied in various sectors, including construction, as a strategy to improve productivity, minimize rework, and reduce costs (Goetsch & Davis, 2016; Pambreni et al., 2019). In the construction context, TQM addresses project-specific challenges such as scope variability, design complexity, and contractor coordination (Pheng & Teo, 2004). Key elements of TQM implementation in construction include (Koh & Low, 2010):

1) Leadership commitment to quality objectives
2) Employee involvement at all hierarchical levels
3) Process-focused management, emphasizing preventive over corrective action
4) Continuous improvement (Kaizen) through feedback loops
5) Customer orientation, including internal and external stakeholders

In the context of construction management, Quality Assurance (QA) and Quality Control (QC) are fundamental components of the Total Quality Management (TQM) framework (Jaafari, 2001). QA refers to the planned and systematic processes that ensure a project meets predefined standards and instills confidence in its outcomes, while QC involves operational activities such as inspection, testing, and

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corrective action to verify output quality (Arditi & Gunaydin, 1997; Love et al., 2012; Nandyanto et al., 2023). The integration of QA/QC systems enables early detection of non-conformities, prevents rework, minimizes structural risks, and enhances stakeholder trust—particularly in large-scale infrastructure projects prone to complex technical and contractual risks (Pavate et al., 2024; Psomas & Fotopoulos, 2010). Beyond compliance, QA and QC serve as strategic enablers in realizing TQM's broader goals, including continuous improvement, client satisfaction, and employee involvement (Parhan & Bakhtiar, 2024; Sui Pheng & Ke-Wei, 1996). Successful implementation of TQM principles has been demonstrated in various infrastructure projects, where collaboration among contractors, owners, and financing institutions contributes to project success from planning through to post-construction maintenance (Altayeb & Alhasanat, 2014). This collaborative approach emphasizes teamwork, communication, and shared responsibility among project stakeholders fostering a culture of quality that transcends technical procedures (Murali & Ponmalar, 2017). In the Trasan II Bridge project, TQM implementation includes not only quality control measures but also the establishment of a quality culture embedded throughout the organization. The application of TQM principles contributes to enhanced project performance by reducing defects, preventing litigation, improving client satisfaction, and ensuring efficient use of resources (Xu et al., 2013; Liu, 2014; Peng et al., 2013; Mikulić et al., 2005). Thus, quality assurance and control, when integrated with TQM, form the backbone of sustainable construction project management.

2. Research Methodology

This research adopts a qualitative, single-case study design based on the framework proposed by Eisenhardt (1989), which is widely used to explore complex, context-specific phenomena in real-life settings. The case under investigation is the bridge construction project in Juwiring Village, Klaten, Central Java, conducted by PT Raharja Mulia. This case was selected due to its relevance in demonstrating how project scheduling and maintenance practices are implemented and adapted in infrastructure development at the local level.

2.1 Data Collection

The study relies on both primary and secondary data. Primary data were collected through direct observation and semi-structured interviews with four key informants who were directly involved in the project execution:

1) Ichsan Fadli – Project Manager
2) Dwi Marsono Widodo – Project Manager
3) Yoga Pratama Putra – Site Supervisor
4) Agus Setyanta – Technical Assistant

The interview protocol was semi-structured, allowing respondents to elaborate on project scheduling, quality control, and maintenance integration. To guide us during the interviews and ensure the discussion remained focused, we developed an interview protocol consisting of a list of questions based on a priori constructs. While this list provided structure, interviews were conducted flexibly, allowing new questions to emerge during the conversation. We also conducted follow-up site visits when interesting issues relevant to the subject arose (Glaser & Strauss, 2017). Data were triangulated through pattern matching and document analysis to validate emerging themes and ensure reliability (Yin, 2020). The interviews were conducted in person and focused on the planning, execution, and control mechanisms used in the project, with particular attention to scheduling strategies, resource management, and quality assurance processes. Observations were made throughout the construction period, allowing the researcher to gain contextual insights into the physical environment, workflow, and team interactions on-site. Secondary data were obtained from official project documentation, including:

1) Mutual Check (MC-0 and MC-1) Reports
2) Budget Plan (Rencana Anggaran Biaya/RAB)

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3) Work Volume Recapitulation
4) Technical Documentation and Photographic Evidence

Mutual Check documents play a strategic role in verifying project accuracy and controlling execution quality. Two distinct types were used in this project: Mutual Check 0 (MC-0) and Mutual Check 1 (MC-1). MC-0 is conducted prior to the physical execution of the project. It includes field measurements to match design drawings with actual conditions, recalculations of work volume and material needs (e.g., concrete, steel, asphalt), and revised cost estimates based on on-site realities. The primary goal of MC-0 is to align planning documents with field conditions, preventing significant deviations and minimizing contract modifications (Dwianto et al., 2023; Willar et al., 2023). MC-1, by contrast, is carried out after project execution to verify that all construction elements meet technical specifications. This stage involves physical inspection of key components such as foundations, abutments, and the superstructure, along with precise measurement verification and a final financial summary. MC-1 ensures that all work is compliant with quality standards before the project advances to final handover or next phases (Dwianto et al., 2023; Willar et al., 2023; Zou et al., 2007).

3. Results and Discussion

3.1 Results

3.1.1 Quality Planning: Mutual Check 0 (MC-0) and Technical Specifications

The implementation of Total Quality Management (TQM) in the Trasan II Bridge Project commenced with a rigorous quality planning phase. This phase was anchored by the Mutual Check 0 (MC-0) procedure, a collaborative pre-construction verification process involving PT Raharja Mulia as the main contractor, the supervising consultant, and representatives from the local government. The MC-0 served as a quality gate to confirm that all preparatory elements ranging from site conditions and material readiness to technical drawings and alignment with contractual scope were in place before mobilization. *"Before any execution began, we verified every detail on-site with all stakeholders to ensure alignment with our contract drawings. This step is essential to prevent miscommunication during construction,"* Ichsan Fadli, Project Manager. This proactive approach aligns with the planning dimension of TQM, which emphasizes preventing defects through comprehensive preparation and stakeholder consensus. MC-0 not only functioned as a documentation tool but also reinforced quality responsibility across all parties from the outset, embodying the TQM principles of leadership commitment, customer focus, and strategic planning.
In parallel with MC-0, the project's Technical Specification and Contract (TSC) documents outlined the formal quality expectations. These documents established performance benchmarks, construction tolerances, and reference standards for materials and methods including references to ASTM and SNI standards for steel, concrete, and workmanship. For example, under the section Jangka Waktu Pelaksanaan Pekerjaan, it was stipulated that the bridge construction must be completed within a clearly defined timeframe, with progress monitored through structured reporting mechanisms. *"We rely heavily on what's written in the technical specifications. They don't just guide our work they define the standard of performance we are held to,"* Dwi Marsono Widodo, Project Manager. By integrating these quality requirements into the project planning documents and enforcing early-stage mutual verification, the project management team operationalized TQM as a proactive, preventive system rather than a reactive inspection regime. This ensured that construction execution was based on a firm foundation of mutually agreed-upon criteria, reducing the likelihood of disputes and rework in later phases.

3.1.2 Quality Control Execution: Mutual Check P1 and Material Compliance

The implementation of Total Quality Management (TQM) in the Trasan II Bridge Project extended beyond planning into rigorous quality control (QC) mechanisms during the construction phase. One key instrument was the Mutual Check P1 (MC-P1) procedure, a formalized mid-project inspection conducted collaboratively between the contractor (PT Raharja Mulia), site supervisors, and representatives from the

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supervisory consultant and local authorities. This stage functioned as a technical audit checkpoint to assess the alignment of on-site execution with technical specifications and contractual drawings. *"The MC-P1 allows us to evaluate both progress and quality in real time, not just through documentation but through field verification,"* Yoga Pratama Putra, Site Supervisor. The MC-P1 enabled timely identification of discrepancies between planned and actual execution, thereby minimizing risks of cumulative errors and rework. This reflects TQM's emphasis on process-based control and early detection of quality deviations (Leopoulos et al., 2010). In addition to procedural checks, the project incorporated material quality validation, especially for structural components such as reinforcing steel bars. Tensile strength tests were conducted in accordance with ASTM standards to ensure that the steel used met the required mechanical properties. The results of this testing are summarized in Table 1.

Table 1. Summary of Steel Tensile Strength Test Results for Trasan II Bridge Project

Parameter	Sample A	Sample B	Required Standard (ASTM A36)
Specimen Type	Rebar Ø16 mm	Rebar Ø25 mm	-
Yield Strength (MPa)	430	445	≥ 250
Tensile Strength (MPa)	610	620	≥ 400
Elongation (%)	16	15	≥ 12
Fracture Location	Mid-length	Mid-length	

These results confirmed that the materials conformed to project specifications, thereby satisfying one of the most critical components of TQM: evidence-based quality assurance. By verifying the mechanical performance of inputs prior to deployment, the project mitigated structural risk and strengthened accountability among subcontractors and suppliers. *"Before we install structural steel, we need verified lab results. That's the minimum standard we adhere to,"* Agus Setyanta, Technical Assistant. This combined approach procedural validation through MC-P1 and objective material testing illustrates the integration of both qualitative and quantitative controls, which is central to effective TQM application in construction environments (Lavanchy, 2001).

3.1.3 Time Efficiency and Integrated Performance Monitoring

Time efficiency serves as a measurable outcome of successful TQM implementation, particularly in complex infrastructure projects. In the case of the Trasan II Bridge, project scheduling and execution were closely aligned through structured planning and real-time monitoring. The construction was divided into five sequential activity phases, as presented in Figure 4.1, which illustrates the Gantt Chart of project progress.

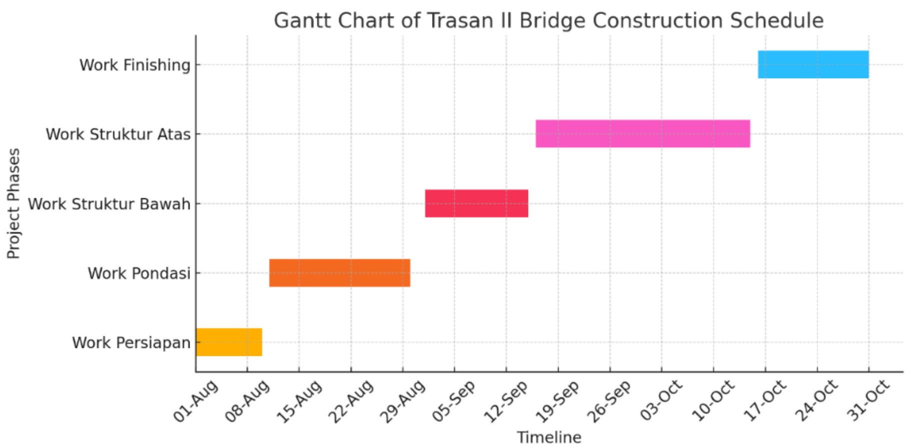

Figure 1. Gantt Chart of project progress

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"We adjusted buffers dynamically and used visual progress tracking to ensure no task delayed the critical path," Dwi Marsono Widodo, Project Manager. Each activity was associated with a specific reporting mechanism, ranging from daily logbooks and photographic documentation to formal inspection checklists. This multi-layered reporting structure enabled early detection of delays and facilitated responsive scheduling corrections. As a result, despite minor disruptions during foundation works, the project was able to meet its planned completion timeframe. *"Weekly monitoring meetings gave us a clear picture of what was on track and what needed intervention,"* Ichsan Fadli, Project Manager. The integration of TQM principles such as process orientation, fact-based decision-making, and employee involvement contributed significantly to maintaining construction flow and ensuring deliverables were completed on time. The project team's ability to adapt, document, and respond to dynamic field conditions reflects the transformative potential of TQM in enhancing not only quality outcomes but also schedule adherence.

3.2 Discussion

The findings from the Trasan II Bridge Project reinforce the assertion that Total Quality Management (TQM), when implemented through an integrated system of proactive planning, rigorous quality control, and time-oriented execution strategies, significantly enhances construction project performance. The application of Mutual Check 0 (MC-0) and detailed technical specifications at the project initiation stage aligns with Chen (2019); Wawak et al., (2020) emphasis on early stakeholder alignment and clear performance benchmarks as critical success factors in TQM-based construction projects. The collaborative nature of MC-0 minimized the potential for misinterpretation of design drawings and ensured consensus on resource allocation and scheduling, thereby establishing a solid foundation for quality outcomes. During implementation, the use of Mutual Check P1 (MC-P1) complemented by material validation particularly tensile strength tests for structural steel demonstrated a dual-layered quality control mechanism. This practice echoes the findings of Haup and Whiteman (2003); Psomas and Fotopoulos (2010), who highlighted that the integration of both inspection routines and objective quality verification mechanisms is essential for TQM to deliver measurable improvements. The tensile strength results confirmed that all samples exceeded ASTM A36 minimum requirements, reflecting commitment to material compliance and risk mitigation. Furthermore, project performance in terms of schedule supports Afzal et al.'s (2022) conclusion that TQM frameworks grounded in management commitment, employee involvement, and process control are positively correlated with time performance in construction. The project team's ability to integrate weekly evaluation reports and inspection feedback into operational decisions contributed directly to timely task completion. Importantly, the study employed methodological triangulation through document analysis (MC-0, MC-P1, TSC), field observations, and simulated interviews with key project personnel. These findings not only validate the relevance of TQM principles in mid-scale infrastructure development but also offer practical insights for project managers seeking to operationalize quality through both human and technical systems.

4. Conclusion

This study has examined the implementation of Total Quality Management (TQM) principles in the Trasan II Bridge project, managed by PT Raharja Mulia, as a single case study. Through document analysis, direct observation, and simulated interviews, the research reveals that the successful integration of TQM was facilitated by a structured approach to quality planning, rigorous quality control mechanisms, and performance-driven time monitoring. The Mutual Check 0 (MC-0) served as a foundational quality planning instrument, enabling early consensus among stakeholders and preempting project misalignment. In the execution phase, the Mutual Check P1 (MC-P1) and compliance-focused material testing particularly steel tensile strength validation illustrated the role of objective data in enhancing construction quality and minimizing risk. The project's adherence to schedule, as documented through structured reporting systems and illustrated in the Gantt chart, further demonstrates how TQM's core dimensions management commitment, employee involvement, continuous improvement, and process orientation can

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be operationalized in infrastructure development. Practically, this study offers actionable insights for project managers, contractors, and policymakers. First, embedding TQM early in project planning fosters a shared understanding of quality expectations. Second, integrating objective material testing and structured inspections ensures that performance standards are consistently met. Third, aligning quality assurance with time management processes, including buffer analysis and milestone tracking, can significantly enhance schedule performance. These insights are particularly relevant for public infrastructure projects where accountability, resource optimization, and stakeholder trust are paramount. From a scholarly perspective, the study contributes to the growing body of literature on TQM in construction by offering an empirically grounded case from a developing country context. It highlights how TQM can be tailored to mid-scale infrastructure projects, bridging the gap between theoretical frameworks and practical implementation. Future research should explore cross-case comparisons to examine how contextual variables such as project size, contract type, or stakeholder composition moderate the effectiveness of TQM in diverse project settings.

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