First International Symposium on Mine Safety Science and Engineering

Work Safety Standardization Grade Evaluation Model and System Development of Bauxite Mines

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Abstract

In order to reasonably evaluate safety standardization grade of bauxite mines, after core requirements of "Basic Norms for Work Safety Standardization of Enterprises "(AQ/T9006-2010), this paper uses 13 first level indexes and 40 second level indexes to estimate safety standardization degree and applies fuzzy comprehensive evaluation theory and analytical hierarchy process to establish safe standardization grade evaluation model of bauxite mines. The actual application showed that the evaluation model was scientific and practical. The paper has developed the evaluation software with complete function and easy operation, which has improved efficiency and normalization of the evaluation.

Selection and/or peer-review under responsibility of China Academy of Safety Science and Technology, China University of Mining and Technology(Beijing), McGill University and University of Wollongong.

1. Introduction

Work Safety is an important policy in China, which is related to the safety of people's lives, property, the whole situation of reform and social stability. In order to further implement the enterprise main responsibilities of safe production and comprehensively promote the standardization of safe production, the State Administration of Work Safety issued the "Basic Norms for Work Safety Standardization of

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Enterprises" (AQ/T9006-2010) [1] in April 2010. After summarizing the coal mines, dangerous chemicals, metal and nonmetal mines, fireworks and crackers, metallurgical and machinery industry, we clearly define "work safety standard" for the first time and unify basic requirements and metrics of the standardization. Work safety standardization of enterprises has entered a new stage of development [2]. The State Council issued the "Circular on Further Strengthening work safety" (Guo Fa [2010] No. 23) in July 2010, which clearly put forward to deeply carry out construction of work safety standardization by making the enterprise standard. The State Security Committee issued the "depth enterprise security product on standardization of guidance" in May 2011, which also clearly pointed out that non-coal mining enterprises should achieve work safety standardization by the end of 2013.

Bauxite Mines are high-risk industries and have many risk factors, its work safety related to the sustainable development of China's aluminum industry [3], the work safety standardization of bauxite mountains can help non-coal mining enterprises to implement the responsibility of work safety, to improve the economic efficiency and management level of enterprises, to achieve scientific management and ultimately improve the level of intrinsic safety.

2. Establishment and application of evaluation model

2.1. Determination of factor set and evaluation set

After considering a variety of evaluation methods, we choose fuzzy comprehensive evaluation method to assess work safety standardization grade of bauxite mines and construct the evaluation model based on fuzzy math theory and AHP [4].

According to the principles of indexes system [5] and combining with the core requirements of "Basic Norms for Work Safety Standardization of Enterprises", we establish evaluation indexes system of work safety standardization grade, including 13 first level evaluation indicators and 40 second level evaluation indicators. 13 first level evaluation indexes are shown in Figure 1.

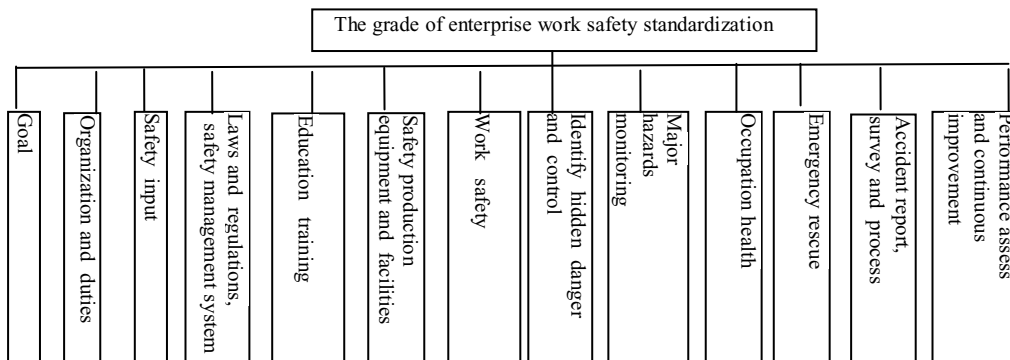Fig.1 First level indexes of Work Safety Standardization grade evaluation of Enterprises

Considering the situation of safety standardization grade which have been released by many enterprises, work safety standardization grade of bauxite mines is divided into five levels = (first, second, third, fourth, fifth), as shown in Table 1.

Table1. Evaluation grade of work safety standardization of bauxite mines

Standardization score	≥90	80~90	70-80	60~70	≤60
Standardization grade	first level	second level	third level	fourth level	fifth level

2.2. Determination of index weights

There are many ways to determine the evaluation indexes weights, such as Delphi, analytic hierarchy process (AHP), principal component analysis, etc. According to the characteristics of bauxite mines and the development of work safety standardization, this paper used the AHP method which combined the qualitative method and the quantitative method to determine evaluation indexes weights. The AHP method use the form of comparing the relative importance of factors in pairs to give the corresponding ratio scale and structure the evaluation matrix in which upper factors is related to subjacent factors, at last, we get relatively important sequence between subjacent factors and upper factors. It should be pointed out that there are a lot of first level indexes, so these weights can be determined by experts directly, too.

According to the main steps of AHP, we finally get all indexes weights shown in Table 2 through calculating and testing.

Table2. A list of work safety standardization grade evaluation factors of enterprise

First level evaluate factors		Second level evaluate factors		Grade(score)				
content	weight	content	weight	First ≥90	Second 80~90	Third 70~80	Fourth 60~70	Fifth ≤60
Goal	0.03	Goal	1	0	0.4	0.5	0.1	0
Organization and duty	0.04	Organization	0.25	0	0.5	0.3	0.2	0
		Duty	0.75	0.1	0.3	0.5	0.1	0
Work safety input	0.03	Work safety input	1	0	0.6	0.3	0.1	0
Laws and regulations and safety management system	0.11	Law and regulation, standard	0.12	0.1	0.2	0.6	0.1	0
		Rules and regulations	0.1	0	0.3	0.5	0.2	0
		Operation rules	0.22	0	0.1	0.7	0.2	0
		Assess	0.22	0	0.4	0.4	0.2	0
		Revise	0.22	0	0.3	0.4	0.2	0
		Files and archives administration	0.12	0.1	0.5	0.4	0	0
Education training	0.06	Education training management	0.3	0	0.3	0.5	0.2	0
		Work safety manager education train	0.16	0.1	0.3	0.5	0.1	0
		Operator education train	0.16	0	0.3	0.5	0.1	0
		Other staff education train	0.08	0	0.1	0.6	0.3	0
		Safety culture construction	0.3	0	0.2	0.3	0.5	0
Production equipment and facilities	0.06	Production equipment and facilities construction	0.54	0	0.3	0.4	0.3	0
		Equipment and facilities operation	0.3	0	0.3	0.5	0.2	0

		management						
		Check new equipment and facilities and remove, scrap the old	0.16	0	0.1	0.6	0.3	0
Work safety	0.17	Production site management and production process control	0.4	0	0.4	0.5	0.1	0
		Work behavior management	0.24	0	0.3	0.5	0.2	0
		Warning marks	0.12	0	0.2	0.7	0.1	0
		Related party management	0.12	0	0.2	0.5	0.3	0
		change	0.12	0	0.2	0.5	0.3	0
Identify hidden danger and control	0.15	Identify hidden danger	0.34	0	0.2	0.5	0.3	0
		Exclusion and range	0.17	0	0.5	0.4	0.1	0
		Hidden trouble management	0.29	0	0.3	0.5	0.2	0
		Forecasting and warning	0.2	0	0	0.4	0.6	0
Major hazards monitoring	0.14	Identification and evaluation	0.54	0.2	0.5	0.3	0	0
		Registration and record	0.3	0.4	0.5	0.1	0	0
		Monitoring and management	0.16	0.3	0.6	0.1	0	0
Occupation health	0.08	Occupational health management	0.54	0.1	0.4	0.5	0	0
		Occupational hazards inform and warning	0.3	0	0.2	0.7	0.1	0
		Occupational hazards declare	0.16	0	0.5	0.4	0.1	0
Emergency rescue	0.05	Emergency institutions and teams	0.1	0	0.2	0.6	0.2	0
		Emergency plan	0.38	0	0.5	0.3	0.2	0
		Emergency equipment, equipment, goods and materials	0.1	0	0.2	0.5	0.3	0
		Emergency drill	0.17	0	0.1	0.7	0.2	0
		Accident rescue	0.25	0	0.3	0.5	0.2	0
Accident report, survey and process	0.05	Accident report	0.25	0.3	0.6	0.1	0	0
		Accident survey and process	0.75	0.1	0.5	0.3	0.1	0
Performance assess and continuous improvement	0.03	Performance assess	0.75	0.2	0.3	0.5	0	0
		Continuous improvement	0.25	0.1	0.3	0.4	0.1	0.1

2.3. Fuzzy comprehensive evaluation model

Fuzzy comprehensive evaluation model is composed of index sets, evaluation sets and single-factor

evaluation sets. $B = A \circ R = (b_1, b_2, \cdots, b_m) = (a_1, a_2, \cdots, a_m) \circ \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}$, b_m is the index of

fuzzy comprehensive evaluation. From the above, we get 13 first level evaluation indexes weights of work safety standardization grade evaluation model of bauxite

mines $A_1 = \begin{bmatrix} 0.03 & 0.04 & 0.03 & 0.11 & 0.06 & 0.06 & 0.17 & 0.15 & 0.14 & 0.08 & 0.05 & 0.05 & 0.03 \end{bmatrix}$.

2.4. Application result

On the basis of actual situation of bauxite mines in Aluminum Corporation of China Limited, we call for ten experts to score and calculate the membership of second level factors in Table 2. This paper omitted the middle calculations, calculated the weight and membership of second level factor, at last, got the evaluation matrix R_1 which is related to first level evaluation factors.

$$R_1 = \begin{bmatrix}
0 & 0.4 & 0.5 & 0.1 & 0 \\
0.075 & 0.35 & 0.45 & 0.125 & 0 \\
0 & 0.6 & 0.3 & 0.1 & 0 \\
0.046 & 0.29 & 0.5 & 0.164 & 0 \\
0.016 & 0.254 & 0.448 & 0.266 & 0 \\
0 & 0.268 & 0.462 & 0.27 & 0 \\
0 & 0.304 & 0.524 & 0.172 & 0 \\
0 & 0.24 & 0.463 & 0.297 & 0 \\
0.276 & 0.516 & 0.208 & 0 & 0 \\
0.054 & 0.356 & 0.544 & 0.046 & 0 \\
0 & 0.322 & 0.468 & 0.21 & 0 \\
0.15 & 0.525 & 0.25 & 0.075 & 0 \\
0.175 & 0.3 & 0.475 & 0.025 & 0.025
\end{bmatrix}$$

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Through the fuzzy comprehensive evaluation, the result of work safety standardization grade membership of bauxite mines is $B = A_1 \circ R_1 = (0.0647 \quad 0.347 \quad 0.4329 \quad 0.1537 \quad 0.0008)$, according to the evaluation standard in table 1, the work safety standardization grade of some bauxite mine of Aluminum Corporation of China Limited is three-level, the score of work safety standardization is between 70 and 80 which is coincide with the actual situation. The correctness of the model is proved.

3 Development of evaluation software

3.1. Target of software development

In order to make the safety standardization grade evaluation model practical and feasible, the paper developed the evaluation software with complete function and easy operation, which has improved efficiency, systematization and normalization of the evaluation [5].

3.2. Software development tools

In order that users can use the software more convenient and efficient, the software structure is B/S which greatly simplifies client computer loads, reduces the costs and workload of system maintenance and upgrade. Considering several development platforms about B/S mode, the paper has choiced.NET

development platform, C# as development language, SQL Server 2005 which is a relational database, very popular as the database [6].

There are five function modules in this evaluation software, the structure design is shown in Figure 2.

- System maintenance. This includes the instructions of the software; the establishment of users and the distribution of roles and the setting of index parameters and the result set.
- Indexes system. Including the selection and establishment of all evaluation indexes; modifying indexes and inquiring indexes.
- Experts scoring. Including the scoring of the second level evaluation indexes; statistical analysis and generate the evaluation matrix.
- Safety standardization grade of enterprise. Including the computational process and the results of fuzzy comprehensive evaluation; getting the membership degree of enterprise standardization grade; ensuring the grade of the safety standardization and providing objective, scientific basis for the enterprise safety management.
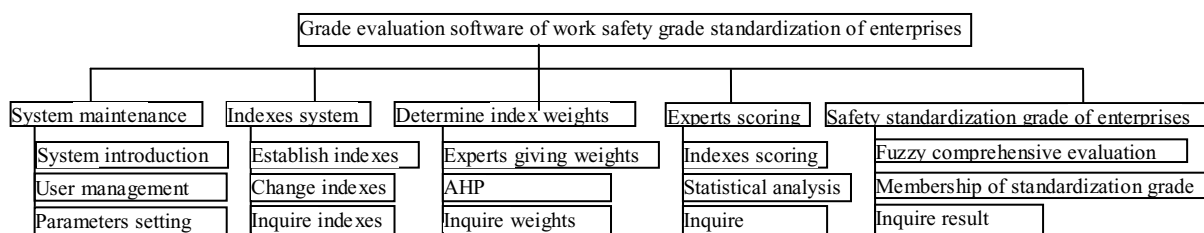
Fig.2. Function structure of work safety grade standardization evaluation software of enterprises

4 Conclusions

- On the basis of core requirements of "Basic Norms for Work Safety Standardization of Enterprises ", using the fuzzy mathematics and AHP, we got a new grade evaluation model about enterprises work safety standardization.
- With some bauxite mine in Aluminum Corporation of China Limited as the research background, establishing an evaluation indexes system level consisted of 13 first level indexes and 40 second level indexes, after practical applications, the evaluation result was consistent with the actual situation of the enterprise, so that the model is correct.
- To develop the simple, practical software on work safety standardization grade evaluation of enterprises, to achieve standardization, science and modernization of standardization grade evaluation and to improve the evaluation efficiency.

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