Risk Assessment Method for Xiangxi Yangtze River Highway Bridge Based on Kent Index Method

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Abstract. Xiangxi Yangtze River Highway Bridge is a long span thrust arch bridge constructed in the Three Gorges Reservoir Area. It is of great significance to evaluate multiple potential risks for project safety management. In this paper, a risk assessment method for bridge construction in reservoir area based on Kent index method is proposed. Four major indexes of risk assessment model for bridge construction in reservoir area are determined: basic index, design index, construction index and risk loss index. Comparing with the risk acceptance criteria, the risk acceptance degree of the bridge construction in the reservoir area is evaluated, which indicates the direction of safety precaution and emergency plan compilation in the construction and ensures the safety of the bridge construction in the reservoir area. The results show that the model has strong practicability and effectiveness, and can provide reference for engineering management departments to realize bridge risk assessment and control.

Introduction

In order to adapt to the economic development, highway construction began to develop to the Three Gorges Reservoir area and mountainous area on a large scale, which led to the development of bridge structure towards the direction of complexity and large span. The risk of bridge construction and maintenance (Figure 1-2) also increased sharply\cite{1}. At present, Xiangxi Yangtze River Highway Bridge is the longest span thrust half-through steel box truss arch bridge in the world. Its construction is difficult and its construction risk is high. In the aspect of bridge safety construction, the bridge is also a key supervision project\cite{2}. Therefore, the risk identification of Xiangxi Yangtze River Highway Bridge is of great significance to the construction of bridges in the Three Gorges Reservoir Area.

Figure 1. Risk of bridge construction. Figure 2. Management of the bridge.

This paper presents a risk assessment model based on Kent index method. According to the structural and construction characteristics of Xiangxi Yangtze River Highway Bridge, the risk factors in the whole construction process of Xiangxi Yangtze River Highway Bridge are studied systematically. The risk accidents caused by risk factors are summarized and the degree of hazard
and the possibility of risk accidents are quantitatively classified. Then through the product of the two to get the magnitude of the risk, and then the main risk factors in the construction process of Xiangxi Yangtze River Highway Bridge are identified.

**Kent Index Method**

There are various risk assessment methods, due to the limitations of the scope of application and their respective advantages and disadvantages, different risk assessment methods are needed to analyze the risk factors in the construction process of different bridge construction systems [1,3]. As shown in Figure 1, Kent method is a systematic analysis method suitable for decision analysis of complex problems such as multi-objective and multi-criteria [4]. According to the structure and construction characteristics of Xiangxi Yangtze River Highway Bridge, this paper builds the construction risk identification model of Xiangxi Yangtze River Highway Bridge by using Kent index method, and checks its reliability.

**Case Analysis**

**Risk Category Analysis**

As the largest steel-box truss with thrust arch bridge in the world, the main span of xiangxi Yangtze river bridge (figure 2) is 519m (calculation span), and the length of main bridge is 531.2m (distance between main bridge junction piers). The construction method of xiangxi Yangtze river bridge is cable-stayed suspension method. The construction process has many risks in the complex environment of the three gorges reservoir area, so it is very necessary to evaluate the risks.
The weight of construction coefficient is determined on the basis of referring to the safety risk assessment guide for highway bridge and tunnel project construction and combining with the analysis result of bridge construction accident in reservoir area. The weight of three-level index coefficient is obtained according to the statistics of bridge accident in reservoir area. First, the value of construction coefficient is determined according to table 1, and then the value of basic coefficient and design coefficient is obtained according to the proportion of basic coefficient, design coefficient and construction coefficient in the statistical analysis of bridge accident in the reservoir area. The value of risk loss coefficient can be referred to the safety risk assessment guide for highway bridge and tunnel construction, which mainly considers direct losses of construction accidents, including casualties and economic losses, as shown in table 1. Other aspects such as construction delay, environmental impact and social impact can be taken into consideration according to the actual situation of the project.

Table 1. Principle of risk loss coefficient.

| level          | disaster | Very serious | serious | larger | slight |
|----------------|----------|--------------|---------|--------|--------|
| Level indicators | E>9      | 2<E≤9 or F>10 | 1≤E≤2 or 1<F≤10 | F=1 or 1<G≤10 | G=1    |
| Economic loss/ten thousand yuan | >1000   | 300-1000     | 100-300 | 30-100 | <30    |
| The scope of score      | 20       | 16           | 12      | 8      | 4      |

Note: E= death, F= serious injury, G= minor injury. When multiple consequences occur at the same time, adopt a high principle to determine the level of risk loss[5].

According to Kent index method based on the reservoir area of bridge construction risk assessment method of Xiangxi Yangtze River Highway Bridge river highway bridge construction safety risk assessment, combined with the engineering practice in accordance with the principle of construction factor score of xiangxi to rate coefficient of the Yangtze River Highway Bridge construction, and to consider three level index weight can be get 3 level index coefficient values, the detailed construction coefficient values shown in table 2 and table 3.
Table 2. Construction coefficient.

| Index type              | Project status                                      | Three-level index coefficient | Calculation of coefficient value |
|-------------------------|-----------------------------------------------------|-------------------------------|----------------------------------|
| The technical level     | higher level of technology                          | 6.6                           | 2.97                             |
| Moral quality           | Strong safety awareness, operational standards, professional | 1.8                           | 0.81                             |
| Safety protection       | Pay more attention to safety and protection         | 1.8                           | 0.81                             |
| Machinery and equipment | normal operation and maintenance                    | 2                             | 0.5                              |
| Construction materials  | Material testing, storage, use qualified            | 3.6                           | 0.9                              |
| Field safety management | Management system qualified, strict inspection      | 8                             | 1.6                              |
| The working environment | The working environment is reasonably arranged       | 2                             | 0.2                              |
|                        | Coefficient of construction                         |                               | 5.58                             |

Table 3. Risk loss coefficient.

| Index type              | Project status                                      | Score | instructions                                                                 |
|-------------------------|-----------------------------------------------------|-------|-----------------------------------------------------------------------------|
| casualties              | No one was killed and several were lightly wounded   | 8     | The value of the project is 6 points according to the actual situation of the project, including environmental impact, construction delay and social impact |
| The economic losses     | Slight loss, basically no effect                    | 4     |                                                                             |
|                        | Risk loss coefficient                               | 18    |                                                                             |

The construction coefficient of Xiangxi Yangtze River Highway Bridge is determined according to table 3, then according to the statistical analysis of the bridge accident in the Basic coefficient, design coefficient, construction coefficient corresponding to the basic reasons, the design and construction reasons get basic coefficient and the proportion of design coefficient values, such as figure 3 illustrates the environment reasons occupy 10%, survey and design reasons occupy 9%, other construction reasons occupy 81%, so the basic coefficient =5.58×0.1÷0.81=0.69, design coefficient =5.58×0.09÷0.81=0.62.

![Figure 3. Evaluation of construction risk factors.](image)

**Conclusion**

In this paper, based on the risk assessment model of Kent method, four major risk categories in the construction of the bridge in reservoir area are concluded. This method is applied to the construction risk assessment of Xiangxi Yangtze river highway bridge, which can quantitatively analyze the risk identification of the bridge in the reservoir area and effectively assess the acceptance of the risk during the construction of the bridge in the reservoir area.
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