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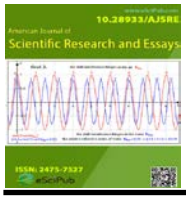

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Fuzzy comprehensive evaluation of fireworks destruction safety based on AHP method

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ABSTRACT

Aiming at a large number of problems such as complexity, ambiguity and uncertainty existing in the destruction of fireworks, ahp-comprehensive evaluation method was applied to the safety evaluation of the destruction of fireworks. Taking A safe destruction operation in guizhou province as an example, combined with the actual situation on site and expert advice, A two-level structure comprehensive evaluation model of four main factors and 17 sub-factors was established, A judgment matrix was constructed, A weight vector was established, and A fuzzy matrix B was established with membership degree to obtain A comprehensive evaluation matrix D. The evaluation results show that the safety of the destruction of fireworks is good, and the evaluation results are consistent with the actual field effect. The applicability and accuracy of AHP- comprehensive evaluation method in the destruction of fireworks were verified.

Keywords: Fireworks; AHP- comprehensive evaluation method; Safety evaluation; The destruction

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The raw materials of fireworks and firecrackers have inflammable, explosive, toxic and other hazards, destruction with high risk, easy to occur safety accidents. On March 26, 2008, a massive explosion occurred during the centralized destruction of fireworks in turpan, xinjiang, causing many casualties. On May 3, 2015, zhangqiu city, henan province destroyed the waste fireworks materials, and a large explosion occurred when unloading the truck, causing casualties. On February 5, 2016, a major explosion occurred in the process of centralized destruction of the remaining raw materials of the closed fireworks and firecrackers factory in guian new district, guizhou province, causing many casualties. Therefore, in order to reduce the occurrence of safety accidents, it is necessary to evaluate the destruction of fireworks accurately and reasonably.

For high-risk industries in domestic and foreign [1-4], ahp-comprehensive evaluation method has a wide range of application in safety analysis and management [5-7]. Since issued regulations on civil explosives to update for the safety management regulations, discussion on the destruction of civil explosives and the safety study of scholars on the destruction of used detonator explosive shells [8,9], however, there is still a lack of corresponding safety evaluation in the destruction of fireworks and firecrackers. In this article, combining with the destruction process of fireworks and firecrackers and the characteristics of accidents, the analytic hierarchy process (AHP) is used to determine the weight of each influencing factor, and the fuzzy comprehensive evaluation method is selected to reasonably evaluate the destruction of fireworks and firecrackers combined with field examples.

1. AHP method and fuzzy comprehensive evaluation method

1.1 The analytic hierarchy process

Analytic hierarchy process (ahp) is a method combining quantitative analysis with qualitative analysis. The basic idea of the method is based on the nature of the problem and the overall goal to be achieved firstly. Then according to the interrelated influence of the factors and the current relation, the factors are decomposed hierarchically to form a hierarchical structure from the bottom up.

1.2 The fuzzy comprehensive evaluation method

Fuzzy comprehensive evaluation method is based on fuzzy mathematics. It USES fuzzy set theory to transform qualitative evaluation into quantitative evaluation, analyzes the influence of sub-factors on the state of the main factors, and combines the hierarchical progression of membership theory to calculate the influence of each factor on the evaluation target.

2. AHP- fuzzy comprehensive evaluation method

2.1 The Structure modeling

Fireworks destroy risk assessment, as the fireworks in the destruction of danger and the complex relationship between various factors, the factors of safety concerns some of them are clear, some are potential uncertainty, using numerical analysis in the form of AHP and fuzzy comprehensive evaluation method for fireworks destroy risk analysis can reflect the index factor objective authenticity, the specific flow of this method is shown in figure 1.

2.2 Construct judgment matrix and consistency test

According to the expert opinions and the actual situation of destruction, "1~9" scale method was used to compare the main factors and obtain the judgment matrix. MATLABr2014 was used to obtain the maximum eigenvalue of the

judgment matrix for one-time test. The formula is as follows:

$$CI = (\lambda_{\max} - n)/(n-1) \quad (1\text{-}1)$$

$$CR = CI / RI \quad (1\text{-}2)$$

In the formula: n-matrix dimension;

CI- consistency index. The smaller CI is, the higher the judgment matrix conforms to complete consistency; otherwise, the lower it is.

RI- average random consistency index, which is related to n, is shown in table 1.

CR- relative consistency index. When CR<0.1, the judgment matrix meets the condition of complete consistency.

The closer CR approaches 0, the better the complete consistency of judgment matrix.

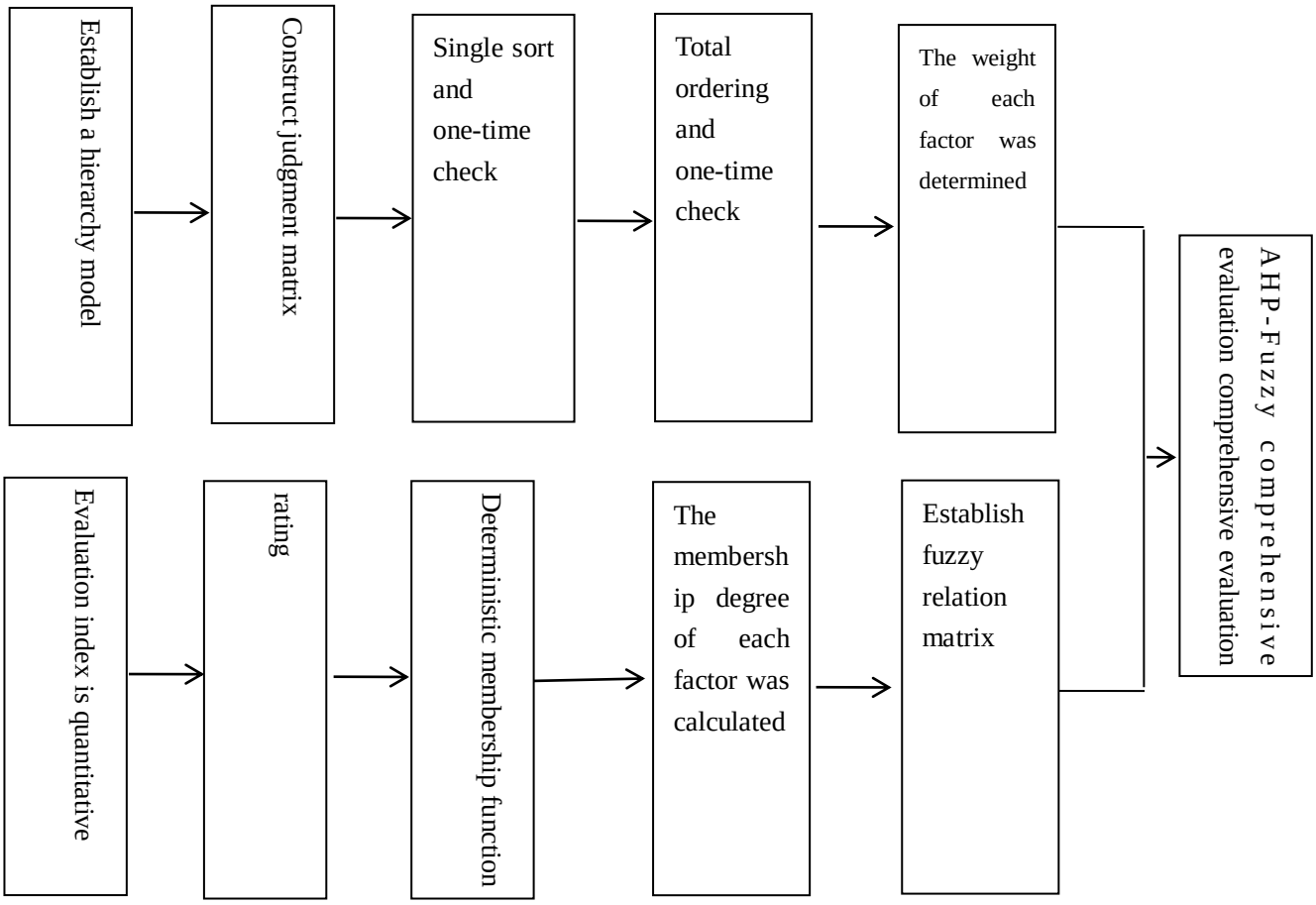

Fig. 1 flow chart of AHP- fuzzy comprehensive evaluation

2.3 Establish factor set and factor weight

Set of factors U={U1,U2... ,Um}, the main factor can be divided into k sub-factors, the set of sub-factors $U_i=\{U_{i1}.U_{i2},.....U_{ik}\}$.

In the evaluation system, the relative importance of the lowest level evaluation index to the content of the highest level is called the weight coefficient, the weight vector is the combination of the weight coefficients, and the weight vector of the main factor A= （ $A_1,A_2,.....,A_m$ ） . The weight vector corresponding to the sub-factor is $A_i=(A_{i1},A_{i2},.....,A_{im})$.

2.4 determine membership

The evaluation set is to grade the evaluation results V1... Vm represents different result

levels respectively and forms the set V={V1,V2... , the Vm}.

There are various methods to determine the factor membership degree, and the appropriate membership function can accurately reflect the factor membership degree.

2.5 Fuzzy comprehensive evaluation

After comprehensive evaluation of each sub-factor set, the results of first-level fuzzy comprehensive evaluation are expressed as follows:

$B_i=A_i \cdot R_i$ （1-3）

The second-order fuzzy comprehensive evaluation matrix R is represented by the first-order fuzzy comprehensive evaluation result Bi, and the comprehensive evaluation result is represented by D:

$$R=\begin{pmatrix} B_1 \\ B_2 \\ ... \\ B_i \end{pmatrix} \quad （1\text{-}4）$$

$D=A \cdot R$ （1-5）

3. The example application

To takes the destruction of fireworks in guizhou province as an example to analyze. The destruction of the huge number of fireworks, a variety of complex, Category i dangerous fireworks has the black gunpowder, the fuse, the bright bead, the fireworks; Category ii dangerous fireworks and firecrackers have closed fireworks and firecrackers semi-finished products, called, thunder, firecrackers. According to the actual characteristics and quantity of fireworks destroyed in multiple sites.

3.1 establish the evaluation system

According to the actual operation of fireworks destruction, the model is divided into 3 levels and 4 parts, and the evaluation index system as shown in figure 2 is established from the four aspects of operating environment, material and transportation, employee quality and safety management.

The judgment matrix in table 2 was calculated and consistency test was performed, CI=0.0757. In table 1, RI was 0.90 and CR=0.0841<0.1, so the judgment matrix m-a met the consistency test.

The judgment matrix in table 3 was calculated and consistency test was carried out, CI=0.0088. According to table 1, RI was 1.12 and CR=0.0079<0.1, so the judgment matrix a1-b met the consistency test.

The judgment matrix in table 4 was calculated and consistency test was performed, CI=0.0116. According to table 1, RI was 1.12 and CR=0.0104<0.1, so the judgment matrix a2-b met the consistency test.

Table 5 judgment matrix was calculated and consistency test was performed, CI=0.0046. Table 1 showed that RI was 0.58 and CR=0.0079<0.1, so the judgment matrix a3-b met the consistency test.

The judgment matrix in table 6 was calculated and consistency test was performed, CI=0.0202. In table 1, RI was 0.90 and CR=0.0224<0.1, so the judgment matrix a4-b met the consistency test.

Table 1 average random consistency index RI

n	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Table 2 judgement matrix M-A numerical table

M	A1	A2	A3	A4	The weight
A1	1	3	7	6	0.45
A2	1/3	1	4	6	0.30
A3	1/7	1/4	1	3	0.09
A4	1/6	1/6	1/3	1	0.16

Table 3 value table of judgement matrix A1-B

A_1	B_1	B_2	B_3	B_4	B_5	The weight
B_1	1	2	4	1/4	6	0.20
B_2	1/2	1	2	1/6	3	0.15
B_3	1/4	1/3	1	1/7	2	0.09
B_4	4	6	8	1	8	0.50
B_5	1/6	1/5	1/2	1/8	1	0.06

Table 4 value table of judgement matrix A2-B

A_2	B_1	B_2	B_3	B_4	B_5	The weight
B_1	1	2	1/4	1	1/5	0.14
B_2	1/2	1	1/6	1/2	1/7	0.09
B_3	4	6	1	4	1/2	0.26
B_4	1	2	1/4	1	1/5	0.14
B_5	5	7	2	5	1	0.41

Table 5 judgment matrix A3-B numerical table

A_3	B_1	B_2	B_3	The weight
B_1	1	2	3	0.4
B_2	1/2	1	2	0.35
B_3	1/3	1/2	1	0.25

Table 6 number table of judgement matrix A4-B

A_4	B_1	B_2	B_3	B_4	The weight
B_1	1	1/2	1/5	1/6	0.23
B_2	2	1	1/4	1/5	0.14
B_3	5	4	1	1/2	0.30
B_4	6	5	2	1	0.33

3.2 Index weight determination

From table 2 to 6 of the judgment matrix, it can be known that the factor weight vector A corresponding to U is equal to (0.45,0.3,0.09,0.16). Ui corresponding weighting vector respectively A1 = (0.2, 0.15,

0.09, 0.5, 0.06), A2 = (0.14, 0.09, 0.26, 0.14, 0.41), A3 =, 0.4, 0.35, 0.25), A4 = (0.23, 0.14, 0.3, 0.33).

3.3 determination of single factor membership

After actual destruction operation, according to the principle of classification of safety evaluation standards, the safety evaluation of fireworks destruction is divided into 5 levels, V={good (I), good (II), general (III), poor (IV), and poor (V)}. The membership function determination methods include fuzzy statistics method, assignment method, expert experience method, binary comparison and sorting method, etc. Quantitative and qualitative factors exist in the destruction of fireworks, and each factor is closely related to the actual site. The expert experience method is used to determine the membership function, and the membership degree RI of each factor is shown in table 7-10.

Table 7 membership degree R1 of environmental factors

Indicators	Comment grade				
	I	II	III	IV	V
Site area	0	0.80	0.20	0	0
climate	1	0	0	0	0
Natural barrier	0	0.80	0	0.20	0
A safe distance from	0	0.70	0	0.3	0.30
Homework time	0	0	0.70	0.30	0

Table 8 membership of substances and transport factors R2

Indicators	Comment grade				
	I	II	III	IV	V
Fire equipment	0	1	0	0	0
Monitoring equipment	1	0	0	0	0
Transport routes and distances	0	0.70	0	0.30	0
Distance between vehicles	0	0.90	0	0.10	0
Character and quantity of the item destroyed	0	0.65	0	0.35	0

Table 9 membership degree R3 of employee quality factors

Indicators	Comment grade				
	I	II	III	IV	V
Safety awareness	0	0.70	0.30	0	0
The technical level	0	0.75	0.25	0	0
Physical and mental state	0	0.8	0.20	0	0

Table 10 membership degree R4 of safety management factors

Indicators	Comment grade				
	I	II	III	IV	V
Emergency plan	0	0	1	0	0
Personnel organization	0	0.75	0	0.25	0
security	0	0.8	0	0.2	0
The security check	0	0.6	0.4	0	0

3.4 First level fuzzy comprehensive evaluation

$$B_1=A_1R_1=[0.2,0.15,0.09,0.5,0.06]\begin{bmatrix}0,0.8,0.2,0,0\\1,0.0,0.0,0,0\\0,0.8,0,0.2,0\\0,0.7,0,0.3,0\\0,0,0.7,0.3,0\end{bmatrix}=[0.15,0.267,0.082,0.186,0]$$

$$B_2=A_2R_2=[0.14,0.09,0.26,0.14,0.41]\begin{bmatrix}0,1.0,0.00,0.0,0\\1,0.0,0.00,0.0,0\\0,0.70,0,0.30,0\\0,0.90,0,0.10,0\\0,0.65,0,0.35,0\end{bmatrix}=[0.09,0.7345,0,0.2355,0]$$

$$B_3=A_3R_3=[0.4,0.35,0.25]\begin{bmatrix}0,0.70,0.30,0,0\\0,0.75,0.25,0,0\\0,0.80,0.20,0,0\end{bmatrix}=[0,0.7425,0.0875,0,0]$$

$$B_4=A_4R_4=[0.23,0.14,0.3,0.33]\begin{bmatrix}0,0.00,1,0.00,0\\0,0.75,0,0.25,0\\0,0.80,0,0.20,0\\0,0.60,0.40,0,0\end{bmatrix}=[0,0.643,0.362,0.095,0]$$

3.5 Secondary comprehensive evaluation

The evaluation matrix R is obtained from (1-4), and the comprehensive evaluation result of the system.

$$isD=AB=[0.45,0.3,0.09,0.16]\begin{bmatrix}0.15,0.267,0.082,0.186,0\\0.09,0.7345,0,0.2355,0.0\\0,0.7425,0.0875,0.00,0.0\\0,0.6430,0.362,0.095,0.0\end{bmatrix}=[0.0945,0.2932,0.062,0.0238,0]$$

According to the principle of maximum membership, where the position corresponding to the maximum membership is the safety evaluation level of the segment target, D indicates that the safety evaluation level of fireworks destruction is II for this time, which is relatively safe and in line with the actual results (see figure 2).

Fig.2 Fireworks and Firecracker Destruction Process

4. conclusion

1) AHP- comprehensive evaluation method is applied to the destruction of fireworks, and safety evaluation with it is accuracy and practicality.

2) the analytic hierarchy process was used to determine the weight of each factor, and the index order of the influence degree of fireworks destruction safety was obtained as follows: operating environment, material and transportation, occupational quality, and safety management. The membership degree was determined by expert experience method, and the fuzzy comprehensive evaluation of destruction operation was carried out by using the evaluation model.

3) reasonably classify all factors, determine their weights, and get the evaluation results consistent with the reality, so as to provide reference and guidance for the importance of factors in the destruction of fireworks.

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