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Study on quantification scheme of weight coefficient for electrical fire risk assessment of high-rise building

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Abstract. Electrical fire is a very important fire type in high-rise building fire. Therefore, it has high research value for risk assessment of electric fire in high-rise buildings. However, it is difficult to accurately obtain the weight index coefficient of electrical fire risk assessment by single qualitative or quantitative risk assessment method, so the reliability and objectivity of electrical fire risk assessment cannot be guaranteed. In order to solve this problem, a method of using numerical simulation to obtain different types of fire risk data is proposed. Then, taking fire risk influencing factors as the research object, a comprehensive fire risk evaluation system is established. Through the comprehensive evaluation system, the electrical fire risk data are evaluated to determine the electrical fire risk weight coefficient. The results show that the fire risk quantification scheme of weight coefficient proposed in this paper can eliminate the subjectivity of traditional expert ratings. The proposed evaluation standard is a comprehensive evaluation system based on the numerical simulation and analytic hierarchy process. Above mentioned method can improve the reliability and accuracy of the weight coefficient of electrical fire risk assessment, and provide a theoretical basis for the research and classification of fire risk.

Keywords: Electrical fire / risk assessment / numerical simulation / analytic hierarchy process (AHP)

1 Introduction

According to the statistics, electric fire accounted for 31% of high-rise building fire in China between 2012 and 2020, and there is a rising trend, especially for the proportion of major fire. Moreover, a large number of fire data statistics show that Electrical fire ranks first in fire causes and direct economic losses caused by fire for many years [1]. Therefore, the electrical fire risk assessment is of great practical significance to fire safety and early warning.

Although many scholars have applied various risk assessment methods to specific fire scenes, most of the research focuses on the field of non-electrical fire. Moreover, due to the complexity and randomness of electrical fire risk factors, it is difficult to accurately obtain the weight coefficient of electrical fire risk assessment by conventional risk assessment methods. Therefore, in the face of the above-mentioned urgent problems that need to be solved, the weight coefficient quantification scheme of electrical fire risk assessment established in this paper needs to achieve the following research objectives: First, establish an electrical fire scenario model, and obtain the risks required for electrical fire risk assessment through numerical simulation

Indicator data. Second, refer to the fire risk assessment specification, use the analytic hierarchy process to establish a comprehensive electrical fire risk assessment system, and evaluate the risk index data. Third, the electrical fire risk assessment results are calculated according to the weight calculation formula to calculate the weight coefficient of the electrical fire risk assessment.

2 Literature review

At present, the researches on fire risk assessment mainly focus on qualitative and quantitative risk assessment. Among the qualitative risk assessment methods, the Failure Tree Analysis (FTA) method is mainly used to analyze the causes and logic of the accident. However, it is inaccurate for the assessment of the likelihood of causing an accident. Ren et al. established an intelligent electrical fire detection system for green buildings with the help of FTA and multi-information fusion method, which reduced the deficiency of single criterion for fault arc detection, and prevented green building electrical fire more comprehensively and accurately [2]. The Preliminary Hazard Analysis (PHA) method is applicable to the initial stage of the project, which can be used to identify the causes of the risk factors and the possible consequences of the accident. But

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the subjective factors of the evaluator have a great influence on the assessment and analysis results of its risk grade. Yhe et al. used preliminary hazard analysis to estimate the correlation between fire hazards [3]. The results are helpful for relevant departments to identify the fire hazards in cultural relics houses, so as to protect the life safety of building residents and the value of cultural heritage. The Failure Mode and Effect Analysis (FMEA) method is mainly used to analyze the influence of local failure on the whole system, but the analysis logic is not clear. It is difficult to analyze the influence of each element when there are too many local elements. Fateme Omidvari et al. used FMEA to classify the factors affecting fire risk and combined with multi-objective decision-making method to evaluate the fire risk of medical and health care environment, which can accurately evaluate the fire risk of hospitals and health centers [4].

Among the quantitative risk assessment methods, The Analytic Hierarchy Process (AHP) method is mainly used for the systematic review of unstructured properties as well as multi-objective, multi criteria, etc. However, this method needs a large amount of data when the evaluation indexes are excessive, and the weight coefficient is difficult to determine. Wenhe Wang et al. analyzed the fire risk index system of residential buildings by using analytic hierarchy process, determined the weight of risk index, and selected three buildings as the fire risk model proposed in the case study. The research results truly reflect the actual situation of fire safety of residential buildings, so as to effectively reduce the fire risk in the system [5]. The character of fuzzy comprehensive evaluation [6–8] is to process fuzzy evaluation object with precise digital method, which can make relatively close to practical and scientifically reasonable quantitative evaluation of the information of the ambiguity of the evaluation object. Mohammad Yazdi et al. established a fuzzy failure tree to analyze the root cause of dangerous events, and then used fuzzy set theory and expert judgment to obtain fault data from accidents. Finally, a risk analysis of the explosion fire case of a spherical hydrocarbon tank was carried out, which showed the feasibility and effectiveness of the proposed model. However, fuzzy comprehensive evaluation is relatively complicated to calculate, and the knowledge level of the assessor has a large effect on the accuracy of the indicator weight vector. The Grey Relational Analysis (GRA) [9] method is characterized by its simple principle, less statistical data needed for evaluation, and its ability to reduce the influence of information asymmetry on evaluation. GRA is mainly used to analyze the nonlinear relationships among the influencing factors of multiple systems. However, the subjective factors have a great influence on the determination of the optimal value of each index. FU Yingcai et al. respectively applied modified analytic hierarchy process (MAHP) and grey relational analysis to comprehensively evaluate the fire hazards of five rubbers. And the analysis verifies that the fire hazard rankings of the two evaluation methods are the same [10].

Fire data are mainly obtained by carrying out fire combustion tests in physical objects or scaled models, which are costly, time-consuming, and risky, and the test results in the same environment will have large fluctuations

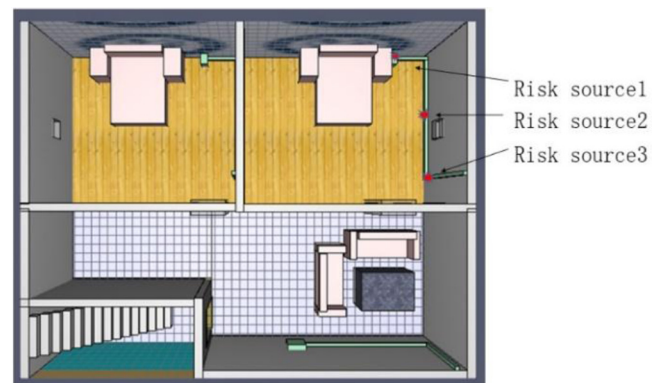


Fig. 1. Scene model diagram of high-rise residential building.

and large errors. Fire numerical simulation can not only carry out deterministic and random quantitative analysis by designing fire scenes for the evaluation object, but also make up for the shortcomings of physical test research, so it has been widely used in the field of building fire risk assessment at home and abroad.

Min-Ho Moon et al. conducted numerical simulations of seven types of building fires [11]. They effectively analyzed the occurrence process and spreading law of indoor fires in buildings through numerical simulation, and determined the fire characteristics of combustibles in buildings. Jen-Hao Chi et al. used numerical simulation of fire to model electrical fire scene [12]. The causes of electrical fires are determined through model analysis, which improves the fairness, objectivity and accuracy of fire investigations. Jae-Min Jyung et al. conducted numerical simulations of electrical fires in the reactor control room in order to reduce the risk of nuclear power plant fires [13]. They verified the electrical fire risk in the control room under two turbulence models, two cable materials and two ventilation conditions through three hypothetical electrical fire scenarios, which provided a theoretical basis for the prevention and emergency treatment of nuclear power plant fires.

3 Scene simulation of electrical fire

In this paper, the fire numerical simulation software is used to build a residential building model. Numerical simulation of electrical fire is conducted in the established building scenarios by analyzing the location where electrical fire occurred and electrical fire hazard source data. Then, the index data is required for electrical fire risk assessment, such as the real-time changes of temperature, flue gas concentration, flame spread degree and carbon monoxide concentration in the electrical fire scene, are obtained. It will provide a reference for the comprehensive assessment system of electrical fire risk.

3.1 Modeling of electrical fire scene

3.1.1 Modeling of architectural scene

In this paper, a 12 m × 10 m × 30 m residential building in a community is taken as the object of study, and a geometric model is established, as shown in Figure 1. 1:1 scale is used

Table 1. Material attribute table of items in scene simulation.

Object	thickness	material
walls, ceilings and floors	0.2m	concrete material
Bed surface	0.2m	Ponderosa material
Bed and sofa	0.4m	Foam material
Electrical wiring	0.04m	PVC and copper
Bedroom floor surface	0.13m	Ponderosa material
Table and chair	0.1m	Ponderosa material

Table 2. Electrical fire risk source data table.

Type of fault	Short circuit	Overload	Ground fault	Poor contact	Arc fault
Heat release rate (KW/m ²)	1500	1000	1500	1800	2500
Fire location	Risk source2	Risk source 1	Risk source 2	Risk source 3	Risk source 3

to build the geometric space model of residential building, and 0.1 m² grid is used to simulate the fire. The residence consists of a staircase, two bedrooms, a living room and a corridor with ventilation and smoke extraction windows to simulate the actual building environment. In order to simulate the reality of electrical fire, this study set up sofas in the living room, beds and electrical wiring in the bedroom.

Due to the complex structure of electrical circuit, it is mainly composed of metal conductor, insulating layer and sheath layer. Electrical line fire is mainly caused by short circuit, overload or poor contact at its electrical fault, resulting in the sharp rise of local temperature of the line, resulting in the pyrolysis of combustible materials in the line, and then electrical fire. And the heat of the line burning mainly comes from the insulating layer and sheath layer. Therefore, in order to simplify the analysis process, only the combustion of the insulation layer and sheath layer of the line is considered, and it is simplified as a thin plate with equal thickness in the electrical fire scene simulation.

Fire numerical simulation in the simulation process sets the initial temperature of the environment for 20 °C. Three thermocouples 1.5 m, 2.0 m, 2.5 m above ground level and meteorological monitoring equipment 2 m above ground level are installed in the center of each room and living room. Furthermore, carbon monoxide concentration, carbon dioxide concentration and flue gas temperature parameter slices are set up at the distance of 2 m from the ground to analyze the risk of electrical fire. The material properties of the items in the scenario simulation are set as shown in [Table 1](#).

3.1.2 Setting of electrical fire risk sources

Electrical fire scene simulation is carried out in the same building scene model. Electrical line faults are divided into short circuit, overload, grounding fault, poor contact and fault arc. According to the data of electrical failure, the

heat release rate and the spatial distribution of the risk sources are obtained as shown in [Table 2](#). The simulation time is 600 s.

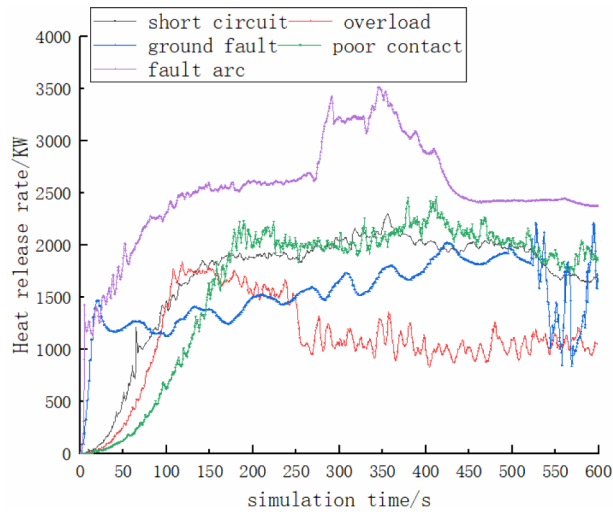
3.2 Results of electrical fire simulation

In this paper, fire risk data are obtained from three indexes of fire numerical simulation, i.e. fire combustion risk, smoke risk and harmful gas risk, and the fire data obtained from each electrical fire scene are comprehensively counted as the basis for comprehensive assessment of electrical fire risk. The simulation results are shown in [Figures 2–4](#).

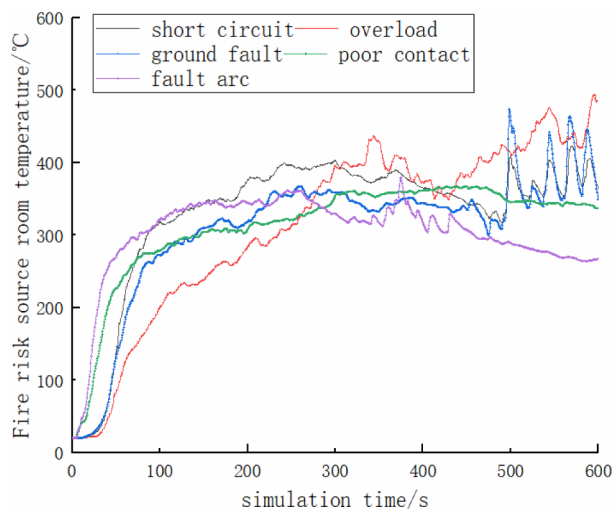
In this paper, the fire combustion risk is evaluated according to the peak value of heat release rate, the room temperature of electrical fire hazard source, the average temperature of other rooms, the degree of flame spread and the ratio of electrical fault in electrical fire. The peak value of heat release rate is an important index for electrical fire risk assessment. Because fire spread, the following requirements must be met: firstly, the fire object can release enough heat to ignite nearby objects; secondly, the fire object heat release rate must be large enough to avoid the cooling effect of the air around the nearby objects caused by heat loss. The room temperature and all room temperature can reflect the burning trend of electric fire and the change of fire danger degree in real time.

The flue gas risk is assessed based on visibility, smoke density, and total smoke release quality. Flue gas is another important factor in electrical fire risk assessment. Because combustion of combustible materials, especially insulation combustion in the electrical lines of electrical fire will release large amounts of smoke, making visibility less visible. The smoke will hinder the evacuation of people in the fire, and also hinder firefighters from fighting the fire. When the smoke density is high, it will also cause a risk of suffocation.

The toxic gas risk is assessed based on the time to the hazardous concentration of carbon dioxide, time to the hazardous concentration of carbon monoxide and peak



(a) Heat release rate change curve



(b) Temperature change curve of burning room

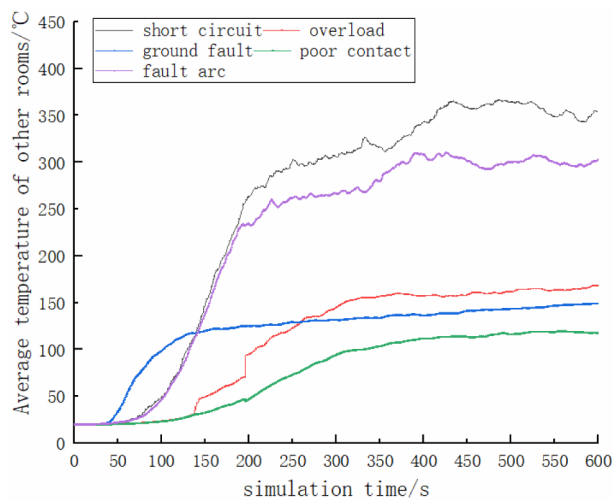
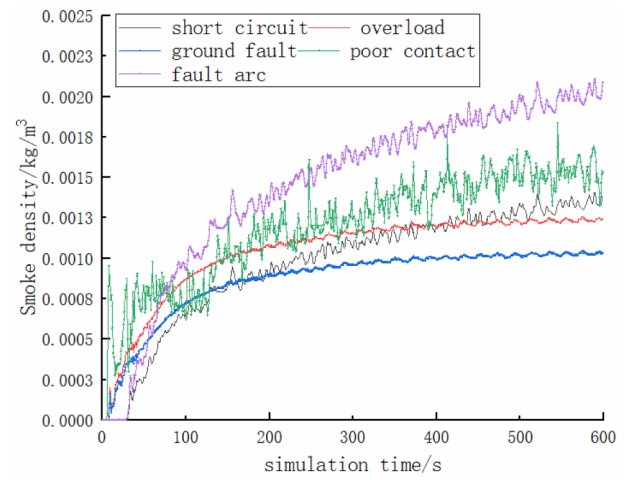
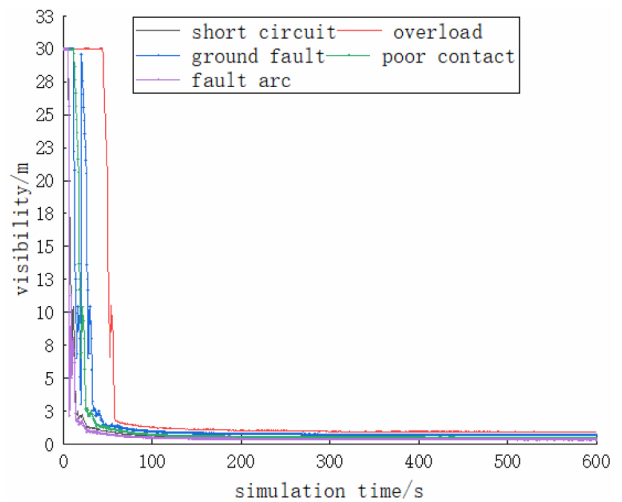


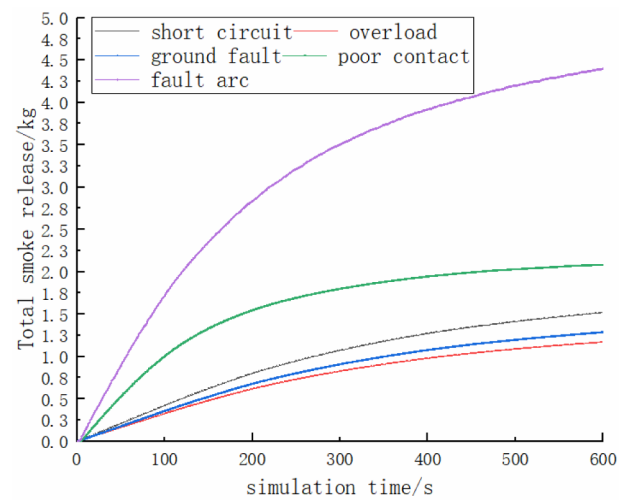
Fig. 2. Fire combustion risk simulation data map. (a) Heat release rate change curve. (b) Temperature change curve of burning room. (c) Average temperature change curve of other rooms.



(a) Smoke density change curve

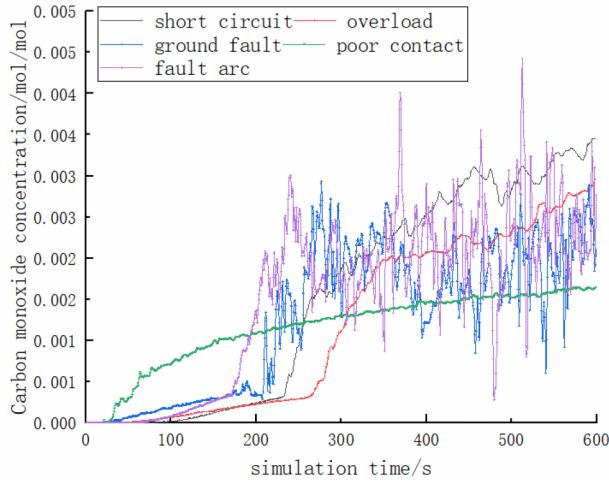


(b) Visibility change curve



(c) Total smoke quality change curve

Fig. 3. Flue gas risk simulation data map. (a) Smoke density change curve. (b) Visibility change curve. (c) Total smoke quality change curve.



(a) CO concentration change curve

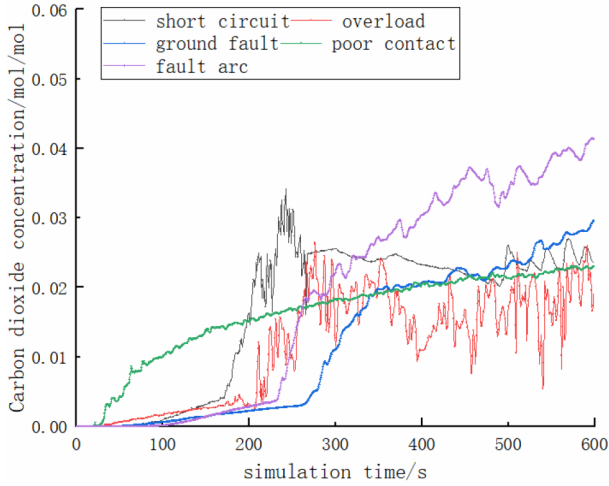
(b) CO₂ concentration change curve

Fig. 4. Toxic gas risk simulation data map. (a) CO concentration change curve. (b) CO₂ concentration change curve.

carbon monoxide concentration. Electrical fire can release harmful gases that cause discomfort, coma, or even death. In addition, in the early stage of fire burning, the harmful gases such as carbon monoxide and carbon dioxide are mainly responsible for the threat to the human body. Their level of poisoning is related to the concentration and the time of human exposure to toxic gas. The toxicity level of the gas is easier to analyze by concentration curves.

4 Comprehensive index evaluation system of electrical fire risk

AHP is a multi-objective decision-making method widely used in various risk assessment fields. It can divide the structure of complex goals into several hierarchical levels. Through layer-by-layer analysis and judgment of the decision-making plan, the single-level ranking and total ranking are calculated. Qualitative and quantitative

analysis on this basis has the advantages of convenience and practicability. Therefore, the assessment of electrical fire risk of high-rise buildings should be comprehensive, rather than one-sided assessment of electrical fire risk from several parameter indicators. This paper makes use of the analytic hierarchy process to establish an electrical fire risk comprehensive evaluation system for electrical fire risks. Considering various index parameters that affect fire risk, a more comprehensive and reasonable electrical fire risk assessment method is adopted to obtain a more accurate and reasonable electrical fire risk weight coefficient.

4.1 Establishment of electrical fire risk assessment system

The basic steps for establishing a comprehensive electrical fire risk assessment system using the analytic hierarchy process are as follows:

- Using AHP to analyze electrical fire risk factors, the electrical fire risk assessment system is divided into three-level hierarchical structure models, i.e. target layer, criterion layer and index layer. Establish a comprehensive evaluation system and scoring standards for electrical fire risk assessment as shown in Table 4.
- According to the results of numerical simulation, electrical fire cases and actual fire situation, 9-scale method is used to construct judgment matrix A , and when determining the weight of indicators at each level, the corresponding importance levels of each indicator at the same level are expressed in the form of comparison of importance levels between indicators.
- The root method is used to solve the maximum eigenvalue $\lambda_{\max}$ of the judgment matrix, and the corresponding eigenvector W is normalized.
- Consistency test is performed on the obtained indicator judgment matrices at all levels. The consistency test method is as follows:

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

where CI is the consistency test index n is the order of the judgment matrix; when $CR = \frac{CI}{RI} < 0.1$, the judgment matrix is considered to possess satisfactory consistency. Otherwise, the test will fail, and the element values of the judgment matrix need to be adjusted and recalculated according to the above steps. RI is a random consistency indicator. The value of RI is shown in Table 3.

(5) After passing the consistency check, the weight value of each index corresponding to the corresponding fire risk factor at the index level is relative to the criterion level. Calculate the weight value relative to the total target, and obtain the total ranking table of the hierarchy as shown in Table 9. According to the above steps, the obtained comprehensive evaluation system and scoring standard for electrical fire risk assessment are shown in Table 3. The results of the constructed electrical fire risk judgment matrix at each level are shown in Tables 5–9. (W_i is the weight value, $BW = \lambda_{\max} B$, and $\lambda_{\max}$ is the maximum eigenvalue of matrix B .)

Table 3. Random consensus indicators.

n	1	2	3	4	5	6
RI	0	0	0.52	0.89	1.12	1.26

Table 4. Comprehensive evaluation system and scoring standard of electrical fire risk assessment.

	Criterion layer	Index layer	0points	1-9points	10points
Comprehensive evaluation system of electrical fire risk weight A		Peak heat release rate C1 (KW)	C1 < 1500	1500 ≤ C1 ≤ 3500	3500 < C1
		Time for the temperature of the hazard room to reach 200°C C2 s	50 < C2	20 ≤ C2 ≤ 50	C2 < 20
		Time for the average temperature of other rooms to reach 140°C C3 s	400 < C3	100 ≤ C3 ≤ 400	C3 < 100
Flame spread C4	Fire combustion risk B1	Not spread	Spread to some rooms	Spread to all rooms	
Rate of accidents in electrical fire C5(%)		C5 < 5	5 ≤ C5 ≤ 60	60 < C5	
Flue gas risk B2	Peak smoke density C6 (kg/m ³)	C6 < 1 × 10 ⁻³	10 ⁻³ ≤ C6 ≤ 10 ⁻²	50 × 10 ⁻³ < C6	
	Time when visibility is less than 3m C7(s)	100 < C7	10 ≤ C7 ≤ 100	C7 < 10	
	Total smoke release quantity C8 kg)	C8 < 0.5	0.5 ≤ C8 ≤ 5	5 < C8	
Toxic gas risk B3	Time of CO ₂ reaching dangerous concentration 2000ppm C9 s	100 < C9	20 ≤ C9 ≤ 100	C9 < 20	
	Time of CO reaching dangerous concentration 800ppm C10(s)	100 < C10	20 ≤ C10 ≤ 100	C10 < 20	
	Peak CO concentration C11 %	C11 < 0.5	0.5 ≤ C11 ≤ 1	1 < C11	

Table 5. Judgment matrix after aggregation – electrical fire risk index evaluation system.

Comprehensive evaluation system of electrical fire risk weight A	B1	B2	B3	Wi
Fire combustion risk B1	1.0000	1.5874	1.4491	0.4265
Flue gas risk B2	0.6300	1.0000	0.5999	0.2345
Toxic gas risk B3	0.6901	1.667	1.0000	0.3390

Calculation results $CI=0.0227$ The total weight of A to the target is 1

Table 6. Judgment matrix after aggregation – fire combustion risk—Fire combustion risk.

B1	C1	C2	C3	C4	C5	Wi
C1	1.0000	1.3104	3.5569	1.2599	0.6300	0.2412
C2	0.7631	1.0000	0.5503	0.7211	0.4368	0.1239
C3	0.2811	1.8171	1.0000	0.9086	0.3969	0.1324
C4	0.7937	1.3867	1.1006	1.0000	0.4642	0.1655
C5	1.5874	2.2894	2.5198	2.2894	1.0000	0.3371

Calculation results: $CI=0.0446$ The total weight of B1 to the target is 0.4265.

Table 7. Judgment matrix after aggregation – flue gas risk.

B2	C6	C7	C8	Wi
C6	1.0000	1.4938	1.7100	0.4330
C7	0.6694	1.0000	2.3208	0.3669
C8	0.5848	0.4309	1.0000	0.2001

Calculation results: $CI=0.0536$. The total weight of B2 to the target is 0.2345

Table 8. Judgment matrix after aggregation – toxic gas risk.

B3	C9	C10	C11	Wi
C9	1.0000	0.6300	0.3467	0.1896
C10	1.5874	1.0000	0.9565	0.3597
C11	2.8845	1.0455	1.0000	0.4507

Calculation results: $CI=0.0307$; The total weight of B3to the target is 0.3390

4.2 The calculation result of Electrical Fire Risk by AHP

4.2.1 Evaluation and weight of electrical fire risk

According to the comprehensive evaluation system and scoring standard of electrical fire risk assessment shown in Table 4, the comprehensive score of fire risk parameters obtained from electrical fire scenario simulation is conducted, and the parameter score $X_i (C_p)$ ($i=1, 2, \dots, n, p=1, 2, \dots, m$) of electrical fire risk sources of the second-level indicators in Table 10 is obtained respectively. (Where, i is the type of electrical fire risk source, p is the risk factor of indicator layer in the comprehensive evaluation system of electrical fire)

The index combination weight in Table 9 and the score of electrical fire risk source parameters in Table 10 are calculated according to the comprehensive scoring formula

$$Q_i = \sum_{p=1}^m \omega(C_p) \cdot X_i(C_p) (p=1, 2, \dots, m) \quad (2)$$

The Comprehensive Electrical Fire Risk Score Q_i in Table 11 is obtained. The comprehensive score of electrical fire risk weight is calculated according to the weight calculation formula:

$$W_i = \frac{Q_i}{\sum_{i=1}^n Q_i} (i=1, 2, \dots, n) \quad (3)$$

Table 9. Total ranking of levels.

Layer C	Layer A	B2	B3	Combined weight w (weight relative to overall objective)	
	B1 0.4265				
	C1	0.2412	—	—	0.1029
C2	0.1239	—	—	0.0528	
C3	0.1324	—	—	0.0565	
C4	0.1655	—	—	0.0706	
C5	0.3371	—	—	0.1438	
C6	—	0.4330	—	0.1015	
C7	—	0.3669	—	0.0860	
C8	—	0.2001	—	0.0469	
C9	—	—	0.1896	0.0643	
C10	—	—	0.3597	0.1219	
C11	—	—	0.4507	0.1528	

Table 10. Comprehensive score and weight value of electrical fire risk factors.

Comprehensive evaluation system of electrical fire risk weight A	Criterion layer	Index layer	Short circuit	Overload	Ground fault	Poor contact	arc fault
Fire combustion risk B1	C1	5.30	3.20	4.80	60	10.00	
	C2	5.30	2.50	4.40	6.10	7.60	
	C3	7.10	2.90	4.30	2.70	7.10	
	C4	6.70	5.90	6.30	5.80	10.00	
	C5	8.00	1.00	7.00	3.00	3.00	
Flue gas risk B2	C6	3.20	2.30	1.70	4.50	5.40	
	C7	6.70	5.70	6.70	7.70	8.00	
	C8	5.80	5.40	5.80	6.80	7.30	
	C9	4.10	4.70	4.80	4.10	4.70	
Toxic gas risk B3	C10	5.20	2.20	4.80	5.50	6.60	
	C11	6.40	5.90	6.70	5.10	8.70	

Table 11. Comprehensive score and weight value of electrical fire risk factors.

Electrical fault type	Short circuit	Overload	Ground fault	Poor contact	arc fault
Comprehensive score Q	17.22	11.29	15.69	15.86	20.88
weight coefficient W	0.219	0.143	0.199	0.201	0.265

Table 12. Ranking of weight coefficients of electrical fire risk assessment.

Determination method of weight coefficient	Short circuit	Overload	Ground fault	Contact resistance Excessive	arc fault
The AHP method in this paper	2	5	4	3	1
Reference AHP method	3	4	-	2	1

Thus, the electrical fire risk assessment weight values W_i are obtained as shown in Table 11.

At the same time, this paper compares the proposed electrical fire risk weight coefficient with the weight coefficient of electrical fire risk factors in the reference "Research on Electrical Fire Risk Assessment Based on Data Mining Technology" [14]. And the weight coefficient results are sorted. The comparison results of electrical fire risk weighting coefficient ranking are shown in Table 12.

It can be seen that although the weight coefficients obtained in this paper are quite different from those obtained in the reference, the order of the weight coefficients has not changed. The main reason is that the reference does not consider the ground fault, and the weight coefficient of the AHP method used in the reference mainly depends on the expert scoring method, and the results are more subjective. The electrical fire risk weight coefficient quantification scheme proposed in this paper obtains risk data through numerical simulation of electrical fire, and uses AHP to establish a comprehensive electrical fire risk assessment system to evaluate the risk data, thereby avoiding the subjectivity of expert scoring. Therefore, the evaluation results of the weight coefficient of electrical fire risk by the method proposed in this paper truly reflect the fire risk of different types of electrical faults.

5 Conclusion

This paper combines numerical simulation and AHP to solve this problem. Taking high-rise residential buildings as an example, the fire risk factors caused by electrical faults are effectively analyzed, and the proposed evaluation scheme of electrical fire risk weight coefficient is compared and verified to be scientific and practical. The main contributions of this research to the development of this field are as follows:

- The numerical simulation and analytic hierarchy process are creatively combined to comprehensively evaluate the electrical fire risk, and the risk weight coefficient of each electrical fire fault is solved. It helps to avoid the subjectivity of traditional expert scoring and improve the accuracy of weight coefficient of electrical fire risk assessment.

- Combined with the characteristics of electrical fire, relevant literature and numerical simulation data, a comprehensive evaluation system of electrical fire risk assessment is established. Through the numerical simulation of electrical fire in high-rise residential buildings, the data of each electrical fire risk index layer under "fire combustion risk", "flue gas risk" and "toxic gas risk" are sorted out.
- Based on the research results of existing scholars, combined with relevant literature and books, this paper establishes a scientific comprehensive evaluation system and scoring standard for electrical fire risk assessment. It also establishes a complete basis and rules for the quantification of each index.
- Taking a high-rise residential building as an example, this paper introduces the weight coefficient quantification scheme of building electrical fire risk assessment, and compares the weight coefficient with other literature to verify the correctness of the electrical fire risk assessment scheme proposed in this paper.

The quantification scheme of the electrical fire risk weight coefficient in this study can evaluate the electrical fire risk by establishing a numerical simulation scenario model and an electrical fire risk assessment index system. Realize the quantification of electrical fire risk and meet the requirements for risk quantification. This study provides important model support for the current high-rise building fire protection system. The results of the weight coefficient will be applied to the high-rise building fire risk assessment and early warning algorithm, which is of great significance for reducing the electrical fire risk of high-rise buildings.

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