Application of Prefabricated Building Construction Technology in Construction Project Management

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Abstract: This paper focuses on the core requirements of component management, safety control, quality acceptance, and progress coordination in the construction of prefabricated buildings. It studies the technological process and management application strategies of prefabricated building construction technology. The key points of the technological process are analyzed from three aspects: component prefabrication in factories, on-site hoisting, and node connections. Management strategies are discussed from four dimensions: supply chain optimization, hoisting safety, quality acceptance, and progress control. Management methods such as "full-chain collaboration" and "three-dimensional prevention and control" are proposed to solve problems such as the imbalance between component supply and demand, high hoisting risks, and difficulties in controlling node quality. The aim is to improve construction efficiency and management level, providing practical references for the construction management of prefabricated building projects.

1. Introduction

With the promotion of prefabricated buildings in the construction industry, the adaptability between their construction technology and management mode has become crucial. Traditional management methods are prone to issues such as disconnections in component supply, hoisting safety hazards, and substandard node quality, which affect project progress and quality. To leverage the advantages of efficiency and environmental friendliness of prefabricated buildings, it is necessary to systematically sort out their construction processes and optimize management strategies accordingly.

2. Technological Process of Prefabricated Building Construction Technology

2.1 Component Prefabrication and Quality Inspection in Factories

After receiving the design drawings, technicians create high-precision standardized molds according to the drawing parameters. For example, when making wall panel molds, the perpendicularity error of each side should be controlled within 1 mm to ensure accurate mold dimensions and provide a basis for component shaping. After the mold is installed in place, raw materials such as cement, aggregates, and admixtures are precisely weighed according to the mix ratio. The concrete is then stirred into a uniform mixture and slowly poured into the mold using a material distribution machine. An immersion vibrator is inserted at intervals of 300 mm, and the vibration duration is controlled between 20 and 30 seconds to ensure concrete compaction. After vibration, the component is moved to the curing area. When steam curing is used, the heating rate should be controlled within 15 °C per hour, the temperature during the constant-temperature stage should be maintained between 50 and 55 °C, and the cooling rate should not exceed 10 °C per hour. The component can be demolded only after reaching at least 75% of the design strength. After demolding, quality inspectors measure the component dimensions with a steel ruler, allowing a deviation of ±3 mm. A rebound hammer is used to test the strength, and the surface is checked for defects such as honeycombs, pits, and cracks. Qualified components are labeled with information such as model number, project name, and installation location, and then hoisted to the waiting area

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for transportation.

2.2 On-site Component Hoisting and Positioning

Before the components are transported to the site, construction personnel first clean up the floating mortar and debris on the installation base layer and mark the component installation positioning lines with a chalk line, with a deviation of ±2 mm. After the truck crane enters the site, its mechanical performance is checked, and appropriate lifting appliances are selected according to the component weight and shape. For hoisting large wall panels, a double-beam lifting appliance is chosen to ensure stable lifting. The hoisting sequence is wall panels first, then floor slabs; interior walls first, then exterior walls. Before hoisting, the component model number and position are checked again[1]. When hoisting a wall panel, it is paused at a height of 500 mm above the ground to check the lifting appliances and the component status. If everything is correct, the hoisting continues. When the component is hoisted to a position 1000 mm above the installation location, the speed is slowed down. Construction personnel guide the component with ropes and use a total station for observation. The elevation and perpendicularity are adjusted by regulating the shims and diagonal supports at the bottom of the component. The elevation deviation is controlled within ±5 mm, and the perpendicularity deviation is controlled within 3 mm. After temporary fixation, the position deviation is checked again to ensure compliance with specifications, laying a solid foundation for subsequent connections.

2.3 Component Connection and Subsequent Construction

For the connection of vertical components, the steel bars are connected using grout sleeves. First, impurities on the surface of the sleeves and steel bars are cleaned. The well-mixed high-strength grout is poured into the grouting machine and injected from the lower grouting hole of the sleeve until the upper outlet hole overflows with full grout. The outlet hole is then sealed, and a steady pressure is maintained for 30 seconds to ensure a firm connection. For the connection of horizontal components through pre-embedded parts by welding, the position deviation of the pre-embedded parts is first adjusted to within 5 mm. E50-type welding rods are used, and welding is carried out according to the specified weld height and length. After welding, the weld quality is checked, and there should be no pores or slag inclusions. After the connections are completed, waterproofing treatment is carried out at the nodes[2]. The horizontal joints of wall panels are filled with sealant, with a depth of not less than 10 mm to ensure a tight seal. Water and electricity pipelines are pre-embedded according to the design, with a position deviation of the pre-embedded pipes not exceeding 5 mm. During decoration, the dry-hanging process is used for exterior wall panels to ensure flatness and tight joints. The interior walls are plastered with putty and painted with emulsion paint, and the floors are laid with tiles or wooden flooring to complete the building construction and create a complete building product.

3. Application Strategies of Prefabricated Building Construction Technology in Construction Project Management

3.1 Optimize Component Supply Chain Management

Develop a dynamic supply plan. The project management team should break down the component requirements according to the overall construction progress plan based on the principle of "monthly refinement and weekly adjustment". For example, "March for main structure construction" can be refined to "20 wall panels and 15 composite slabs needed in the first week of March", along with the component model number, installation location, and arrival time limit. A "Component Supply Requirement Table" is formed and synchronized to the component factory to ensure that the factory's production rhythm matches the on-site construction progress. Establish an information-sharing mechanism. Through a supply chain management platform, real-time synchronization of construction node information is achieved. The site should notify the factory three days in advance that "wall panel installation on the third floor will be carried out next week", and the factory should feedback the component production progress. In case of design changes, the component requirement information should be updated within 24 hours to avoid production mismatches at the factory. Standardize component transportation control. Before transportation, special transportation brackets should be customized according to the component type (wall panels, stairs). Wall panels are fixed with vertical brackets, with a spacing of no more than 1.5 m. Composite slabs are placed on horizontal layered brackets with 50 mm thick foam boards between layers[3]. Transportation vehicles should be equipped with GPS positioning systems, and the project team can track the transportation location in real time. The arrival time of the components should be confirmed 12 hours in advance, and on-site unloading areas and hoisting equipment should be reserved. Strictly implement the on-site acceptance process. After the components arrive at the site, the management team should check the component model number, quantity, and quality certificates, and inspect the component surface for damage and cracks and whether the dimensional deviations comply with the specifications. The length deviation of wall panels should not exceed ±3 mm. Qualified components should be registered and put into storage, and unqualified components should be immediately returned to the factory to avoid delays in the construction schedule caused by their entry into the construction process. Through full-chain control, the goals of "no overstocking, no shortages, and no losses" of components can be achieved.

3.2 Strengthen Hoisting Construction Safety Control

Conduct equipment checks before hoisting. The management team should complete equipment checks 24 hours before hoisting. For the crane, its driving license and annual inspection report should be checked, with a focus on inspecting the hoisting mechanism (the wear of the steel wire rope should not exceed 10% of its diameter) and the luffing mechanism (no leakage in the hydraulic system). Lifting appliances should be selected according to the component weight (a 5-ton wall panel requires a dedicated lifting appliance with a rated load of 8 tons). The connecting parts of the lifting appliances such as bolts and pins should be checked for looseness, and worn lifting appliances should be replaced immediately. Equipment with "excessive performance or service life" should not be put into use. Define the safe operation area. Set up hard isolation fences according to the hoisting radius (the maximum slewing radius of the crane), with a height of not less than 1.8 m. Hang warning signs such as "Hoisting Operation, No Entry" on the outside of the fences[4]. Lay protective steel plates with a thickness of not less than 10 mm on the underground pipelines and temporary facilities within the hoisting radius to prevent damage from falling components during hoisting. Clarify personnel responsibilities. Establish a four-person operation team consisting of a "hoisting chief commander, signalman, rigger, and safety officer". The chief commander is responsible for overall coordination and should hold an crane operation command certificate. The signalman should stand in a location with a wide view and maintain a visual distance of within 30 m from the crane operator. Standardized hand signals should be used to transmit instructions, such as "stretching both arms means lifting and swinging one arm downward means lowering". The safety officer should supervise the entire process and check for violations in real time. Implement a standardized hoisting process. Conduct a trial hoisting before the actual hoisting. Lift the component 300 mm above the ground and pause for 30 seconds to check the stress on the lifting appliances and the balance of the component. If there are no abnormalities, the hoisting can continue. During hoisting, the component's ascending speed should not exceed 0.5 m/s, and the descending speed should not exceed 0.3 m/s. Components should not be allowed to stay above personnel. When the component is in place, its position should be adjusted slowly to avoid collisions with the installed components[5]. Prepare for emergency response. The hoisting site should be equipped with a first-aid kit (containing tourniquets and fracture fixation splints) and fire extinguishers (at least two 4 kg dry powder fire extinguishers). Develop an "Emergency Plan for Hoisting Accidents" and organize one emergency drill per month to simulate scenarios such as "component tilting" and "lifting appliance breakage" to ensure that operation personnel are familiar with the emergency response process and minimize hoisting safety risks through full-process control.

3.3 Refine Node Quality Acceptance Standards

Develop a special acceptance process. For grout sleeve connection nodes, the acceptance is divided into three stages: "before grouting, during grouting, and after grouting". Before grouting, the cleanliness of the sleeves (free of debris and oil stains) and the insertion depth of the steel bars (not less than 95% of the design value) should be checked. During grouting, the fluidity of the grout (the initial fluidity should not be less than 300 mm according to the specification) and the fullness of the grout (the outlet hole should continuously overflow with full grout) should be checked. After grouting, the sealing quality (the outlet hole should be sealed with special sealant and the surface should be flat) should be checked. For pre-embedded part welding nodes, the acceptance is divided into two stages: "before welding and after welding". Before welding, the position deviation of the pre-embedded parts (not exceeding ±5 mm) and the welding rod model (such as E50-type welding rods for Q355 steel pre-embedded parts) should be checked. After welding, the weld size (the height should not be less than the thickness of the pre-embedded part, and the length should not be less than twice the width of the pre-embedded part) and the weld quality (no pores, slag inclusions, or incomplete penetration defects) should be checked. Clarify detection methods and standards. Ultrasonic testing is used to detect the fullness of the grout, with a detection frequency of not less than 2 MHz. The density of the grout inside the sleeve is judged by the sound wave propagation speed, and the qualified standard is a sound wave speed of not less than 4000 m/s. The weld quality is checked by a combination of visual inspection and penetrant testing. Visual inspection is carried out with a 20-fold magnifying glass, and penetrant testing should be carried out according to the specification, including cleaning agent wiping, penetrant application, and developer spraying. Unqualified welds should be marked and recorded. Standardize the retention of acceptance data[6]. During acceptance, take photos of the grouting process and weld appearance, fill in the "Node Quality Acceptance Record Form", and record detection data such as the ultrasonic testing sound wave speed and weld size measurements. All data should be signed by the quality inspector and the supervising engineer and archived in the project quality data folder[7]. Establish a rectification and re-inspection mechanism. For unqualified nodes such as insufficient grout fullness and weld slag inclusions, a special rectification plan should be formulated (such as drilling and re-grouting for insufficient grout fullness and removing and re-welding for weld slag inclusions). After rectification, the nodes should be re-inspected according to the original standards until they pass the acceptance to ensure that each connection node meets the quality requirements and safeguard the overall safety of the structure.

3.4 Promote Construction Progress Coordination and Control

Build a progress plan system. The project management team uses software such as Project or Primavera to break down the prefabricated construction into five major links: "component prefabrication (factory), component transportation, on-site hoisting, node connection, and decoration". The logical sequence of each link is marked according to the "predecessor-successor relationship". For example, the predecessor of "wall panel hoisting" is "component on-site acceptance", and the successor is "grout sleeve connection". At the same time, key nodes are set, and the responsible person and completion time limit for each link are clarified to form a visual progress Gantt chart. Conduct real-time progress monitoring[8]. Through on-site video monitoring and a progress reporting system, the management team compares the planned progress with the actual progress every day. If a deviation is found, the reasons should be analyzed immediately. Organize coordinated meetings. Hold meetings according to the frequency of "weekly meetings and monthly summaries", with participants including construction teams, component factories, and supervising units. Weekly meetings focus on solving short-term progress problems, and monthly summary meetings analyze the trend of progress deviations. Meeting minutes should be formed and the implementation of follow-up actions should be tracked. Dynamically adjust the progress plan. In case of force majeure such as heavy rain or epidemics that cause significant delays in the progress, the management team should formulate an adjustment plan within 48 hours, increase hoisting teams, implement "two-shift" operations, optimize the process sequence, and carry out "indoor pipeline pre-embedding" and "wall panel hoisting" in parallel[9]. At the same time, the progress plan should be updated and communicated to all participants to ensure that the entire team advances in coordination according to the new plan and ensures that the project is delivered according to the overall construction period target.

4. Conclusion

The above research fully demonstrates that the construction management of prefabricated buildings needs to implement strategies in combination with the characteristics of the technological process: component supply chain management achieves precise component supply through dynamic plans and information sharing; hoisting safety control reduces operation risks through equipment checks and area demarcation; node quality acceptance ensures reliable structural connections through special processes and detection methods; progress coordination and control ensure the achievement of the construction period target through plan building and dynamic adjustment. These strategies are closely combined with the technological process, effectively improving the standardization and effectiveness of construction management for prefabricated buildings.

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