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Quality and Safety Risk Assessment of Prefabricated Construction

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Abstract:

This paper identifies the construction safety risk of prefabricated housing project. This paper uses the questionnaire data combined with TOPSIS method to obtain the attribute weight corresponding to each risk index and the square sum of the distance between positive ideal value and negative ideal value, which is used as the standard for ranking the advantages and disadvantages of risk indicators. Combined with entropy theory, this paper sorts and screens the risk factors, and constructs the risk index evaluation system. This paper analyzes the rationality of reliability and validity of the questionnaire to ensure the reliability of the questionnaire. In this paper, Bayesian network method is used to analyze the construction safety risk factors of prefabricated housing project. This paper uses the combination of risk matrix method and analytic hierarchy process (AHP) to evaluate the overall risk, get the risk level, and weigh whether to deal with the risk in combination with the risk acceptance principle. On this basis, this paper puts forward specific measures to deal with the construction safety risk of prefabricated housing project.

Keywords: *Prefabricated House, Project Construction, Safety Risk, Entropy Theory.*

I. INTRODUCTION

The survey found that the incidence of safety accidents on the construction site is very high. Statistics show that on average, three people die in construction safety accidents every day [1-2]. For the construction enterprises with the continuous strengthening of the management concept of "human text", the health and safety risks faced by employees must be paid special attention. Once a safety accident occurs, the enterprise must face a series of problems such as economic compensation and damage to the corporate image [3]. Therefore, construction safety management should be highly valued by enterprises. The development of prefabricated housing in China is in the initial and exploratory stage [4]. Problems such as lack of in-depth understanding of basic theory, immature construction technology and insufficient management experience are more likely to cause certain potential safety hazards, cause great harm to

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employees' body and mind, affect the construction progress and quality, and are not conducive to the development of prefabricated housing industrialization [5-6].

It can be seen that the research on the construction safety of prefabricated residential projects is very meaningful and necessary. By constructing a scientific and reasonable construction safety risk evaluation system, this paper makes a systematic and in-depth analysis and Research on construction safety, and puts forward corresponding risk prevention and control countermeasures, so as to provide some reference for project managers. Reduce the probability of safety accidents, and constantly promote the sound and rapid development of China's housing industrialization.

II. IDENTIFICATION OF CONSTRUCTION SAFETY RISK FACTORS OF PREFABRICATED RESIDENTIAL PROJECTS

1.Identification method and process of construction safety risk factors of prefabricated residential projects

Risk identification plays a very important role in the process of project construction. It is the premise of risk analysis and evaluation [7]. The so-called risk identification refers to the process of systematically identifying, judging, classifying and determining various risks affecting the objectives of construction projects by using specific methods on the basis of collecting relevant data. There are many methods to identify risk factors, which can be roughly divided into two categories: subjective risk identification methods and objective risk identification methods. Each method has its own applicable conditions, advantages and disadvantages [8-9]. When identifying the risk of specific construction projects, the appropriate risk identification method should be selected according to its own characteristics.

(1) Scenario analysis. This method is mainly used for risk identification of projects with long duration and many variable factors, and some economic, technical and other factors need to be considered [10]. Generally, it is necessary to construct scenarios and design possible risk situations in the future on the basis of assuming possible risk factors. (2) Fault tree analysis. This method is mainly used for risk identification in the form of diagrams, which arranges the project risks from coarse to fine, from large to small, and decomposes the risks, so that it is easier to identify all risk factors of the project. Relevant data or statistical experiments must be available when using this method. (3) Flow chart method. This method mainly reflects the whole process of risk identification, analyzes and studies each link and stage of the project, finds the potential risk factors of the project, and can provide a clear decision-making basis for project decision-makers. (4) Historical data statistics. This method is mainly through the research of historical literature, the collection of relevant experts and scholars' descriptions of risk factors, and the process of sorting and screening according to needs.

2.Screening of risk factors based on TOPSIS method

TOPSIS (technology for order preference by similarity to ideal solution) is a sort method to

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compare multiple schemes according to different indicators. We usually call it "sort method close to ideal value". The basic principle of this method is to find the positive ideal value and negative ideal value of each scheme by using the data matrix, then calculate the distance between each scheme and the positive and negative ideal value, and finally use the distance between each scheme and the optimal scheme as the ranking basis.

From the definition of risk, quantifying risk is actually quantifying the possibility and consequences of safety events, which can provide a clearer basis for risk decision-making. This paper mainly quantifies the safety risk from two important aspects: the probability of risk occurrence and the degree of risk impact (risk loss). Finally, the risk evaluation also depends on the internal attributes of these two indicators. The specific requirements of the risk evaluation system are shown in Figure 1:

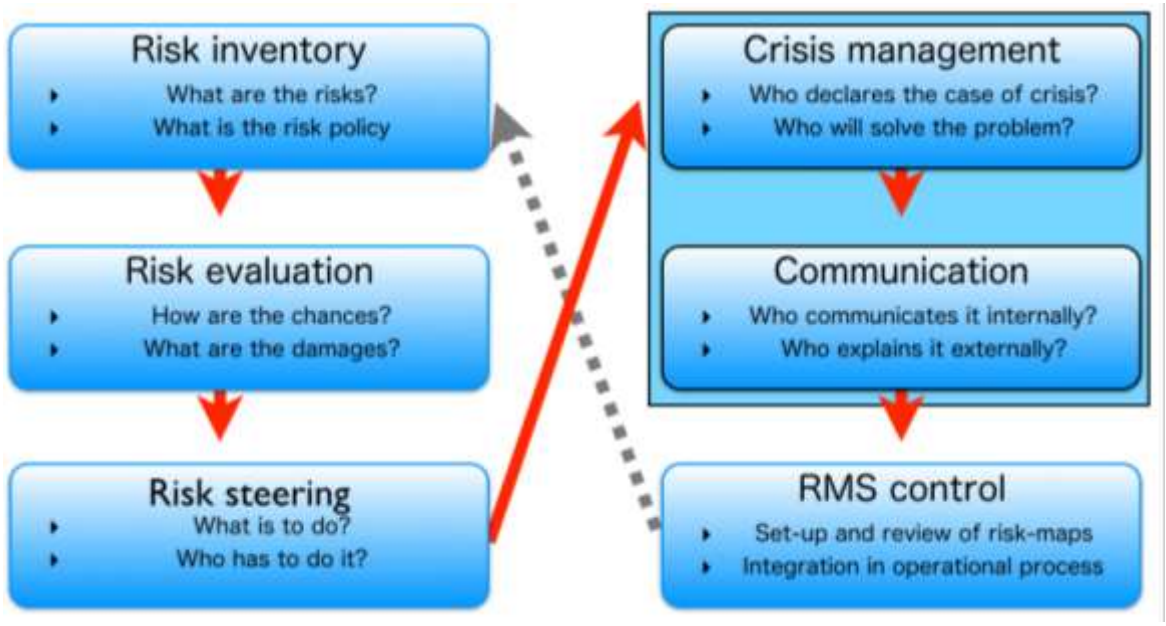

Fig 1: Risk index evaluation system

Referring to DB31 / T 688-2013 code for construction quality and safety risk management of construction engineering, this paper divides the risk occurrence probability and impact degree into five levels. According to the description of risk indicators, 0-4 points are assigned for the scoring standard of the questionnaire. The specific contents are shown in Table 1:

TABLE I. Rating and scoring criteria

RISK LEVEL	CLASS I	CLASS II	CLASS III	CLASS IU	CLASS V
PROBABILITY OF RISK	Hardly happen	Rarely occurs	Happen once in a while	More frequent	Frequent occurrence

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OCCURRENCE					
RISK LOSS DEGREE	Negligible	To consider	Average	Serious	Very serious
SCORE VALUE	0	1	2	3	4

III. CONSTRUCTION SAFETY RISK ANALYSIS AND EVALUATION OF PREFABRICATED HOUSING PROJECT BASED ON BAYESIAN NETWORK

1.Construction safety risk analysis of prefabricated housing project based on Bayesian network

(1) Bayesian network parameter learning. Bayesian network parameter learning is to determine the conditional probability distribution of nodes after building the network structure model, and find several factors with the largest probability as the key influencing factors of the project. Usually, when the data is known, the maximum likelihood estimation (MLE) algorithm is used. This method calculates the value probability of the parent node after knowing the value of the parent node set. Its basic principle is to find a parameter to maximize the likelihood function.

(2) Bayesian network reasoning analysis. Bayesian reasoning is a reasoning method based on probability distribution. It is an analysis tool different from other data mining model reasoning. Each node of Bayesian reasoning can input and output information to make it more flexible and effective in the reasoning process. Its main purpose is to calculate the probability distribution of risk when the network structure and data are known. Usually, Bayesian reasoning is divided into accurate reasoning and approximate reasoning. Accurate reasoning algorithm is generally suitable for some simple simple simple connected networks. However, approximate reasoning can solve some large-scale or high-density Bayesian networks, and take a compromise between running time and reasoning accuracy to solve the problem. Representative algorithms include approximate reasoning based on search and approximate reasoning algorithm based on random simulation.

In conclusion, the Bayesian network structure diagram of construction safety risk of prefabricated residential project can be used to obtain the construction safety risk factors that have a great impact on the project, which can be used as the basis for risk prevention.

2.Construction safety risk assessment of prefabricated housing project

This paper mainly uses the risk matrix method to evaluate the risk. This method was proposed by the Electronic Systems Center (ESC) of the U.S. Air Force in April 1995. It is a risk evaluation method combining qualitative and quantitative. From the domestic research status, we can combine this method with analytic hierarchy process (AHP) for risk assessment.

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According to the idea of risk matrix, the construction safety risk factors of prefabricated residential projects are divided, and the risk level is expressed in terms of risk influence degree and risk occurrence probability, which is divided into three levels: high, medium and low, which are expressed by R3, R2 and R1 respectively. The survey data are processed according to this classification standard, which is mainly used for parameter learning of Bayesian network structure.

This paper mainly studies the risk from the two aspects of risk occurrence probability and risk loss degree. There is a certain connection between these two aspects. We can quantify the risk level scale according to the definition of risk scale and the experience of risk management, as shown in Table 2:

TABLE II. Quantitative standard of risk level scale

RISK LEVEL	R1	R2	R3
QUANTITATIVE STANDARD	0.1	0.4	0.7

The column of risk matrix constructed by this method is mainly composed of risk column, risk influencing factor column, risk loss degree column, risk grade column and risk weight column.

According to different risk levels, we can use different treatment principles and adopt different solutions. Generally speaking, we will take some basic methods when dealing with risks, and formulate reasonable countermeasures in combination with the actual economic situation and objectives of the project. In order to achieve the minimum cost and obtain the maximum safety results. This is also a part of risk management. Common risk response measures include:

(1) Risk avoidance. This risk response method in the project mainly refers to finding the risk factors with high probability of occurrence and serious loss after completing the risk identification and evaluation. At the same time, the project is unable to bear the cost of avoiding the risk or find effective measures to deal with it, so it is necessary to change the original work plan or abandon the project to reduce the risk loss. (2) Risk mitigation. Risk mitigation is to take measures to reduce the risk occurrence probability and loss degree to the tolerable range of the project itself, without risk mitigation and other problems of the project itself. (3) Risk transfer. This risk control method mainly refers to that the project manager transfers the risk to another department or organization through certain methods (contract or insurance) to reduce the risk impact of his own project. (4) Risk retention. Risk retention generally refers to a strategy undertaken by the project itself when risks occur. Compared with other methods, it will neither reduce the possibility of risk nor reduce the loss of risk. It is to reserve some funds for risk response before the project starts. If the risk does not occur, the project reduces the cost in the process.

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IV. CASE ANALYSIS

1.Introduction of a prefabricated residential project

The project is located in the south of Dingyuan road and the west of Shuangwan Road, Chengyang District, Qingdao. The building purpose is residential building, and the seismic fortification standard is standard fortification building. It consists of three single buildings. Building 1 is a network, one floor underground and two floors above the ground. The building height is 7.55 meters. Building 2 and building 3 are residential buildings, with building heights of 35.1 meters and 36.1 meters respectively. The design service life of the building is 50 years.

Project features: (1) the foundation of the project is still in the form of cast-in-situ concrete, and the three floors and above of the main body are in the form of assembly. The required components are prefabricated in advance and then transported to the project site for assembly and construction. It has high technical requirements, high degree of mechanization and less number of workers, but it requires high quality and fast construction speed. (2) The terrain of the project is relatively flat and the stratum structure is relatively simple. No adverse geological effects that hinder the site excavation are found, and the site is relatively open, which is conducive to the stacking of on-site construction materials and the placement of tower cranes. (3) The construction period of the project is tight, and the required construction process is complex and not good at it. Therefore, it is necessary to manage and coordinate the construction site, reasonably intersperse the construction processes, and complete the project on time with quality and quantity. (4) The project is close to the kindergarten, and the construction environment is complex. It is necessary to control the noise and ensure the environmental sanitation around the construction site. Therefore, in the construction organization design, we should strengthen the control in this regard, reasonably arrange the construction, and do a good job in the coordination of urban management and traffic police.

2.Application of Bayesian network in construction safety risk analysis and evaluation of residential project

The Bayesian network structure model of safety risk of the project is constructed through structural learning to further analyze the safety risk factors of the project.

(1) Structural learning. Firstly, with the help of the data of the previous questionnaire, we need to use the software Ge nie2.0 to learn the structure of Bayesian network. Taking the previously screened risk factors as nodes, we can sort out the two groups of data obtained from the survey and show them with the data size in the risk matrix table, get a new group of data, import it into the software, and select K2 algorithm for structure learning.

(2) Structural optimization. This paper analyzes the relationship between each of the 16 risk factors selected by the project and other factors through the experience of experts. The specific selection criteria are shown in Table 3.

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(3) Parameter learning. Next, the processed survey data is imported into the software Ge nie2.0, the Bayesian network structure and data are matched, the state of each node is corresponding to the risk level one by one, and then the maximum likelihood estimation method is used for parameter learning.

TABLE III. Factor selection criteria

SCORE	0	1	2	3	4
RELATIONSHIP DESCRIPTION	Irrelevant	Less relationship	Relation general	Great relationship	It's very relevant

To sum up, in the research on the risk influencing factors of the prefabricated residential project, through the construction and analysis of Bayesian network structure, it is found that the key risk influencing factors are the lack of on-site management P_5. Unreasonable setting of lifting points W_2, improper stacking position of PC components M_1, wrong hoisting operation W_4, cross collision interference W_5 during tower crane operation, lack of on-site risk inspection and detection Ws, etc. Pay special attention to these factors in project construction to minimize the impact of risks.

V. CONCLUSION

Then the rise of the prefabricated construction industry, which has obvious advantages in environment, quality and construction technology, breaks the traditional building model and is more in line with the requirements of modern people's environmental protection, safety and efficiency. The research on the development of prefabricated building in China is in the primary stage. Many experts and scholars mostly focus on value analysis, technical requirements, development status and development advantages. There is little research on the security issues involved. Therefore, based on reading a large number of domestic and foreign literature and understanding the relevant theoretical content, this paper studies the construction safety risk of prefabricated housing project. And put forward preventive suggestions, which is of great significance for the development of prefabricated building construction safety in China.

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