Problems and Solutions of Building Electrical Facilities Installation in Assembled Building Construction

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Abstract: Due to the modular characteristics of prefabricated buildings, there are many inadaptability in traditional electrical installation methods, which leads to a series of problems in design, construction, acceptance and management. This paper analyzes the causes of key problems, and puts forward systematic solutions from four aspects: design optimization, technological innovation, process improvement and management improvement. In terms of design optimization, it is suggested to deepen the standardized design system, promote the forward collaborative design of multiple disciplines, and realize the deep integration of electrical interfaces and prefabricated components. In terms of technical innovation, the precise electrical pre-embedding technology and new connection and laying materials in prefabricated components are put forward to improve the installation efficiency and accuracy. In terms of process improvement, the process control in prefabrication stage and field installation stage is emphasized to ensure the installation quality. In terms of management improvement, it is suggested to build a digital collaborative management platform for the whole process, establish a quality control system for the whole process, and realize refined management. Through comprehensive measures, the problems in the installation of electrical facilities in prefabricated buildings can be effectively solved, the installation quality and efficiency can be improved, and the safety and functionality of buildings can be guaranteed.

1. Introduction

Under the tide of global construction industry's transformation to industrialization and intelligence, prefabricated buildings have become an important carrier to achieve the goal of "double carbon" by virtue of their core advantages of standardized design, factory production and assembly construction. However, as the "nerve center" of the building, the installation of electrical system has exposed a series of adaptability problems under the assembly construction mode. The contradiction between the production accuracy of prefabricated components and the deviation of electrical pipeline embedment, the cooperative dilemma between site hoisting operation and electrical connection process, and the detection of faults by traditional acceptance criteria and new connection technology have become the key technical bottlenecks restricting the high-quality development of prefabricated buildings [1]. The particularity of the installation of electrical facilities lies in that it runs through the whole life cycle of the building. In the design stage, it is necessary to coordinate the relationship between the strong and weak current system and the building space; in the production stage, it is necessary to realize the deep integration of electrical interfaces and prefabricated components; in the construction stage, it is necessary to solve the timing conflict of multi-disciplinary cross-operation; and in the operation and maintenance stage, it is necessary to ensure the reliable operation of the intelligent system.

2. Sorting out typical problems in electrical installation

Typical problems in electrical installation are shown in Figure 1. The electrical installation of prefabricated buildings needs to strengthen coordination from the design source, carefully control

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the construction process, strictly control the acceptance link, and build an efficient management and coordination mechanism, so as to ensure the quality and progress of the project and realize the reliability and safety of the building function.

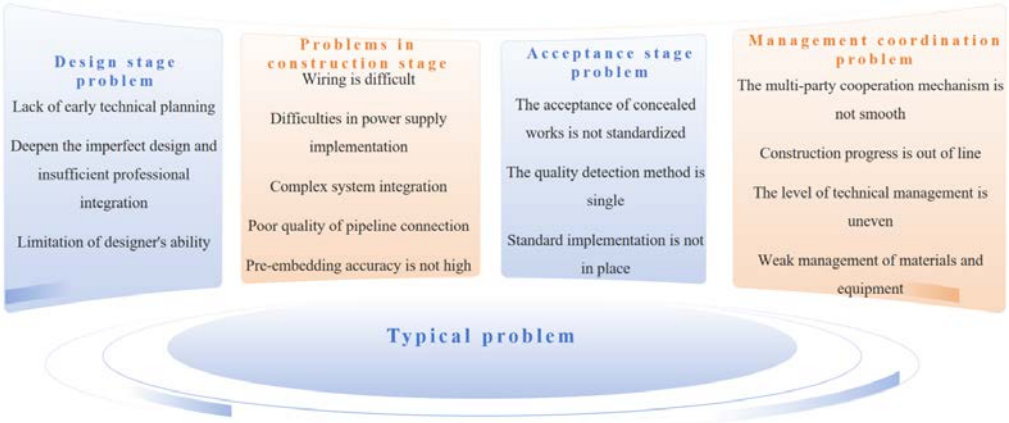

Figure 1 Illustration of typical problems in electrical installation

2.1 Design stage problem

In some projects, the pre-technical planning link was not added before the scheme design, which led to insufficient in-depth design content for the subsequent production and processing of prefabricated components, and it was difficult to achieve the goals of standardized design and factory production [2]. There are loopholes in the in-depth design of construction drawings, and there is a lack of in-depth communication and cooperation among disciplines, which leads to frequent problems such as the deviation of the position of the connection hole between the horizontal pipeline and the vertical pipeline and the displacement of the junction box. Because of accumulated errors and poor communication, it is easy to cause cross collision of electromechanical pipelines and unreasonable reserved holes. Designers don't have a deep understanding of the professional construction specifications and techniques, and there is a lack of communication among the professions within the design institute, resulting in contradictions in drawings and improper selection of materials. For example, the specifications of the selected pipes are not up to standard, the number of reserved holes in the inlet and outlet pipelines of the household box is calculated incorrectly, the knock-out holes of the embedded junction box do not match the diameter of PVC, and the insufficient buried depth of the junction box in the laminated plate leads to slurry leakage and blockage.

2.2 Problems in construction stage

The modular characteristics of prefabricated buildings limit the traditional flexible wiring methods. If the modular wiring scheme is not planned in advance, the module size is accurately measured and the wiring space is reserved, it will be difficult to complete the wiring work efficiently. Compared with the traditional power supply mode of underground pipeline or wall trough, the power supply of prefabricated buildings is facing challenges because of the characteristics of prefabricated components and assembly. Especially when the reserved holes cannot be set, the covering connection method is needed, but this method may affect the protective effect of conductor and cable. Electrical facilities need to be highly integrated with other systems, and the lack of unified interface standards will lead to difficulties in equipment interconnection and unstable signal transmission, which will affect the overall operating efficiency of the system [3]. The connection between precast concrete wall and pipeline in composite floor is prone to problems, and the material grade of PVC conduit is not enough and the connection is not firm; The thickness of the protective layer of the conduit in the composite floor is insufficient, especially for the conduit of the fire protection system; The arrangement of conduits in truss steel bars is chaotic, and the spacing is too small, which leads to the obstruction of threading. The positioning of electrical pipelines and junction boxes in prefabricated components is inaccurate, and the elevation control is

poor, which leads to the increase of gouging phenomenon of wallboard in the later period, which not only destroys the structure but also wastes materials, seriously affecting the construction quality and progress [4].

2.3 Acceptance stage problem

The content of concealed engineering acceptance record is incomplete, and the image data is not retained according to the standard, which makes it difficult to trace back later. Some projects did not strictly implement the handover inspection system, and the handover parts and process records of equipment and electrical specialty and civil engineering specialty were missing, which affected the responsibility identification [5]. Over-reliance on visual inspection, lack of advanced detection tools and methods, it is difficult to find hidden quality problems such as loose line connection and poor grounding, which makes some unqualified items flow into the next process. Failing to carry out the acceptance strictly according to the national standard "Code for Acceptance of Construction Quality of Building Electrical Engineering" and the local standard "Code for Construction Quality and Acceptance of Assembled Building Equipment and Electrical Engineering", resulting in the substandard quality of some projects.

2.4 Management coordination problem

Lack of communication and cooperation between construction, design, production, construction and supervision units and untimely information transmission make it difficult to update design changes to all links synchronously, and rework frequently occurs in construction, which delays the construction period. The mechanical and electrical specialty still uses the traditional cast-in-place structure construction method, and the coordination with other specialties is insufficient, and the construction rhythm is inconsistent, so it can not give full play to the advantages of rapid and efficient prefabricated buildings, resulting in the overall progress lag [6]. The technical level of construction enterprises varies greatly. Some enterprises lack the construction experience of assembled building electrical engineering, and their ability to apply new technologies such as BIM is weak, so it is difficult to meet the complicated requirements of pre-embedded prefabricated components and pipeline connection. The inspection of incoming materials is not strict, and unqualified materials flow into the construction site; Improper storage and maintenance of equipment will affect the service life and performance stability and increase the later operation and maintenance costs.

3. Cause analysis of key problems

In the construction of prefabricated buildings, the installation of building electrical facilities is an important link, and its installation quality directly affects the safety, functionality and future maintenance cost of the whole building [7]. The causes of key problems about the installation of building electrical facilities in prefabricated building construction are shown in Figure 2. In the electrical installation of prefabricated buildings, the causes of key problems mainly include the mismatch between design and prefabrication and insufficient precision, the lack of skills of construction personnel and the confusion of on-site management, the poor compatibility of unqualified materials and equipment, weak safety awareness and lax quality control, and the lack of coordination between disciplines and the poor cooperation of supply chain. These problems affect the workload, quality and efficiency of installation, the safety and stability in the construction process, the overall construction progress and the effectiveness of resource utilization.

Causes of key problems	Safety and quality control issues	Weak safety awareness
		Quality control is not strict
	Coordination and cooperation	Insufficient coordination among majors
		Poor supply chain coordination
	Design and prefabrication problems	Design mismatch
		Insufficient prefabrication accuracy
	Construction technology and management problems	Insufficient skills of construction personnel
		Site management is not in place
	Material and equipment problems	The material quality is unqualified
		Poor equipment compatibility

Figure 2 Causes of key problems in the installation of building electrical facilities in prefabricated building construction

The installation of building electrical facilities faces many challenges in the construction of prefabricated buildings. It is necessary to take comprehensive measures to solve these problems from the aspects of design, construction, materials, safety and coordination. By improving the adaptability of design, strengthening the skills training of constructors, selecting high-quality materials and equipment, strictly implementing safety and quality control standards, and strengthening the coordination among disciplines, the quality and efficiency of electrical installation in prefabricated buildings can be effectively improved, and the safety and functionality of buildings can be ensured.

4. Research on systematic solutions

4.1 Design optimization strategy

4.1.1 Deepen the standardized design system

Formulate the Electrical Embedded Interface Standard for Prefabricated Buildings, and specify the size, location, elevation and load requirements of electrical reserved holes/boxes/conduits for key components such as prefabricated wallboard, floor slab and balcony. Aiming at the standardized house type used in high frequency, an electrical embedded module library is established, and the optimal scheme is solidified through BIM parametric design, which reduces the later adjustment [8].

4.1.2 Promote multi-professional forward collaborative design

Relying on BIM platform to integrate professional models of architecture, structure, electromechanical (including electrical) and decoration, the "pipeline comprehensive balance" will be carried out simultaneously in the scheme stage. The key solutions are as follows: ① avoidance of electrical conduit and structural reinforcement;②The strategy of ″less pre-embedding and more post-assembly" for electrical pipelines in prefabricated components; ③ Electrical continuity design of assembly nodes (by embedding connecting sleeves or reserving post-pouring grooves). After the design is completed, the "Fabrication Drawing of Prefabricated Components" containing electrical embedded information (indicating the electrical point coordinates of each component) will be output as the direct basis for factory production.

4.2 Technological innovation path

4.2.1Precise electrical embedding technology in prefabricated components

Develop an "adjustable embedded box fixer" based on magnetic attraction/mechanical anchorage, and ensure that the center deviation of the box is ≤3mm (usually 5-10 mm in traditional cast-in-place casting) through integrated embedding of factory molds; For the conduit in the cast-in-place layer of the composite floor slab, the combination of "flexible galvanized steel conduit+positioning mesh" is adopted to prevent the concrete from deviating [9]. BIM model is used to generate "three-dimensional coordinate two-dimensional code" of electrical embedded points,

and the actual position and design deviation are compared in real time by laser scanner during on-site installation, and the out-of-tolerance item is automatically warned.

4.2.2 New connection and laying materials

Popularize thin-walled galvanized steel pipes and flame-retardant PVC electrical sleeves to meet the requirements of lightweight and transportation of prefabricated components; Research and develop "quick plug-in conduit connector" to solve the problem of low efficiency of field pipeline splicing. Set "positioning guide groove" in the embedded position of large equipment such as distribution box and weak box, and integrate sensors to feedback the embedded depth and levelness in real time; For the equipotential connection of the assembled bathroom, the "embedded copper bar+detachable terminal" is adopted, which is convenient for later debugging.

4.3 Process improvement measures

The technological core of assembled electrical installation is "pre-embedding of prefabricated components+on-site post-assembly coordination", and it is necessary to solve the problems of missing burial, dislocation and rework caused by traditional "extensive" construction through standardized operation flow and refined quality control.

4.3.1 Process control in prefabrication stage

Formulate the Operating Rules for Electrical Embedding of Prefabricated Components, and define the fixed order of boxes/conduits, including binding of structural steel bars → installation of locators → concealed acceptance criteria before laying conduits and concrete pouring; Conduct "Special Training for Electrical Embedding of Prefabricated Components" for workers, and hold relevant certificates after passing the examination. Before leaving the factory, each batch of prefabricated components shall be inspected for electrical embedment points through "3D scanning+manual review", and can be transported to the site only after passing the inspection.

4.3.1 On-site installation process optimization

For the pipeline in the cast-in-place layer of the composite floor slab, the technology of "BIM lofting+laser projector guidance" is adopted to ensure that the pipeline and the reserved interface of prefabricated components are strictly aligned; For the wire passing through the pipe at the seam of precast wallboard, use "flexible sealing sleeve" (with fire-proof and flame-retardant layer) to avoid pipeline damage caused by seam cracking. The installation of terminal equipment such as distribution box, switch socket, etc. shall be carried out in strict accordance with the sequence of "measuring and setting out (according to BIM coordinates) → basic treatment (leveling of prefabricated wall surface) → equipment fixing (using expansion bolt+lock washer) → wiring debugging", and it is forbidden to slot and make holes at will. If post-slotting is needed, it is limited to non-load-bearing prefabricated members with a depth of ≤ 20 mm.

4.4 Management promotion scheme

4.4.1 Full-process digital collaborative management

Build a "assembled building electrical installation management platform", integrating BIM model, component production data, construction schedule and quality acceptance records. The functions include: ① Design end: real-time pushing the change of electrical embedment to factories and construction units; ② Production end: the factory uploads the quality inspection image of electrical pre-embedded prefabricated components, and the platform automatically compares the design model; ③ Construction end: the field personnel enter the installation progress and problems through the mobile APP, and the system automatically sends orders to the responsible party.

4.4.2 Whole process quality control system

Control beforehand. Before construction, organize "design disclosure+training on key points of pre-embedded prefabricated components", and make clear the quality standards of each link, with the deviation of junction box ≤3mm and the sealing rate of junction box 100%;

Control in the matter. Key working procedures, such as electrical interface inspection after prefabricated components are hoisted in place, and insulation test setting "stop point" after post-installation pipeline laying, shall be jointly accepted by the supervision unit, the construction unit and the construction unit;

Post control. After the completion of the project, the electrical installation data will be entered into the building operation and maintenance database to provide accurate positioning information for later maintenance. The BIM model will be used to quickly query the prefabricated wall panel number corresponding to a certain distribution box.

5. Conclusion

In the construction of prefabricated buildings, the installation of building electrical facilities faces many challenges, including the lack of pre-technical planning in the design stage and loopholes in deepening design; Modular wiring is difficult in the construction stage, and pipeline connection is prone to problems; Incomplete records in the acceptance stage and lack of testing tools; Lack of communication and cooperation among various units in management and coordination. The causes of these problems involve mismatch between design and prefabrication, lack of skills of construction personnel, unqualified materials and equipment, lax safety and quality control, and poor coordination among specialties. Aiming at these problems, a systematic solution is put forward. In design, we should deepen the standardized design system and promote the positive collaborative design of multi-majors; In terms of technological innovation, develop accurate embedded technology and new connecting and laying materials; Process improvement needs to optimize prefabrication and field installation process; Build a digital collaborative management platform and establish a whole process quality control system in management. Through these measures, the quality and efficiency of electrical installation in prefabricated buildings can be effectively improved, and the safety and functionality of buildings can be ensured, thus promoting the high-quality development of prefabricated building industry.

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