Risk Analysis of Project Construction under the New Crown Epidemic Situation

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Abstract. The aim of this paper is to avoid construction project losses based on the normalized situation of prevention and control new crown epidemic. This paper takes an example of Shu Xiang Garden project in Anhui. An early warning system of epidemic risk based on was constructed and applied to risk analysis. Index system and expert survey were conducted to identify the risk factors and divide them into major risk and general risk. In addition, this paper carried out a special assessment of interpretative structural modelling to directly reflect the influence factors of the cost risk. The results show the overall risk belonging to level III is extremely high risk and risk management is the most critical factor to reduce the cost risk. The paper concludes with recommendations from four aspects of epidemic control, balanced progress, information technology and risk transfer to reduce risk and provides a theoretical basis for epidemic risk management.

Keywords. New crown epidemic, early warning index system, ISM, risk management.

1. Introduction

As a labour-intensive industry, construction projects suffered unprecedented impact of epidemic in 2020. With epidemic situation improves, the Ministry of Housing and Urban-Rural Development, according to the local epidemic severity, introduced several policies for resumption of work and production. There is not yet agreement on how the responsibility of epidemic diseases will share. The judicial practice of claim payment is highly uncertain during the period of epidemic and there is a lack of the relevant legal provisions [1]. When the epidemic situation is relatively stable, the signed contract will not apply to force majeure. Because of differences of specific risks, it may be defined as situational changes or accidents. According to the construction contract, Deng X M [2] believed that the loss of work stop-and-stop caused by the epidemic could be claimed as force majeure, and the risk and responsibility sharing should be handled according to force majeure. Xiao Z [3], based on the “Law on Prevention and Treatment of Infectious Diseases”, pointed out that the performance of labour contracts could not be completely based on force majeure rules, and the compensation mechanism for losses should be established according to the epidemic situation compulsory measures. Li M J [4] analysed the risk of contract settlement caused by increased costs under the influence of the epidemic; Zhao H X [5] analysed the responsibility sharing of construction period and cost from the perspective of force majeure. It is conceivable that epidemic risk management will decide the fate of the enterprise. However, so far, few studies have been constructed a comprehensive risk early warning index system of construction project [6].

At present, the epidemic situation in China has been basically brought under control, but the increase in imported cases from abroad and the possibility of small outbreaks may still be caused by...
imported living organisms carrying the virus. Under such circumstances, construction companies should strictly prevent and control the epidemic at densely staffed construction sites. In addition, the enterprise should formulate relevant risk emergency plans specifically to reduce the impact of accidents caused by the epidemic [7]. Taking this into consideration, this paper reviews the risk identification and monitoring during epidemic situation of construction industry. It establishes an early warning system based on Construction Contract Construction Project (GF -- 2017-0201).

2. Construction Risk Management Procedures
Owing to the persistence of the epidemic prevention and control, the corresponding risk management is a dynamic information flow and feedback process to ensure the realization of the project objectives with the minimum risk management costs [8].

There are four main steps: (1) Risk identification: Risk identification is the first step of risk management. It is based on the characteristics of engineering projects during the epidemic period that we should select appropriate methods for risk identification. When preliminary risk list is determined, integrate it into the final risk list to build an indicator system. (2) Risk assessment: Analyse the degree of risk association, establish an appropriate risk assessment model, and assess the possibility and consequences of risks. (3) Risk management: When the epidemic occurs, start the risk management plan to deal with the emergency and try to reduce the loss to the minimum. Then judge whether the contract can continue to be performed or to be claimed on account of the situation. (4) Risk monitoring: Carry out real-time monitoring of risks based on the early-warning index system, control the identified risks within the target range and monitor whether there are other risks [9]. As mentioned above, we can build risk management procedures with the characteristics of the epidemic, as shown in figure 1.

![Risk management procedures](image)

Figure 1. Risk management procedures.

3. Case Study
This paper takes Anhui Shu Xiang Garden project as an example to analyse the risk of this project through the method of ISM (Interpretative structural modelling). The project is located at west of Chaoyang Road, Huangshan, Anhui, covering a total area of 26971.57 m², with a construction area of 168,330.2 m². As is the case with the construction projects during the epidemic, the project was suspended for several months. There is a construction risk after the resumption of work. Through risk management, the project can avoid losses and achieve the project objectives.

3.1. Risk Early Warning Index Analysis
The relevant litigation results of claims emerged for the risk during the epidemic period based on the provisions of “General contract terms” and “model text” such as “force Majeure”, “change of circumstances” and “accident”. The risk analysis carries out from the perspective of the owner and the
contractor respectively to ensure the accuracy of risk discrimination during the epidemic [10]. 3.2. Evaluation of Important Early Warning Risk Indicators

The quantification of risk index assessment mainly depends on the risk rate of the project, which is the probability of hindering the realization of the project target when the risk occurs [11]. The equation of risk rate shows as equation (1):

$$ P_r = P(X < X_0) $$

Based on the risk rate, the risk quantity of engineering project can be calculated. It is defined as equation (2):

$$ R = f(P_r, q) $$

As shown in the equation above, $R$ represent significant risks during the outbreak; $q$ represents the impact of risk occurrence on the project, which is called loss value including direct economic loss and indirect economic loss. Considering that the impact of the epidemic on the project is ultimately reflected in the increase of costs, which mainly causes direct and indirect economic losses, the weights are obtained by comprehensively considering the impact degree of different indicators on the overall cost in combination with expert opinions. The possibility of important risk early warning indicators is defined as equation (3):

$$ p = P_r \times W $$

Therefore, according to China's current epidemic situation and epidemic prevention and control regulations, the first-level index cost risk in the list of risk early warning indicators is selected for further risk assessment (See table 1).

| Evaluation index               | Weight | Degree of risk ($P_r$) | W*P_r |
|-------------------------------|--------|------------------------|-------|
|                               |        | Relatively high (1.0)  | High (0.8) | Medium (0.6) | Less (0.4) | Little (0.2) |       |
| Labor increase risk           | 0.2    | √                      |       |       |       |       | 0.16  |
| Material increase risk        | 0.1    | √                      |       |       |       |       | 0.06  |
| Implement cost increase risk  | 0.1    | √                      |       |       |       |       | 0.06  |
| Management cost increase risk | 0.1    | √                      |       |       |       |       | 0.06  |
| Special epidemic cost         | 0.2    | √                      |       |       |       |       | 0.2   |
| Loan financing risk           | 0.05   | √                      |       |       |       |       | 0.01  |
| Risk assessment cost          | 0.1    | √                      |       |       |       |       | 0.04  |
| Measures fee increase risk    | 0.15   | √                      |       |       |       |       | 0.12  |
| Sum                           |        |                        |       |       |       |       | 0.71  |

$p \leq 0.30$ is the first level which indicates the possibility of cost risk increases is little. $0.30 \leq p \leq 0.70$ is the second level which is more likely to raise risk. $p \geq 0.70$ is the third level which indicates the possibility of cost risk increases is extremely high. As the charts above show, $p = 0.71$ suggest the risk of Shu Xiang Garden project should be extremely high. Most of evidence has emerged regarding the COVID-19 outbreak. Thus, effective measures should be taken to control the project cost according to various cost risk indexes.

3.2. Cost Risk ISM Modelling

Interpretative structural modelling is a method which can transforms a multivariate problem into several sub-variable problems to analyse a complex industrial structure. The factors that influence cost
risk make up a complex system. the hierarchical ISM can effectively build cost risk influence factor structure, which can directly reflect the influence factors of the hierarchy, which is easy to operate and practical.

3.2.1. The Calculation of Adjacency Matrix. There are eight indicators of cost risk, which was determined by the Expert group. In this context, we build an adjacency matrix to analyse relation and layer structures of cost risk factors. As is shown in matrix A:

\[
A = \begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 \\
1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \\
\end{bmatrix}
\]

\(a_{ij} = 1\) means factor \(i\) have a direct effect on factor \(j\); \(a_{ij} = 0\) means factor \(i\) have no direct effect on factor \(j\).

3.2.2. The Calculation of Reachability Matrix. Reachability matrix is an effective tool for identifying whether a directed graph to be strongly or weakly connected graph. Adjacency matrix can be transformed into reachability matrix through matrix iterative analysis. According to the Boolean operation, we can compute matrix \((A + I)\) to the \(n\)th power until the algorithm of intersection until equation is gained. In the expression, \(M\) is the reachability matrix; \(I\) is an identity matrix; \(n\) is a natural number:

\[
M = (A + I)^{n+1} = (A + I)^n \neq (A + I)^{n-1}
\]

(4)

As shown in the equation above, we can get the reachability matrix \(M\):

\[
M = \begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 \\
1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \\
\end{bmatrix}
\]

It can be seen from the matrix that \(F3\) has no interaction with other factors, and the new reachability matrix \(M'\) is obtained by modifying the matrix \(M\):
3.2.3. Division of Relation. After obtaining the reachable matrix, the hierarchy is divided according to the equation (5).

\[ R(F_i) \cap Q(F_i) = R(F_i) \]  

(5)

\( F_i \) is the element of an entity set formed by a reachable matrix; \( R(F_i) \) is reachable set, which \( F_i \) is a collection of elements can be reached; \( Q(F_i) \) is antecedent set, which is the collection of elements that have the potential to reach \( F_i \). Results of division is in table 2.

| Risk factor | Accessible set \( R(F_i) \) | Antecedent set \( Q(F_i) \) | \( R(F_i) \cap Q(F_i) \) |
|-------------|-----------------------------|-----------------------------|------------------------|
| A           | 1                           | 124578                      | 1                      |
| B           | 2                           | 278                         | 2                      |
| C           | 4                           | 4                           | 4                      |
| D           | 5                           | 57                          | 5                      |
| E           | 6                           | 67                          | 6                      |
| F           | 2578                        | 7                           | 7                      |
| G           | 28                          | 278                         | 28                     |

As shown in table 2 above, A is labour increase risk. B is material increase risk. C is management cost increase risk. D is special epidemic cost. E is loan financing risk. F is risk assessment cost. G is measures fee increase risk. the seven factors are divided into three levels: the first level \{A, F\}; the second level \{B, C, D, G\} the third level\{F\}. The various factors are arranged to establish the interpretation structure model (See figure 2).

![Risk directed graph](image)
3.2.4 Analysis of ISM Model of Cost Risk. The first level factors are direct cause. As a result of the epidemic, people become the biggest variable in the risk of construction costs. The control of labour cost is an important link to control the increase of cost risk. Labour cost is generally increased during the epidemic. Thus, the control of labour cost can directly control the cost. Of note, lending policies may be tightened, and the success of financing will also become a major factor affecting the success of the project. The second level factors are indirect cause, but they have asserted deep influence on cost risk. The cost of the project is composed of the material cost, epidemic disease special cost, management fee and measure fee. These factors may not change costs significantly, but they are the most significant cost savings. The third level factors are root cause. The cost of risk management controls the occurrence of risks from the root, so attaching importance to risk management can affect the project cost to the greatest extent.

4. Conclusion

4.1. Enforce Special Epidemic Control Measures
We will allocate special funds for epidemic control and ensure the purchase of medical equipment such as masks, alcohol, disinfectants, and thermometers. The site shall be under closed management, and the access of personnel shall be strictly examined and approved according to the local epidemic level. Unnecessary travel shall be prohibited, and workers whose future work is in areas with low risk of COVID-19 or above shall be quarantined for observation, and preventive measures shall be taken. Clarify engineering change handling procedures due to the outbreak. In case of suspected cases, the entire site should be disinfected immediately and close contacts quarantined. According to the construction plan, we should avoid work slowdown when making the schedule. We suggest to ensure that there are no confirmed cases in the closed environment of the construction site and reduce the risk of high personnel health costs caused by the epidemic.

4.2. Control the Balance of Schedule and Cost
Schedule targets are closely related to cost targets in practice. If implemented in accordance with the equationted schedule plans, costs and resources can generally be well integrated; If there is a delay, the cost and resource input will also be affected and changed. The outbreak has put most projects at risk of idle time cost; therefore, it is bound to speed up the pace of construction and change the schedule and plan nodes for dealing with the negative impact of schedule delay. Moreover, the increase in the cost of charrette should also be considered. It is important to balance cost and schedule for controlling the comprehensive cost to the minimum. We suggest using PERT along with cost accumulative curve, network optimize technique.

4.3. Remote Risks Control by Supply Chain and Bim Technology
With the development of BIM and other new information technologies in the Internet of Things, it has become more feasible to reduce the on-site office of management personnel and reduce the on-site labour density. Meanwhile, the accuracy and continuity of information technology can effectively control the occurrence of risk accident. The application of blockchain technology during the epidemic effectively controlled the development of the epidemic. Internet of Things technology includes automatic identification technology, location tracking technology, image acquisition technology, sensor, and sensor network technology, etc. Moreover, the application of BIM technology enables managers to achieve the construction goals without working from home and prevent the epidemic from affecting the project schedule to ensure the timely completion of the construction period. BIM technology includes 4D simulation structured model management, 5D data integration, visual graphics environment, etc.
4.4. Financial Risk Transfer

Many insurance companies launched targeted risk-prevention products, which domestic insurance companies have introduced products to cover COVID-19 risk. Choosing the right large machinery insurance can greatly reduce the risks in transit and storage. To reduce risk. The employer may use special contract terms to transfer some of the cost risk. For example, it is stipulated in the contract that the base unit price will not be adjusted during the construction period to transfer the risk of price rise to the contractor. However, the contract party should also consider the risk may cause disruption to the project.

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