

# A Review on Quality Management of Prefabricated Buildings

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## Abstract

This paper reviews the research on quality management of prefabricated buildings at home and abroad. In this paper, the literature reading method is used to summarize the development of prefabricated buildings at home and abroad, the research status of quality management, and the quality management of prefabricated buildings. The conclusion is that the quality management of prefabricated buildings is very necessary. Finally, combined with the development of prefabricated buildings in China, this paper puts forward the conclusion that it is necessary to further study and establish a perfect quality management mechanism in order to better promote prefabricated buildings.

## Keywords

Prefabricated Buildings, Quality Management, Literature Review

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## 1. Introduction

Different from traditional cast-in-place buildings, prefabricated buildings have the advantages of short construction cycle, high production efficiency, energy saving and environmental protection (Zhang et al., 2020). These advantages respond to the requirements of green buildings and sustainable development in China. In many developed countries, prefabricated buildings have developed mature. At present, Chinese buildings are still based on the traditional cast-in-place concrete buildings, but there are many disadvantages in the construction of cast-in-place buildings, such as greater construction noise, more construction waste, poor construction environment and so on. And these shortcomings may affect the life of the residents around the construction site. The assembly construction mode completes the production, processing and maintenance of components in the component factory in advance, and then delivers them to the

construction site by means of transportation for installation and splicing. Compared with cast-in-place buildings, it is more environmentally friendly and construction environment is better, and the prefabricated construction mode has a relatively short construction period. Thus, prefabricated buildings are more in line with China's concept of green development. However, the development of prefabricated buildings in China started late, and the quality management of prefabricated buildings has not formed a perfect system. This hinders the promotion of prefabricated buildings in China. Quality is the core of a construction project. Therefore, quality management is very important, and it is also very important for the development of prefabricated buildings. Therefore, the research on the quality management of prefabricated buildings is of great significance.

This paper investigates the relevant research contents of prefabricated building quality management at home and abroad. Firstly, the research situation of prefabricated building is sorted out. Secondly, it investigates the research situation of prefabricated building quality management abroad. Thirdly, it summarizes the research situation of prefabricated building quality management. Finally, it points out the problems existing in the quality management of prefabricated buildings in China, and puts forward further research directions in order to promote the development of prefabricated buildings in China.

## 2. Literature Research

### 2.1. Research on Prefabricated Buildings

Prefabricated buildings are buildings obtained by assembling prefabricated components on the construction site. These prefabricated components are produced, processed and maintained by prefabricated component factories (Tam et al., 2007). The prefabricated construction mode can solve the problems of on-site construction and better control the quality of construction. Moreover, the prefabricated construction mode can protect the surrounding environment, reduce the occurrence of engineering accidents, and effectively shorten the construction period to a certain extent (Jaillon & Poon, 2009). Because of these advantages, prefabricated buildings have been widely used. Based on this, many foreign scholars have carried out in-depth research on prefabricated buildings. Pavese systematically expounded the theory of prefabricated structure system, empirically analyzed the structural performance of prefabricated buildings, and determined the correlation between structural performance and various factors (Pavese & Bourna, 2011). Fard's research focuses on safety management in the construction stage and puts forward suggestions to improve the safety of production and construction of fabricated building components (Fard et al., 2017). Hwang developed a decision support system to calculate the volume of prefabricated building components through theoretical analysis and practical simulation (Li et al., 2019). Kasperzyk proposed an automatic system that can dismantle and reorganize prefabricated buildings (Kasperzyk et al., 2017). Jaillon's research

compares several different structural types of buildings and finds that the use of prefabricated buildings can shorten the construction period and improve the construction efficiency (Jaillon & Poon, 2009). Teng's research focuses on the environmental friendliness of prefabricated buildings. Combined with carbon emission and the whole life cycle of buildings, it is concluded that prefabricated buildings have less carbon emission in the whole life cycle and stronger ability to protect the environment (Teng et al., 2018). Loss discussed the application of mixed building materials in prefabricated buildings, and put forward a new direction of mixing wood and steel structure (Loss et al., 2016a).

## 2.2. Research on Quality Management

The international quality standard ISO9000:2000 defines quality as follows (Gagnon, 1997): "quality refers to the degree to which a set of inherent characteristics meet the requirements", and the definition is marked at the same time. 1) Quality can be modified by adjectives excellent, good, poor, etc. 2) Inherent and given are the opposite. It refers to something inherent in something, especially the permanent characteristic. Generally speaking, the content of quality management covers the planning of the organization's quality strategy, the allocation of resources, and systematic activities. Quality management has a very important role and broad intelligence. Therefore, quality management in quality management belongs to the function of managers at all levels, needs to be led by the highest leadership.

Foreign research on construction quality management started earlier and developed more mature (Table 1). Moody believes that the essence of construction engineering is quality management. In the construction quality management, it is necessary to realize the harmony and unity of all elements. To comprehensively consider the construction quality management, based on quality management to promote the improvement of construction quality. Quality management can not only create economic benefits, but also promote the development of enterprises (Moody & Shanks, 2003). Through research, Thomas and other scholars found that work quality is the premise to ensure product quality. The most direct impact on product quality is the quality of work. Based on this, the construction

**Table 1.** Research on quality management.

Research contents	Literature author
1. Quality management is the core of construction engineering.	(Moody & Shanks, 2003), (Ng et al., 2012), (Akinci et al., 2006)
2. Formulating construction specifications and improving construction technology can improve the quality of construction projects.	(Dweiri & Kablan, 2007), (Vonder et al., 2007), (Chen & Wang, 2006)
3. Improving quality management can improve the economic benefits of enterprises and realize sustainable development.	(Srivannaboon & Milosevic, 2007), (Jung et al., 2009), (Thompson et al., 2007)

management of construction project quality runs through all stages of the project, including the management and control of the project quality and work quality of the main participants in the project. At the same time, every post of the construction unit must pay attention to the quality function, so as to give full play to their respective roles (Ng et al., 2012). Dweiri and other scholars believe that in order to improve the quality of construction projects, we should build a system to ensure the construction quality of construction projects. The construction quality control ability of construction engineering can be improved by formulating the construction quality specification of construction engineering (Dweiri & Kablan, 2007). Vonder mentioned in the study that the influence of construction technology on the quality management of construction projects is very important. The purpose of ensuring the quality of construction projects is to pay full attention to the advancement and applicability of new technologies, materials and techniques in the construction process. So as to ensure the continuous improvement of construction technology and technical level, and then improve the quality of construction engineering (Vonder et al., 2007). Through research, Akinci pointed out that the goal of quality control is that quality management can achieve the expected effect. Therefore, in quality control, it is necessary to make quantitative analysis of the test results on the basis of quality testing. In this way, the problems existing in construction quality management can be solved effectively (Akinci et al., 2006). Chen believes that the construction quality is closely related to national property safety and people's life and property safety. To continuously improve the construction quality level of construction engineering, it is necessary to establish a quality assurance system of the whole process of the project (Chen & Wang, 2006). Srivannaboon research points out that based on the long-term goal, the key content of engineering project management is construction quality management. Construction quality management plays a direct role not only in the success or failure of the whole construction project, but also in the sustainable development of enterprises. Based on this, in order to realize the development of enterprises, construction enterprises must build a construction quality management system with their own characteristics (Srivannaboon & Milosevic, 2007). Jung's research points out that management is a kind of productivity. Therefore, enterprises need to build a strict quality management responsibility system and quality assurance system. So as to strictly control every link in the construction process. At the same time, each part of each subdivisional project in the construction process is refined, so as to clarify the responsibility of quality management, so as to carry out comprehensive quality management for the construction quality management of construction engineering (Jung et al., 2009). Thompson pointed out through research that the core and focus of enterprise management is quality management, and the development of enterprises is inseparable from quality control. The development of enterprises must be based on the business strategy of quality-oriented economic development, and constantly strengthen the management of quality. For

construction projects, quality management runs through the whole life cycle. So as to continuously improve the economic benefits of the enterprise and realize the sustainable development of the enterprise (Thompson et al., 2007).

### 2.3. Foreign Research on Quality Management of Prefabricated Buildings

Many scholars have put forward valuable opinions on the quality management of prefabricated buildings. They found out the factors affecting the quality management of prefabricated buildings (Table 2). Specifically, in terms of prefabricated construction project management, Jabar et al. Deeply analyzed and excavated 50 relevant documents on prefabricated construction quality management worldwide from 2000 to 2012, and divided the influencing factors of the construction stage into three periods: the first, the middle and the second (Jabar et al., 2013), including: 1) the early stage of construction: the cost is high; Large working volume; Lack of relevant mechanical equipment and testing facilities; Lack of professional prefabricated parts production and installation personnel; The specification and experience of production personnel are not up to standard; Lack of coordination and cooperation among all parties in the early stage. 2) Mid construction period: technical workers lack relevant experience; Poor emergency handling capacity; Less on-site assembly experience; Low efficiency of construction management; Lack of cooperation and communication among project

**Table 2.** Factors affecting the quality management of prefabricated buildings.

Factors	Literature author
1. Cost of prefabricated buildings	
2. Prefabricated building construction technology	
3. Professional quality inspection equipment	
4. Relevant experience of Engineering Manager	
5. Coordination and cooperation of participants	
6. Weather environment	
7. Unreasonable component installation	(Jabar et al., 2013), (Murray et al., 2003),
8. The space for installation on the construction site is limited	(Loss et al., 2016b),
9. The handover of procedures during construction is ambiguous	(Mohammad, 2013), (Marasini et al., 2001)
10. Rough schedule and work arrangement	
11. Unqualified production materials	
12. Lack of experience of quality inspectors	
13. Relevant policies are not perfect	
14. professional and technical personnel	
15. preliminary planning	

participants; Bad weather affects the transportation of prefabricated products; Unreasonable component installation; The space for installation on the construction site is limited; The handover of procedures during construction is ambiguous; The quality inspection personnel lack of inspection on the process, resulting in poor quality control results, etc. 3) Later stage of Construction: there are defects in the project function; Unsightly; Defects in quality. From the perspective of macro environment, Murray and other scholars pointed out that the relevant factors affecting the quality of prefabricated construction projects are: insufficient management organization and market strategy; The schedule is rough and inconsistent with the actual work arrangement; Lack of mechanization and electronization; Each stage is independent and lacks the participation, discussion and communication of relevant parties; Failure to use advanced technology such as BIM and advanced production process for design and construction; Lack of good cooperation from all parties involved in the construction process; Relevant risk management measures are not taken seriously; Lack of effective management of project supply chain. This study has certain reference value (Murray et al., 2003). Loss pointed out through research that the factors affecting the construction quality of prefabricated buildings include: lack of experience of managers and immature personnel technology; Unqualified production materials; the mechanical equipment is not advanced; Inadequate management; lack of experience of quality inspectors (Loss et al., 2016b). Through his own experience, Mohammad conducted a qualitative study on the influencing factors of prefabricated building quality management, and the analysis results include the following reasons: the relevant policies and regulations are not perfect; Lack of relevant project quality inspection system; Immature industry environment; The project management mode is not mature; Lack of relevant management and technical personnel in the industry; The industry technology is not mature; The emergency mechanism for project quality problems has not been established; Lack of preliminary planning and feasibility study (Mohammad, 2013).

Moreover, many scholars also have in-depth discussions on the quality management of prefabricated buildings (Table 3). From the perspective of comprehensive utilization of prefabricated components, Jailon deeply studied the recycling of prefabricated components, fittings and formwork in the field of prefabricated buildings. For example, the plastic template used in production, due to its excellent flame retardant, anti-corrosion, water resistance and corrosion resistance, can be crushed into powder after repeated use, and then processed into a new template as raw material for use, which greatly reduces the cost on the template (Jaillon & Poon, 2009). Tam wrote in his article that if a project uses a large number of prefabricated components and parts, the transportation and installation of prefabricated components and parts may greatly prolong the construction progress, because most of the prefabricated components are transported from the manufacturer to the construction site. In this process, if there is no effective route planning and management, the project progress will be greatly

**Table 3.** Research on quality management of prefabricated buildings.

Research contents	Literature author
1. Only when workers master construction skills can they ensure the progress and quality of prefabricated construction projects	(Tam et al., 2007)
2. The storage mode of prefabricated components is very important for the quality management of prefabricated buildings	(Marasini et al., 2001)
3. The combination of RFID and BIM Technology can better realize the quality management of prefabricated buildings	(Motamedi & Hammad, 2009)
4. Apply AR and BIM Technology to quality management and schedule management	(Behzadan et al., 2011)
5. BIM and repcon are linked in two directions to simulate the project progress and effectively control the construction quality of prefabricated concrete buildings	(Staub-French et al., 2008)

affected, which is more time-consuming than the traditional cast-*in-situ* construction method. As for the technical training of construction personnel, because the prefabricated building is very different from the traditional cast-*in-situ* building in many construction processes, it involves that workers need to further learn the machine operation and installation skills in the on-site construction and installation stage. Only workers master the construction skills can ensure the project progress and quality (Tam et al., 2007). In terms of safe storage of prefabricated components, Marasini and other scholars pointed out that prefabricated components are often stacked on unsafe sites due to the lack of experience of inventory managers and the inability to select appropriate storage locations. This is not only detrimental to the protection of the integrity of prefabricated components, but also detrimental to the safety management of the construction site (Marasini et al., 2001). Ismail and other scholars collected opinions on the factors affecting the construction quality by issuing questionnaires to well-known experts in the field of prefabricated buildings and construction industrialization in Malaysia, and divided them into five categories: management factors, workplace factors, work team factors, on-site safety factors, materials and construction machines and tools factors. Site safety factors: quality problems caused by safety problems. The factors of materials and construction machines and tools are mainly the impact of the quality of materials and construction machines and tools and the incorrect operation method of construction machines and tools on the project quality (Ismail et al., 2012). This study will make up for this deficiency. Motamedi proposed that the data stored in the RFID tag represent the information in the BIM database, and conceptually designed the data format in the RFI tag in this method, and conducted a verification study on the life cycle management of HVAC system and fire protection system in the business school building of Concordia University, which partially verified the feasibility of the proposed method, making the information acquisition and

access of construction components more convenient (Motamedi & Hammad, 2009). By applying augmented reality technology in civil engineering teaching, Behzadan described the application of AR (augmented reality) technology combined with BIM Technology to quality management and schedule management of engineering construction, and put forward relevant software and hardware requirements for the application of AR technology (Behzadan et al., 2011). Sherl used msaccess to associate the BIM model with their self-developed project schedule management program repcon in a two-way way to realize the schedule simulation of the project. Any schedule adjustment can be displayed through 4D simulation, so as to effectively control the construction quality of prefabricated concrete buildings (Staub-French et al., 2008).

#### 2.4. Domestic Research on Quality Management of Prefabricated Buildings

China's research on the quality management of prefabricated buildings started relatively late. Although the state strongly supports the development of prefabricated buildings, the development of domestic prefabricated building market is not mature, and the standard system is not perfect. Most of the research still stays in the preliminary stage and needs further in-depth discussion (Tam et al., 2007). In China, the government has taken corresponding incentives to improve the situation. It is proposed that by 2026, the share of prefabricated buildings in new buildings should account for 30% (Wang et al., 2019). The quality of prefabricated buildings can be divided into the following three parts: building entity quality, production process quality and management system quality (Mao & Xu, 2011). Zhang believes that the project management of prefabricated building construction includes three main control objectives, namely quality, schedule and cost. There is no doubt that quality management is particularly important in the construction of prefabricated buildings (Zhang & Tsai, 2021). Because the production quality of prefabricated components will directly affect the building itself to a great extent. Once the prefabricated building has quality problems, it will cost a lot of cost for maintenance, and may even shorten the service life of the building. Secondly, the quality of prefabricated buildings is closely related to users' use feeling and personal safety. More importantly, if prefabricated buildings frequently produce quality problems, it will directly affect the market recognition of prefabricated buildings, and then affect the development of prefabricated buildings. Therefore, we must pay attention to the quality management of prefabricated buildings and promote the rapid and stable development of prefabricated buildings in China (Zhang & Tsai, 2021). Compared with the traditional cast-*in-situ* concrete buildings, the quality management of prefabricated buildings is more challenging. Because the construction methods of prefabricated buildings are different, and this construction mode has just started in China, there is a lack of sufficient cases for reference. The construction method of prefabricated buildings is easy to cause quality problems such as on-site con-

struction mismatch and affect the project progress. In addition, there are few literatures on the quality management of prefabricated buildings. China has not formed a perfect quality management theory in this regard, which seriously limits the healthy development of prefabricated buildings (Hong et al., 2018). Quality problems in prefabricated buildings usually cause many adverse effects, such as responsibility disputes, delay in construction period, resulting in increased cost, etc. (Mao et al., 2016).

### **2.5. The Summary of This Chapter**

This chapter introduces the research status of prefabricated building, and then introduces the research status of quality management. On this basis, the research on quality management of prefabricated buildings by domestic and foreign scholars is summarized. The research limitations and future prospects mentioned in the following paper are introduced.

### **3. Limitations of Research**

Whether the quality of buildings is guaranteed has always been a key issue in the construction industry. Prefabricated buildings have been well developed in foreign construction markets such as the United States, Europe and Japan. Therefore, the research on the quality management of prefabricated buildings abroad is also carried out earlier. Relatively speaking, the quality management of prefabricated buildings to form a certain system. However, the research on the quality management of prefabricated buildings in China is still insufficient. The existing research mostly stays in the qualitative description, lacks quantitative analysis and relevant case verification, and the research results lack scientificity and reliability to a certain extent. It is found that there are still deficiencies in the discussion and solutions of the factors affecting the quality management of prefabricated buildings in China. In the future research, we can increase the discussion on these aspects.

### **4. Conclusion**

This paper reviews the research progress of prefabricated building quality management at home and abroad. This paper adopts the method of literature reading to summarize the development of prefabricated buildings at home and abroad, the research status of quality management and the quality management of prefabricated buildings. It is found that it is very necessary to carry out quality management for prefabricated buildings. At present, China's prefabricated building is vigorously promoted, quality management cannot be ignored. We must pay more attention to the study of prefabricated building quality management. From the comparison of domestic and foreign literature, it is found that there are few researches on prefabricated building quality management in China.

Compared with cast-*in-situ* buildings, prefabricated buildings have many advantages and are more in line with the environmental protection requirements

of green buildings in China. Therefore, they should be vigorously promoted. However, at present, the market recognition of prefabricated buildings in China is not high, mainly because residents have limited trust in their quality. Therefore, in the future research, we should deepen the exploration of quality management of prefabricated buildings, so as to better promote prefabricated buildings in China.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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