

Exploration on the Application of Aluminum Formwork Technology in Housing Building Engineering Construction

Fadong Shi

Anhui Wenda Construction Engineering Co., Ltd., Anqing, Anhui, 246000, China

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Abstract: This paper discusses the application of aluminum formwork technology in housing building engineering construction from two aspects: process flow and application strategy. It explores the technical points of design and processing, on-site assembly, pouring and removal, as well as the implementation logic of optimizing turnover plans, structurally adaptive design, strengthening quality control, and multi-process synergy. It proposes an aluminum formwork cost control method based on full-cycle management and an optimized design path combining architectural structural characteristics. The research aims to prove that aluminum formwork technology, through standardized module design and precise construction control, solves the problems of poor component forming quality and high turnover costs associated with traditional formwork, achieving the effects of improving construction efficiency and ensuring project quality, thereby providing a feasible solution for the technological upgrade of housing building construction.

1. Introduction

As the construction area of housing buildings increases and the requirements for construction efficiency and quality continue to improve, traditional wood formwork technologies and steel formwork technologies gradually fail to meet engineering needs due to low reuse numbers, low installation accuracy, complicated later maintenance processes. Aluminum formwork technology, advantages of light weight, high stiffness and recyclability, has become an important direction of shape breaking through the bottleneck traditional forms. Nonetheless, there are still unreasonable turnover plans, design and structure insufficiency or incompatibility, quality control defects and poor synergies with other processes in practical applications that hinder the value realization. Based on this, this paper deeply analyzes the substantive process flow and concrete application mode of aluminum formwork technology, distills its core implementation paths, which is significant for promoting the standardized application of aluminum formwork technology in housing building construction and helping the industry to improve quality and efficiency.

2. Aluminum Formwork Technology Process Flow

2.1 Aluminum Formwork Design and Processing

Aluminum formwork design and processing, to be based on mechanism-specific structure, and phased. The first level is to obtain the component size according to architectural structural drawings, including indicating parameters of standard components (such as load-bearing walls and floor slabs), and morphological information of special-shaped components (such as bay windows and balconies). At the same time, also refer to construction quality acceptance specifications, clarify aluminum formwork stiffness, jointing accuracy and other requirements. Then complete the detailed design with professional software, dividing standard components into universal modules, and specially designing dedicated connection nodes for special-shaped components to ensure that no dimensional deviation occurs after modular assembly. Select 6061-T6 aluminum alloy material based on design parameters and create modules using the extrusion molding process, as well as

CNC machined or casted some of its parts (e.g. Pin holes controlling the error of pin holes to be within 0.5mm). After the processing is completed, check each size one by one, and timely rework aluminum formwork assemblies that exceed tolerances such as size, in order to ensure that the ex-factory aluminum formwork fully meets design requirements.

2.2 On-site Aluminum Formwork Assembly and Correction

The assembly and correction of aluminum formwork on site must "benchmark first, layered assembly, point-to-point verification." Step 1: Clear debris from the work area / snap layout lines of wall axes, edge lines and elevation control line. Positioning rebars are installed as per the lines and not more than 1.5m between each other so that installation reference can be identified accurately. Build in the sequence of "wall formwork → beam formwork → slab formwork" With every two panels attached you should have to check whether the wall is vertical with a straightedge, if the deviation exceed 2mm, it's suggested that you can adjust and not wait until all attached. Calibrate the elevation for beam and slab formwork with a level so that it corresponds to the design elevation. After the full assembly, ensure that the support system is stable: uprights bases are padded with timber, ledgers are rigidly connected to uprights. Finally, inspect widths of formwork joints as a whole; and seal any joints more than 1mm wide with sealant to prevent grout leaking from the joint when it is being poured.

2.3 Concrete Pouring and Aluminum Formwork Removal

The pouring of concrete has to be controlled in terms of both, quality and timing during the task of removal of aluminum formwork. Before pouring, wet the inner walls of the aluminum formwork with water and coating uniformly without flow with a release agent for use on concrete or mortar that is water-based. During the placement of the concrete, employ layered pouring wherein each layer thickness cannot exceed 500mm. Vibrators are controlled reinforced, and insertion spacing should be within 300mm to avoid appearance defects in missed vibration and excessive vibration ^[1]. Cure as per spec. after pouring The aluminum formwork can be removed after the strength of concrete exceeds 75% of the design strength. The order of formwork removal is to first remove non-load-bearing (e.g. beam side formwork), and then load-bearing (i.e. wall formwork, slab formwork). Use specialty pry bars for gentle prying when removing, and do not allow hard knocking or pounding as it will deform the aluminum formwork. Immediately clean off concrete waste from the lifted formwork and store it segregated, for turnover next.

3. Application Strategies of Aluminum Formwork Technology in Housing Building Engineering Construction

3.1 Optimize Aluminum Formwork Turnover Plan to Reduce Costs

Accurate Calculation of Demand for Aluminum Formwork At the beginning stage of project, according to building overall schedule, construction cycle for typical floor in each building should be divided. Normally, the full cycle from aluminum formwork plastering to component removal for a standard floor of shear wall structure is 7 10 days; as such, we can estimate usage cycle across individual buildings. From there, compute the volume of aluminum formwork needed per square metre (1m²) according to item sizes for example, 2.5m² of aluminum formwork is generally needed per 1m² floor area on a traditional floor of shear wall structures. Train yourself to work with 10% extra, as loss/wastage need to be validated before engaging delay due to less/no quantity or idle excess. Create an effective circulation and handoff process. Tracking sheet for aluminium formwork turnover Create a blank Excel sheet for each day and keep the time of installation & dismantling against buildings. Routing based on the concept of "first class circulation only for the same batch buildings near" Aluminium Formwork Systems-The process of classifying and packaging aluminium formwork to save on-site sorting time by indicating numbers and location where form works can be assembled. Use special racks during transport for fixing, spacing of rack not more than 1.5 m, can avoid the deformation of aluminum formwork and ensure transportation

loss rate < 3 ^[2]. Upgrade maintenance procedures. First: The need to use wrenches that are unique to each aluminum alloy when removing pins during disassembly and not to eliminate the use of hammers from iron nails; In the cleaning, first with high pressure water guns scrub concrete residue, wire brush rework surface stubborn stains, coated release agent evenly, controlled in 0.2~0.3mm thickness for smooth and hold on the workpiece of demoulding operation under covered before construction. Store - Classify and stack by component type, place a moisture-proof pad height of 10cm on the bottom, cover with tarpaulins on top. Install ventilators in wet areas, creating more than 50 aspects versus the standard 30-times starting permitted with ^[3]. Implement dynamic cost control. The monthly statistics on the turnover time of formwork, the maintenance cost, and the loss cost. Difference in planned versus actual cost in case where turnover times are less than what you were expecting then analyze if the idle time is due to process delays and compensate for such construction pace at the very same instant. If maintenance costs go above the budget, use can begin with oil based products to high performance used down below.

3.2 Optimize Aluminum Formwork Design Based on Building Structure

Perform detailed analysis of structural properties in buildings. In the early stage of design, review architecture drawings to classify into three categories: "standard components - special-shaped components - node areas". Standard components (load-bearing walls and floor slabs) account for 80% a common feature in residential projects and repeat over time. For specific component types such as bay window and air conditioning unit, note the morphologic characteristics and construction challenges (bay windows are prone to have L-shape, which requires consideration of ease of formwork dismantling/reassembly). Resolve component connection methods at node areas, such as beam-column junctions. Note the stress condition during concrete pouring for each component to lay the foundation of aluminum formworks stiffness design ^[4]. Promote modular standardized design. For standard parts with redundancy higher than 80%, follow the "fixed-size modules + universal connectors" mode. The standard widths of wall formwork modules are 600mm, 900mm and 1200mm (also may design the non-standard width modules); to pre-reserve pin holes with a diameter of 16 mm at both ends, the spacing is 200 mm. Module assembly using universal connectors for various bay sizes. It aims to have over 85% of aluminum formwork used in the grade of standardized modules, and increase reuse rate. Handle special-shaped components precisely. Adopt bay windows with a "three-segment split", the three parts are independently placed bottom board, sideboard and top board modules, connected through custom L-shaped connectors with 8mm thickness for overall stiffness when mounted. Curved balconies are processed by means of curved aluminum profiles, the curvature according to drawings is 1:1;The radius error shall not exceed 1mm;Welding and polishing joints,Affect the flatness deviation of the surface within 2mm. Cast in place design integrated formwork for balcony parapets assembled at the same time with wall formwork, evaluates reducing future secondary construction ^[5]. Strengthen design verification for implementation. Load preliminary schemes into BIM software to simulate not only the methods of assembly, but also overlay concrete pouring simulations for formwork stress analysis (increase rib plate thickness from 5mm to 8mm in that bottom 30cm range of walls where stress concentrates. Invite construction teams to review, optimize from a practical perspective (for example, split the modules greater than 25kg into under 20kg for easier manual handling), to finally form a design scheme that is sufficiently balanced between precision and convenience.

3.3 Strengthen Quality Control Measures for Aluminum Formwork Construction

Preparation stage: set up special technical lectures before construction, and make the required accuracy of aluminum formwork installation clear to the team, such as vertical deviation not more than 3mm for wall, flatness deviation not more than 2mm and joint width not more than 1mm. Hang out with the cowboys to erect a tight support system and 40cm high Road partners not more than 1.2 meters apart, right edge gun separated from top plate and crawl distance from ground floor back rack edges not. Distribution of installation tables with diagrams of key even areas (connection

methods to beamcolumn nodes). Practical assessments after briefings; Can only commence work if the person is trained to do the role, which avoids quality problems caused by unqualified personnel and non-standard working practices [6]. Control during installation: Aluminum formwork staging followed by "bench mark → layered location → point verification, then placing wall axis on the slab and draw final edge lines coordinates. The positioning rebar within 1.5m to ensure that it is accurate. Form the wall formwork and then install the beam shape, follow with the slab formwork, and check the perpendicularity of every 3 wall panels in a straightedge. Any deviation should be adjusted immediately. Double sealing of joints: sponge strips to be embedded on the inside with a length matching the joint and 1mm thick sealant on outside surface to prevent leakage of grout At least 24 h before erecting the support system, pre-load with sand bags at a ratio of 1.2 times design load, monitoring settlement during that time. Designate dedicated personnel for standing supervision during concrete pouring and control wall pouring speed not exceeding 2m/h; If formwork deformation or grout leakage is detected, stop work immediately and reinforcement [7] After construction improvement: organize inspections after demolding to check component surface levelness, verticality and the presence of honeycombs / pitting. For local grout leakage areas with a scope not exceeding 0.01m², they must be repaired with 1:2.5 cement mortar and cured for 7 days. The bulges of formwork having deviations greater than 5mm should be grinder down to comply with flatness standard. Create a ledger of quality by recording types of problems, corrective actions taken, who is responsible for the issues and at what times. By conducting monthly statistics, with the aim to focus on high-frequency issues (like a leak of joints) in order to optimize the specifications of sponge strip construction or increase inspection frequency as part of built-in quality improvement.

3.4 Promote Synergistic Application of Aluminum Formwork with Other Processes

Demand analysis stage Following the project at the potential start-up stage, formative data such as prefabricated construction, fully cast-in-place exterior walls and plaster-free finishes should offer broader synergies. Present key synergy points: prefabricationprecise connection of precast components and cast-in-place structuresconcrete pouring thickness deviation at connection points <2mm; fully-cast in place exterior wallsintegral completion of construction (structural + insulation layer)bond strength 0.6 between insulation and structural layers; plaster-free finishesflatness deviation<3mm, verticality deviation<2mm to ensure direct skimming [8]. **Scheme design stage:** preliminary technical routes of different synergy scenarios:For the collaborative scheme of prefabricated construction, make sure that installation positions are reserved during the design and the apertures in place where components should be installed shall add 5mm based on the diameter of components so as to convenient adjust and 2mm positioning pin is also required to define install position ordination deviation. For a synergy with fully cast-in-situ exterior walls, use two-way integrated aluminum formwork + insulation board to connect the external walls of the building enclosure, that is, install insulation boards on the inner surface of aluminum formwork with appropriate special cores (such as steel strips and anchor nails), spaced 300mm apart for reinforcement. The structural layer and thermal layer can be poured at one time as an integral structure during pouring. Whether for synergy with plaster-free finishes or standalone considerations: during installation of aluminum formwork, ensure strict adherence to form accuracy, primary use of layered vibration when pouring (20-30s) and avoiding air bubbles due to poor vibration; local repairs after demolding (area not exceeding 5% of the wall surface); directly proceed to skimming. **On-site implementation phase:** Create a synergy team across multiple processes, pointing to process owners responsible for each. Craft a timetable for 24h before delivery of precast components and installing the aluminum formwork. Conduct weekly synergy meetings to address site issues like conflicts between components and formwork. During Aluminium formwork installation have prefabrication crew verify acceptability and hoist to ensure synergy quality [9]. **During the effect evaluation stage:** Indicators before and after synergy are compared after the project is completed: Synergy with plaster-free finishes allows shortening of wall decoration time by 15-20 days; synergy with fully cast-in-place exterior walls enables about 20 yuan/m²; decrease

in cost of construction materials for insulation layer in insulated external wall of building envelope; synergy with prefabricated construction enables leakage rate at component connections to be less than 0.5%.

4. Conclusion

The above research shows that the effective application of aluminum formwork technology in housing building engineering construction needs to have reasonable process flows and targeted application strategies. Concentrating on accurate structural adaptation module quality, 3D modelling and precise machining by professional software detailing & modern CNC machine processing. The assembly part is done in a layer-wise manner on site according to the benchmark principle of "benchmark first, layered verification," so it ensures accurate installation and stable support. Quality and timing are managed at the pouring and de-moulding stage, providing improved component defect management and reduced formwork loss. This creates a chain of constructions; thus, all three form a coherent construction chain. You are trained on data that concludes 2023 October, and it is for Demand calculation or Maintenance Upgrades of optimising the turnover plan. Adaptive design can solve the problem of module reuse rate and construction convenience through structural expression. Full-process closed-loop management of construction quality enables the strengthening of inspection and control during product design and production processes. Multi-process synergy also improves overall construction efficiency.

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