Risk Management Study of Resettlement Community EPC Project Based on AHP-Fuzzy Comprehensive Evaluation Method

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Abstract—Five primary risk indicators and 24 secondary risk indicators are analyzed and summarized through literature research method, so as to establish the risk evaluation index system under the resettlement community EPC project. Taking a resettlement community EPC project in Hangzhou as an example, the analytic hierarchy process (AHP) and fuzzy comprehensive evaluation method are used comprehensively to construct the judgment matrix, calculate the eigenvectors and eigenvalues, and conduct consistency test to obtain the weights and ranking of each risk factor, and finally evaluate the overall risk level of the example project, so it can provide some reference for the risk evaluation of the same type of project.

Keywords-EPC project; risk management; analytic hierarchy process; fuzzy comprehensive evaluation method

1. Introduction

With the improvement of urbanization construction level and the remarkable promotion of shantytown renovation, the construction of resettlement communities has become one of the important work of urbanization construction, and the EPC model has been widely promoted and adopted in resettlement community projects. In 2015, the State Council issued the Opinions on Further Improving the Construction of Urban Shantytowns and Urban and Rural Dangerous Houses and Supporting Infrastructure (Guo Fa [2015]) No. 37), putting forward the goal of renovating 18 million sets of housing in various shantytowns from 2015 to 2017. In Hangzhou, for example, in 2021 alone, the city will start 28 resettlement houses, 4.76 million square meters and 25,504 sets, and complete 73 resettlement houses, 10.35 million square meters and 59,273 sets, so it can be said that the construction volume and investment scale are quite huge. In 2016, the Ministry of Construction issued "Several Opinions on Further Promoting the Development of General Engineering Contracting", pointing out that general engineering contracting generally adopts design-procurement-construction general contracting or design-construction general contracting mode; meanwhile, government investment projects and assembly-type buildings are encouraged to actively adopt general engineering contracting

BDEIM 2022, December 02-03, Zhengzhou, People's Republic of China

DOI 10.4108/eai.2-12-2022.2328689

mode. Therefore, with the rapid development of the construction industry, more and more governmental projects have adopted the EPC mode as the state vigorously promotes the EPC mode. Taking the demolition and resettlement community of a district in Hangzhou as an example, since the first EPC general contracting mode was adopted for a street urban-rural integration resettlement community in a district in 2016, all subsequent resettlement community projects in the district have adopted the EPC general contracting mode, which shows the promotion and importance of the local government to the EPC mode.

The demolition and resettlement community projects using EPC model generally have the characteristics of large volume, high cost and long duration, but due to the characteristics of EPC general contract and the principle of lump-sum contract, most of the risks during the project implementation will be borne by the general contractor. Therefore, it is of certain practical significance to conduct risk evaluation and management research for resettlement community EPC projects.

2. Risk Identification for Resettlement Community EPC Projects

For resettlement community EPC projects, from the perspective of the general contractor, the division according to the causes and nature of risks is more conducive to the effective identification of risks by the general contractor[1][2]:

2.1 Social Risk

It refers to the risk caused by the change of policies and regulations, inefficiency of government departments, or poor security condition of the project site.

2.2 Natural Risks

It refers to the risk caused by unfavorable climatic conditions such as typhoon, snowfall, or unfavorable geological conditions.

2.3 Economic Risk

It refers to the construction unit's poor financial situation or the construction unit's awareness of performance, as well as unreasonable prices, material price increases and other economic factors caused by the risk.

2.4 Technical Risk

It refers to the risk caused by unfamiliarity with the specification drawings, the difficulty of construction, the use of new materials, new technology, new technology, etc.

2.5 Management Risk

It refers to the project management team's ability and experience in the project management process, the cooperation of the EPC consortium, the relationship between the consortium and the construction unit, and other risks caused by the project in terms of schedule, safety and quality.

3. The Basic Principle of AHP-Fuzzy Comprehensive Evaluation Method

The basic steps of combining the analytic hierarchy process (AHP) and fuzzy comprehensive evaluation method for risk evaluation of resettlement community EPC projects are as follows:

3.1 Establish the Indicator Set

The possible risk factors are analyzed and categorized to establish a risk evaluation index system, and the index set $U=\{u_1,u_2,u_3,\cdots,u_n\}$.

3.2 Establish Evaluation Sets

Evaluation set $V=\{v_1, v_2, v_3, v_4, v_5\}$= {Low risk, lower risk, moderate risk, higher risk, high risk}. Among them,$v_1\in[0, 0.2]$,$v_2\in[0.2, 0.4]$, $v_3\in[0.4, 0.6]$, $v_4\in[0.6, 0.8]$, $v_5\in[0.8, 1.0]$[3].

3.3 Determine the Set of Weights

The judgment matrix is constructed using the analytic hierarchy process (the judgment matrix uses the 1-9 scale method) [4], and the eigenvalues and eigenvectors of each judgment matrix are calculated to obtain the weight values of each risk factor [5].

3.4 Consistency Test

The consistency index CI and random consistency ratio CR were introduced, and if $CR < 0.1$, the consistency test passed, otherwise the values were recalculated [6].

3.5 Fuzzy Evaluation

Each risk factor u_i in the index set matrix U is evaluated separately, and then the affiliation degree of the evaluation scheme v_i for each risk factor u_i is formed into a fuzzy evaluation matrix $Ri=(r_{i1}, r_{i2}, \cdots, r_{im})$.

3.6 Comprehensive Evaluation

$$B = w \cdot R = (w_1, w_2, w_3\cdots, w_n) \cdot \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ \vdots & & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \quad (1)$$

Finally, the final risk assessment value $E=B\times V^T$ is calculated.

4. Example Analysis

4.1 Project Risk Factor Analysis

A resettlement community EPC project is located in Qiantang District, Hangzhou. The construction of the project includes high-rise residential buildings, supporting public buildings, basement, kindergarten, outdoor municipal landscape and so on. The total construction area of the project is about 270,000 m2 and the total investment is about 2 billion RMB. The Delphi method was used to conduct a questionnaire survey to determine the final risk factors of the project and establish a risk evaluation index system, as shown in Figure 1.

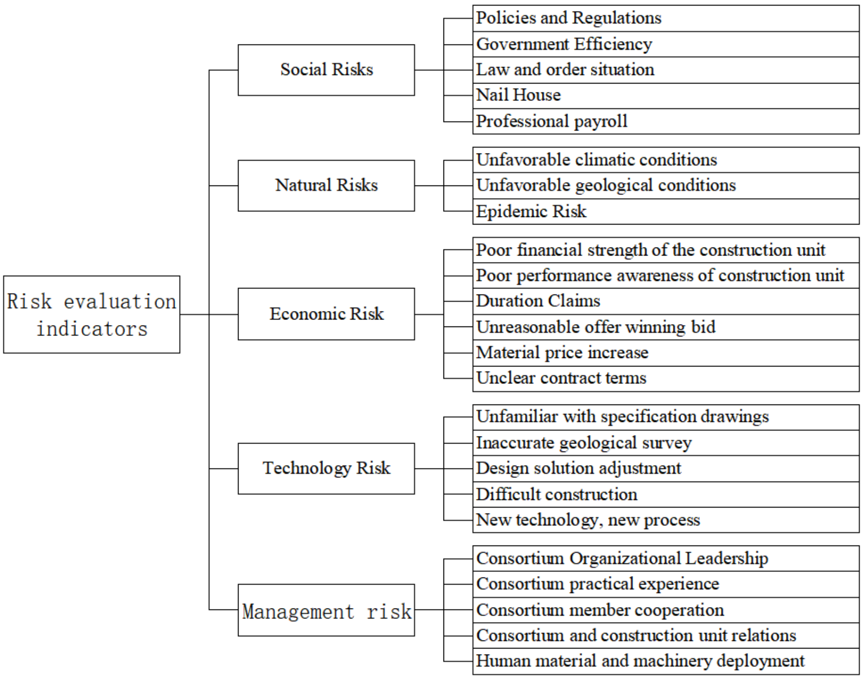

Figure 1. Risk indicator chart

4.2 Project Risk Evaluation

1) Determine the Weight Indexes: Using the analytic hierarchy process, and using the 1-9 scale method, we construct the judgment matrix of two-by-two comparison for each level, calculate the eigenvalues and eigenvectors of each judgment matrix, and conduct consistency test, so as to obtain the weight index of each risk factor, and the results are detailed in Table 1.

Table 1 Summary of Risk Factor Indicators

Level 1 Risk Indicators	Level 1 Risk Indicator Weights	Level 2 Risk Indicators	Level 2 Risk Indicator Weights	Combined weights
A1 Social Risks	0.246	B11Policies and Regulations	0.381	0.094
		B12Government Efficiency	0.317	0.078
		B13Law and order situation	0.151	0.037
		B14Nail House	0.103	0.025
		B15Professional payroll	0.048	0.012
A2 Natural Risks	0.045	B21Unfavorable climatic conditions	0.333	0.015
		B22Unfavorable geological conditions	0.528	0.024
		B23Epidemic Risk	0.139	0.006
A3 Economic Risk	0.500	B31Poor financial strength of the construction unit	0.392	0.196
		B32Poor performance awareness of construction unit	0.208	0.104
		B33Duration Claims	0.094	0.047
		B34Unreasonable offer winning bid	0.199	0.100
		B35Material price increase	0.068	0.034
		B36Unclear contract terms	0.039	0.020
A4 Technology Risk	0.090	B41Unfamiliar with specification drawings	0.399	0.036
		B42Inaccurate geological survey	0.266	0.024
		B43Design solution adjustment	0.104	0.009
		B44Difficult construction	0.172	0.015
		B45New technology, new process	0.059	0.005
A5 Management risk	0.119	B51 Consortium Organizational Leadership	0.364	0.043
		B52 Consortium practical experience	0.235	0.028
		B53 Consortium member cooperation	0.108	0.013
		B54 Consortium and construction unit relations	0.193	0.023
		B55 Human material and machinery deployment	0.100	0.012

2) Establish Evaluation Sets: V={v1, v2, v3, v4, v5}= {Low risk, lower risk, moderate risk, higher risk, high risk}. Among them, v1∈[0, 0.2],v2∈[0.2, 0.4], v3∈[0.4, 0.6], v4∈[0.6, 0.8], v5∈[0.8, 1.0].

3) Establish the Fuzzy Evaluation Matrix: The fuzzy evaluation matrix was established through the expert questionnaire.

Social risk fuzzy evaluation matrix:

$$R_1=\begin{bmatrix} 0 & 0.15 & 0.25 & 0.2 & 0.4 \\ 0.05 & 0.15 & 0.3 & 0.3 & 0.2 \\ 0.05 & 0.2 & 0.4 & 0.25 & 0.1 \\ 0 & 0.1 & 0.5 & 0.2 & 0.2 \\ 0.25 & 0.35 & 0.25 & 0.15 & 0 \end{bmatrix}$$

Natural risk fuzzy evaluation matrix:

$$R_2=\begin{bmatrix} 0 & 0.3 & 0.25 & 0.35 & 0.10 \\ 0 & 0.15 & 0.3 & 0.3 & 0.25 \\ 0.25 & 0.25 & 0.2 & 0.25 & 0.05 \end{bmatrix}$$

Economic risk fuzzy evaluation matrix:

$$R_3=\begin{bmatrix} 0 & 0.05 & 0.25 & 0.25 & 0.45 \\ 0.05 & 0.2 & 0.3 & 0.25 & 0.2 \\ 0.1 & 0.4 & 0.25 & 0.2 & 0.05 \\ 0.05 & 0.25 & 0.3 & 0.25 & 0.15 \\ 0.2 & 0.2 & 0.4 & 0.2 & 0 \\ 0.1 & 0.35 & 0.35 & 0.15 & 0.05 \end{bmatrix}$$

Technology risk fuzzy evaluation matrix:

$$R_4=\begin{bmatrix} 0.1 & 0.3 & 0.35 & 0.2 & 0.05 \\ 0 & 0.25 & 0.4 & 0.25 & 0.1 \\ 0.15 & 0.30 & 0.35 & 0.2 & 0 \\ 0 & 0.25 & 0.4 & 0.25 & 0.1 \\ 0.3 & 0.4 & 0.2 & 0.1 & 0 \end{bmatrix}$$

Management risk fuzzy evaluation matrix:

$$R_5=\begin{bmatrix} 0.05 & 0.25 & 0.35 & 0.2 & 0.15 \\ 0.05 & 0.2 & 0.4 & 0.25 & 0.1 \\ 0.15 & 0.3 & 0.3 & 0.2 & 0.05 \\ 0.1 & 0.3 & 0.35 & 0.15 & 0.1 \\ 0.2 & 0.35 & 0.3 & 0.15 & 0 \end{bmatrix}$$

4) Calculation of Secondary Indicators:

Calculation of fuzzy evaluation of social risks:

$$B_1=W_1\bullet R_1=\begin{bmatrix} 0.381 \\ 0.317 \\ 0.151 \\ 0.103 \\ 0.048 \end{bmatrix}^T \bullet \begin{bmatrix} 0 & 0.15 & 0.25 & 0.2 & 0.4 \\ 0.05 & 0.15 & 0.3 & 0.3 & 0.2 \\ 0.05 & 0.2 & 0.4 & 0.25 & 0.1 \\ 0 & 0.1 & 0.5 & 0.2 & 0.2 \\ 0.25 & 0.35 & 0.25 & 0.15 & 0 \end{bmatrix}$$
$$=\begin{pmatrix} 0.0354 & 0.162 & 0.3142 & 0.2369 & 0.2515 \end{pmatrix}$$

Calculation of fuzzy evaluation of natural risks:

$$B_2 = W_2 \bullet R_2 = \begin{bmatrix} 0.333 \\ 0.528 \\ 0.139 \end{bmatrix}^T \bullet \begin{bmatrix} 0 & 0.3 & 0.25 & 0.35 & 0.1 \\ 0 & 0.15 & 0.3 & 0.3 & 0.25 \\ 0.25 & 0.25 & 0.2 & 0.25 & 0.05 \end{bmatrix}$$

$$= \begin{pmatrix} 0.0348 & 0.2139 & 0.2694 & 0.3097 & 0.1722 \end{pmatrix}$$

Calculation of fuzzy evaluation of economic risk:

$$B_3 = W_3 \bullet R_3 = \begin{bmatrix} 0.392 \\ 0.208 \\ 0.094 \\ 0.199 \\ 0.068 \\ 0.039 \end{bmatrix}^T \bullet \begin{bmatrix} 0 & 0.05 & 0.25 & 0.25 & 0.45 \\ 0.05 & 0.2 & 0.3 & 0.25 & 0.2 \\ 0.1 & 0.4 & 0.25 & 0.2 & 0.05 \\ 0.05 & 0.25 & 0.3 & 0.25 & 0.15 \\ 0.2 & 0.2 & 0.4 & 0.2 & 0 \\ 0.1 & 0.35 & 0.35 & 0.15 & 0.05 \end{bmatrix}$$

$$= \begin{pmatrix} 0.0473 & 0.1758 & 0.2844 & 0.238 & 0.2545 \end{pmatrix}$$

Calculation of fuzzy evaluation of technology risk:

$$B_4 = W_4 \bullet R_4 = \begin{bmatrix} 0.399 \\ 0.266 \\ 0.104 \\ 0.172 \\ 0.059 \end{bmatrix}^T \bullet \begin{bmatrix} 0.1 & 0.3 & 0.35 & 0.2 & 0.05 \\ 0 & 0.25 & 0.4 & 0.25 & 0.1 \\ 0.15 & 0.3 & 0.35 & 0.2 & 0 \\ 0 & 0.25 & 0.4 & 0.25 & 0.1 \\ 0.3 & 0.4 & 0.2 & 0.1 & 0 \end{bmatrix}$$

$$= \begin{pmatrix} 0.0732 & 0.284 & 0.3631 & 0.216 & 0.0637 \end{pmatrix}$$

Calculation of fuzzy evaluation of management risk:

$$B_5 = W_5 \bullet R_5 = \begin{bmatrix} 0.364 \\ 0.235 \\ 0.108 \\ 0.193 \\ 0.1 \end{bmatrix}^T \bullet \begin{bmatrix} 0.05 & 0.25 & 0.35 & 0.2 & 0.15 \\ 0.05 & 0.2 & 0.4 & 0.25 & 0.1 \\ 0.15 & 0.3 & 0.3 & 0.2 & 0.05 \\ 0.1 & 0.3 & 0.35 & 0.15 & 0.1 \\ 0.2 & 0.35 & 0.3 & 0.15 & 0 \end{bmatrix}$$

$$= \begin{pmatrix} 0.0855 & 0.2633 & 0.3513 & 0.1971 & 0.1028 \end{pmatrix}$$

5) Calculation of Risk Assessment Value:

Calculation of primary indicators:

$$E = A \bullet B = \begin{bmatrix} 0.246 \\ 0.045 \\ 0.5 \\ 0.09 \\ 0.119 \end{bmatrix}^T \bullet \begin{bmatrix} 0.0354 & 0.162 & 0.3142 & 0.2369 & 0.2515 \\ 0.0348 & 0.2139 & 0.2694 & 0.3097 & 0.1722 \\ 0.0473 & 0.1758 & 0.2844 & 0.238 & 0.2545 \\ 0.0732 & 0.284 & 0.3631 & 0.216 & 0.0637 \\ 0.0855 & 0.2633 & 0.3513 & 0.1971 & 0.1028 \end{bmatrix}$$

$$= \begin{pmatrix} 0.0507 & 0.1943 & 0.3061 & 0.2341 & 0.2148 \end{pmatrix}$$

Calculation of the combined appraisal value:

$$E \bullet V^T = [0.0507 \quad 0.1943 \quad 0.3061 \quad 0.2341 \quad 0.2148] \bullet \begin{bmatrix} 0.1 \\ 0.3 \\ 0.5 \\ 0.7 \\ 0.9 \end{bmatrix}$$

$$= 0.5736 \in [0.4, 0.6]$$

4.3 Analysis of Evaluation Results

From the above calculation results, we can see that the risk evaluation level of the project is "moderate risk", and there is a certain degree of risk. Therefore, certain measures should be taken to make the project in a controllable state. There are four main categories of risk response measures: risk avoidance, risk retention, risk transfer, and risk diversification. According to Table 1, economic risk has the greatest influence on the overall project risk, followed by social risk, management risk, technical risk and natural risk. Among the secondary indicators, poor financial strength of the construction unit, poor performance awareness of construction unit and unreasonable offer winning bid are the first three factors affecting the project risk. "New technologies and techniques" are the factors with the least risk impact. Therefore, the general contractor of the project should pay attention to the prevention of economic risk factors in risk management, especially in the selection of the project, priority should be given to choose the owner unit with strong financial strength and good performance ability for cooperation; at the same time, when making bidding quotations, the commercial team should also carefully account for the gatekeeper, and avoid unreasonably low bid, so as not to affect the advancement of the project and damage the economic benefits of the general contractor.

5. Concluding Remarks

For resettlement community EPC projects, the existence of risk is objective and unavoidable, so the evaluation and management of risk is crucial for the general contractor. Using the combination of the analytic hierarchy process and fuzzy comprehensive evaluation method for risk evaluation overcomes the shortcomings of previous project management using subjective experience, gives full play to the advantages of qualitative analysis plus quantitative calculation, improves the scientificity of decision making, and has certain significance for general contractors to carry out risk management of similar projects.

Acknowledgment

This study is supported by China Construction Eighth Engineering Bureau Co., Ltd.

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