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ANALYSIS OF COUNTERMEASURES FOR RISK MANAGEMENT OF CONSTRUCTION ENGINEERING

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ABSTRACT
With the continuous progress of the social economy, construction building projects have been greatly developed. Construction building projects have been greatly improved in the number, size and investment and other aspects. Coupled with the growing quality of living, the construction building projects are also required to put forward more requirements in the quest for continuous improvement. The benefits of conducting risk analyses in the planning of construction projects are widely acknowledged. However, the actual implementation of procedures notably differs significantly across industry segments. At the same time, in the process of the construction project, it is inevitable to encounter some uncertain factors, which make construction projects face many risks. If no active measures are taken to deal with these risks, then it is likely to give rise to serious quality problems in construction projects. This would bring huge economic losses, and pose a serious threat to people's life and property security. Therefore, it is very important to strengthen the risk management aspect of construction engineering construction projects. This article analyzes the different forms of process improvement used in the development of construction projects in Chengdu City, China. Through interviews, one project was selected as a case study. The research aimed to analyze the meaning, allocation principles and strategies of engineering risks. It adopted a combination of theoretical analysis and practical research, and combined qualitative and quantitative research methods to study risk awareness of projects, attempting to look at risk prevention plans in a more scientific and reasonable manner. This would lead to the realization of reasonable allocation of risks to provide a maximizing the possibility of the success of a project

Keywords:
Construction engineering. Construction project. Risk management.

INTRODUCTION

These years, the construction industry has developed rapidly in China which has an active market. The stakeholders of the construction industry have to elevate their comprehensive capacity to respond to the intense competition and seek more benefits. For each construction project, effective management is very important in the successful realization of the project. Construction projects have some common points, such as huge goods and materials consumption, long construction period, wide coverage, single process, a number of participants, high demands of coordination and so on. It is those characteristics that lead to the existence of many risks starting from the feasibility study stage, reconnaissance and design stage, construction stage, and the completion certification of a project. If those risks are not managed well, they may cause serious damage to the stakeholders and even result in a project not being completed. This is an undesirable circumstance that no one wants to see. So, this study has its grounds in the need to pay attention to risk management works and to improve the risk management theory. There is a strong practical significance of this study.

Risk management is an essential part of construction projects which aims at identifying the potential risks associated with a project and responding to those risks to reduce them to an acceptable extent. Risk management is indeed a dynamic tool that must be continuously applied throughout the project life cycle (Lu & Yan, 2013). Risk management is based on intuition and past experience for a high level of judgment. There are three main processes in risk management which are risk

identification, risk analysis, and risk response. It should be borne in mind that the main principle of risk management is not about eliminating all the risks but controlling them properly. The construction project is overwhelmed by many predictable and unpredictable risks due to different sources of uncertainty, which include the performance of construction parties, resource availability, environmental conditions (Serpella et al., 2014), the involvement of other parties, and contractual relations. The main objectives of risk management in a construction project include completing the project within the specified cost and time and within the required quality, safety, and environmental limits.

In terms of involvement in research and application of theories of engineering project risk management, China started relatively late, and in many respects, it is quite backward compared to developed countries（Liang, 2018). The market is chaotic. It is precisely because of these shortcomings that research, application, and development should be done. In construction project management, risk management, like other forms of management including safety management, contract management, information management, etc., is a very important part of management (Qiu, 2018).

The environment of construction projects is very complicated and is easily affected by natural and social factors. In view of these influencing factors, under normal circumstances, construction personnel often lack knowledge of strong preventive measures and means, and methods to achieve effective control, which in turn leads to project goals that do not meet expected requirements and ultimately leads to "risks" (Zhou, 2019）. Therefore, in order to protect the economic benefits of construction enterprises, it is necessary to fully understand the nature of risks, effectively identify the risks of engineering projects, analyze and study the root causes of risks, and make correct judgments on the impact of risks, and based on this, effective measures can be taken to achieve effective risk control (Xiao, 2019)l. Once the countermeasures and plans are improperly adopted, it will increase the construction cost of the construction enterprise and adversely affect the economic benefits of the enterprise (Zhou, 2020).

This study investigated the site at the flower park construction project in Anren Town, Chengdu, China. Project-related experts were selected, and a direct communication relationship with these experts was established. All expert opinions were collected by way of correspondence. Through a questionnaire, the identification, analysis and evaluation of risks, risk management workers can recognize the nature and characteristics of the risks they are facing, and have evidence to rely on when formulating risk control strategies. Through this, the plans formulated are more reasonable and effective. It reduces the possibility of encountering risks, increases the chances of making profits, improves the ability to deal with emergencies, improves management quality, and provides important reassurance for the smooth completion of the project and the realization of various goals.

LITERATURE REVIEW

Various industries will have project risk management, but different industries have different characteristics. As far as the construction industry is concerned, its risks are greater, and management is more complex and more difficult. Risk management of construction projects refers to the identification, analysis, and evaluation of potential risks by the construction unit, and effective disposal measures (Raisbeck, 2018) to deal with the impact of risks, so as to make the construction safe at the lowest cost. A scientific management method to obtain the greatest degree of assurance, risk management of construction projects is to effectively control the construction period, quality, cost, and safety of construction projects.

There are many problems in the risk management of construction projects. In the actual construction process, it is inevitable to encounter natural risks, which are often unavoidable, mainly involving natural disasters such as severe weather conditions and mudslides. Although the natural

environment often causes great risks, it can be prevented with scientific construction plans. In terms of economic risks, in the current economic environment which is facing problems, the operation of construction projects often comes with great risks, such as the increase in labor costs and the adjustment of construction material costs. In the process of construction engineering, the safety of construction sites is one of the main issues. Because construction projects often require a large number of construction personnel, engaged in high-altitude operations, this results in greater construction risks. This in turn requires prior identification and prevention of possible risks.

For all staff engaged in risk management of construction projects, （Lu et al., 2002）clarifying the risks is conducive to the macro-control of the direction and focus of the work, and it can also make the risk management work organized and conducive to improving management efficiency. In short （Wei, 2000）the content of project risk management can be summarized into the following four characteristics: Risk identification, Risk analysis, Risk response, and Risk treatment.

In construction projects, it is not only necessary to identify risks, but also to conduct risk analysis based on the results of risk identification to assess the possibility of various risks and the magnitude of the impact on the project. There are many methods for risk assessment, and the comprehensive evaluation method is a commonly used evaluation method, including the lowest evaluation price and the comprehensive scoring method (Zhou, 2019). This mainly requires qualitative analysis that is supported by quantitative analysis. Sufficient relevant information needs to be obtained to make a reasonable overall evaluation of project risks. The second is the analytic hierarchy process, which needs to determine the evaluation object, as well as the criteria, details, and various indicators of this evaluation activity, and establish a hierarchical risk evaluation model based on these data. After establishing the model, the judgment matrix can be developed. In practical applications, it is necessary to arrange the order according to the relative weights of various risks.

RESEARCH METHODOLOGY

The methodologies used in this study include quantitative and qualitative approaches to analyze the data obtained. The data was analyzed using SPSS software. The qualitative and quantitative data were combined and analysed using the Fuzzy analysis method. First, the relevant expert engineers involved in the project construction were identified, and then direct correspondence with these experts was established, with a total of 17 interviewees, including senior engineers, designers, construction engineers and cost engineers. Expert opinions were collected by way of correspondence. These experts include designers, engineers and project managers. This research obtained data from a case study conducted in Chengdu, China. The researcher had a face to face contact with each expert and explained the purpose of the questionnaire, and then briefly explained the content of each part of the questionnaire. The experts then completed the questionnaire and were interviewed. Finally, these opinions were collected and integrated. Based on this, feedback was given to experts, and opinions were then collected again.

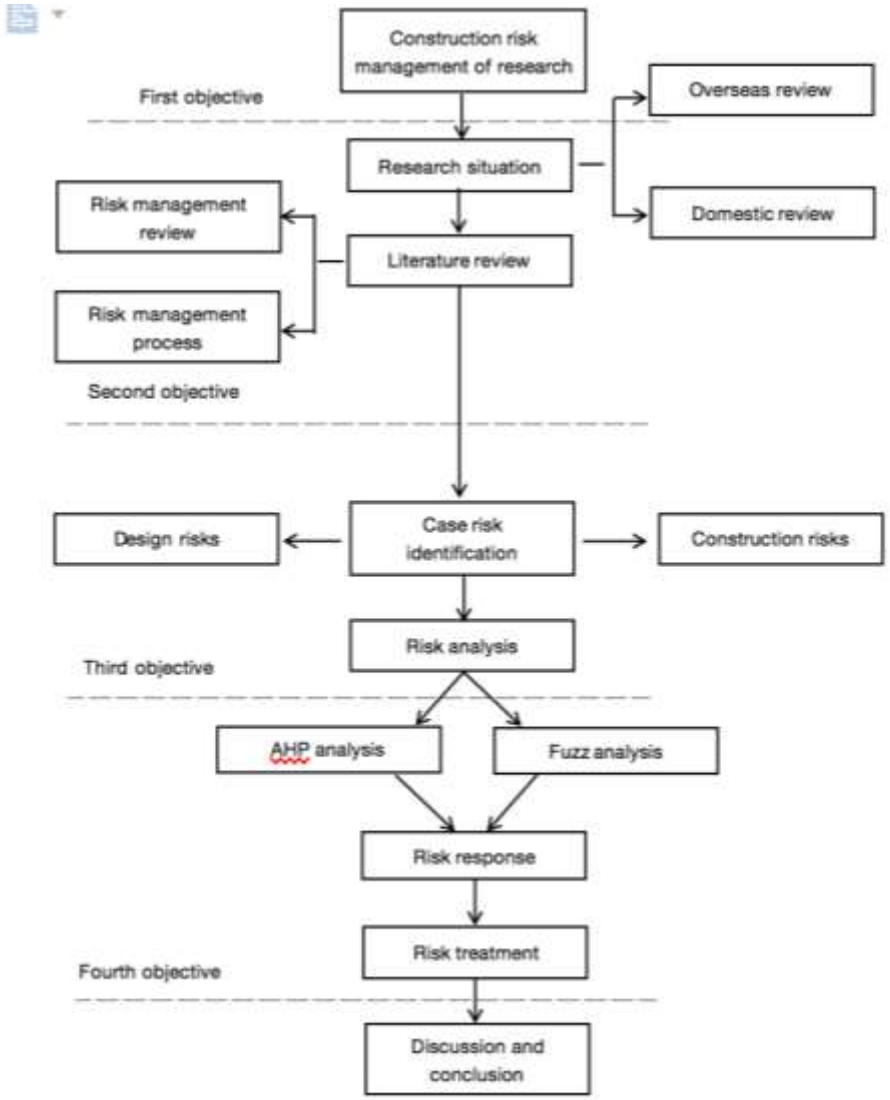

Figure 1: Research Framework

RESULTS AND DISCUSSION

The Flower Park Project is located in Anren Town, Chengdu City, Sichuan Province. The park covers an area of 39 acres, including 32 acres of green space and 2.8 acres of water, with a green space rate of about 83%.

According to the introduction of the construction project risk identification index system, combined with the actual situation of the Flower Park Project in Anren Town, the project risk fuzzy analysis method was identified. The primary risk factors are mainly design stage risks, construction stage risks, bidding stage risks and other risks. The fuzzy comprehensive evaluation method is a comprehensive evaluation method based on fuzzy mathematics. The comprehensive evaluation method transforms qualitative evaluation into quantitative evaluation according to the membership degree theory of fuzzy mathematics, that is, using fuzzy mathematics to make a general evaluation of things or objects restricted by many factors. It has the characteristics of clear results and strong systematicness, which can better solve vague and difficult-to-quantify problems, and is suitable for solving various non-deterministic problems.

Table 1: Statistics of the measurement results of each item of the scale

Items	strongly disagree (%)	disagree（%）	Neutral (%)	Agree(%)	Very much agree（%）	mean	standard deviation
I don't think a feasibility analysis has been done on the construction project	24.27	28.87	31.38	12.13	3.35	2.414	1.085
I think the lack of project risk management plan for construction projects	24.27	30.13	33.47	9.62	2.51	2.360	1.031
I think construction projects are planned hastily and not well enough	21.34	36.40	28.03	9.62	4.60	2.397	1.068
I think the information provided by the owner of the construction project is incomplete and the requirements are not clear	25.10	36.82	24.27	9.62	4.18	2.310	1.079
I think the planning conditions for construction projects have changed	23.43	30.13	30.13	12.97	3.35	2.427	1.086
I think the unit in charge of the construction project has made an improper choice of the design unit	37.24	19.67	22.18	19.25	1.67	2.285	1.200
I think that the selection of the design scheme by the unit responsible for the construction project is at risk	20.92	32.64	29.29	12.55	4.60	2.473	1.095
I think the construction project is not designed according to the normal design stage	26.78	33.47	24.27	12.55	2.93	2.314	1.087

I think the scope of the design content of the construction project is not clear	19.67	31.38	30.96	12.13	5.86	2.531	1.114
I think construction drawings for construction projects are not deep enough	22.59	28.87	30.96	13.81	3.77	2.473	1.099
I think the review and supervision system of the design company corresponding to the construction project is not perfect	19.25	33.89	30.96	12.97	2.93	2.464	1.036
I don't think the skills and methods of the designers involved in the construction project are adequate	22.18	32.64	29.71	12.13	3.35	2.418	1.065
I think the construction process of the construction project is flawed	24.69	35.98	23.85	12.13	3.35	2.335	1.079
I think there is a problem with the quality of construction equipment for construction projects	28.03	30.54	29.29	8.37	3.77	2.293	1.080
I think construction projects have engineering quality risks	23.85	36.40	28.03	8.79	2.93	2.305	1.022
I think there is a risk of construction delay in construction projects	26.36	34.73	27.62	7.11	4.18	2.280	1.062
I think the general design document of the construction project is not very guiding	27.20	35.56	26.78	7.53	2.93	2.234	1.027
I think that the construction operators of construction projects have insufficient experience and ability	30.96	29.29	25.94	10.46	3.35	2.259	1.107
I think there is a lack of material preparation for construction projects	30.54	29.29	28.03	10.46	1.67	2.234	1.051
I think the construction responsibility of the construction project is not clear	45.19	21.76	14.23	18.41	0.42	2.071	1.170
I think there is a situation in which construction projects are designed and constructed at the same time	27.62	32.22	25.10	10.04	5.02	2.326	1.131
I think the construction side of the construction project is not skilled enough	26.36	37.24	24.69	8.37	3.35	2.251	1.043

I think the design bidding process for construction projects is illegal and non-standard	19.25	27.62	33.89	16.32	2.93	2.561	1.067
I think there is a risk of ambiguous assignment of responsibilities between the two parties in the design contract terms in construction projects	21.34	29.71	33.05	13.39	2.51	2.460	1.048
I think the design bidding documents for construction projects are irregular and inaccurate	33.05	15.90	22.59	26.36	2.09	2.485	1.253
I think the construction bidding process of construction projects is illegal and irregular	20.08	32.64	30.13	14.23	2.93	2.473	1.056
I think the construction bidding documents for construction projects are irregular and inaccurate	21.34	28.45	28.03	17.57	4.60	2.556	1.143
I think there is a risk of ambiguous assignment of responsibilities between the two parties in the construction contract terms of a construction project	20.08	34.31	28.45	13.39	3.77	2.464	1.072
I think natural disasters often occur in the location of construction projects	18.41	36.82	30.54	10.04	4.18	2.448	1.035
I think construction projects are vulnerable to government policy adjustments	35.15	19.25	19.25	25.52	0.84	2.377	1.227
I think the geographical environment risk is high in the location where the construction project is located	20.92	30.54	33.05	10.88	4.60	2.477	1.080
I think the economic situation where the construction project is located has deteriorated	20.08	35.98	26.78	14.64	2.51	2.435	1.047

Through frequency analysis and description, the percentage ratio and corresponding mean value of each item option in the above table were counted. The results are shown in the above table. According to the weight of the AHP method, the fuzzy comprehensive evaluation was further carried out in combination.

1) Design Risk Judgment Results

$$\mathbf{a1} = \begin{pmatrix} \mathbf{0.2427\ 0.2887\ 0.3138\ 0.1213\ 0.0335} \\ \mathbf{0.2427\ 0.3013\ 0.3347\ 0.0962\ 0.0251} \\ \mathbf{0.2134\ 0.3640\ 0.2803\ 0.0962\ 0.0460} \\ \mathbf{0.2510\ 0.3682\ 0.2427\ 0.0962\ 0.0418} \\ \mathbf{0.2343\ 0.3013\ 0.3013\ 0.1297\ 0.0335} \\ \mathbf{0.3724\ 0.1967\ 0.2218\ 0.1925\ 0.0167} \\ \mathbf{0.2092\ 0.3264\ 0.2929\ 0.1255\ 0.0460} \\ \mathbf{0.2678\ 0.3347\ 0.2427\ 0.1255\ 0.0293} \\ \mathbf{0.1967\ 0.3138\ 0.3096\ 0.1213\ 0.0586} \\ \mathbf{0.2259\ 0.2887\ 0.3096\ 0.1381\ 0.0377} \\ \mathbf{0.1925\ 0.3389\ 0.3096\ 0.1297\ 0.0293} \\ \mathbf{0.2218\ 0.3264\ 0.2971\ 0.1213\ 0.0335} \end{pmatrix}$$

$$\mathbf{Aa1} = \begin{pmatrix} \mathbf{0.1187\ 0.0788\ 0.1072\ 0.0755\ 0.146\ 0.0396\ 0.0392\ 0.0753\ 0.1057\ 0.1051\ 0.0373} \\ \mathbf{0.0716} \end{pmatrix}$$

$$\mathbf{Ba1} = \mathbf{Aa1} \cdot \mathbf{Ra1} = (\mathbf{0.2347}\ \ \mathbf{0.3141}\ \ \mathbf{0.2926}\ \ \mathbf{0.1213}\ \ \mathbf{0.0373})$$

The results show that in terms of design risk, the surveyed groups chose "strongly disagree" with 23.47%, "disagree" with 31.41%, "neutral" with 29.26%, and "agree" with 12.13%. The "high" rate is 3.73%, and the conclusion is "disagree" according to the principle of maximum membership, indicating that the design risk of the building project is low.

2) Construction Risk Judgment Results

$$\mathbf{Ra2} =$$

$$\mathbf{Ra2} = \begin{pmatrix} \mathbf{0.2469\ 0.3598\ 0.2385\ 0.1213\ 0.0335} \\ \mathbf{0.2803\ 0.3054\ 0.2929\ 0.0837\ 0.0377} \\ \mathbf{0.2385\ 0.3640\ 0.2803\ 0.0879\ 0.0293} \\ \mathbf{0.2636\ 0.3473\ 0.2762\ 0.0711\ 0.0418} \\ \mathbf{0.2720\ 0.3556\ 0.2678\ 0.0753\ 0.0293} \\ \mathbf{0.3096\ 0.2929\ 0.2594\ 0.1046\ 0.0335} \\ \mathbf{0.3054\ 0.2929\ 0.2803\ 0.1046\ 0.0167} \\ \mathbf{0.4519\ 0.2176\ 0.1423\ 0.1841\ 0.0042} \\ \mathbf{0.2762\ 0.3222\ 0.2510\ 0.1004\ 0.0502} \\ \mathbf{0.2636\ 0.3724\ 0.2469\ 0.0837\ 0.0335} \end{pmatrix}$$

$$\mathbf{Aa2} = (\mathbf{0.1229\ 0.0988\ 0.1431\ 0.0975\ 0.0510\ 0.0944\ 0.0722\ 0.0696\ 0.1328\ 0.1178}\ )$$

$$\mathbf{Ba2} = \mathbf{Aa2} \cdot \mathbf{Ra2} = (\mathbf{0.2822}\ \ \mathbf{0.3291}\ \ \mathbf{0.2560}\ \ \mathbf{0.1000}\ \ \mathbf{0.0329})$$

The results show that in terms of construction risk, the surveyed groups chose "strongly disagree" with 28.22%, "disagree" with 32.91%, "neutral" with 25.60%, and "agree" with 10.00%. The proportion of "high" is 3.29%, and according to the principle of maximum membership, the conclusion is "disagree", indicating that the construction risk of the building project is low.

3) Bidding Risk Judgment Results

$$\mathbf{Ra3} = \begin{pmatrix} \mathbf{0.1925\ 0.2762\ 0.3389\ 0.1632\ 0.0293} \\ \mathbf{0.2134\ 0.2971\ 0.3305\ 0.1339\ 0.0251} \\ \mathbf{0.3305\ 0.1590\ 0.2259\ 0.2636\ 0.0209} \\ \mathbf{0.2008\ 0.3264\ 0.3013\ 0.1423\ 0.0293} \\ \mathbf{0.2134\ 0.2845\ 0.2803\ 0.1757\ 0.0460} \\ \mathbf{0.2008\ 0.3431\ 0.2845\ 0.1339\ 0.0377} \end{pmatrix}$$

$$\mathbf{Aa3} = (\mathbf{0.2567\ 0.1715\ 0.0868\ 0.243\ 0.0851\ 0.1568}\ )$$

$$\mathbf{Ba3} = \mathbf{Aa3} \cdot \mathbf{Ra3} = (\mathbf{0.2131\ \ 0.2930\ \ 0.3050\ \ 0.1583\ \ 0.0306})$$

The results show that in terms of bidding risk, the surveyed groups chose "strongly disagree" with 21.31%, "disagree" with 29.30%, "neutral" with 30.50%, and "agree" with 15.83%, the proportion of "high" is 3.06%, and according to the principle of maximum membership, the conclusion is "neutral", indicating that the bidding risk of the construction project is low.

4) Other Risk Judgment Results

$$\mathbf{Ra4} = \begin{pmatrix} \mathbf{0.1841\ 0.3682\ 0.3054\ 0.1004\ 0.0418} \\ \mathbf{0.3515\ 0.1925\ 0.1925\ 0.2552\ 0.0084} \\ \mathbf{0.2092\ 0.3054\ 0.3305\ 0.1088\ 0.0460} \\ \mathbf{0.2008\ 0.3598\ 0.2678\ 0.1464\ 0.0251} \end{pmatrix}$$

$$\mathbf{Aa4} = (\ \mathbf{0.2486\ 0.2618\ 0.2479\ 0.2417})$$

$$\mathbf{Ba4} = \mathbf{Aa4} \cdot \mathbf{Ra4} = (\mathbf{0.2382\ \ 0.3046\ \ 0.2730\ \ 0.1541\ \ 0.0301})$$

The results showed that, in terms of other risks, the surveyed group chose "strongly disagree" with 23.82%, "disagree" with 30.46%, "neutral" with 27.30%, and "agree" with 15.41%. “High" was 3.01%, and according to the principle of maximum membership, the conclusion was "disagree", indicating that other risks of the construction project are low.

5) Second-level Fuzzy Judgment Results

According to the single-factor first-level evaluation made above, combined with the first-level index weight of the AHP, the second-level fuzzy evaluation was carried out.

$$\mathbf{Ra} = \begin{pmatrix} \mathbf{0.2347} & \mathbf{0.3141} & \mathbf{0.2926} & \mathbf{0.1213} & \mathbf{0.0373} \\ \mathbf{0.2822} & \mathbf{0.3291} & \mathbf{0.2560} & \mathbf{0.1000} & \mathbf{0.0329} \\ \mathbf{0.2131} & \mathbf{0.2930} & \mathbf{0.3050} & \mathbf{0.1583} & \mathbf{0.0306} \\ \mathbf{0.2382} & \mathbf{0.3046} & \mathbf{0.2730} & \mathbf{0.1541} & \mathbf{0.0301} \end{pmatrix}$$

$$\mathbf{Aa} = (\mathbf{0.2703\ 0.4124\ 0.2541\ 0.0632})$$

$$\mathbf{Ba} = \mathbf{Aa} \cdot \mathbf{Ra} = (\mathbf{0.2490\ \ 0.3143\ \ 0.2794\ \ 0.1240\ \ 0.0333}\ )$$

In the overall measurement results of the risk in the design and construction stage of construction projects, the surveyed group chose "strongly disagree" with 24.90%, "disagree" with 31.43%, "neutral" with 27.94%, and "agree" The proportion of "high" is 12.40, and the proportion of "high" is

3.33%. According to the principle of maximum membership, the conclusion is "disagree", indicating that the overall risk of the construction project in the design and construction stage is low.

Overall, this study mainly introduces the use of different analysis methods to analyze and explore the collected data. The research mainly adopts the questionnaire survey to obtain the survey data. Then SPSS analysis software was used to analyze the data to find out the risk indicators of the project. The analysis indicated that the overall risk in the design and construction phases of the construction project was low and this is aligned to the expected results.

CONCLUSION

Through the specific situation of the construction of the Flower Park Project, the actual problems were put forward. After the preliminary analysis of the project risk factors, the risk of the project was evaluated, and the fuzzy method was used to obtain the main risk factors for the project. For the main risk factors identified by scientific methods, a set of corresponding risk suitability response strategies were established to effectively prevent unknown risks and minimize the uncertainty of risks. So far, based on practical examples, a more comprehensive understanding of project risk management was derived from theory, minimizing the risks encountered by engineering projects, which played a guiding role in the risk management of future engineering projects.

At the same time, based on the literature read, the workflow of construction engineering and the risk management process was sorted and analyzed. By studying risk management at home and abroad, understanding risk management methods, and combining construction engineering, a set of risk identification methods that conform to the characteristics of construction engineering design were identified where the reference value was summarized, and a reasonable control method to reduce the impact of risks was given. This enriches the construction engineering risk management system and provides effective theoretical guidance for the healthy development of the industry.

This study discusses the relevant factors of construction engineering risk and uses a combination of theoretical analysis and event research. The combination of qualitative and quantitative approaches, and systematic analysis leads to a more comprehensive analysis of the design risk, construction risk, and bidding risk of construction engineering. The law of occurrence and development helped to discuss the theories and methods of risk management and draw research results and conclusions. It is believed that the current construction engineering risk awareness is very weak, and the awareness of risk management should be improved to make the future and development direction of risk management clear. The methods of risk identification and control will be more abundant and perfect, and the risk management of construction projects will be more efficient.

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