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RELIABILITY ASSESSMENT OF FIRE IN HIGH-RISE BUILDING BASED ON CLEAR RATIONAL NUMBER

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ABSTRACT

Reliability assessment is more and more important for the design and construction of the building. The common models used today have the shortcomings of subjectivity. In order to find a more effective method for the structure reliability assessment, a novel mathematic, the clear mathematics was proposed. After the brief introduction of the basic knowledge of the clear mathematic, the assessment model based on the clear set was set up. Engineering practice in the fire reliability assessment of a high-rise building shows the efficiency and the rationality of the method. This study provides a novel method for the structure fire reliability assessment and other comprehensive assessment.

Keywords: *Fire Reliability Assessment, Clear Mathematics, Clear Rational Number*

1 INTRODUCTION

The rapid development of the technology has prompted the development of basic construction, and more and more high-rise buildings were constructed. Some buildings are more than 500 meters. Accidents caused by the ignoring of the structural fire reliability are often occurred [1-7]. The fire reliability assessment of high-rise buildings has significance in theory and practice. But, the traditional methods employed have the many shortcomings, for example, the fuzzy set which is the common tool of comprehensive assessment does not meet the three principles of measurement and it has the shortcoming of subjectivity [8, 9]. This situation has signified the methods study of the reliability assessment of high-rise buildings.

Based on this, a novel mathematic tool, the clear mathematics was introduced. And the reliability assessment model was set up. Then, its efficiency and the rationality are shown through the application in the engineering practice.

The rest of the paper was organized as follows. First, the basic knowledge of the clear mathematics was briefly introduced. Then, the assessment model based on clear set was set up and was employed to the fire reliability assessment of a high-rise building. And the advantage of the method was introduced.

2 ASSESSMENT MODEL BASED ON CLEAR SET

2.1. Brief Introduction Of The Clear Mathematics

Proposed by Wu Huaying and WU Heqin in 2007, the clear mathematics is a new mathematics which overcomes the shortcomings of the fuzzy mathematics and the unascertained mathematics. The biggest advantage of the clear mathematics is that it meets the three principles of the measurement. The basic knowledge of the clear mathematics was introduced in [10]. Here, we will not repeat them.

2.2. Fire Reliability Assessment Model

The fire reliability assessment of high-rise buildings was categorized into 5 grades: great negative influence, little negative influence, no influence, little positive influence and great positive influence, which were expressed by $\upsilon_1, \upsilon_2, \upsilon_3, \upsilon_4, \upsilon_5$ respectively. Then, the evaluation set $V = \{\upsilon_1, \upsilon_2, \upsilon_3, \upsilon_4, \upsilon_5\}$ was developed. And every factor in it was assigned with the value 2 , 4 , 6 , 8 , 10 respectively. $V = \{2, 4, 6, 8, 10\}$. And the fire reliability assessment factors of the high-rise buildings were divided into m disjoint subsets $U = \{u_1, u_2 \ldots\ldots u_m\}$, the first level of factors $u_i (i = 1, 2, 3 \ldots m)$ was subjected to n factors $u_i = \{u_{i1} u_{i2} \ldots u_{in}\}$ in the second level , in

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which $u_{ij}(i=1,2,\ldots,m;j=1,2,\ldots,n)$ was subjected to k factors $u_{ij}=\{u_{ij1},u_{ij2}\ldots\ldots u_{ijk}\}$ in the third level.

(1) Simple- level assessment

First, the clear rational number of factors in the bottom level (the third level) was determined through the marks given by the groups of experts. Take a factor u as an example, the marks given to the factor u were the 5 assigned values in the evaluation set and these 5 assigned values were determined by 5 groups of experts $\mu_l=\{a_1,a_2,a_3\ldots\ldots a_m\};l=1,2,3,4,5$ respectively. If m_1 experts in group of experts a agreed with the assigned value υ, and other $m-m_1$ experts did not state their position or disagreed, then the experts who agreed with this assigned value made the set $\Delta\mu_l=\{a_1,a_2,a_3\ldots\ldots a_{m_1}\}$.

Then the clear rational number of the factor was determined as follows:

$$\underline{A}(x)=\begin{cases}\dfrac{|\Delta\mu_1|}{|\mu_1|}=\alpha_1 & x_1=2\\ \dfrac{|\Delta\mu_2|}{|\mu_2|}=\alpha_2 & x_2=4\\ \dfrac{|\Delta\mu_3|}{|\mu_3|}=\alpha_3 & x_3=6\\ \dfrac{|\Delta\mu_4|}{|\mu_4|}=\alpha_4 & x_4=8\\ \dfrac{|\Delta\mu_5|}{|\mu_5|}=\alpha_5 & x_5=10\end{cases} \qquad (1)$$

For the comprehensive marks, their clear rational number can be obtained by the Equation (2).

$$\underline{C}(x)=\sum_{i=1}^{k}w_i\underline{A_i}(x) \qquad (2)$$

Where ω is the weight of every factor, it can be assigned by experts.

The clear rational number of comprehensive marks can be shown as follows:

$$\underline{C}(x)=\begin{cases}\beta_1 & x_1=2\\ \beta_2 & x_2=4\\ \beta_3 & x_3=6\\ \beta_4 & x_4=8\\ \beta_5 & x_5=10\end{cases} \qquad (3)$$

And the mean value of clear rational number is:

$$E(\underline{C}(x))=\frac{\sum_{i=1}^{5}x_i\beta_i}{\sum_{i=1}^{5}\beta_i} \qquad (4)$$

(2) Multi-level assessment

Based on the method above, the first level clear rational number set $A_{ij}=\{\underline{A}_{ij1}(x),\underline{A}_{ij2}(x)\ldots\underline{A}_{ijk}(x)\}$ and its mean set $E_{ij}=\{E(\underline{A}_{ij1}(x)),E(\underline{A}_{ij2}(x))\ldots E(\underline{A}_{ijk}(x))\}$ can be obtained.

For the second level evaluation, the second level clear rational number set $A_i=\{\underline{C}_{i1}(x),\underline{C}_{i2}(x)\ldots\underline{C}_{in}(x)\}$ and its mean set $E_i=\{E(\underline{C}_{i1}(x)),E(\underline{C}_{i2}(x))\ldots E(\underline{C}_{in}(x))\}$ can be determined by Equation (2).

For the third level evaluation, the third level of clear rational number set $A=\{\underline{C}_1(x),\underline{C}_2(x)\ldots\underline{C}_m(x)\}$ and mean set $E=\{E(\underline{C}_1(x)),E(\underline{C}_2(x))\ldots E(\underline{C}_m(x))\}$ can be determined by calculating $\underline{C}(x)=\sum_{i=1}^{k}w_i\underline{A_i}(x)$.

Until now, through the calculation of $A=\{\underline{C}_1(x),\underline{C}_2(x)\ldots\underline{C}_m(x)\}$ of the third level of clear rational number, the final comprehensive clear rational number $\underline{C}(x)$ can be obtained, and its mean $E(\underline{C}(x))$ was the final assessment result. The advantage of the clear set is that it can provide the importance level of all indexes through the sorting of the average value of the clear numbers.

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3 ENGINEERING PRACTICE

In order to verify the efficiency of the method proposed here, the assessment of a high-rise building was completed. The height of the high-rise building is 120m. The indexes system is shown in Figure 1.

By using this method, we can obtain the results of the first level assessment which is shown in Table 1

And the second level result is $E=\left(0.121,\quad 0.102,\quad 0.113,\quad 0.292,\quad 0.372\right)$. The final score of the high-rise building is 67.78, which belongs to the rank of "little positive influence". By suing the fuzzy comprehensive assessment, we obtained the result is 70.13.

From the results, we can know that the given high-rise building should strengthen fire prevention activities. We can also know that the "Fire emergency plan" (u_5) and "Personnel training" (u_4) are the two most important factors.

Table I: Results Of The First Level Assessment

Indexes	Results of the assessment
u_1	(0.181, 0.277, 0.213, 0.092 , 0.120, 0.117)
u_2	(0.381 , 0.212, 0.407)
u_3	(0.233, 0.407, 0.211, 0.149)
u_4	(0.073, 0.065 , 0.177 , 0.208 , 0.055 , 0.193 , 0.229)
u_5	(0.093 , 0.170 , 0.103 , 0.155 , 0.097 , 0.178 , 0.204)

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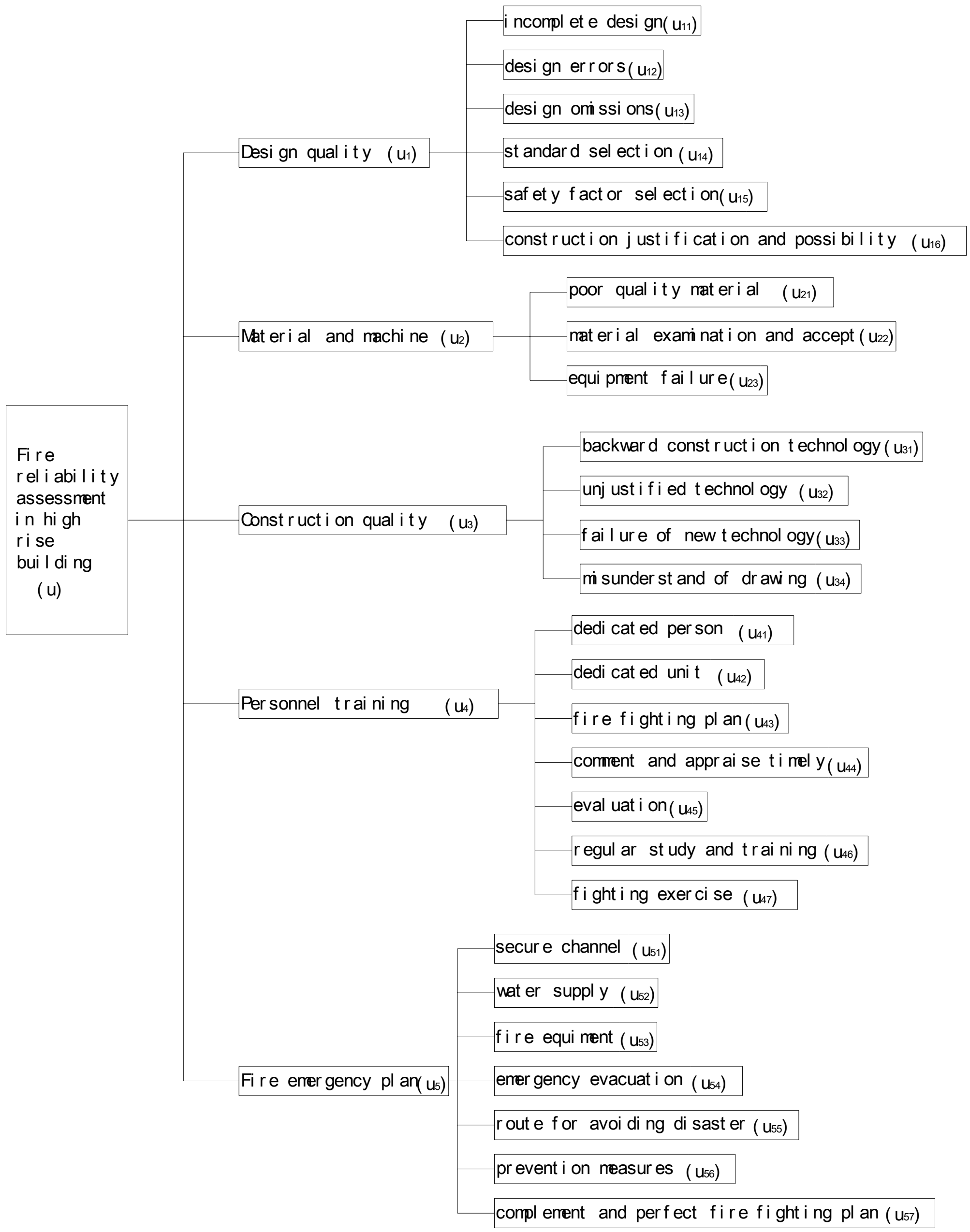

Fig 1: The Indexes System Of The Assessment

4 CONCLUSION

The reliability assessment of fire in high-rise building is more and more important. We proposed a novel method based on a new mathematic tool: the clear rational number set. By using the assessment model proposed here, we can get the average value of every factor in every level, and know the influence degree of every factor. This study has significance in theory and practice for the fire reliability assessment of civil engineering structures and other structures. And the method can be employed in other comprehensive assessment problems.

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