Research on risk assessment of subway construction based on triangular fuzzy number and Bayesian network

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Abstract: With the rapid development of subway construction in China, the risk management of subway projects has become a research hotspot. The construction stage of subway project is the risk-prone stage, which is very important to the risk management of the project. The Bayesian network is used to analyze and evaluate the main risk factors during the subway tunnel construction. Its evaluation method and results can provide some guidance for the risk management during the construction. Due to the characteristics of high quality requirements and difficult construction of subway construction projects, there are many potential risk factors in the construction process of subway construction projects and accidents are easy to occur. How to evaluate the risk factors in the process of subway construction more scientifically and accurately has become an important topic in the risk management of subway project. Based on the method of Bayesian network and fuzzy comprehensive evaluation, this paper introduces the concept of triangular fuzzy number, and tries to find a risk evaluation method suitable for the subway construction process, to evaluate the risk factors of subway construction.

1. Introduction

With the further development of China's economy, the traffic problems faced by cities are increasing. Subway is an effective way to relieve the traffic pressure in cities. The construction of light rail such as subway has become the main content of current urban traffic construction [1]. At present, the pace of urbanization in our country is getting faster and faster. More and more cities choose subway as a means to relieve traffic pressure and begin to speed up their own subway construction process [2]. Due to the characteristics of high quality requirements and difficult construction of subway construction projects, there are many potential risk factors in the construction process of subway construction projects, which are prone to accidents [3]. The surrounding environment of subway construction is complex, the construction period is long, the technology is complex, the types of construction equipment required are various, the professional jobs and personnel involved are numerous and cross each other, and the requirements on quality, technology, construction safety and quality of management personnel are high [4]. In order to ensure the safety of personnel and property during the construction of the tunnel project and the expected benefits of the project, it is necessary to evaluate and manage the potential risks existing in the construction of the tunnel project.

Subway, as a form of urban public transportation to relieve the pressure of urban traffic, has received the support and vigorous development of the state. Its development speed can be described as changing with each passing day [5]. Compared with other construction projects, subway construction is difficult and requires high quality. At the same time, there are many risk factors that affect the quality of the project. Due to the late start of subway construction in our country, the safety control management experience and the ability to deal with risks during subway construction are insufficient [6]. These characteristics determine that there are more safety hazards in the subway

construction process, and the possibility of accidents is large, resulting in frequent accidents during the construction of the subway, resulting in large casualties and economic losses [7]. How to more scientifically and accurately evaluate the risk factors in the subway construction process and determine the main risk factors has become an important issue in the risk management of subway projects. With the development of security risk probability prediction theory, Bayesian network technology is increasingly used in security risk probability assessment as an evaluation method that describes the uncertainty of accident polymorphism and accident logic.]. Based on Bayesian network and fuzzy comprehensive evaluation method, this paper introduces the concept of triangular fuzzy number, tries to find a risk evaluation method suitable for subway construction process, and evaluates the risk factors of subway construction.

2. The Basic Principle of Risk Assessment Based on Triangular Fuzzy Number

The occurrence of subway accidents is caused by the joint action of various influencing factors. In fact, accidents have many external manifestations. The most obvious manifestation of each accident is taken as the basis for classifying accident types. Bayesian is mainly composed of two aspects: the graphic structure of the network and the network parameters. In the process of Bayesian network representation, the main content is a complex network diagram including nodes and arcs. Bayesian network is a combination of probability analysis and graph theory. It is a directed graph model. Through this network, various data can be summarized and integrated reasoning can be carried out on these data. Bayesian can be intuitively expressed as a network diagram structure and converted into a network node space constraint state. Through effectively connecting multiple nodes, staff members form a network structure expressing different risk factors and establish corresponding network models [9]. Bayesian network also has the ability to describe the accident polymorphism and the uncertainty of accident logic relationship, which is more suitable for the analysis of the safety and reliability of complex systems. As various risks are easy to occur in subway construction, it is necessary to carry out risk assessment in subway construction, identify, analyze and control various subway construction risks as early as possible and in time, which can effectively reduce or reduce the risks.

There are many types of subway accidents, but there is a trend that the proportion of accident types is different. There are many types of main causes of subway accidents. According to the main external forms of accidents, the types of subway risk accidents are determined. For the collected statistical samples of Metro risk accidents, we can get a simple classification according to the types of accidents, as shown in the Table 1.

Table 1 Types of subway risk accidents in recent years

Accident type	Collapse	Fire	Flood	Object strike	Fall from a height	Poisoning	Explosion	Get an electric shock	Other
Number of accidents	42	5	8	8	2	1	1	1	8

Although there are many types of accidents involved in subway accidents in recent years in our country, the occurrence of risk accidents is obviously concentrated, and the types of accidents such as landslides, mechanical injuries and water disasters are the main types of risk accidents. Bayesian network and fault tree are very similar. Both describe the causes of accidents and their logical relationships, and can find out the causes of accidents and their logical relationships through analysis. The occurrence of risk accidents is the external manifestation of subway project construction risks, and the causes of subway risk accidents are also hidden construction risk factors. The node parameters and structure of the network determine the basic content of Bayesian network and also affect its operation content. The occurrence of subway accidents is closely related to human factors such as poor safety management. Whether the safety management and preventive

measures for risk accidents are in place will have a significant impact on the risk accidents. Therefore, it is necessary to clarify the node information under different working conditions to ensure that decision-making nodes can propose solutions according to existing problems. Under specific conditions, the probability of each node can be checked according to the independent dependence and causality between different variables. In actual operation, the use of fault tree can easily draw the logical relationship and sequence of each event.

3. Risk Assessment Model of Subway Project Construction Based on Bayesian Network

3.1 Design Idea of Risk Evaluation Index System for Subway Construction

Through subway accident analysis, we can clearly understand the main types of subway accidents, their causes and consequences, and then we can determine the set of risk factors to be considered in the subway construction process by analyzing the main causes of these accidents. Fault tree can't calculate the probability of top event or other intermediate events conveniently, so we can transform the fault tree to Bayesian network to facilitate our calculation. Different identification results can be obtained for risk factors during subway construction according to different methods and procedures, and a fault tree is constructed by adopting a work decomposition structure and a risk decomposition structure [10]. Since there are many risk sources during the subway construction phase, and at the same time, it is necessary to ensure the comprehensiveness of the risk identification process and to ensure that no risk omission occurs during the risk identification, the risk identification of subway projects needs to be scientific, reasonable and rigorous. Since the network node mainly describes the risk factors that may occur during the construction phase, these nodes can be set to specific names. The subway construction risk refers to the various uncertainties in the subway construction process. This uncertainty is reflected in economic losses, construction workers' casualties, construction environment impact and damage, construction period delays and engineering quality durability.

The basic theory of project group and schedule management mainly analyzes the connotation and characteristics of the project group, the connotation of project management and the progress management method. Developing a project plan is one of the reasons why many people are unwilling to make a plan because they need to consider and answer many questions. The pain curve points out that developing a project plan is indeed a painful thing, but it will reduce the pain during the project implementation process and later. The project management life cycle pain curve is shown in Fig. 1.
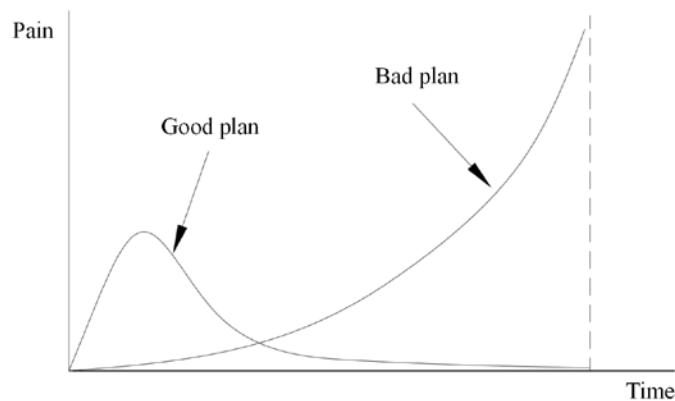

Fig. 1 Project management life cycle pain curve

The Bayesian network outputs the probability values, so when integrating, we can combine all the base classifiers with the probabilistic prediction values of the test data to obtain the final discriminant result:

$$w_{ij} = w_{ij} + a(\frac{X_i}{m} - w_{ij}) \tag{1}$$

Then the final output:

$$d(x, y) = \sqrt{\left(\sum (x_1 - y_1)^2\right)}$$

(2)

For the input layer, the inputs and outputs are the same, namely:

$$T(x, y) = \frac{x \bullet y}{\|x\|^2 \times \|y\|^2} = \frac{\sum x_1 y_1}{\sqrt{\sum x_1^2} \sqrt{\sum y_1^2}}$$

(3)

In the construction process, the approval and supervision system is not sound enough. The construction authorities and quality supervision agencies in many areas do not understand some of the problems in the construction process. The building itself is a non-self-contained system that exists independently of nature and needs to rely on the absorption of natural resources to satisfy its own independent operation. It is difficult to systematically, efficiently and comprehensively solve various problems that arise during engineering design or construction. Modern building projects have clear traffic lines, reasonable functional divisions, and combined with aesthetic technology to form a comprehensive office space. The Fig. shows the application method of construction safety survey technology in construction practice.
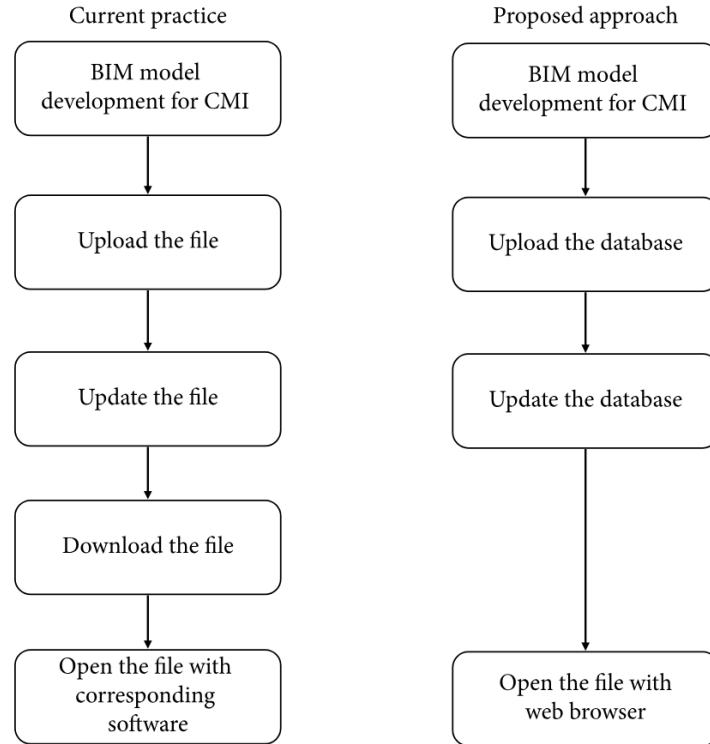

Fig. 2 Application method of construction safety survey technology in construction practice

3.2 Establishment of Risk Assessment Index System for Subway Construction

The identification of subway project construction risks must follow the basic principle of comprehensiveness, so the initially obtained risk factors are not only complicated in hierarchical structure but also numerous in number. Whether the geological conditions are clear and whether the geological risks can be tolerated will directly determine the results of risk assessment during the construction phase. The risk situation of construction period can be reflected by the increase of project scope, lack of schedule, lack of flexibility in schedule, failure to keep pace with the latest construction situation in time, lack of supervision during construction period and rework. The ultimate goal of the project construction is to ensure that the project can meet the requirements as scheduled and meet the expectations of the owner in terms of the final function. After obtaining the initial list of subway construction risks, some preliminary screenings are needed to reduce the

number of risk factors and reduce the workload of the risk indicator system research. In order to investigate the risk status of the subway construction and the construction period, it is necessary to consider the factors related to cost management and construction period control involved in the subway construction. According to the independence, the logical probability in the fault tree is used to express the conditional probability in the Bayesian network, and the probability of the bottom event is used to calculate the joint probability distribution of the leaf node. The construction unit will carry out the review and re-testing work immediately after receiving the basic data measurement data. The construction unit will study and deploy its own control network according to the measurement data provided by the construction unit.

4. Conclusion

As a public rail transit mode strongly supported by the Chinese government, the subway is in the early stage of development, but it has become a hot spot for investment and academic research. Through the Bayesian network, the unpredictable construction risk occurrence can be correctly recognized and has good economic value. For the construction workers, when using the Bayesian network method, it is necessary to pay attention to the joint application of multiple technologies. Using the triangular fuzzy number to determine the target weight, the subjective judgment in the process of determining the weight of factors is more in line with people's thinking habits and expressions, and fully consider the fuzzy factors existing in the analysis of the problem. The Bayesian network method has strong visibility and can evaluate the probability of incomplete data sets due to insufficient construction history data. For subway construction projects, there are many risk factors and complex relationships among them. The evaluation standard of AHP is difficult to accurately express the importance of each other. The introduction of triangular fuzzy number makes the evaluation results more accurate and effective. The calculation results of the probability of the bottom event will affect the calculation of the probability of the top event, which needs to be focused on. In the process of subway tunnel construction, using Bayesian network to evaluate the safety risk of subway construction is an effective way to evaluate the reliability and safety of the system.

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