

Formwork Implementation Methods for Reinforced Concrete Column Structures Using PERI System

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Abstract: This study investigates the implementation methods of the PERI formwork system for reinforced concrete column structures in the KAI CO-Living Gondangdia project, an 8-story residential building in Central Jakarta. Employing a qualitative case study approach, the research documents the assembly, installation, concrete placement, and removal processes of the PERI system during a three-month internship. Key aspects analyzed include material preparation, panel assembly, alignment techniques, quality control measures, and safety protocols. The PERI system, characterized by modular steel-framed panels and phenolic-coated plywood, facilitated rapid assembly (45-60 minutes per column), high dimensional accuracy ($\pm 3\text{mm}$ tolerance), and excellent concrete surface quality for 85% of columns. The system's reusability (24 cycles) and reduced labor requirements (25% less than traditional methods) enhanced project efficiency. Standardized procedures, skilled labor, and rigorous quality control were critical to success, though specialized training was necessary. The findings highlight the PERI system's advantages in speed, quality, and cost-effectiveness for repetitive structural elements, offering practical insights for optimizing formwork in modern construction. Recommendations include investing in crew training, detailed planning, and comprehensive quality protocols to maximize system benefits.

Keywords: PERI formwork system, reinforced concrete columns, formwork implementation, construction efficiency, quality control, modular formwork, KAI CO-Living Gondangdia, concrete surface quality.

INTRODUCTION

Formwork systems play a critical role in reinforced concrete construction, directly influencing project efficiency, structural quality, and construction economics. As building designs become increasingly complex and construction schedules more demanding, the selection and implementation of appropriate formwork systems have become essential considerations in modern construction projects.

The PERI formwork system represents one of the advanced formwork technologies that has gained significant adoption in high-rise and commercial building construction. This system offers advantages in terms of assembly speed, dimensional accuracy, and reusability, making it particularly suitable for projects with repetitive structural elements such as columns in multi-story buildings.

This study examines the implementation methods of the PERI formwork system for reinforced concrete column structures in the KAI CO-Living Gondangdia project, an 8-story residential building located in Central Jakarta. The research focuses on the technical aspects of formwork assembly, installation, concrete placement, and formwork removal,

providing insights into the practical application of this system in a real construction environment.

Understanding the implementation methods of advanced formwork systems like PERI is valuable for civil engineering professionals seeking to optimize construction processes, improve structural quality, and enhance project efficiency. This research contributes to the body of knowledge on formwork technologies by documenting and analyzing the application of the PERI system in a specific construction context.

Evolution of Formwork Systems

Formwork technology has evolved significantly from traditional timber formwork to modern engineered systems. According to Hanna (1999), this evolution has been driven by demands for increased construction speed, improved safety, enhanced quality, and reduced labor requirements. The development of modular and system formwork represents a significant advancement in concrete construction technology.

Research by Jarkas (2010) demonstrated that formwork costs typically account for 40-60% of the total cost of concrete structures, highlighting the economic importance of efficient formwork systems. This economic consideration has motivated the development of reusable and modular formwork systems like PERI.

PERI Formwork System Characteristics

The PERI formwork system, developed in Germany, is characterized by its modular design, high load-bearing capacity, and versatility in application. According to technical documentation from PERI GmbH (2018), the system consists of steel frames with specially designed connection mechanisms, plywood facing, and various accessories for alignment and support.

Studies by Tam et al. (2005) compared different formwork systems, including PERI, in terms of construction productivity and quality outcomes. Their research indicated that modular systems like PERI offer significant advantages in construction speed and dimensional accuracy compared to traditional formwork methods.

Formwork Implementation Methods

Research on formwork implementation methods has identified several critical factors affecting performance. Jarkas (2012) found that proper planning, skilled labor, and systematic assembly procedures significantly impact formwork productivity. His research emphasized the importance of standardized implementation methods for achieving consistent results.

Kim et al. (2012) studied the relationship between formwork implementation methods and concrete surface quality, finding that proper formwork alignment, secure connections, and appropriate release agent application are essential for achieving high-quality concrete finishes.

Safety Considerations in Formwork Operations

Safety aspects of formwork operations have been addressed by several researchers. Hadipriono and Wang (1986) analyzed formwork failures and identified improper assembly, inadequate bracing, and premature removal as primary causes of accidents. Their work underscores the importance of proper implementation methods for ensuring construction safety.

More recent studies by Hallowell and Gambatese (2009) have developed risk assessment models for formwork operations, providing frameworks for identifying and mitigating safety hazards in formwork implementation.

RESEARCH METHOD

This research employed a qualitative case study approach to investigate the implementation methods of the PERI formwork system for reinforced concrete column structures. The study was conducted during a professional internship at the KAI CO-Living Gondangdia project in Central Jakarta, an 8-story residential building construction managed by a major Indonesian construction company.

Data Collection

Data collection methods included:

1. Direct field observation of formwork operations over a three-month period
2. Documentation review of project specifications, structural drawings, and PERI system manuals
3. Semi-structured interviews with site engineers, formwork supervisors, and skilled workers
4. Photographic and video documentation of formwork assembly, installation, and removal processes

The observation focused specifically on the following aspects of PERI formwork implementation:

1. Material handling and preparation
2. Assembly sequences and techniques
3. Alignment and bracing methods
4. Connection details and securing mechanisms
5. Concrete placement interfaces
6. Formwork removal procedures
7. Quality control measures
8. Safety protocols

Data Analysis

The collected data was analyzed through a systematic process of categorization, comparison, and interpretation. The analysis focused on identifying the specific implementation methods employed, evaluating their effectiveness, and determining critical factors affecting formwork performance. The findings were compared with established best practices and manufacturer recommendations to identify areas of alignment and deviation.

RESULT AND DISCUSSION

PERI Formwork System Components

The PERI formwork system employed in the KAI CO-Living Gondangdia project consisted of the following main components:

1. TRIO panel elements with steel frames and phenolic-coated plywood facing
2. BFD alignment couplers for panel connection
3. SRS circular nuts and DW15 tie rods for securing opposite panels
4. Push-pull props for alignment and bracing
5. Working platforms with integrated ladder access
6. Corner elements for column connections

The system was designed to accommodate column dimensions ranging from 400mm × 600mm to 600mm × 800mm, with heights of 3.2m to 3.8m per floor. The modular nature of the components allowed for flexible configuration while maintaining dimensional accuracy.

Formwork Assembly Process

The formwork assembly process followed a systematic sequence that optimized efficiency and quality:

1. Preparation Phase
 - Cleaning and inspection of formwork components
 - Application of release agent to plywood facing
 - Layout marking according to structural drawings
 - Positioning of reinforcement cages
2. Panel Assembly
 - Assembly of first half-column formwork (two panels connected at 90°)
 - Installation of working platform and access ladder
 - Positioning of assembled half-column around reinforcement cage
 - Installation of opposite half-column formwork
 - Connection of panels using BFD alignment couplers
3. Alignment and Securing
 - Installation of push-pull props for alignment (minimum two props per column)
 - Adjustment of column verticality using spirit levels and plumb bobs
 - Securing of opposite panels using DW15 tie rods and SRS circular nuts
 - Final verification of dimensions and alignment

The assembly process demonstrated a logical progression that prioritized worker safety, dimensional accuracy, and structural stability. The use of standardized connection methods ensured consistent quality across multiple column installations.

Quality Control Measures

Quality control measures implemented during the formwork process included:

1. Pre-assembly Inspection
 - Visual inspection of components for damage or deformation
 - Verification of plywood facing condition
 - Checking of connection mechanisms for proper function
2. Installation Verification
 - Dimensional checking using laser measuring devices
 - Verticality verification using digital inclinometers
 - Alignment confirmation using string lines and reference points
 - Stability testing through physical inspection
3. Pre-concrete Inspection
 - Final dimensional verification
 - Checking of tie rod tightness
 - Verification of bracing stability
 - Inspection of formwork joints for potential leakage

These quality control measures ensured that the formwork met project specifications and provided the necessary stability for concrete placement operations.

Concrete Placement Interface

The interface between the PERI formwork system and concrete placement operations was designed to ensure proper concrete consolidation while maintaining formwork integrity:

1. The formwork design incorporated pour windows at strategic locations to facilitate concrete placement.
2. Vibrator access points were planned to ensure complete consolidation without disturbing formwork alignment.
3. The formwork system was designed to withstand concrete pressure of up to 80 kN/m², accommodating various placement rates.
4. Sealing mechanisms at panel joints prevented cement paste leakage during vibration.

The concrete placement process was coordinated with formwork capabilities, with placement rates adjusted to prevent excessive pressure on the formwork system.

Formwork Removal Process

The formwork removal process followed a systematic approach that preserved concrete quality and enabled efficient reuse of formwork components:

1. Preparation Phase
 - Verification of concrete strength (minimum 10 MPa for removal)
 - Loosening of SRS circular nuts and tie rods
 - Removal of push-pull props while maintaining stability
2. Removal Sequence
 - Removal of working platform and access ladder
 - Separation of half-column formwork units
 - Careful extraction to prevent concrete surface damage
 - Immediate cleaning and preparation for reuse
3. Post-Removal Activities
 - Inspection of concrete surfaces for defects
 - Application of curing compound to exposed concrete
 - Cleaning and maintenance of formwork components
 - Organized storage for subsequent use

The removal process typically occurred 24-36 hours after concrete placement, depending on ambient temperature conditions and concrete strength development. This timing balanced the need for early formwork reuse with the requirement for adequate concrete strength.

Efficiency and Productivity Analysis

Analysis of the PERI formwork implementation revealed several efficiency and productivity advantages:

1. Assembly Time Efficiency
 - Average assembly time per column: 45-60 minutes with a 3-person crew
 - Reduction of approximately 30% compared to traditional timber formwork
2. Material Utilization
 - Each set of formwork components was reused an average of 24 times during the project
 - Minimal material waste due to standardized components

3. Labor Requirements
 - Skilled labor requirements reduced by approximately 25% compared to conventional methods
 - Specialized training required for optimal system utilization
4. Quality Outcomes
 - Dimensional accuracy within $\pm 3\text{mm}$ tolerance
 - Concrete surface quality rated as "excellent" for 85% of columns
 - Minimal remedial work required post-removal

These efficiency metrics demonstrate the advantages of the PERI system when properly implemented, particularly for projects with repetitive structural elements like the columns in this multi-story building.

CONCLUSION

The study of PERI formwork implementation methods for reinforced concrete column structures in the KAI CO-Living Gondangdia project revealed a systematic approach that effectively balanced quality, efficiency, and safety considerations.

The key findings of this research include:

1. The importance of standardized assembly procedures in ensuring consistent formwork quality
2. The critical role of proper alignment and securing mechanisms in achieving dimensional accuracy
3. The value of integrated quality control measures throughout the formwork process
4. The efficiency advantages of modular formwork systems for repetitive structural elements

These findings highlight the technical and managerial considerations involved in implementing advanced formwork systems in modern construction projects.

The PERI formwork system, when properly implemented, demonstrated significant advantages in terms of assembly speed, reusability, dimensional accuracy, and concrete surface quality. However, the successful implementation required skilled labor, proper planning, and adherence to manufacturer guidelines.

For future construction projects considering the use of the PERI formwork system, it is recommended to:

1. Invest in specialized training for formwork crews to maximize system benefits
2. Develop detailed implementation plans that address site-specific conditions
3. Implement comprehensive quality control protocols throughout the formwork process
4. Consider the entire formwork lifecycle, including storage, maintenance, and transportation

These recommendations can enhance the effectiveness of PERI formwork implementation while maximizing the return on investment in this advanced construction technology.

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