# Study on Comprehensive Evaluation of Mine Construction Project Management Based on AHP-FUZZY

**Xiaoqiang GAO [1], Jingyan ZHU [2]**

[1] School of Mechanics and Civil Engineering, China University of Mining and Technology (Beijing), Beijing 100083, China

[2] School of Civil Engineering, North China University of Technology, Beijing 100144, China

*Corresponding author's e-mail: 3166954095@qq.com

**Abstract.** Coal mine construction has investment huge, long cycle, high quality characteristics, higher requirements have been put forward for the mine construction project management. This paper establishes the three-level evaluation index system of mine construction project management from four aspects, which include the project goal, the owner, the supervision unit and the contractor, establishes the project management comprehensive evaluation model based on the AHP method and the FUZZY method, and combined with engineering examples to verify. The results show that the evaluation index system of the index is reasonable. The calculation results of the model is proved that the comprehensive evaluation result is the same as the actual result of the project and has good reliability. The evaluation index system and the evaluation model can provide reference for the evaluation of mine construction project management effect.

## 1. Introduction

Coal mine construction is a complex system engineering, which is involving many units and complicated processes. The characteristics of large-scale investment in mine construction are crucial to the development of coal enterprises [1]. The service life of mines is generally tens or even hundreds of years, and the quality of its construction is related to the 100-year plan of the enterprise. The characteristics of the long period of mine construction have determined that the mine needs a scientific and reasonable project management mode as a guarantee during the construction process [2]. Therefore, the selection of the management mode of the pre-construction mine construction project is the premise and basis for the efficient and smooth implementation of the modern mine construction project [3, 4]. As a construction unit, coal enterprises can only use the scientific project management method and scientific evaluation of the project management mode to achieve the expected goals of investment, progress and quality, and lay a solid foundation for the smooth operation of the mine [5,6]. This paper discusses the three aspects of the owner, project, contractor and supervision unit as the starting point, establishes a comprehensive evaluation index system and related evaluation models, and comprehensively and accurately evaluates the mine construction project management mode adopted by the owner.

## 2. Establishment of Evaluation Index System for Management Model of Mine Construction Projects

Drawing on the existing research results, adding previous interviews, combined with the characteristics of coal mine construction project management, the mine construction project management model

evaluation index system is established from three aspects: project objectives, owners, supervision units and contractors. The evaluation indicators are divided into three. The major categories are: control of project objectives ($B_1$), ability support needs of the owner ($B_2$), and support capabilities of contractors and supervisors ($B_3$). Each major category includes a number of specific evaluation indicators. The detailed indicator system is shown in Figure 1.
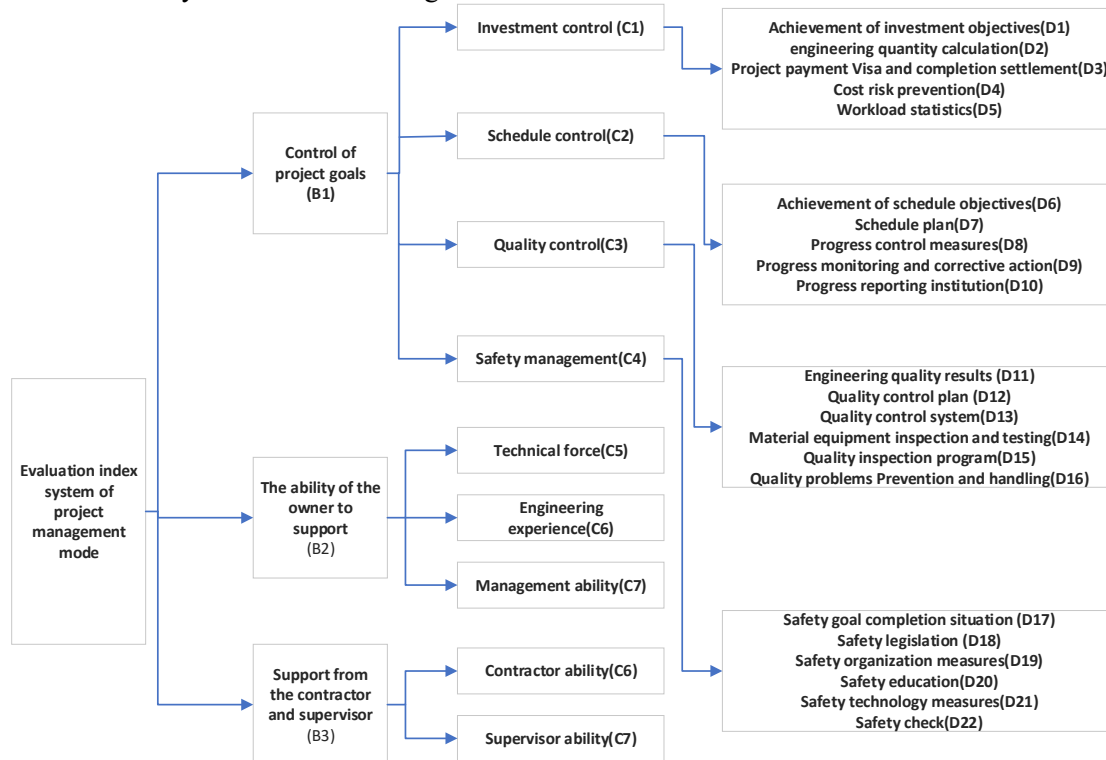


Figure 1. Three-level index system for project management mode evaluation.

## 3. Construction of AHP-FUZZY evaluation model

According to the indicator system shown in Figure 1, for the multi-level indicator system, the mature fuzzy evaluation model is applied. The specific steps for model building are as follows [7]:

(1) Factor set and comment set

The evaluation factor set U is the evaluation index system. $V=\{v_1, v_2,...,v_m\}$, generally four levels of excellent, good, medium and poor.

(2) Index weight matrix

The index weight reflects the relative importance of the index. In this paper, the AHP method is used to determine the weight of the index. Since the method is mature, it will not be repeated here.

(3) Single factor evaluation matrix

Where n and m represent the number of elements in U and V, respectively, the evaluation matrix R represents:

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{pmatrix}$$

It should be pointed out that there may be qualitative indicators and quantitative indicators for $r_{ij}$ in the matrix. For quantitative indicators, trapezoidal and semi-trapezoidal fuzzy distribution calculations are often used. After the calculation, the linear dimensionless method is used to convert the actual

measured value into 0-1, which makes it comparable. For qualitative indicators, the expert group evaluates each index of the evaluation object in relative rank, and the membership degree is the quotient that judges that an indicator belongs to the corresponding number of experts and the total number of experts.

(4) Perform fuzzy comprehensive evaluation

Assume that the indicator of analysis is a secondary indicator system. The first level evaluation: Let the weight of each factor in $U_i$ be $W_i$, and the total evaluation matrix of factors in $U_i$ be $R_i$, then: $W_i \cdot R_i = B_i = (b_{i1}, b_{i2}, ..., b_{in})$, $i = 1, 2, ..., N$. The second-level evaluation: Let U's various factors $U_i$ importance degree fuzzy subset is $W = (W_1, W_2, ..., W_N)$, then U's total evaluation matrix $R = (B_1, B_2, ..., B_N)$ T = $(W_1 \cdot R_1, W_2 \cdot R_2, ..., W_N \cdot R_N)$ T. Then the total (secondary) comprehensive evaluation result is obtained, that is, $B = W \cdot R$. Thus, a comprehensive evaluation result of $U = (U_1, U_2, ..., U_K)$ is obtained. By analogy, multi-level fuzzy evaluation can be achieved.

## 4. Application of AHP-FUZZY evaluation model
Luneng Heze Coal and Electricity Company has two coal mines, namedA and B, A mine has been completed and the overall construction is in good condition. B Mine is still in the process of preparation, in order to better evaluate the B mine project management and improve the project management level. This paper selects A mine as an evaluation example, the evaluation index and the correctness of the model, and the accuracy of the evaluation results are of great significance to B mine.

*4.1. Determination of factor sets and reviews*
Set the factor set U as shown in Figure 1. Set the level 4 comment set, V={excellent, good, medium, bad}.

*4.2. Determine the indicator weight matrix*
The evaluation team consists of 4 members from the construction party and external experts, and calculates the weight according to the AHP method.

(1) The weight of the first-level indicator. The first-level indicator "controlling the project objectives, the ability support of the owners, and the degree of support of the contractor and the supervisor" is: w={0.7143 0.1429 0.1428}.

(2) Secondary indicator weights

"Investment control, schedule control, quality control, safety control" weights of each indicator: $w_1$ = {0.1719 0.1719 0.1902 0.466}.

"Technical strength, engineering experience, management ability" weights of each indicator: $w_2$={0.625 0.2385 0.1365}. .

"Contractor Capability, Supervisory Unit Capability" weights of each indicator:$w_3$={0.8 0.2}.

(3) Three-level indicator weight calculation:

The weight of each indicator in "Investment Control" is $w_{11}$={0.57 0.1141 0.1283 0.1506 0.0369}

The weight of each indicator in "Progress Control" is: $w_{12}$={0.4853 0.2070 0.2070 0.0662 0.0345}

The weight of each indicator in "Quality Control" is: $w_{13}$={0.4853 0.0545 0.0545 0.0933 0.1567 0.1567}

The weights of the indicators in "Safety Management" are: $w_{13}$={0.5159 0.0563 0.0563 0.0981 0.1818 0.0917}

$C.R.$<0.01 of each judgment matrix, it is considered that the consistency of each judgment matrix is acceptable.

*4.3. Determine the single factor evaluation matrix*
(1) Calculation of membership degree of quantitative indicators

Drawing on the relevant research results, referring to the expert opinions, fully consider the actual situation of the A mine construction, and set the three quantitative indicators level of the schedule advance rate, investment savings rate and project quality results as shown in Table 1.

The evaluation values of the above indicators in Luneng Heze Coal and Electricity Company A Mine are shown in Table 2:

Table 1. Quantitative index evaluation level interval.

| index | excellent | good | medium | bad |
|---|---|---|---|---|
| Progress control target completion status (%) | ≥8 | $4 \leq x < 8$ | $0 \leq x < 4$ | $< 0$ |
| Investment control target completion (%) | ≥6 | $3 \leq x < 6$ | $0 \leq x < 3$ | $< 0$ |
| Engineering quality results | ≥85 | $75 \leq x < 85$ | $65 \leq x < 75$ | $< 65$ |

Table 2. A mine quantitative index value.

| index | plan | reality | saving rate |
|---|---|---|---|
| Progress control target completion status（month） | 55.5 | 53.5 | 3.6% |
| Investment control target completion（ten thousand yuan） | 249809.88 | 243121.88 | 2.68% |
| Engineering quality results | | 87 | |

Combining the indicators of Tables 1 and 2, the fuzzy membership degree distribution function of the above indicators is established, and the fuzzy membership degree of the three indicators is calculated, as shown in Table 3.

Table 3. A mineral quantitative index membership.

| index | excellent（$r_{11}$） | good（$r_{12}$） | medium（$r_{13}$） | bad（$r_{14}$） |
|---|---|---|---|---|
| Progress control target completion status | 0 | 0.4 | 0.6 | 0 |
| Investment control target completion | 0 | 0.3933 | 0.6067 | 0 |
| Engineering quality results | 0.7 | 0.3 | 0 | 0 |

(2) Calculation of membership degree of qualitative indicators

Nine experts were selected to review the relative grades of each qualitative indicator. According to the qualitative determination criteria determined above, you can get:

① investment control indicator fuzzy membership matrix:

$$R_{11} = \begin{pmatrix} 0 & 0.3933 & 0.6067 & 0 \\ 0.4444 & 0.4444 & 0.1111 & 0 \\ 0.6667 & 0.3333 & 0 & 0 \\ 0.2222 & 0.5556 & 0.1111 & 0.1111 \\ 0.5556 & 0.3333 & 0.1111 & 0 \end{pmatrix}$$

②Progress control indicator fuzzy membership matrix:

$$R_{12} = \begin{pmatrix} 0 & 0.4 & 0.6 & 0 \\ 0.2222 & 0.6667 & 0.1111 & 0 \\ 0.4444 & 0.5556 & 0 & 0 \\ 0.3333 & 0.4444 & 0.2222 & 0 \\ 0.2222 & 0.6667 & 0.1111 & 0 \end{pmatrix}$$

③Quality control index fuzzy membership matrix:

$$R_{13} = \begin{pmatrix} 0.7 & 0.3 & 0 & 0 \\ 0.2222 & 0.6667 & 0.1111 & 0 \\ 0.1111 & 0.6667 & 0.2222 & 0 \\ 0.2222 & 0.5556 & 0.1111 & 0.1111 \\ 0.2222 & 0.6667 & 0.1111 & 0 \\ 0.3333 & 0.6667 & 0 & 0 \end{pmatrix}$$

④ Security management indicator fuzzy membership matrix:

$$R_{14} = \begin{pmatrix} 0.8889 & 0.1111 & 0 & 0 \\ 0.4444 & 0.5556 & 0 & 0 \\ 0.3333 & 0.5556 & 0.1111 & 0 \\ 0.2222 & 0.7778 & 0 & 0 \\ 0.7778 & 0.1111 & 0.1111 & 0 \\ 0.3333 & 0.3333 & 0.3333 & 0 \end{pmatrix}$$

⑤The owner's ability and support indicators are fuzzy membership matrix:

$$R_{2} = \begin{pmatrix} 0.2222 & 0.4444 & 0.3333 & 0 \\ 0.5556 & 0.2222 & 0.2222 & 0 \\ 0.2222 & 0.4444 & 0.3333 & 0 \end{pmatrix}$$

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⑥Contractor and supervisor's support indicator fuzzy membership matrix:

$$R_3 = \begin{pmatrix} 0.7778 & 0.1111 & 0.1111 & 0 \\ 0.6667 & 0.2222 & 0.1111 & 0 \end{pmatrix}$$

### 4.4. Perform fuzzy comprehensive evaluation

(1) Conduct a first-level evaluation. $B_{11}=w_{11}\cdot R_{11}=\{0.1903\ 0.4137\ 0.3793\ 0.0167\}$, according to the principle of maximum membership degree, the evaluation result of investment control target is good; $B_{12}=w_{12}\cdot R_{12}=\{0.1677\ 0.4995\ 0.3327\ 0\}$, the evaluation result of progress control target is good; $B_{13}=W_{13}\cdot R_{13}=\{0.4650\ 0.4787\ 0.0459\ 0.0104\}$, the quality control target evaluation result is good; $B_{14}=w_{14}\cdot R_{14}=\{0.6961\ 0.2467\ 0.0570\ 0\}$, and the safety management target evaluation result is excellent.

(2) Perform secondary evaluation

$B_1=w_1\cdot(B_{11},B_{12},B_{13},B_{14})T=\{0.4743\ 0.3631\ 0.1577\ 0.0048\}$, similarly, $B_2=w_2\cdot R_2=\{0.3017\ 0.3914\ 0.3068\ 0\}$; $B_3=w_3\cdot R_3=\{0.7556\ 0.1333\ 0.1111\ 0\}$ .

From the point of view of the control of the project objectives, the project results are excellent; from the perspective of the owner's ability and support, the results are good; from the ability and support of the contractor and the supervisor, the result is excellent.

(3) Perform fuzzy comprehensive evaluation

$B_3=w\cdot(B_1,B_2,B_3)T=\{0.4899\ 0.3343\ 0.1724\ 0.0035\}$

Luneng Heze Coal and Electricity Company A mine construction project management comprehensive evaluation results are excellent. From the results, it is also in line with the actual construction of the A mine.

## 5. Conclusion：

Through the comprehensive evaluation of the management effect of mine construction projects, it can be seen that:

(1) The three-level indicator system for the evaluation of the management model of coal mine construction projects, which involves indicators of investment, quality, schedule, safety and other stakeholders of the project. It can be seen that the comprehensive and scientific selection of indicators is for project management. The basis of the comprehensive evaluation;

(2) Using the comprehensive evaluation model based on AHP-FUZZY to evaluate the mine construction management mode, the evaluation results are the same as the actual construction effect of the mine, indicating that the establishment of the model is effective;

(3) The evaluation model based on AHP-FUZZY can avoid the defects of qualitative evaluation, making the evaluation result more scientific and reasonable. The index system and evaluation model have reference significance for the evaluation of China's coal mine construction project management level.

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