Key Issues and Solutions in the Implementation of Prefabricated Building Engineering Supervision

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Abstract: With the acceleration of construction industrialization, prefabricated buildings are widely used due to advantages such as green efficiency and controllable quality. However, engineering supervision, as the core link of quality and safety control, has not yet fully adapted to the characteristics of "factory production + on-site assembly" in prefabricated construction. In terms of practice, the prominent problems are disconnection in component quality control, accumulation of on-site installation risk and inefficient collaboration among participants as well as insufficient professional capabilities of supervision personnel. Not only does this lead to construction difficulties, but these causes can also jeopardise the safety and functionality of structures. With this in mind, this article focuses on the focus of supervision work in prefabricated building engineering and targeted technical solutions to hope that through the analysis of relevant content, it can provide reference ideas for improving prefabricated construction project quality supervision system.

1. Introduction

In the context of China strengthening the transformation and upgrading of the construction industry, vigorously developing green construction, prefabricated buildings play an important carrier role in achieving construction industrialization because of their factory prefabrication on-site assembly advantage. But, precast concrete structures present more complicated situation than cast-in-place concrete and its engineering supervision. On one hand, problems occurring in construction determines the efficiency of prefabricated building construction; on the other hand, they directionly affect structural safety and performance. Based on this, in-depth analysis of the key issues in the implementation of prefabricated building engineering supervision, combined with exploring practical optimization paths through engineering practice, holds significant practical value and theoretical importance for improving the prefabricated building supervision system and promoting high-quality development of construction industrialization.

2. Core Requirements for Prefabricated Building Engineering Supervision

Based on the particularities of prefabricated building construction, its engineering supervision needs to break through the traditional supervision framework to ensure project quality and safety [1]. The first principle of prefabricated building supervision is the requirement for whole-life-cycle management. Compared to traditional buildings whose supervision is limited to the construction stage, the quality of prefabricated buildings stems from multi-facets such as "design-production-construction-acceptance". If any one link has omission, then the overall quality defects. During the design phase, supervision should intervene early to review at least partial splitting schemes of components and focus on checking whether split components are conducive to factory production, transportation, hoisting and on-site installation, otherwise unreasonable design will increase manufacturing difficulty or even low installation risk. For example, if prefabricated wall panels are cut too big, they may lift the width limit of transportation vehicles, or exceed the carrying capacity of hoisting machinery, requiring supervision to work together with design units to select a reasonable splitting size. During production, supervision must place personnel at the component plant to oversee critical processes (e.g., rebars processing, formwork setting and fixing

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embedded parts) ensuring that it complies with design drawings and specifications. In parallel, the raw material intake records, concrete mix ratio reports, component curing records and other information of each factory must be reviewed to control the quality of components from the source. During the construction phase, supervision is primarily needed in monitoring processes of component hoisting, connection joint construction, and waterproof sealing, among others; since concealed works such as grouting sleeves and mortar anchor laps need to be verified after filling up materials like concrete or cement paste. Supervision is aimed at evaluating the overall quality of the project as a whole, in accordance with component factory certificate and production process record, on-site installation test report and other data in acceptance phase that meets final acceptance requirements.

3. Key Issues in the Implementation of Prefabricated Building Engineering Supervision

3.1 Disconnection Between Component Production and Supervision Control

Because prefabricated building components are mass-produced in factories, the traditional supervision model "emphasizes the site and ignores the factory", which easily leads to a governance gap. These disconnection directly expose component quality risks when arriving to the site. The connection of supervision with the production link is overall weak. The general bulk of projects will only depend on factory certificates and visual inspections when items arrive, instead of getting into the weeds with regard to their production processes for more thorough oversight. From rebar processing aspect, some factories try to simplify the tying process in order to increase efficiency, so that there are too large spacing or too small cover thickness of rebar. However, because supervision is not at the factory, such problems are only found during assembling of components where rework is impossible; only design changes for reinforcement increasing costs and delaying schedules.

What's more, there is a deeper contradiction for component production that molds need to be debugged separately and then concrete needs to be poured into the mold before being steam-cured or air-dried in several procedures that can comprehensively affect the final quality. For example, if the average amount of deviation between a mold and its intended design is uncorrected in that batch, then it may drive some parts out-and-over geometric tolerances; similarly, insufficient vibration applied to prepared concrete creates internal voids that take away from structural load-bearing. The Existing Problems with Current Supervision Work factory production, there is no uniform supervision process. The functions of stationed supervision personnel have not been clearly defined, and the sampling inspection mechanism for production processes have not been established which caused component quality control in a passive acceptance state.

3.2 Supervision Risks in On-site Hoisting and Connection Joints

On-site hoisting and connection joint construction are the key links for the quality and safety of prefabricated buildings, and also the high-risk points of supervision work. So the current link supervision omission, is mainly manifested as the process control lax and technical detection not strict. In the case of hoisting operations, supervision can review preliminary plans but often just as a formality, and without checking if equipment selection or lifting point design were grounded in how the project is actually going to be implemented. In one project where a large precast composite slab was hoisted, the crane had enough lift capacity but not a long enough boom which resulted in an excessively acute hoisting angle. The problem was not picked up through supervision and ultimately resulted in a loss of control when the component tipped over, impacting on scaffolding.

Compared with the exposed works, the supervision defects in connected joint construction are more concealed, particularly for works the suppression bases grouting sleeves and mortar anchor laps etc., as it is difficult to see and judge its quality by visual observation. Some projects only have supervision see the preparation of the grouting material, and do not observe whole bar grouting process. Contractors may run into incomplete, or missed grouting that would otherwise go unnoticed by the means of visual inspection alone and be hard-pushed to rectify it later on. In addition, for bolted connections, the supervision may not check the tightening torque with torque

wrenches as required by codes and standards, resulting in bolt loosening which weakens the stability of connections. Supervision control is also weak on sealuclant application. After all, leakage problems can arise at a later stage if the sealant is not checked by supervision in terms of continuity and thickness. What is driving these risks is the quality of critical joints being.

3.3 Low Supervision Efficiency under Multi-Party Collaboration

There are many stakeholders in prefabricated buildings, including design, production construction and transportation. The supervision work of these entities is faced with a dilemma of "Difficult coordination and Slow progress", because of the information barriers and low collaboration, has seriously affected the overall project efficiency. Traditional modes of human communication have a long delay at the information transmission level. In case change notifications are not synced with the specific component plant, and the supervision unit in a timely manner, it generally leads to mismatches between produced components and on-site needs. In one example, for a project the design unit changed the position of reserved openings in prefabricated wall panels but did not promptly notify the plant. Supervision also failed to intervene in a timely manner to assess the impact of the change, leading to the disposal of 20 wall panels that had already been produced and incurring major financial losses. At the same time, the lack of unified information recording standards leads to an inability to share data, such as components manufacturing progress and on-site construction plans, which makes it impossible for supervision departments to grasp the overall progress in a timely manner or anticipate supply-demand conflicts.

Supervision is poorly coordinated and integrated across the collaboration mechanism level. The right and responsibilities among participants are often vaguely defined, making buck-passing easy. Road restrictions due to delays in transportation of components leading to on-site hoisting downtime, transporters may say "road restrictions," component plants will say "production was completed as scheduled," and contractors will complain that "supervision did not coordinate beforehand," causing supervision, due to the fact that there is no clear collaborative responsibility list, unable to quickly locate a responsible party and instead having to passively coordinate for resolution of problems thereby delaying issue resolution. In addition, supervision is hardly ever able to set up a structured communication process in a partnership. Meetings that take place more or less after the event rather than before, when it might be possible to avert conflict. Such as when the component production plan does not comply with hoisting such as supervision does not conduct coordination meetings involving design, production and construction units in general beforehand it will finally results in on-site congestion of components or stop work due to waiting for materials which seriously affects the efficiency. In the context of invisible information flow, vague responsibility division and inefficient coordination between supervision entities, supervisors cannot break free from a passive state of "being drowned," leading to an inability to fulfill their fundamental function of controlling quality.

4. Solutions to Key Issues in Prefabricated Building Engineering Supervision

4.1 Building a Whole-Process Supervision and Control System for Component Production

To fix the disconnection between component production and supervision control, the traditional model of "post-event acceptance" needs to be broken and a supervision mechanism covering the entire production process needs to be established.

This is the first measure, a mixture of "stationed factory supervision + special inspections." Based on the production plan, the supervision unit takes responsibility for deploying personnel skilled in prefabricated components to the factory, where they are critical at all stages from mold to inspection of work processes: At mold acceptance stage, check consistency between mold size and drawings, focusing particularly on leaks resulting from gaps between molds; during rebar processing, real-time monitoring of cutting and tying accuracy, measuring dimensions against drawings and leveling adjustments along with stamping services or requirements.

Second, improve the sampling mechanism for production processes. Supervision personnel

should sample parts in batch of several key links such as concrete pouring and steaming curing. For example : Curing- Observing slump tests during concrete pouring to confirm the workability is in compliance with requirements; wind, temperature, humidity and duration is measured at unfavorable steam curing environment which could induce inadequate strength of components caused by improper curing. At the same time, establish a traceability file for component production, stationed supervision records key process inspection information such as "production time", raw material batch number, and key process inspection results. Each batch of components forms a one-component-one-file system to facilitate quality tracing in the future.

Lastly, improve control at the intake acceptance stage. In addition to regular visual inspection, supervision of construction needs to deploy tools such as laser distance meters or rebar scanners that utilize embedded parts and rebar distribution information. Defective components are firmly rejected to prevent defective components from entering the construction site and blocking quality risks at the source [2].

4.2 Standardizing Supervision Procedures for On-site Hoisting and Connection Joints

In response to the supervision risk from on-site hoisting and connection joints, a full-chain supervision process of "pre-approval-process control-post-inspection" should be established. Supervision must conduct review of the hoisting plan submitted by the contractor before these operations are carried out, focusing on whether equipment selection matches component weight and site conditions, whether lifting point design meets structural requirements and emergency plans cover contingencies like overturning or mechanical failure after launching at high speed. Hoisting can occur only after approval. Simultaneously confirm the qualification of hoisting operation personnel and verify lifting appliances and slings inspection report, determine that both apparatuses and personnel meet the requirements for safe operation [3].

Hoisting supervision should adopt full-time observer-style supervision, controlling hoisting operations in real time: observing the load at each lifting point during lifting to ensure that the lifting points are evenly stressed and prevent cracking of hoisted components due to stress concentration; supervising operators' control over speed and attitude during movement to prevent collisions with pylons and scaffolds or other structures; after positioning, checking if the temporary stabilization measures are adequate (e.g., angle of installation of braces, tensioning distance of guy ropes) to keep components stable when connection work is performed later, avoiding the risk of instability before initiation of proper connection.

The most important thing that supervision control needs to focus is connection joint construction. For grouted sleeve connections, supervision is required to observe the preparation of the grout, check the type and mix ratio of each batch, supervise that it be filled according to specifications and then verify internal grout fullness with endoscopes or ultrasonic testing. In the case of bolted connections, supervision shall use torque wrenches to inspect point by point the tightening torque of each bolt so that it meets design requirements. Of which, when apply sealant, observe if the sealant is continuous and there is no insufficient thickness that will cause leakage in later stage due to poor sealing.

4.3 Establishing a Multi-Party Collaborative Supervision Work Mechanism

To remedy the low supervision efficiency under collaborative multi-party, collaboration mechanism should be designed in both information sharing and responsibility coordination perspective. Build a multi-party collaborative supervision platform based on BIM technology, and combine information such as design drawings, component production plans, on-site construction schedules and design change notifications onto the platform to allow all participants to check in real time, with synchronous uploading of updates. For instance, once the design unit starts a modification the platform alerts automatically the component plant of this, as well as contractors and supervision units. It allows supervision to assess the influence of the change on production and construction as soon as possible, so that they can communicate with the plant about adjusting production plans accordingly. To prevent no avail production.

Second, set up a periodic meeting ritual to collaborate. Under the leadership of the supervision

units, weekly coordination meetings are to be held among participants from design, production, construction, transportation etc. The purpose is: Participants report on work progress and issues needing coordination; feedback from component plant with production progress and components will be ready for transport; Contractor explains the hoisting plan on site and how prepare the site for heavy lifting; Transporter reports routes/routes taken as well as delivery schedules. Supervision coordinates relative to this information, rearranging the order of component arrival to match on-site hoisting requirements and mitigate conflicts between the timing of supply and construction sequencing.

Also, specify a list of duties to be shared amongst the participants. The responsiblities of every links, for example component production as well as transporation and connection system supervision unit should carding the suitable entities. Such as the responsibility for export protection passes to the exporter, on-site lifting safety responsibilities of contractors mobile cranes designed adjustments in technical information design unit. This list clarifies responsibilities so that there is no buck-passing when the going gets tough. During the collaborative work, supervisory authorities must monitor responsibilities and track problems in a timely manner to request rectification from units that fail to perform according to their roles and ensure that collaborative work can be orderly carried out so as to improve supervision efficiency.

5. Conclusion

Well, optimizing the engineering supervision of prefabricated buildings is just an inevitable requirement for adapting to construction industrialization. The core lies in breaking the limits of the traditional supervision model. We need to form systematic solutions for key issues in component production, on-site operations, and multi-party collaboration. The proposed solutions—building a whole-process supervision system for component production, standardizing procedures for on-site hoisting and connection joints, and establishing a collaborative work mechanism—are not isolated. In practical engineering applications, you have to flexibly adjust them based on project scale, component types, and technical conditions. Doing so actually contributes to the sustainable development goals of the construction industry.

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