

Implementation of Column Formwork Works on the 10th Floor in the Construction of Sky House Alam Sutera Phase 3 Building

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ABSTRACT

Formwork is a crucial component in reinforced concrete structural works. This study specifically discusses the application of aluminum formwork for column elements in high-rise buildings. Time inefficiency and quality issues encountered when using wooden or conventional formwork are major problems frequently found on construction sites. This study aims to identify the advantages and disadvantages of using aluminum formwork for columns and to evaluate its impact on construction time and the quality of the resulting product. The research employed a qualitative descriptive approach through direct observation and interviews with workers and project managers at the Sky House Alam Sutera Phase 3 building project. The results show that aluminum formwork can be installed and dismantled faster than wooden formwork, and it produces a smoother and more precise concrete surface. However, aluminum formwork has a higher initial procurement cost. Nevertheless, it is more cost-effective in the long term if properly maintained and reused multiple times. Due to its efficiency, neatness, and durability, aluminum formwork is a suitable choice for high-rise building projects.

ARTICLE HISTORY

Received 2 August 2025
Accepted 1 December 2025
Published 10 December 2025

KEYWORDS

Formwork; Column;
Construction Project; Sky
House.

1. Introduction

Reinforced concrete structures are the best choice for the construction of multi-storey buildings because they are strong, durable, and economical. The first stage in the construction process is formwork work, which functions as a temporary mold to hold fresh concrete in order to form structural elements such as beams, columns, and floor slabs (ACI Committee 347, 2014; Neville & Brooks, 2010). In Phase 3 of the Sky House Alam Sutera Building construction project, formwork work is very important for completing the 10th floor structure. Errors in formwork installation, such as incorrect dimensions or unstable installation, can cause structural damage or even construction failure (Hanna, 2016). At this stage, formwork work must be carried out carefully because the 10th floor structure includes the middle and upper parts of a high-rise building. Floor height, workload, scaffolding systems, and work safety are specific concerns. Therefore, the implementation of formwork must be carried out systematically and in accordance with working drawings and technical standards. The author intends to study and understand how the formwork process for columns, beams, and floor slabs of the 10th floor structure is carried out in the field, starting from material preparation to installation and dismantling techniques. This is very important to improve technical knowledge and readiness to face the world of work in the construction field (Trijeti & Hermawan, 2011). In addition to functioning as a temporary mold, formwork also plays a crucial role in maintaining dimensional accuracy, alignment, and surface quality of reinforced concrete elements, particularly columns in high-rise buildings. Inadequate formwork selection may lead to construction delays, material waste, and poor concrete finish quality. Therefore, selecting

an appropriate formwork system becomes a key factor in ensuring construction efficiency and structural performance (ACI Committee 347, 2014; Neville & Brooks, 2010). Along with technological developments in the construction industry, modern formwork systems such as steel and aluminum formwork are increasingly applied in high-rise projects. These systems are considered capable of improving installation speed, dimensional precision, and concrete surface quality compared to conventional timber formwork. Moreover, reusable formwork systems provide economic advantages for projects with repetitive structural elements and multiple floors (Hanna, 1999; Kodek & Vukomanović, 2018; Kaming et al., 1997).

2. Methods

This study uses a direct field observation method combined with document analysis to obtain primary and secondary data. Primary data were collected through observations during project implementation, supplemented by documentation and interviews with related parties to strengthen the validity of the information. Meanwhile, secondary data were obtained from official project documents such as shop drawings, technical specifications of tools and materials, S-curves, and work implementation flow diagrams. The selection of this method was carried out to ensure that the data used were relevant, accurate, and able to describe field conditions factually. This approach allows researchers to obtain a comprehensive picture of labor productivity, equipment needs, materials, and work duration which are the focus of the study. The data obtained were then processed through stages of organization and analysis. Information from observations, interviews, and documentation was systematically arranged to facilitate interpretation and conclusion drawing. The analysis was carried out by linking field findings with relevant literature and technical standards, so as to produce a comprehensive discussion regarding the implementation of formwork work (Nasikhin, 2023). The results of this analysis were used to identify factors affecting productivity, work method effectiveness, and the suitability of field implementation with the work plan. This approach ensures that the research results have strong validity and can be used as a reference for similar research or practices in the future. Direct field observation is a commonly applied method in applied civil engineering research because it enables researchers to capture actual construction conditions. This method allows the identification of conformity between planning documents and real implementation, including labor productivity, equipment utilization, and technical constraints encountered on site (Oglesby et al., 1989; Clough et al., 2015). Linking field observations with established standards and literature ensures that the findings are not only descriptive but also analytically valid (Fellows & Liu, 2015).

3. Results

3.1 General Project Information

The Sky House Alam Sutera+ Phase 3 Project is located on Jalan Jalur Sutera Boulevard, Kunciran, Tangerang City, Banten. This project is owned by PT. Risland Sutera Property and carried out by the main contractor PT. Adhi Persada Gedung using the FIDIC contract system. The project implementation period is 699 days, starting on July 1, 2024, followed by a maintenance period of 365 days. The scope of work includes structural work, architecture, decoration, gondola, and other works. The building has a total of 40 floors (1 basement + 38 main floors + 1 roof) with a height of 129.2 meters and a land area of 162,265 m². Consultants involved include PT. Megatika Internasional, Overseas Design Institute, PT. Stadin Strukturindo Konsultan, PT. Rayosa Cipta Mandiri, and PT. Dacrea Engineering.

3.2 Site Plan and Work Zone

The division of work areas into zones aims to facilitate supervision and control during construction work, especially in high-rise building projects which have high complexity.



Figure 1. Site Plan



Figure 2. Work Zone

3.3 Formwork Specifications

In column structural work, a modern formwork system is used with several important components. The main components used include column panels, adjustable braces, base plates, adjustable kickers, tie rods, and wing nuts. Column panels function as the main mold for forming vertical elements, while adjustable braces are used to maintain panel stability during the casting process. Base plates function as the main support base, while adjustable kickers are useful for strengthening the panel base. Tie rods and wing nuts are used as inter-panel fasteners to prevent shifting during casting. This system allows for a more precise, faster, and safer column forming process compared to conventional formwork systems (Trijeti & Hermawan, 2011; Krawczyk & Skrzypczak, 2019).

3.4 Measuring Equipment Specifications

In project implementation, several measuring tools are used to ensure dimensional and elevation accuracy of the building structure. One of the main tools used is a theodolite with the TOPCON DT-200 type. This tool has a magnification of 30 times, a length of 152 mm, and an objective lens diameter of 45 mm. This theodolite allows measurement of horizontal and vertical angles with a high level of accuracy. In addition, a TOPCON AT-B4 waterpass instrument is also used, which has a magnification of 24 times and an accuracy of 7.9 inches. This tool is useful for determining flatness and elevation of

building surfaces. For length measurements, a BISON brand roll meter with a tape length of 100 meters is used, made of fiberglass with a width of 13 mm and a thickness of 0.5 mm. Another tool is a NANKAI brand string line which has a string length of 30 meters and a weight of 500 grams. This tool is very useful in the marking process and marking elevation points and building line directions.

3.5 Mobility Equipment Specifications

To support smooth project implementation, various mobilization equipment are used consisting of measuring tools and formwork systems. Measuring tools used include theodolites, waterpass instruments, roll meters, and string lines. These tools are routinely used in the land preparation stage, formwork installation, and structural elevation checking. In addition, the formwork system used consists of several types, such as column formwork using column panels, adjustable braces, base plates, adjustable kickers, tie rods, and wing nuts. For beam and floor slab work, additional components such as deck props and steel supports are used. All of this equipment is designed to support installation speed, temporary structural stability, and ease of dismantling after casting. This entire work system plays an important role in ensuring the final quality of structural elements and construction process efficiency.

4. Discussion

4.1 Work Implementation Procedure

In the implementation of construction of the Sky House Alam Sutera+ Phase 3 project, the division of work areas is carried out into four zones. This zoning strategy aims to increase supervision effectiveness and facilitate the control process during construction work implementation. With this approach, calculations of labor, equipment, materials, and work volume requirements can be carried out more accurately and systematically. Although the division is carried out into four zones, the discussion in this article is focused on one zone, namely Zone 1 located on the 10th floor. Based on project data, it is known that the building has a height of 129.2 meters, consisting of one basement floor, 38 main floors, and one roof, with a land area of 162,265 m². As a high-rise apartment building, the number of structural elements on the typical 10th floor consists of 39 columns and 29 beams. Specifically for Zone 1 on that floor, there are 14 columns and 11 beams. The use of a typical column grid with spacing between columns of 6–8 meters and a beam-to-column ratio of approximately 2.5–3:1 forms the basis for the preparation of material and structural requirement calculations. The application of zoning systems in high-rise building construction is an effective construction management strategy to control work complexity. Zoning enables better coordination between work teams, more accurate resource allocation, and improved monitoring of construction progress. This approach also contributes to enhancing occupational safety by allowing focused supervision in each work area (Kerzner, 2017; Hinze, 2006).

4.2 Column Formwork Work

Column formwork work in the Sky House Alam Sutera+ Phase 3 project was carried out with systematic planning based on work area zoning. The 10th floor as a typical floor was divided into four zones to facilitate the distribution of work volume and analysis of resource requirements. On this floor, the total number of columns is 39 units, with the highest distribution found in Zone 1 with 14 columns. The other zones consist of 8 columns in Zone 2, 9 columns in Zone 3, and 8 columns in Zone 4. Zone 1 was chosen as the focus of analysis because it has a higher structural density and represents the dominant complexity of work. The process of estimating material requirements begins by assuming column dimensions based on high-rise building standards, namely 100 × 60 cm for main columns and 110 × 60 cm for edge columns. For Zone 1, columns with a

height of 3 meters consist of 6 main columns and 8 edge columns. From the measurement of the perimeter of each column, the total formwork area required reaches 147.6 m². If using steel panels measuring 1.2 × 2.4 meters (equivalent to 2.88 m² per panel), then 51.2 panels are required, and after adding a 10% allowance, the total panel requirement becomes 56.3 units. In Zone 2, with 6 main columns and 2 edge columns, the calculated formwork area reaches 78 m² and results in a panel requirement of 27 units, which increases to 29.7 units after adding an allowance. Thus, the total steel panel requirement for both zones reaches 86 units. In addition to the main panels, there are also supporting materials required in significant quantities to ensure formwork stability during the casting process. These include 173 adjustable braces, 173 base plates, 173 adjustable kickers, as well as fasteners in the form of 344 tie rods and 688 wing nuts. Further calculations of formwork equipment requirements were carried out based on the division of column types.

Each column code (K1 to K4) represents differences in column type and location in each zone. K1 and K2 are columns in Zone 1, while K3 and K4 are in Zone 2. Each type has specific calculations of equipment requirements, adjusted to the dimensions and number of columns. As an example, K1 type columns require 15.1 steel panels, 30.2 adjustable braces, and 60.4 tie rods, while K2 type requires more, namely 31.1 steel panels and 124.4 tie rods. When recapitulated as a whole, the formwork equipment requirements for 22 columns in both zones include 69 column panels, 138 adjustable braces, 69 base plates, 69 adjustable kickers, 276 tie rods, and 552.5 wing nuts. These values indicate the logistical complexity of the work that must be managed properly. In addition, labor calculations were also carried out, referring to standard productivity of craftsmen and workers for column formwork work, namely 0.33 and 0.66 OH/m² respectively. The results of the analysis estimate that to complete all formwork work in Zone 1 and Zone 2, a total of 89 OH is required with a composition of 22 craftsmen and 44 workers divided over several working days according to the capacity of each zone. In general, column formwork work was carried out over nine working days using a crew rotation system. One formwork crew consists of 10 people, namely 1 foreman, 3 scaffold craftsmen, 4 assistant craftsmen, and 2 workers. Each type of column requires a different work duration depending on the formwork surface area, where large columns such as K2 require up to 4 working days, while small columns such as K4 can be completed in 1 working day. The implementation schedule was arranged in stages from the first week to the eighth week to avoid resource accumulation and maintain work continuity in the field. With this structured approach, the entire column formwork work process was designed to be efficient, measurable, and aligned with structural requirements and actual field conditions. The clarity of estimation data and recapitulation of requirements also provides a strong basis for project logistics management and cost control.

4.3 Analysis of Column Formwork Strength

The analysis of formwork strength aims to ensure that the entire formwork system used in column work is able to withstand the loads imposed, both from fresh concrete pressure during casting and from external influences such as wind and heavy equipment vibration in the field. In the Sky House Alam Sutera+ Phase 3 project, the analysis focused on columns with a height of 3 meters and maximum dimensions of 100 cm × 60 cm, which are general characteristics of vertical structural elements on a typical floor in Zone 1. The evaluation results show that the lateral pressure generated by fresh concrete on the formwork surface is still within safe limits. Steel panels with a thickness specification of 6 mm used in the formwork system are proven to be able to withstand this pressure with a working stress level of 120 MPa. Meanwhile, the bending strength of the panels reaches 235 MPa. Thus, the formwork system has a safety factor of 1.9, which means it meets the technical feasibility criteria for vertical structural work. This value indicates that the formwork panels do not experience a risk of failure during the casting process. Meanwhile, for fastening elements such as tie rods, the analysis results also show that

the actual tensile stress that occurs is far below the tensile capacity of the material used. Tie rods with a diameter of 16 mm have a maximum tensile strength of 400 MPa, while the actual tensile load experienced only produces a stress of 21.49 MPa. This shows that the tie rods have a very high safety factor, reaching 18.6. This high level of safety ensures that the tie rods are not only able to maintain the stiffness of the formwork system during the casting process, but also contribute to the geometric stability of the panels during the early concrete hardening period. Thus, it can be concluded that the design and materials of column formwork, including supporting components such as panels and tie rods, have met strength and stability requirements according to construction standards for high-rise buildings. The results of this analysis also confirm that the formwork system designed for this project is safe to use and does not require additional modifications in terms of structural strength. The analysis of formwork strength is essential to ensure that the formwork system can safely resist lateral pressure from fresh concrete during casting. Factors such as concrete casting height, pouring rate, and vibration method significantly influence the magnitude of pressure acting on formwork. Proper calculation and safety factor evaluation are necessary to prevent formwork failure and ensure construction safety (ACI Committee 347, 2014; Mosley et al., 2012).

4.4 Work Implementation Method

The work implementation strategy in this project is divided into four main zones to optimize implementation efficiency, quality control, and resource distribution. In this article, the discussion is centered on Zone 1. The work process begins with area preparation which includes cleaning from standing water, mud, and gravel, as well as ensuring column elevation points. The next step is the measurement process using theodolite or waterpass instruments to determine column positions and axes as well as reference elevations. After that, formwork installation is carried out by paying attention to column dimensions according to the plan, and supported by support systems such as props, clamps, and bracing. The next stage is checking the stability and watertightness of the formwork, ensuring all joints and stiffeners are strong. After being declared ready, concrete casting is carried out in sequence: columns, beams, slabs, and final result inspection is conducted (Banua *et al.*, 2020). The general workflow is shown in the following figure.



Figure 3. Work Zone

4.5 Column Measurement Work

At the column measurement stage in the field, this activity is carried out by two main workers, namely one surveyor and two surveyor assistants. Each personnel uses measuring devices such as theodolites and automatic levels for tasks including column axis marking work, height checking, and casting elevation measurement. In construction,

column measurement is carried out to ensure that the position and dimensions of columns are in accordance with working drawings. This process begins with preparing measuring tools such as theodolite, waterpass, and measuring tape, as well as studying working drawings to determine the position and number of columns to be installed. Next, a reference point or benchmark is selected as the basis for field measurement. From this reference point, measurements are carried out to ensure column locations match the structural drawings, and the measurement results are marked directly in the field, usually using string or special markings on the surface. Before starting construction work, all column points are rechecked to ensure that column positions, distances, and directions are completely in accordance with the plan. The following is a flowchart for the implementation of column measurement work.

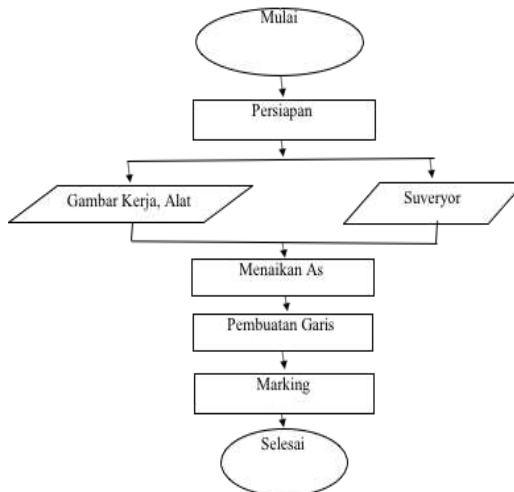


Figure 4. Flowchart of Column Measurement Work

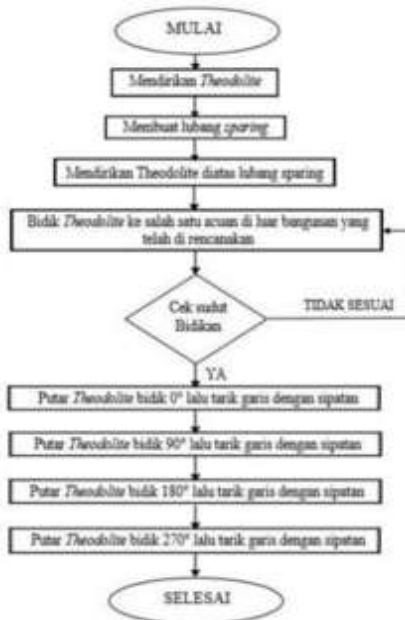


Figure 5. Flowchart of Column Axis Marking Work

4.6 Column Formwork Work

The stages of formwork work begin with the preparation of tools and materials, such as formwork panels, wrenches, waterpass, and nails. Then column position measurement is carried out, followed by assembly and installation of panels around the reinforcement. Column verticality is checked with a waterpass and supports are installed so that the panels do not shift. The process continues with checking panel dimensions and watertightness, then concrete casting is carried out evenly using a concrete vibrator (Shodiq *et al.*, 2024). The stages of this work are illustrated in the following figure.

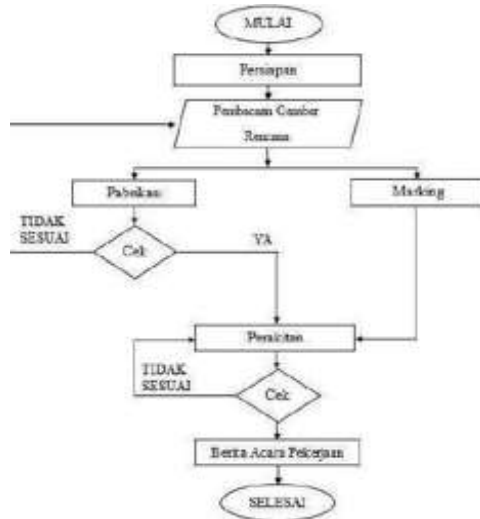


Figure 6. Flowchart for the Implementation of Column Formwork Work

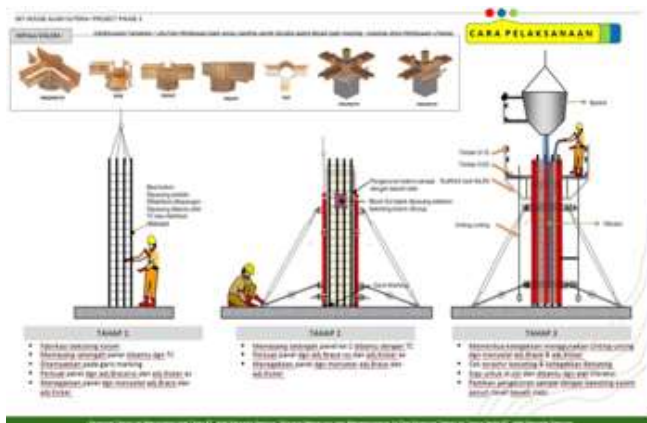


Figure 7. Stages of Column Formwork Implementation

4.7 Column Formwork Dismantling Work

Column formwork is dismantled after the concrete reaches its initial strength, usually 24–48 hours after casting. The work area is cleaned and warning signs are installed before dismantling outer components such as tie rods and support pipes. Panels are then removed one by one carefully using a rubber hammer to avoid damaging the concrete. After all panels are removed, the concrete is inspected to ensure there is no damage such as cracks or peeling surfaces. If defects such as honeycombing are found, immediate repairs are carried out using instant mortar (Aldy Kristian, 2024). These stages are illustrated in the following figure.



Figure 8. Flowchart of Column Formwork Dismantling

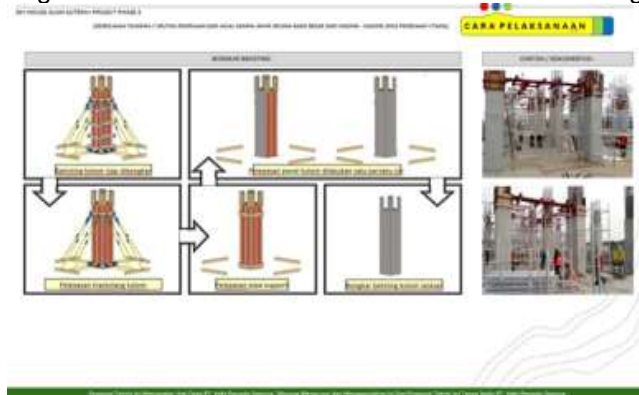


Figure 9. Formwork Dismantling

5. Conclusions

The implementation of column formwork work must be carried out according to the sequence of work, starting from column axis marking, installing column shoes, assembling formwork panels, installing formwork reinforcements, and finally checking verticality. Good planning before starting work, especially regarding the required number of formwork panels, can help speed up the installation process and make it easier for workers in the field. In addition, material waste can be avoided because the exact number of panels truly needed is known. Thus, the work becomes more efficient, cost-effective, and does not waste much time due to dismantling and reinstalling incorrect panels. Knowing the number of required workers is very important so that the duration of formwork work can be clearly calculated. If the number of workers and the required time are known, project management becomes more organized. Delays can be avoided and work schedules can be arranged better, so that project time targets can be achieved according to plan. Proper integration between technical planning, resource management, and field supervision is a key factor in achieving optimal construction quality in high-rise building projects. The use of an appropriate formwork system, supported by accurate calculations and effective zoning strategies, contributes significantly to construction efficiency and safety. These findings are consistent with previous studies emphasizing

the importance of integrated construction management approaches in structural work implementation (Chitkara, 2014; Project Management Institute, 2021).

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