



Construction Precision Control and Quality Improvement of Aluminum Formwork Systems in Residential Buildings

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Abstract

Aluminum formwork systems, as a key technology in modern residential building construction, are widely used to improve construction quality and accuracy due to their advantages, such as high precision, standardized design, modular assembly, and reusability. This paper analyzes the structural characteristics and applications of aluminum formwork systems, focusing on key factors for controlling construction accuracy, such as environmental impact, material selection, and installation techniques. Through comparative analysis, the effects of aluminum formwork systems and traditional formwork systems in the same project are compared, clarifying the significant advantages of aluminum formwork systems in shortening construction cycles, improving accuracy, and enhancing quality stability. Particularly in structural accuracy, the aluminum formwork system controls errors within $\pm 2\text{mm}$, while traditional formwork is $\pm 5\text{mm}$. Combined with on-site testing methods, laser measuring instruments, and total stations are used to monitor construction accuracy in real time, ensuring that construction processes meet design standards. Research shows that aluminum formwork systems effectively improve construction efficiency, reduce errors and rework, and ensure building quality and structural stability, becoming an important technical support for residential building construction.

Keywords

Aluminum formwork system; construction precision; construction quality; optimization strategies

1. Introduction

With the continuous increase in requirements for construction refinement and quality in residential buildings, traditional formwork methods—characterized by significant human operational errors, long construction cycles, and unstable quality—have become insufficient to meet the demands of modern construction. Owing to their light weight, high strength, modular structure, standardized manufacturing, and recyclability, aluminum formwork systems can significantly improve construction accuracy, stabilize structural quality, and shorten construction duration. Exploring the application of aluminum formwork systems in residential buildings and their effectiveness in enhancing construction precision and quality is of great theoretical and practical significance for improving construction management, raising building standards, and achieving economic benefits.

2. Application of Aluminum Formwork Systems in Residential Buildings and Construction Precision Control

The application of aluminum formwork systems in residential buildings has become increasingly widespread,

mainly due to their outstanding capability in controlling construction precision. Through modular planning, aluminum formwork systems precisely control the dimensions of building components to the millimeter level, greatly reducing errors caused by human factors in traditional construction methods. Standardized dimensions and factory-based production ensure that the size and shape of each aluminum formwork panel are strictly regulated, enabling rapid on-site assembly and reducing human operational errors [1]. This high-precision design and construction approach effectively guarantees structural accuracy, especially for key components such as walls, slabs, and columns, ensuring their flatness, verticality, and thickness meet design requirements. The application of aluminum formwork systems reduces rework rates, shortens construction periods, and ultimately lowers capital investment in construction projects.

Despite their significant advantages in enhancing construction precision, aluminum formwork systems still face certain challenges in practical application. Changes in construction environments can affect precision control; variations in temperature and humidity may cause thermal expansion or contraction of aluminum alloys, thereby influencing construction accuracy. During construction, environmental monitoring and corresponding measures—such as appropriate adjustment and compensation of aluminum formwork—are required to maintain high precision under various conditions. In addition, the construction of aluminum formwork systems must strictly follow regulations, and construction personnel must receive specialized training to master standardized operating procedures, ensuring correct installation of each formwork panel. By integrating laser measurement technologies and intelligent monitoring systems, real-time monitoring of formwork installation precision can be achieved, further improving construction accuracy and ensuring that building quality meets expected standards.

3. Mechanisms of Aluminum Formwork Systems in Quality Improvement

3.1 Main Quality Control Measures and Methods

Ensuring high quality during construction is the cornerstone of project success. Quality control covers all stages from design and material procurement to construction and inspection. Accurate material control is the foundation of construction quality, as material quality directly affects the final building performance. When adopting aluminum formwork systems, selecting high-strength and durable aluminum alloy formwork is essential. In practice, project teams should conduct comprehensive quality inspections and verifications for each batch of aluminum formwork materials to ensure compliance with design requirements and standards. Common inspection methods include physical performance tests (such as tensile and compressive strength tests), dimensional accuracy checks (for example, controlling aluminum formwork dimensional errors within ± 1 mm), and evaluations of corrosion resistance [2]. These measures help ensure that materials used in construction do not suffer from deterioration or deformation.

Whole-process quality supervision is a key method for maintaining stable construction quality. Full-process supervision emphasizes detailed inspection and management at every stage from project initiation to completion. During construction operations, contractors should establish standardized operating procedures and use quality checklists and construction records for documentation and review. Aluminum formwork installation must strictly follow regulations, as even minor deviations can affect subsequent construction quality. Professional measuring instruments—such as laser levels and total stations—should be used to monitor installation accuracy in real time, ensuring that each formwork component is positioned correctly. Through real-time data monitoring frameworks, construction personnel can promptly correct formwork positions and angles, preventing deviations during construction. Cross-inspection is also an effective quality control approach; by implementing mutual inspections among different construction teams, quality standards at each stage can be enforced, potential risks can be identified promptly, and corrective actions can be taken, thereby reducing construction deviations and quality defects.

3.2 Role of Aluminum Formwork Systems in Ensuring Construction Quality

Aluminum formwork systems play a crucial role in ensuring construction quality, primarily reflected in enhanced construction accuracy, reduced construction duration, and improved stability. Through standardized design and integrated assembly, aluminum formwork systems ensure dimensional accuracy and uniform installation of each component. In conventional construction practices, deformation of formwork and manual installation errors often lead to dimensional deviations, compromising overall construction quality [3]. In contrast, aluminum formwork systems use high-precision aluminum alloy materials, combined with factory-based manufacturing and modular planning, allowing strict control over the size and shape of each formwork panel. During construction, aluminum formwork assembly is simple and efficient, achieving high standards of flatness and verticality for walls and slabs, eliminating dimensional errors and nonstandard practices common in traditional formwork construction. The precision error of

aluminum formwork is generally controlled within ± 2 mm, significantly lower than the ± 5 mm tolerance typical of traditional formwork, thus greatly improving overall building quality [4].

Aluminum formwork structures also contribute to quality assurance by reducing operational errors and improving construction efficiency. Due to their ease of assembly and straightforward operation, even less experienced workers can quickly master installation techniques, reducing quality defects caused by improper operation. The reusable nature of aluminum formwork materials ensures consistent precision and uniformity during repeated installations, minimizing quality deviations caused by formwork damage or wear. To further enhance quality stability, aluminum formwork systems are often integrated with intelligent monitoring technologies for real-time construction supervision. During installation, laser measuring instruments or total stations can be used for precise measurement of installation positions, ensuring accurate alignment of each formwork panel and minimizing construction deviations.

3.3 Key Measures and Technical Paths for Improving Construction Quality

The key to improving construction quality lies in refining each step of the construction process and implementing standardized and rational management measures. Optimizing pre-construction planning is the foundation for improving construction outcomes. At the project initiation stage, comprehensive assessments and precise planning should be conducted regarding the construction environment, materials, personnel, and equipment. High-quality aluminum formwork materials should be selected to ensure strength, toughness, and dimensional accuracy, preventing quality issues arising from material defects [5-6]. Rigorous construction drawing design and detailed construction plans are also essential for maintaining construction quality. Adequate preparation and planning before construction can reduce quality risks caused by operational errors or material defects, ensuring smooth project execution.

Implementing full-process quality management is a critical approach to improving construction quality. During project execution, supervision and feedback mechanisms at each stage should be strengthened to ensure continuous quality control. Real-time data monitoring methods, using sensors and monitoring devices, can be applied to inspect aluminum formwork installation accuracy and concrete pouring quality, allowing rapid identification and correction of deviations. These intelligent control measures enhance construction precision and reduce omissions associated with manual inspections, ensuring stable construction quality. Establishing a robust quality feedback system is also essential; after each construction stage, phased quality inspections should be carried out, and construction techniques and methods should be optimized based on actual conditions to meet quality standards at all project stages.

4. Application Effect Evaluation and Optimization Strategies of Aluminum Formwork Systems

4.1 Evaluation Indicators for the Application Effect of Aluminum Formwork Systems

The evaluation of aluminum formwork system performance should cover multiple dimensions to fully reflect its impact on construction precision, quality, and economic benefits. Construction duration is a key indicator; by comparing traditional formwork with aluminum formwork systems, it is evident that aluminum formwork significantly shortens construction time. Its modular design and lightweight properties enhance installation, dismantling, and reuse efficiency, reducing labor time and eliminating delays, thereby accelerating overall project progress [7]. Construction accuracy is another core indicator; with standardized and high-quality design, aluminum formwork systems achieve precise structural dimensions, reduce human errors, and improve construction precision.

The stability of construction quality is also a critical evaluation criterion. The repetitive use and modular design of aluminum formwork systems ensure consistency across construction processes, reducing quality variations caused by material or personnel changes. Through multiple rounds of quality checks, concealed works inspections, and final acceptance, the effectiveness of aluminum formwork systems in reducing quality fluctuations and enhancing stability becomes evident. Economic benefits are another important consideration. The adoption of aluminum formwork systems reduces material waste, labor costs, and management expenses [8]. Especially in large-scale residential projects, the reusability of aluminum formwork can significantly cut costs. By comparing total project costs with those of traditional construction methods, the positive impact of aluminum formwork systems on economic efficiency can be demonstrated.

4.2 Evaluation Methods and Standards for Quality and Precision Improvement

In applying aluminum formwork systems, evaluation of quality and precision improvements is typically conducted using comparative analysis and on-site inspection methods. Comparative analysis involves comparing the performance of aluminum formwork systems with traditional formwork systems within the same project, clearly

demonstrating advantages in construction time, precision control, and quality reliability. Aluminum formwork systems can reduce construction periods by approximately 20%–30%, particularly in multi-story residential buildings, where installation and dismantling efficiency and material reusability are crucial. Improvements in construction precision are another focus; by comparing key parameters such as wall verticality, slab elevation, and opening positions, aluminum formwork systems achieve precision control within ± 2 mm, whereas traditional systems often exceed ± 5 mm, thereby ensuring structural stability and aesthetic quality.

On-site inspection methods utilize high-precision measuring instruments to monitor various parameters throughout the aluminum formwork construction process, ensuring compliance with predetermined standards. Common instruments include laser measuring devices, total stations, and levels, which accurately measure wall verticality, slab thickness, and door and window opening dimensions, keeping errors within design tolerances. Standardized inspection measures are based on requirements in GB 50209-2010 Unified Standard for Construction Quality Acceptance of Building Engineering and GB/T 50300-2013 Code for Engineering Project Management. These standards specify acceptance criteria, such as allowable wall verticality deviation ≤ 3 mm/3 m, slab thickness deviation ≤ 5 mm, and door/window opening dimensional deviation ≤ 2 mm. On-site inspection conducted according to these standards provides reliable data support for optimizing the quality and precision of aluminum formwork systems, ensuring construction outcomes meet design requirements and industry quality norms.

4.3 Case Analysis of Optimization Strategies and Implementation Paths

In a high-rise residential project in Beijing, optimization of the aluminum formwork system application was mainly reflected in coordinated improvements across design, construction techniques, and personnel training. First, the project team conducted customized aluminum formwork design tailored to the building's irregular façade and complex structure, ensuring precise compatibility between the formwork system and the structural layout. To enhance construction precision, modular aluminum formwork and efficient assembly techniques were adopted, reducing errors during construction and ensuring accuracy in key structural components such as walls and slabs. Laser tracking measurement technology was also introduced to monitor installation deviations in real time, controlling errors within ± 2 mm. Compared with traditional formwork errors (typically ± 5 mm), precision control was significantly improved.

In addition, to ensure smooth implementation of the aluminum formwork system, comprehensive technical training was provided to construction personnel, emphasizing operational specifications and precision control methods, thereby significantly reducing human operational errors. During construction, regular quality inspections and data analyses were conducted to ensure compliance with predefined quality standards. Upon project completion, the outcomes met the requirements of GB 50209-2010, including wall verticality deviation ≤ 3 mm/3 m and slab thickness deviation ≤ 5 mm. Through these optimization measures, the project not only shortened the construction cycle by approximately 20% but also significantly improved the precision and stability of quality control, effectively avoiding the accuracy deviations and quality issues associated with traditional formwork. The project provides a replicable experience for similar future developments.

5. Conclusion

Through standardized and modular design and high-precision installation, aluminum formwork systems effectively enhance construction accuracy and structural quality in residential building projects, while shortening construction cycles and reducing costs. Combined with whole-process quality control, intelligent monitoring, and construction personnel training, aluminum formwork systems significantly reduce construction deviations and rework, ensuring project stability and reliability. Their application not only improves the technical level of residential construction but also provides a feasible technical pathway and practical experience for achieving efficient and refined management in the construction industry.

References

- [1] Ashwin K, Paul VK. Comparison of aluminum and tunnel formwork for high-rise construction. *Discov Civ Eng*. 2025;2(1).
- [2] Liu X, Bo O, Chen J, et al. Optimization of Formwork Structure Node for Housing Construction Project to Eliminate the Influence of Accumulative Deformation of Aluminum Alloy Formwork. In: *Hydraulic and Civil Engineering Technology VIII, Part 1: Proceedings of the 8th International Technical Conference on Frontiers of HCET 2023*. 2023:218-24.
- [3] de Abreu MM, Lordsleem Jr AC. Aluminum formwork system: loss and productivity. *Built Environ Proj Asset Manag*. 2019;9(5):616-27.

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- [4] Zhang BQ, Sun WX. Application of the Aluminum Formwork in High-Rise Construction. *J Qinghai Norm Univ (Nat Sci Ed)*. 2015.
 - [5] Liu X, Bo O, Chen J, et al. Optimization of Formwork Structure Node for Housing Construction Project to Eliminate the Influence of Accumulative Deformation of Aluminum Alloy Formwork. *Adv Transdiscipl Eng*. 2023.
 - [6] Liu Y. Research on the Application Points of Aluminum Alloy Formwork Construction Technology in High-rise Buildings. *Building Structure*. 2022;7(6).
 - [7] Barcons SP. Improvements in systems construction of reinforced concrete or other material through modular and integral formwork high precision. 2002.
 - [8] On course for the future with ultra-modern precision formwork. *Betonwerk Fertigteil-Tech/Concrete Plant Precast Technol*. 2023;(6):89.