

Analysis of the Factors Influencing the Vulnerability of the GERT Network for the Quality Chain Based on Visual Boundary Positioning for Service-Oriented Manufacturing Systems

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Abstract: As the basic element of assembled buildings, the effective control and management of the quality of precast concrete components is the key to ensure the quality and safety of assembled buildings. To strengthen the quality chain control of prefabricated components in prefabricated building projects, the paper applies the quality chain theory and the graphical review technology to the quality management of precast components and comprehensively analyzes and summarizes the quality influencing factors in the entire process of forming prefabricated components from five aspects: personnel, equipment, systems, environment, and materials. The paper also analyzes the influencing factors of GERT network vulnerability of precast component quality chain from four aspects of design, production, transportation and assembly of precast components, so as to provide reference and reference for quality chain control of precast components of assembled buildings.

1. Introduction

As a pillar industry of China's national economy, the construction industry's high-quality development is of great practical significance. However, the traditional construction side of the construction industry has high energy consumption, high pollution, low efficiency and high labor intensity, which is not conducive to promoting the healthy development of China's construction industry. In order to change the problems arising from the traditional construction production methods, the assembled construction method with reduced resource and energy consumption, reduced environmental pollution and improved quality of construction products has gained more and more attention and importance.

With the development of industrialization, the advanced technology and management methods in manufacturing industry have been continuously integrated and applied to the construction industry, gradually forming the construction method of industrialized construction represented by assembled building, which is the main path to modernize the construction industry with standardized design, factory production, assembled construction, information management and intelligent application as

its main features. It is mainly made of prefabricated components made in factories and assembled at the construction site.

As the core component of the assembled concrete structure building, effective control and management of quality of prefabricated components is the key to ensure the quality and safety of the assembled building, so the study of the quality management of prefabricated components has important practical significance and engineering practice value. The quality of prefabricated components is an important part of the structure of assembled buildings, and its quality runs through the design, production, transportation and assembly of assembled buildings, with each link interlocking to form a quality chain of prefabricated components. Compared with the cast-in-place operation in the traditional construction industry, the quality of prefabricated components of assembled buildings is formed in one or more links, and its complexity and uncertainty make it impossible to effectively control the quality of assembled buildings. Graphical Evaluation and Review Technique (GERT) is a new stochastic network technology that can perform structural model analysis for many socio-economic systems, and is widely used in project risk management, product development, predictive analysis, failure analysis, quality evaluation, etc. The quality control process of prefabricated components is extremely complex, and some traditional quality control methods are difficult to control from the whole production chain, while using GERT network model as a carrier of quality flow to study the quality control of the production chain of prefabricated components for assembly building projects will help to control each link of prefabricated components, and it is expected to discover the key links, which has certain advantages.

2. Literature Review

The developed countries abroad represented by France, Germany, Britain, the United States, Japan, Singapore, etc. have accumulated a lot of practical experience about the production of assembled building components, on-site construction and management due to the early start of research on assembled buildings and the increasing maturity of assembled building technology, and then the assembled buildings have been gradually popularized and promoted in China, and our scholars have also conducted In-depth and rich research has been conducted.

This paper compares the literature on quality management of PC components for assembled buildings at home and abroad as follows:

There are papers discussed the application of BIM models for precast concrete elements in assembled buildings [1]. These studies focused on specific areas in the life cycle of precast projects such as construction and inventory management for efficient design, fabrication and construction of precast structures [2]. Eisenbach proposed a micro-prestressure connection method for the rapid assembly and simple disassembly of concrete structural elements in assembled buildings by identifying the mechanics of structural connections, which contributes to the improvement of the lifting quality of prefabricated elements and the advancement of construction technology in assembled buildings [3]. Li et al. used system dynamics to study the relationship between the roles of the prefabricated element production supply chain, resources and schedule [4]. Gary thinks about the quality chain from the perspective of project life cycle and emphasizes the importance of identifying critical quality nodes and conducting quality inspection records or reviewing the results [5].

Zhou et al. discussed the countermeasures that should be taken for the quality management of components from the perspective of information technology in view of the current status of quality management in prefabricated component manufacturing enterprises [6]. Zhu conducted an in-depth analysis of the nodal connection technology of precast components through a series of experiments and using the finite element software ABQUS [7]. Chen et al. optimized the design of prefabricated components for assembled buildings based on the QFD-DSM model, which enhanced the information interactivity between the design elements of prefabricated components and improved

the design quality [8]. Guo took the production process of precast components as the research object, and used various methods such as principal component analysis to extract some key factors affecting the production quality, and established a quality evaluation index system for the production process of precast concrete components on this basis [9]. Gong et al. found the problems of low visualization, difficulty in real-time monitoring of production progress and production line status, and inefficient information transfer in the precast component production process, based on which he proposed a monitoring system that can perform real-time information-driven monitoring of component production [10]. He et al. showed through their study that the quality of raw materials, concrete discharging quantity, and vibrator are the main causes of defects in the appearance of precast components, and proposed corresponding prevention and control measures for these causes [11].

In summary, the quality chain management concept and method are of great reference value for the study of the quality of prefabricated components of assembled buildings with the nature of industrialized products. At present, most of the studies based on quality chain management focus on the macro quality issues of the whole construction project during the construction process, and there is still a lack of further systematic research on specific quality subjects from the micro perspective. This paper takes prefabricated components as the research object, combines its own characteristics, based on the theory of quality chain management, and conducts research around the quality of prefabricated components of assembly building projects, which has certain guiding significance for improving the quality of prefabricated components of assembly building projects.

3. Influencing Factors of GERT Network Vulnerability in the Quality Chain of Prefabricated Components of Prefabricated Building

The production of prefabricated components for assembled building projects is usually industrialized and completed by factory processing, but they are different from ordinary manufacturing products, which is due to the fact that prefabricated components need to be custom designed according to the assembly needs of each building project, and the production of components also has to be coordinated with the construction progress of the project, so prefabricated components for assembled building projects generally cannot be produced in single pieces, nor can they be. Therefore, the prefabricated components of assembly building projects cannot be produced in single pieces, nor can they be completely mass produced. In view of this, this paper analyzes the factors influencing the vulnerability of GERT network of prefabricated components quality chain in design, production, transportation and assembly of assembly building projects.

3.1. Design Session

3.1.1. Deepening Design of Prefabricated Components

Prefabricated component deepening design means refining, supplementing and improving the design drawings, so that the information of the drawings can be expressed accurately and the components can meet the requirements of design, production and construction site installation. The deepening design of prefabricated components can ensure the quality and performance of components, improve construction efficiency and safety, and reduce construction cost and risk. Therefore, it is necessary to take full account of the actual situation and demand when deepening the design and adopt a scientific, reasonable and feasible design plan.

3.1.2. Prefabricated Component Detail Design

Component detail drawings are mainly used as production shop processing and assembly, according to the steel structure design drawings and component layout drawings using a larger

proportion to draw, all types of large and small parts of the components should have detailed numbering, size, hole positioning, beveling practices, plate assembly details, weld seam details, and should be provided in the component detail drawings parts material table and this figure of the component processing instructions required, the material table should contain at least part number, thickness, specification, quantity, weight, material, etc, Thickness, specifications, quantity, weight, material, etc. In the expression can be used front view, side view, axial side view, cross-sectional drawings, index details, parts details, etc. Each component number should correspond to the component lay out, the parts should be as far as possible in the order of the main and secondary parts number. Component details should be positioned in the size, elevation control and parts positioning, component center of gravity position, etc. Components should be drawn as far as possible according to the actual size of the drawing, the slender components, in the direction of length and width can be drawn using a different ratio. For the oblique size should indicate the slope, when the member is multi-arc section, should indicate the radius of curvature and arc height. In a word, the depth of expression of the detailed drawing design of the components should be to meet the minimum requirements for the processing and production of the components, in the drawing expression should be as detailed as possible.

3.2. Production Chain

3.2.1. The Quality of Raw Materials Such as Concrete and Reinforcing Steel

Prefabricated components production of raw materials quality, directly affect the quality of prefabricated components, the national construction authorities require the construction materials used in the project before use must have factory certification, factory inspection reports and other relevant information, and to be required to carry out re-inspection. The current standards and test procedures, the construction materials test sampling method, sampling frequency, sampling representative quantity are clearly specified. However, due to the uneven level of sampling personnel, the lack of in-depth understanding of the performance of construction materials and the test methods and quality assessment standards, or out of economic interests, the lack of representativeness of material sampling, sampling frequency is not enough, the number of representatives is not exact, resulting in test results can not reflect the actual situation more comprehensively, so that some of the unqualified construction materials due to omission of inspection, leaving a risk to the quality of prefabricated components.

3.2.2. Stability of Production Line Equipment

Equipment is relatively stable in the process of component production and is a source of risk that can be reasonably controlled. The factors affecting the quality of prefabricated components in equipment risk include not only advanced and professional equipment, but also reasonable maintenance cycle and professional maintenance personnel. Generally multi-functional production lines can produce some common planarized components such as beams, columns, balconies, etc. There are also some specific production lines for different sizes of sandwich insulation, exterior wall pegboards, laminated double-sided walls, etc. Different maintenance measures should be adopted for different production lines to ensure the quality of production equipment. The advanced nature of the equipment, whether the use of equipment operation is appropriate, whether the equipment is maintained on time, etc. are possible risk points.

3.2.3. Production Line System Program

System program risk refers to whether the production program and management system developed by the enterprise are reasonable, which must be done before the enterprise formally put into production technical delivery and program acceptance work. The management system is the

foundation of the long-term development of an enterprise, and the management of the enterprise should be highly vigilant and fully adopt the opinions of the staff to fix the loopholes of the management system in time. Specifically, it includes whether the design scheme at different stages is reasonable, whether the production scheme is reasonable, whether the inspection scheme is reasonable, whether the transportation scheme is reasonable, etc. The product quality traceability of prefabricated components and product quality standards will have a long-term impact on the quality of prefabricated components.

3.3. Transport Links

3.3.1. Component Transportation and Loading and Unloading Program

The timely delivery of assembled prefabricated components will directly affect the progress of construction, which is closely related to the interests of construction units and developers. Therefore, the distribution management of prefabricated components of assembled buildings will affect the whole construction process, which is very important to both the builders, developers and prefabricated component manufacturers. Therefore, the study of the distribution scheme of prefabricated components of assembled buildings will effectively reduce the probability of early or late delivery, reduce the cost of secondary handling or waiting for unloading, thus reducing the cost of using prefabricated components, and finally make the prefabricated component manufacturers, constructors and developers get the most satisfactory results, which will help China's construction industrialization process and upgrade the residential industry.

3.3.2. Component Transportation Fixing and Protection Measures

According to the background of strong national support for the development of assembled buildings at this stage, it has brought the opportunity for prefabricated processing enterprises to flourish, leading to the diversification of prefabricated components. At this stage, the general prefabricated components mainly include prefabricated walls, slabs, columns, beams, stairs, balcony slabs and other types. The distribution method and protection method chosen by the enterprise are directly related to the quality problem and cost of the finished products, so avoiding non-essential losses in the transportation stage and reducing the cost in transportation can reduce the waste of resources and also improve the competitiveness of the enterprise.

3.4. Assembly Link

3.4.1. Construction Personnel Risk

Personnel is the most unstable factor in the construction process of assembly building projects, and is a risk source prone to quality problems. According to the specialization and industrialization of prefabricated components, it is known that the overall requirements for the professional quality of employees involved in the construction of assembly building projects are high, while the development of assembly building in China is still in the primary stage, the overall quality of workers are not very high, coupled with the enterprise's pursuit of production speed and profit, often lack of training of relevant business knowledge of employees, the workers' work attitude is less positive, in a certain degree of risk to the quality of the project.

3.4.2. Component Connection and Fixing Technology

As a kind of building development method with functions of earthquake resistance, energy saving, heat preservation and fire prevention, assembled building is constructed by producing building materials as prefabricated components and combining these prefabricated components by

construction units at the construction site, which is an important direction of modern building structure development. The key point to ensure the integrity of the assembled structure is the connection quality of the prefabricated components. The overall performance of the assembled building and the reliable connection performance of the prefabricated elements are the key to the assembled structure, and the connection quality between the prefabricated elements closely affects all kinds of performance, such as the workability and durability of the node connection, which will have a direct impact on the reliability of the connection between the prefabricated elements and the safety of the overall structure.

4. Conclusion

As the basic components of assembled concrete buildings, the effective control and management of the quality of precast components is the key to ensure the quality of assembled buildings. This study focuses on the quality of precast components of assembled buildings, applies the quality chain theory and the graphical review technique to the quality management of precast components, analyzes the factors influencing the vulnerability of the GERT network of precast component quality chain from four aspects of precast component design, production, transportation and assembly, and comes up with: deepening design of precast components, detailed design of precast components, quality of raw materials such as concrete, steel production line equipment stability, production line system scheme, component transportation and loading and unloading scheme, component transportation fixation and protection measures, construction personnel risk, component connection fixation technology, etc. are important influencing factors of precast component GERT network vulnerability. This paper is a guide to further deepen, expand and improve the content system of precast component quality management research.

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