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COMPARATIVE ANALYSIS OF TIME AND COST ALLFORM AND SEMI SYSTEM FORMWORK BANK MANDIRI PIK 2

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ABSTRAK

Pekerjaan bekisting merupakan salah satu komponen kritis dalam konstruksi beton bertulang karena memengaruhi mutu struktur, durasi pelaksanaan, dan biaya proyek secara keseluruhan. Penelitian ini bertujuan untuk menganalisis dan membandingkan waktu serta biaya pelaksanaan pekerjaan bekisting sistem Allform (aluminium), Semi Sistem, dan kombinasi keduanya pada Proyek Pembangunan Gedung Bank Mandiri PIK 2 Tower A. Metode penelitian yang digunakan adalah analisis komparatif berbasis data proyek, meliputi perhitungan pendimensian bekisting, analisis kekuatan dan lendutan komponen bekisting, perencanaan siklus kerja, estimasi durasi pelaksanaan menggunakan Microsoft Project, perhitungan biaya berdasarkan Analisis Harga Satuan Pekerjaan (AHSP), serta evaluasi efektivitas dan efisiensi menggunakan metode Weighted Scoring dengan bobot biaya 50% dan bobot waktu 50%. Hasil penelitian menunjukkan bahwa sistem Allform menghasilkan durasi pelaksanaan tercepat, yaitu 230 hari, dengan biaya pembelian terendah di antara ketiga sistem sebesar Rp47,34 miliar; sistem Semi Sistem memiliki durasi terlama, yaitu 322 hari, dengan biaya sewa terendah sebesar Rp27,71 miliar; sedangkan sistem kombinasi menghasilkan durasi 282 hari dengan biaya sewa sebesar Rp37,18 miliar. Berdasarkan hasil Weighted Scoring, alternatif bekisting Allform sewa memperoleh skor tertinggi sebesar 0,9945 dan ditetapkan sebagai sistem bekisting paling optimal untuk Tower A Bank Mandiri PIK 2 karena memberikan keseimbangan terbaik antara percepatan waktu pelaksanaan dan efisiensi biaya. Penelitian ini memberikan rekomendasi praktis dalam pemilihan sistem bekisting pada proyek gedung bertingkat dengan karakteristik serupa.

Kata kunci : bekisting allform; bekisting semi sistem; waktu pelaksanaan; biaya pekerjaan; efisiensi.

ABSTRACT

Formwork work is a critical component in reinforced concrete construction because it affects structural quality, execution duration, and overall project cost. This study aims to analyze and compare the execution time and cost of Allform (aluminum), Semi System, and combined formwork systems in the Bank Mandiri PIK 2 Tower A Building Construction Project. The research method applied is a comparative analysis based on project data, including formwork dimensioning calculations, strength and deflection analysis, work cycle planning, duration estimation using Microsoft Project, cost calculation based on Unit Price Analysis (AHSP), and effectiveness-efficiency evaluation using the Weighted Scoring method with a cost weight of 50% and a time weight of 50%. The results indicate that the Allform system produces the fastest execution duration of 230 days, with the lowest purchase cost among the three systems, at IDR 47.34 billion; the Semi System has the longest duration of 322 days with the lowest rental cost of IDR 27.71 billion; while the combined system results in a duration of 282 days with a rental cost of IDR 37.18 billion. Based on the Weighted Scoring results, the rented Allform alternative obtained the highest score of 0.9945 and was determined as the most optimal formwork system for Tower A of Bank Mandiri PIK 2, as it provides the best balance between execution time acceleration and cost efficiency. This study provides practical recommendations for formwork system selection in high-rise building projects with similar characteristics.

Keywords *: allform formwork; semi system formwork; execution time; work cost; efficiency.*

1. INTRODUCTION

Formwork is a temporary structure that serves as a mold for fresh concrete during the casting process until the concrete gains sufficient strength to support its self-weight. The selection of an appropriate formwork system significantly influences structural quality, construction speed, and project cost efficiency, particularly in high-rise building projects where structural work is highly repetitive across successive floors [6], [7].

Previous studies have demonstrated that the type of formwork system has a significant impact on construction time and cost. Krawczynska-Piechna [5] reported that modern formwork systems can accelerate structural construction cycles compared with conventional systems. Wibowo et al. [1] compared several formwork systems in Indonesian high-rise building projects and identified significant differences in terms of cost, quality, construction time, and material waste. Studies conducted by Supriyono et al. [2], Alyarana [3], and Arsanti [4] further concluded that aluminum formwork generally provides shorter construction durations, whereas conventional or semi-system formwork tends to require a lower initial investment cost, particularly under rental schemes.

The Bank Mandiri PIK 2 Tower A Building Construction Project is a 22-story high-rise office building featuring a spiral architectural design, which results in variations in the dimensions of columns, beams, and slabs on nearly every floor. This geometric complexity makes the selection of an appropriate formwork system a critical factor affecting project performance in terms of both construction time and cost. Three alternative formwork systems were considered for implementation in this project, namely the Allfram (aluminum) system, the Semi-System formwork, and a Combined Allform–Semi-System formwork.

Based on the foregoing, this study aims to analyze and compare the construction time and cost associated with the Allform, Semi-System, and Combined Allform–Semi-System formwork systems in the Bank Mandiri PIK 2 Tower A Building Construction Project. Furthermore, the study seeks to identify the optimum formwork system based on effectiveness and cost-efficiency analyses.

2. METHODOLOGY

This study employed a descriptive comparative approach using a case study of the Bank Mandiri PIK 2 Tower A Building Construction Project, located on Jalan Jenderal Sudirman, CBD SAT 1 Block, Tangerang Regency, Banten Province, Indonesia. The research focused on the formwork of structural elements, including columns, beams, and slabs, under three formwork scenarios: (1) a full Semi-System formwork, (2) a full Allform formwork, and (3) a Combined Allform–Semi-System formwork, in which the Lower Ground (LG) to the second floor utilized the Semi-System, while columns from the third floor to the roof employed the Allform system and the beam–slab elements continued to use the Semi-System.

The study utilized both primary and secondary data. Primary data were obtained through field observations and project documentation. Secondary data consisted of the Detail Engineering Design (DED) drawings, the Bill of Quantities (BoQ), the 2025 Standard Unit Price Analysis (HSPK) of Tangerang Regency, the Work Method Statement (WMS), and the project's General and Technical Specifications (RKS).

The formwork design analysis began with the identification of the technical specifications of each formwork system, followed by structural loading analysis considering self-weight, fresh concrete load, construction live load, and lateral pressure exerted by fresh concrete. Subsequently, strength and deflection checks were performed using a safety factor of 3, based on the allowable stress and allowable deflection of the formwork materials. If the design failed to satisfy the specified criteria, the spacing between formwork components was redesigned until all requirements were met.

The construction time analysis was conducted by establishing the work cycle for formwork installation, inspection, concrete casting, and formwork removal for each system. Labor productivity and workforce requirements were then calculated based on the total formwork area to be installed. The construction schedule was developed assuming a six-day workweek (Monday–Saturday), commencing on 2 March 2026, and was prepared using Microsoft Project to determine the total construction duration for each formwork system.

The cost analysis involved calculating the quantities of formwork and scaffolding works based on the Bill of Quantities (BoQ), preparing the Unit Price Analysis (AHSP) for the installation and dismantling of each 1 m² of formwork by considering labor, material, and equipment costs, and subsequently estimating the total project cost (RAB) under two procurement alternatives, namely rental and purchase, to determine the most economical option.

The effectiveness and efficiency evaluation was carried out using the Weighted Scoring method. The cost and construction duration of each alternative were first normalized against their respective minimum values. The normalized values were then multiplied by the predetermined weights of 50% for cost and 50% for construction duration, and summed according to the following equation:

$$\text{Score} = (0.50\times\text{Normalized Cost})+(0.50\times\text{Normalized Duration}) \quad (1)$$

The alternative with the highest score was identified as the optimum formwork system for implementation in the Bank Mandiri PIK 2 Tower A Building Construction Project.

3. RESULTS AND DISCUSSION

This section presents the results of the analyses of the design, construction implementation, construction time, and cost of the Allform, Semi-System, and Combined Allform–Semi-System formwork systems applied to the Bank Mandiri PIK 2 Tower A Building Construction Project. The findings are further discussed by relating them to the underlying theoretical concepts and previous studies.

3.1. Project Overview

The Bank Mandiri PIK 2 Building Construction Project is a high-rise office development featuring an architectural concept inspired by a coral reef ecosystem, symbolizing the interconnectedness and sustainability of the financial sector. Tower A, which serves as the case study in this research, consists of 22 stories, reaches an elevation of +97.00 m, and provides approximately 1,600 m² of office floor area. The project is executed under a Design and Build lump-sum contract, which requires accurate cost estimation and quantity take-off from the early stages of project planning. The building's spiral architectural design introduces inclined columns from the fourth floor onward, along with variations in the dimensions and reinforcement configurations of structural elements on nearly every floor. Consequently, the selection of an appropriate formwork system plays a critical role in improving the efficiency of superstructure construction.

3.2. Comparison of Formwork Design and Material Requirements

In the Semi-System formwork, the primary materials consist of 18-mm phenolic plywood, a hollow steel frame, and steel walers as stiffening members. The results of the strength and deflection analyses indicate that the spacing of the hollow steel frame for column formwork ranges from 18 to 28 cm, while the spacing of the column walers is uniformly 80 cm. For beam formwork, the spacing of the hollow steel frame varies between 25 and 150 cm, depending on the beam type, whereas the spacing of the hollow steel frame for slab formwork ranges from 70 to 100 cm, depending on the slab thickness. In contrast, the Allform system utilizes prefabricated aluminum panels. The spacing of the column panel walers is standardized at 120/240/120 cm for all column types, while the spacing of the pipe supports ranges from 100 to 150 cm for beam formwork and 140 to 150 cm for slab formwork.

These findings indicate that the Allform system exhibits a higher degree of design standardization than the Semi-System. This observation is consistent with the modular characteristics of aluminum formwork described by Hanna [6] and Peurifoy & Oberlender [7], who noted that modular aluminum formwork facilitates the replication of formwork layouts for structural elements with similar dimensions, thereby improving fabrication efficiency and enhancing quality control during construction.

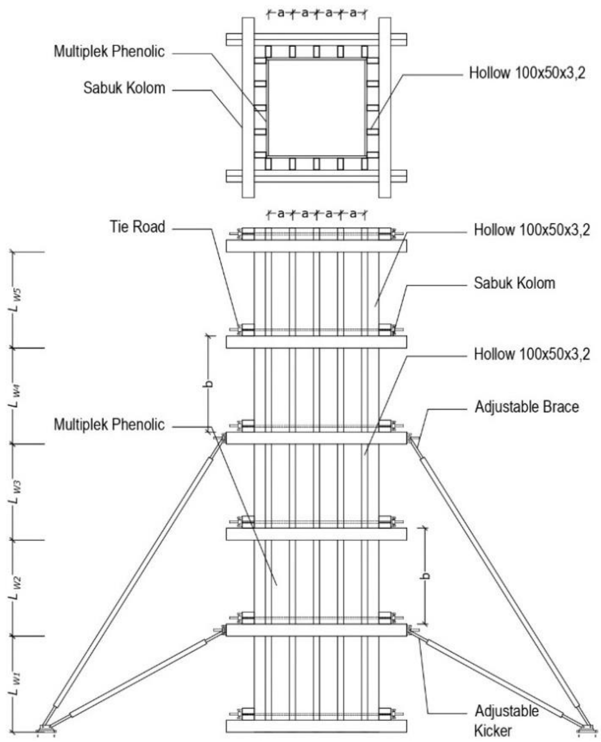

Figure 1. Semi-System Column Formwork

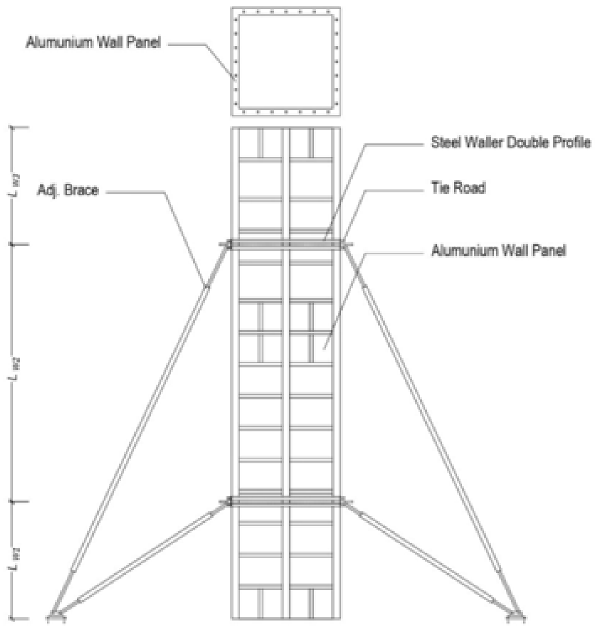

Figure 2. Semi-System Beam and Slab Formwork

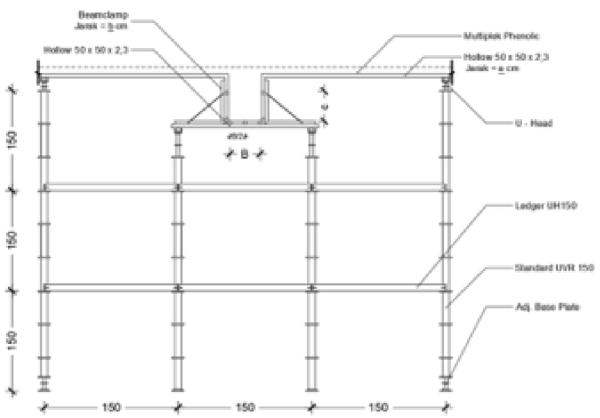

Figure 3. Allform Column Formwork

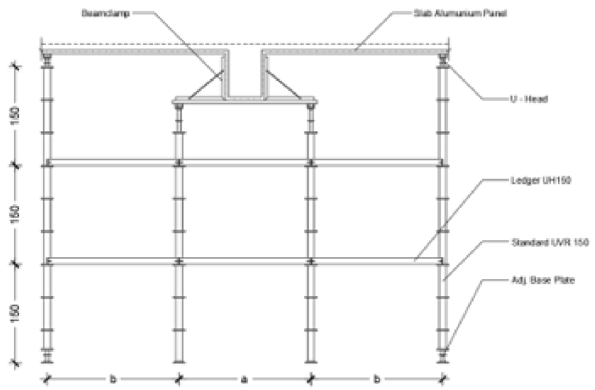

Figure 4. Allform Beam and Slab Formwork

3.3. Comparison of Construction Methods and Work Cycles

The formwork construction strategy adopted in this project was developed based on the rotation of formwork materials between floors, with sufficient beam and slab formwork materials allocated to support two floors under construction simultaneously. Column construction on the subsequent floor commenced 48 hours after the casting of the beam and slab on the floor below, while slab formwork was removed 14 days after concrete casting in accordance with SNI 7831:2012 [9].

Under the Semi-System method, the work cycle reached column concrete casting on Day 5 and beam–slab concrete casting on Day 13, as all formwork assembly and dismantling activities were performed manually on site. In contrast, the Allform method achieved a significantly shorter work cycle, with column concrete casting on Day 4 and beam–slab concrete casting on Day 9. This improvement is consistent with the characteristics of modular aluminum formwork, which is lightweight and allows rapid assembly and dismantling [6]. For the Combined Allform–Semi-System method, the work cycles for both columns and beam–slab elements remained identical to those of the Semi-System (Day 5 and Day 13, respectively), since beam and slab formwork in all Combined scenarios continued to utilize the Semi-System.

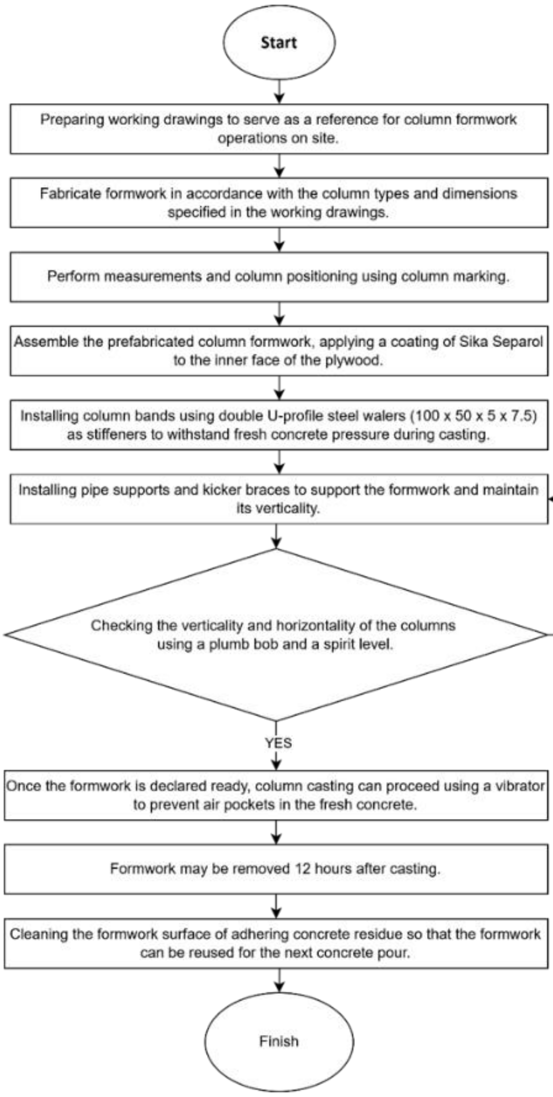

Figure 5. Flowchart of the Semi-System Column Formwork Process

The column construction process begins by preparing working drawings as a structural reference for on-site operations. Next, the formwork is fabricated according to specified dimensions, followed by accurate column positioning through site marking. During assembly, Sika Separol is applied to the inner plywood face. To withstand fresh concrete pressure during casting, column bands made of double U-profile steel walers are installed, alongside pipe supports and kicker braces to maintain verticality. A critical quality check is then performed using a plumb bob and spirit level; if alignment is incorrect, supports are adjusted until precise verticality and horizontality are achieved. Once approved, column casting proceeds using a vibrator to eliminate air pockets in the concrete. After a 12-hour curing period, the formwork is safely removed and thoroughly cleaned of adhering concrete residue, ensuring the materials are ready to be reused for the next concrete pour.

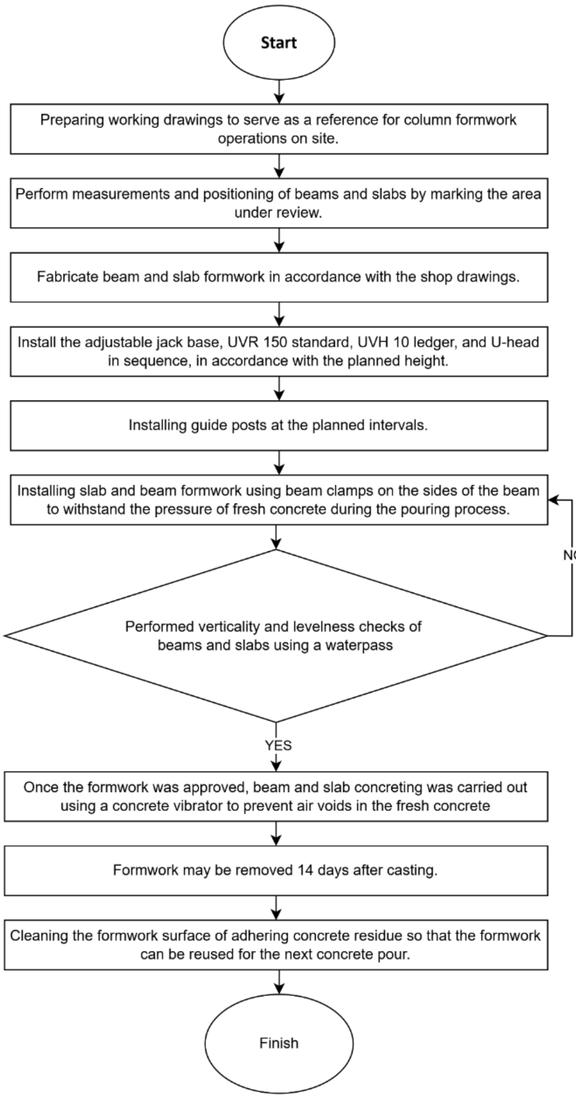

Figure 6. Flowchart of the Semi-System Beam and Slab Formwork Process

The construction process for beams and slabs begins with preparing working drawings as an on-site reference. Workers then perform precise measurements and positioning by marking the review area, followed by fabricating the formwork according to shop drawings. Next, the scaffolding system—comprising an adjustable jack base, UVR 150 standard, UVH 10 ledger, and U-head—is assembled sequentially to the planned height, alongside guide posts installed at specified intervals. Beam and slab formwork is then erected using beam clamps to withstand fresh concrete pressure during pouring. A critical check assesses verticality and levelness using a waterpass; if unaligned, the formwork installation is adjusted. Once approved, concreting proceeds using a concrete vibrator to eliminate air voids.

Finally, after a 14-day curing period, the formwork is removed and thoroughly cleaned of adhering concrete residue, ensuring it can be reused for the next pour.

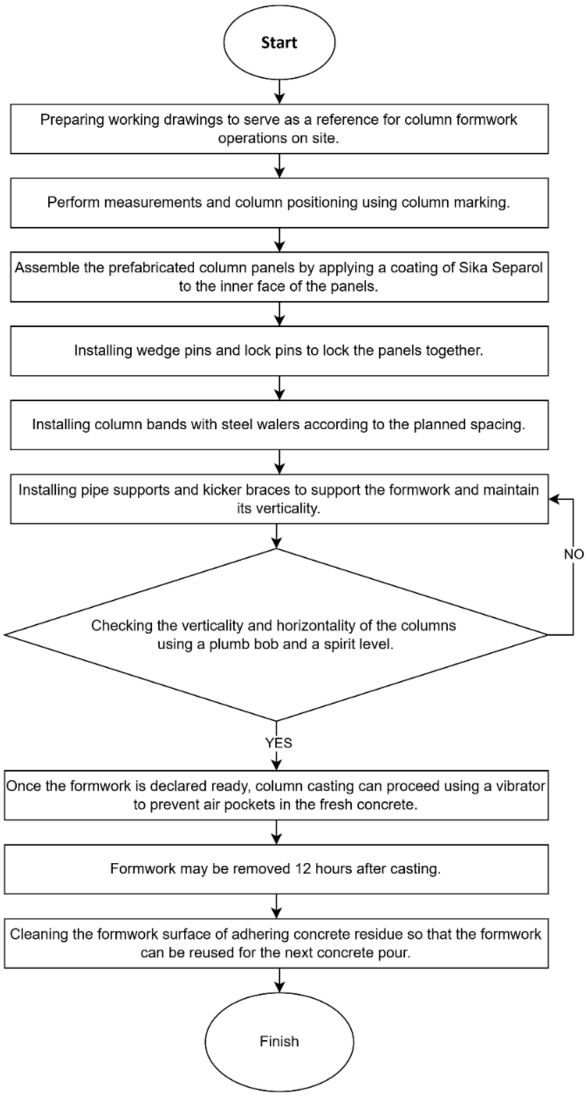

Figure 7. Flowchart of the Allform Column Formwork Process

The column construction process begins with preparing working drawings as an on-site reference. Next, workers perform measurements and precise column positioning using column marking. Prefabricated column panels are then assembled after applying a coating of Sika Separol to their inner faces. To secure the structure, wedge pins and lock pins are installed to lock the panels together, followed by column bands with steel walers at planned spacing intervals. Pipe supports and kicker braces are subsequently installed to maintain vertical stability. A critical quality check assesses verticality and horizontality using a plumb bob and spirit level, readjusting braces if alignment is incorrect. Once declared ready, column casting proceeds using a vibrator to prevent air pockets. After a 12-hour curing period, the formwork is removed and thoroughly cleaned of adhering concrete residue so it can be reused for the next pour.

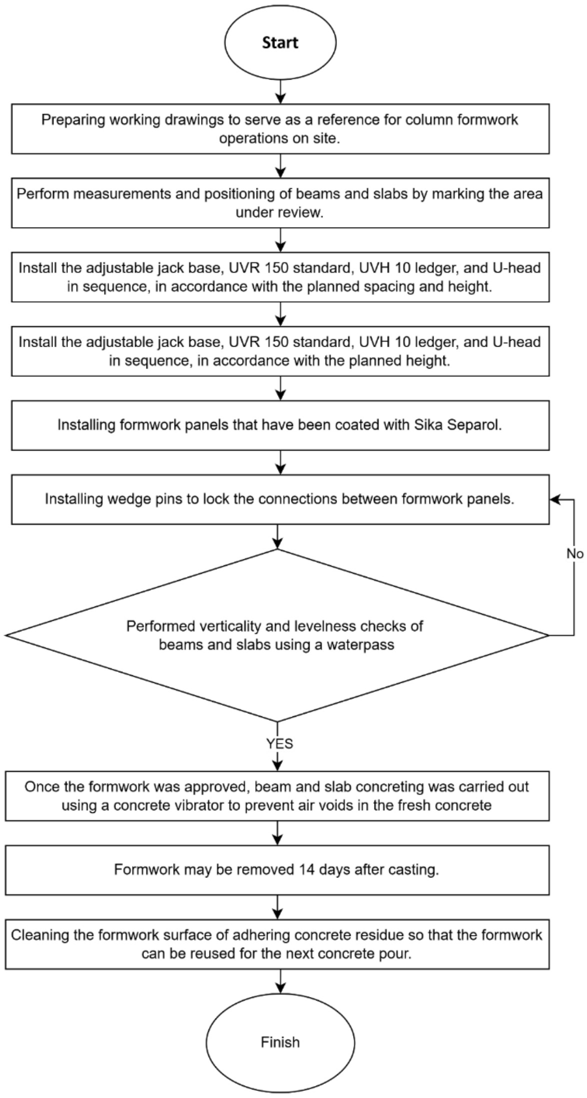

Figure 8. Flowchart of the Allform Beam and Slab Formwork Process

The construction process begins by preparing working drawings as an on-site reference, followed by performing measurements and positioning of beams and slabs by marking the reviewed area. Next, the supporting scaffolding system—consisting of an adjustable jack base, UVR 150 standard, UVH 10 ledger, and U-head—is sequentially installed in accordance with the planned spacing and height requirements. Following this, formwork panels pre-coated with Sika Separol are installed, and wedge pins are inserted to securely lock the panel connections together. Workers then perform verticality and levelness checks using a waterpass; if the alignment is incorrect, the connections are readjusted.

Once approved, beam and slab concreting proceeds using a concrete vibrator to prevent air voids in the fresh concrete. After a 14-day curing period, the formwork is removed and thoroughly cleaned of adhering concrete residue so that the materials can be reused for the next pour.

3.4. Comparison of Formwork Construction Duration

The construction schedules for each formwork system were developed using Microsoft Project, and the resulting construction durations are presented in Table 1.

Table 1. Summary of Total Formwork Construction Duration

Formwork System	Duration (days)	Remarks
Semi-System	322	Longest duration
Allform	230	Shortest duration
Combined	282	Moderate duration

Source: Analysis Results

The Semi-System required the longest construction duration, totaling 322 days, as the fabrication and installation of formwork for all structural elements—including columns, beams, and slabs—were performed manually on site. The Combined Formwork System required 282 days, as the columns on most floors utilized the more productive Allform formwork, while the beam and slab elements continued to employ the Semi-System. The Allform system achieved the shortest construction duration, requiring only 230 days, because all structural elements utilized prefabricated aluminum panels that accelerated formwork assembly, dismantling, and relocation between floors. These findings are consistent with those reported by Wibowo et al. [1] and Supriyono et al. [2], who likewise found that the use of aluminum formwork significantly reduced construction time compared with conventional or semi-system formwork.

3.5. Comparison of Formwork Construction Costs

The cost analysis was performed based on the Unit Price Analysis (UPA) for the installation and dismantling of 1 m² of formwork. The unit costs were then multiplied by the corresponding work quantities obtained from the Bill of Quantities (BoQ) to estimate the Project Cost Budget under two procurement alternatives, namely rental and purchase, as presented in Table 2.

Table 2. Comparison of Formwork Construction Costs

Formwork System	Purchase Alternative (IDR)	Rental Alternative (IDR)
Semi-System	48.679.341.364	27.713.609.392
Allform	47.340.358.680	28.023.095.237
Combined	64.899.144.991	37.175.994.009

Source: Analysis Results

3.6. Effectiveness and Efficiency Analysis Using the Weighted Scoring Method

The effectiveness and efficiency of each formwork system were evaluated using the Weighted Scoring method, with cost and construction duration assigned equal weights of 50% each. The evaluation results are presented in Table 3.

Table 3. Weighted Scoring Results (50% Cost Weight and 50% Time Weight)

Alternative	Duration (days)	Score	Rank
Allform (Rental)	230	0,9945	1
Semi Sistem (Rental)	322	0,8571	2
Allform (Purchase)	230	0,7927	3
Combined (Rental)	282	0,7805	4
Semi-System (Purchase)	322	0,6418	5
Combined (Purchase)	282	0,6213	6

Source: Analysis Results

3.7. Advantages and Disadvantages of Each Formwork System

The Allform system offers several advantages, including a shorter construction cycle, lower labor requirements due to its lightweight and modular characteristics, and high cost efficiency under the rental procurement scheme. However, its primary drawback is the substantial initial investment required under the purchase scheme, making it less economical for short-duration projects or single-use applications. The Semi-System provides greater flexibility in accommodating structural elements with non-standard geometries and offers relatively low rental costs. Nevertheless, it is associated with longer construction durations, higher labor requirements resulting from manual assembly and dismantling, and the limited reusability of plywood panels. The Combined Formwork System combines the advantages of Allform for column construction with the flexibility of the Semi-System for beam and slab formwork. However, the need to coordinate two different formwork systems increases construction complexity, resulting in the highest overall implementation cost among the three alternatives.

3.8. Factors Affecting Differences in Construction Time and Cost

The differences in construction time and cost among the formwork systems are influenced by several factors, including the degree of prefabrication and modularity of the formwork components, the reusability of materials throughout successive concrete casting cycles, the structural complexity resulting from the building's spiral architectural design, labor productivity associated with each installation method, and the procurement strategy adopted, namely rental or purchase. These findings are consistent with the study by Krawczynska-Piechna [5], which concluded that the selection of an appropriate formwork system has a significant impact on the productivity and cost performance of high-rise building construction projects.

3.9. Determination of the Optimal Formwork System

Based on the Weighted Scoring analysis, which assigned equal weights to cost and construction duration (50:50), the Allform system under the rental procurement scheme was identified as the most suitable formwork alternative for Tower A of the Bank Mandiri PIK 2 Building Construction Project. This conclusion is supported by several considerations: its rental cost is nearly equivalent to that of the lowest-cost alternative (approximately IDR 309 million higher than the Semi-System rental option), it achieves the shortest construction duration, reducing the overall project schedule by 92 days compared with the Semi-System, it obtained the highest Weighted Scoring value (0.9945), and it eliminates the need for substantial upfront capital investment required under the purchase scheme.

4. CONCLUSION

The results of this study demonstrate that the selection of a formwork system significantly affects the construction duration and cost of the Bank Mandiri PIK 2 Tower A Building Construction Project. The Allform system achieved the shortest construction duration (230 days), while the Semi-System required the longest (322 days). In terms of cost, the Semi-System under the rental procurement scheme was the most economical (IDR 27.71 billion), whereas the Allform system was the most economical under the purchase scheme (IDR 47.34 billion). Based on the Weighted Scoring analysis with equal weights assigned to cost and construction duration (50:50), the Allform system under the rental procurement scheme was identified as the optimal alternative, achieving the highest score (0.9945) with a total cost of IDR 28.02 billion and a construction duration of 230 days. Therefore, the Allform rental system is recommended for high-rise building projects with characteristics similar to those of Tower A of the Bank Mandiri PIK 2 Building Construction Project.

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