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# *Risk Management of Supply Chain in Prefabricated Buildings: A Case Study of Leishenshan Hospital*

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***Abstract:*** Based on the research of other scholars, this article divides the prefabricated building supply chain into six stages: design and development, production procurement, warehousing and transportation, lifting construction, and facility recycling. Taking the well-known prefabricated building of Leishenshan Hospital as an example, this study analyzes the possible risks of these six stages in the prefabricated building supply chain, such as insufficient design capabilities, production efficiency, the low standardization level of molds, transportation policy constraints, insufficient protection of components during the warehousing and transportation stage, insufficient organizational capacity, inadequate supervision, and problems such as missing recycling processes. Due to the special nature of Leishenshan Hospital, which has received great attention, some risks that have been avoided due to special reasons have been proposed, and the power of management personnel has been strengthened for these risks, digitization and standardization of molds, and strengthen on-site management level. From this study, construction, component production, and design enterprises can learn from measures such as increasing awareness of component recycling.

***Keywords:*** Prefabricated buildings, Supply chain, Risk management, Leishenshan Hospital

## 1. Introduction

Prefabricated buildings can alleviate the shortage of labor resources to a certain extent, help enterprises improve their ability to control construction quality and schedule, and make significant contributions in reducing the use and pollution of energy resources, providing strong support for the sustainable and healthy development of the construction industry [1]. As an important component of the construction development industry chain, the prefabricated building supply chain refers to the joint participation of various construction-related enterprises in the construction process of projects, a specialized division of labor based on their positioning, and simultaneous cooperation [2]. The construction quality, operation, and sales level affect not only the personal and property safety of project participants but also the stability of people's lives and the development of the national economy. It actively promotes prefabricated buildings in China, and supply chain management is an important way for participating enterprises to enhance their strength, transform, and upgrade. Supply chain risk management is an important component of supply chain management. Effective supply chain risk management is conducive to timely taking positive response measures to risks, adjusting the supply chain structure, improving resource integration advantages, improving supply chain operation safety, and accelerating the healthy development of prefabricated buildings. This research

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is based on this background to conduct research. Taking Leishenshan Hospital as an example, risk identification and evaluation analysis of the prefabricated building supply chain are carried out, which is beneficial for engineering units better to manage the risk of the prefabricated building supply chain, assume the responsibility of supply chain risk control, leverage the advantages of supply chain management, and promote the healthy development of prefabricated buildings.

Generally speaking, a prefabricated building is a new building model whose core feature is to prefabricate building components in the factory and then assemble and install them on-site. Compared to traditional construction methods, prefabricated buildings have obvious industrial characteristics [3]. By precisely processing various components in the factory, the quality and accuracy of the components can be effectively guaranteed, thereby improving the overall construction quality of the building [4]. Prefabricated buildings mainly include prefabricated concrete structure buildings, steel structure buildings, modern wooden structure buildings, etc. They adopt standardized design, factory production, information management, and intelligent applications to transfer much on-site work from traditional construction methods to factories.

The definition of prefabricated building supply chain by domestic and foreign scholars is as follows: The first definition starts from the demand perspective, incorporating information flow, material flow, and capital flow from a series of processes such as bidding, project initiation, and acceptance, and is a functional and dynamic alliance composed of different stakeholders. The second definition is led by the general contractor, who controls the flow of information, materials, and funds and combines the production relationships of different enterprises in the production process to achieve joint operation, thus forming a functional network structure [5].

From the perspective of the supply chain, risk management of prefabricated buildings can effectively compensate for the shortcomings of traditional risk management in dealing with small probability risks and cascading risks, enhance the risk response ability of prefabricated building supply chains, and thus improve the level of prefabricated building supply chain management.

## 2. The Reasons for choosing Leishenshan Hospital as the Research Target

Leishenshan Hospital is located in Huangjiahu, Jiangxia District, Wuhan City, with a building area of 6 * 104 square meters and a total of two buildings [6]. Wuhan Leishenshan Hospital is designed and constructed using prefabricated steel structures. The hospital mainly includes several functional areas, such as a medical housing area, medical security area, and medical auxiliary area, designed according to infectious disease hospitals' standards. In a very short period, the design team fully utilized the unique advantages of prefabricated buildings. After optimizing the overall layout, they carried out a modular integrated design on the structural system, peripheral protection system, equipment pipeline system, and interior system of prefabricated buildings, according to the requirements of rapid industrial construction. Using BIM information management technology and the joint efforts of all participating parties, they completed the construction of such a special engineering project of global concern [7]. A project with a normal construction period of 2 years was completed in just 12 days in history [8].

The Leishenshan Hospital was led by the China Construction Third Engineering Bureau, a relatively senior institution in China. Coupled with the special period and the attention of the whole country, it has effectively avoided many risks in the supply chain of prefabricated buildings. The problems that exist in this project are a common problem in the supply chain of prefabricated buildings. In addition, the risks avoided due to special attention should also be those that would normally occur. Therefore, some risks the project avoided during the risk research phase for special reasons will be proposed.

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## 3. Supply Chain Risk of Prefabricated Buildings Based on Leishenshan Hospital

According to the research, the prefabricated building supply chain can be divided into the following stages: design and development stage, production and procurement stage, warehousing and transportation stage, lifting construction stage, and facility recycling stage [9].

### 3.1. Design and Development Phase

Zhongnan Architectural Design Institute, a state-owned enterprise with extensive experience in prefabricated building design, carries out the design of Leishenshan Hospital. However, there are still areas for improvement in connection methods and waterproofing engineering during the design phase [10]. This has led to an increase in construction time and leakage issues during the practical stage.

From this, it can be seen that the biggest risk in the design stage of prefabricated buildings is the current need for more design capabilities in China. Insufficient design capability may lead to increased construction difficulty or inability to carry out construction, among other consequences.

### 3.2. Production and Procurement, Storage and Transportation Stage

Generally speaking, there should be drawbacks in these two stages, such as insignificant production advantages, low production efficiency, low standardization of molds, transportation policy constraints, and insufficient protection of components during the warehousing and transportation stage [9].

However, because Leishenshan Hospital is a special prefabricated building built during the special epidemic period and directly led by the state, coupled with the free assistance of major enterprises such as PetroChina, many possible risks have been eliminated and invisible. If transportation policies constrain this risk, at that time, China Railway Construction Corporation (CRCC) prioritized the release of construction-related materials for highways, which led to this risk being avoided. However, these risks need to be noted in normal prefabricated building construction.

### 3.3. Hoisting Construction Phase of Leishenshan Hospital

At this stage, due to the large amount of work, multiple functional requirements, and tight construction schedule of the Leishenshan Hospital project. The command center of Leishenshan Hospital is facing difficulties such as urgent time, limited personnel resources, and numerous participating units, which greatly tests the organizational ability of the command personnel. This resulted in an average construction time of only 3 hours per person for 300 construction workers. Due to the urgency of time, there are no transportation and installation conditions for large-scale equipment on site [11]. This resulted in workers having to transport and install by hand. This is a problem caused by insufficient organizational capacity.

However, at this stage, the project also effectively avoids a type of risk - regulatory issues. Generally speaking, there may be some risks in the construction supervision part due to the need for more effective supervision over key nodes, hidden areas, and others. However, due to the live broadcast of Leishenshan Hospital, which is supervised by the audience, the usual regulatory issues need to be highlighted.

### 3.4. Recovery Phase

In the data search process, no relevant information was collected, meaning the Leishenshan Hospital project is unavailable for collection. However, recycling construction waste is important for the construction industry to save resources and protect the environment. It is also one of the methods

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investors use to recover funds. As a relatively large project, it is regrettable that Leishenshan Hospital did not proceed with this stage.

Of course, this is more than just a problem with this project. Currently, garbage recycling technology needs to meet the requirements of the reverse supply chain in the Chinese market. The constraints of traditional thinking and weak environmental awareness hinder the development of construction recycling technology.

## 4. Risk Countermeasures for Supply Chain Management of Prefabricated Buildings

### 4.1. Risk Countermeasures during the Design and Development Phase

Based on production equipment and modular requirements, some requirements are divided into modular universal products to meet mass production needs and large-scale supply. This requires continuous practice and summary, selecting component product series with wide applicability, high technological maturity, and a simple process. Summarize a directory of universal component products to provide a reference for design enterprises and form a series of product supply capabilities. In addition, based on the characteristics of serialized component products, construction enterprises can establish and improve proprietary organizational management and process methods through practice and improve project efficiency through intelligent construction.

In addition, according to the level of regional technological development and industrial supporting capacity, promoting component series products with regional characteristics according to local conditions can effectively reduce the complexity of the supply chain. Implementing the “Three Board” system in Jiangsu Province in 2017 is a good practice based on industrial capabilities [12]. It will greatly improve industry product generalization if several sets of cost-effective component product series can be formed.

### 4.2. Risk Countermeasures for Production and Procurement, Storage and Transportation Stage

Faced with the impact of the epidemic and the international situation, practitioners in the construction industry should recognize that the security of the industrial chain and supply chain is related to the stable development of the industry. Supply chain management is not just about purchasing products but also an important bridge for collaborative design, production, construction, and recycling. Especially for prefabricated building supply chain management, it is necessary to connect well with design, production, and construction needs. It is recommended to establish supply chain management positions within the enterprise and improve the position of management personnel in coordinating various links, supplier management, demand forecasting, etc., establish a sound responsibility management system, and play the role of supply chain management in these four stages.

In addition, supply chain management can also be included in the scope of project total benefit allocation, that is, design, production, construction and other links can be integrated into a unified management framework. If the engineering general contracting management mode is adopted, and during the bidding stage of the general contracting project, the bidding unit must clarify the component supplier and include indicators such as component product quality, warehousing and transportation, and post-service in the project indicators. The overall project benefits are linked to production, transportation, and other performance, so the design, production, and construction stages work together to maximize the total project benefits.

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### 4.3. Risk Countermeasures during the Hoisting Construction Phase

In the actual construction process, because most of the construction personnel hired by the construction unit are migrant workers, their professional and technical construction level is relatively low, and their operational standardization is low, there may be situations where construction personnel do not follow the regulations for construction, and most of them lack safety awareness. When conducting on-site management, it is necessary not only to ensure the safety and construction management of construction personnel but also to regularly invite experts to provide training on the professional skills of construction personnel to improve their construction proficiency. At the same time, attention should be paid to training management personnel in their skills. Improving management skills can effectively reduce construction risks. Regular training can increase the awareness of construction personnel towards safe and standardized construction, regulate their behavior, and make quality management more standardized. This not only ensures the safety of the construction process but also accelerates the construction progress and improves the quality of the project.

### 4.4. Risk Countermeasures During Facility Recycling Phase

Component recycling is an effective means of capital recovery, but there is a need for a systematic supply chain system in China. Therefore, enterprises need to strengthen the awareness of component recycling to increase market demand in this area. A relevant market and a supply chain system related to component recycling emerge only when this demand increases.

## 5. Conclusion

This research takes the well-known prefabricated building of Leishenshan Hospital as an example, dividing the supply chain of prefabricated buildings into six stages and conducting risk analysis one by one: in the design and development stage, there is a problem of insufficient design capability, so this article proposes a solution of modularizing and standardizing components; In the stages of production procurement and warehousing transportation, there are problems such as low production efficiency, low standardization of molds, and transportation policy constraints, as well as insufficient protection of components during the warehousing and transportation stage. Therefore, this article proposes solutions to incorporate these into performance management. In the lifting construction stage, problems include insufficient organizational capacity and inadequate supervision. This article proposes solutions such as training for regulatory and construction personnel. Due to the current blank space in China, this article hopes construction companies will pay more attention to this issue in the stage of facility recycling. However, in the supply chain of prefabricated construction, China is still in the early stage of vigorous development. The management of the supply chain of prefabricated construction projects needs to be further improved and enhanced, requiring more mature processes and management methods or combination forms, as well as strengthening awareness of relevant links, to promote the better development of the prefabricated construction industry.

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