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RESEARCH ON SAFETY EVALUATION OF ASSEMBLY BUILDING CONSTRUCTION BY INTEGRATING ENTROPY POWER METHOD AND NETWORK ANALYSIS MODEL

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ABSTRACT

Unlike the traditional construction mode of rough operation, assembly building construction implements the concept of green development in terms of energy consumption and environmental adaptability. Although assembly construction can effectively reduce construction energy consumption and improve the environmental resilience of building construction work, there is an urgent need for an effective safety assessment model for construction development due to the imperfect operation system and harsh construction environment in the construction industry. Therefore, the study analyzes the relationship of construction safety factors by using Analytic Network Process (ANP) to filter safety evaluation indexes according to the importance ranking. At the same time, the objective weights of safety indicators were determined by the entropy weight method, and the subjective weights determined by the ANP method were combined to construct the safety evaluation model for the construction of assembled buildings. The experiment shows that the maximum similarity between the comprehensive evaluation results of the model in the simulation of safety evaluation of high-rise residential construction and the actual evaluation criteria is 0.772. The experiment proves the reliability of the evaluation of the model, which reduces the safety loopholes and operation hazards for the construction of assembled buildings.

KEYWORDS

Assembly building construction, Entropy power method, Network analysis method, Construction safety index

INTRODUCTION

As the structural transformation and optimization of the building construction industry proceeds, the disadvantages of the traditional construction model with poor risk resistance and high energy consumption become more and more prominent, and the progress of the assembled building construction model adapts to the requirements of economic and social development for the efficiency of residential construction [1]. The assembled building construction model focuses on the individual needs of the customer for accessories and the logistics management of accessories, while considering the planning and control of the delivery and assembly of prefabricated building systems. Peng Li, a domestic scholar, proposed a case-based reasoning based multi-objective optimization model for clustering construction suppliers. This method can optimize the management of the construction party and guide the construction into green transformation. At the same time, foreign scholars [2]. Anna Adamczak, Bugno and others tested the flexural strength of fiber cement building materials and proposed the possibility of using acoustic emission and wavelet analysis to test cellulose fiber reinforced cement plates [3]. Based on the frontier achievements of the academic community, the study determined the safety index assessment system for assembly building construction and the subjective weights of the indexes based on text mining and network analysis, introduced CR values to modify the weight matrix, and used the entropy weighting method to

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determine the objective weights of the indexes. After calculating the comprehensive weights, the cloud model was used to characterize the quantitative scores as the degree of risk, and the similarity was used to evaluate the performance of the ANP-EW model constructed by the study. Through the combined application of the subjective and objective weights and the cloud conversion algorithm, it is expected to provide an effective and accurate risk assessment method for the emerging development of assembled buildings.

RELATED WORKS

The application of entropy weight method, network analysis and cloud transformation model by domestic and foreign scholars has become mature. Yu K et al. established an index system of factors influencing coal miners' unsafe behavior and used the weights determined by ANP as the influence coefficients among variables to construct a system dynamics (SD) model of coal miners' unsafe behavior. Experiments showed that the method provides theoretical support and methodological guidance for improving coal miners' safety [4]. Zheng used ANP to derive subjective weights in multi-attribute decision making and proposed a hybrid hesitant fuzzy language factor analysis method to cluster attributes as principal factors. Experiments show that the method can be applied to physical health assessment with graduate students [5]. Abedin S F et al. prioritize different QoS requirements of heterogeneous IoT applications in fog networks by using an AHP implementation analysis framework to initiate stable associations between fog network infrastructure (i.e., fog devices) and IoT devices. The results show that the association of the method possesses stability and higher efficiency in resource allocation with high utility gain [6]. Li Z et al. proposed a data-driven algorithm based on the entropy and TOPSIS methods for analyzing the applicability potential of shallow geothermal energy. Experiments showed that the algorithm can overcome the subjectivity of expert experience and is suitable for selecting the best site [7]. Liang Wei et al. proposed an entropy method with a multi-step reverse cloud transformation algorithm based on sampling replacement (MBCT-SR) for a risk assessment model of long-distance gas transmission pipelines in mines [8]. Chen J Q et al. A transformer bushing fault prediction method based on entropy-weighted TOPSIS and gray prediction theory, using TOPSIS assessment method to convert the insulation assessment problem into a vector space distance problem, and verified the effectiveness of the method by example [9]. Luo J used entropy-weighted TOPSIS and barrier based on 2016 statistical data and population flow data degree model to measure the centrality of cities in the Yangtze River Economic Belt (YREB) and the factors affecting the centrality [10]. Sivaprasad P V et al. constructed an optimization model for alloy-X laser microdrilling process variables based on a joint entropy-based-Dunn's similarity algorithm. It was shown that the method can account for the thermal effects during the metallurgical processing performed in the micro-hole [11].

Akter S. et al. investigated the increasing convergence of artificial intelligence, blockchain, cloud transformation, and data analytics for technology operations and value propositions [12]. Symvoulidis C. et al. presented a cloud-based system for electronic health records (EHR) that uses an object storage architecture to store healthcare data and enable authenticated healthcare professionals to accelerate the delivery of health services in an emergency, in an automated but secure manner [13]. Wu Q et al. developed an entropy-weighted cloud evaluation model to calculate evaluation metrics for the energy utilization potential of air conditioners based on the results of the analysis of the structure and operating mechanisms of large building air conditioners [14]. Fang et al. proposed a four-dimensional hyperchaotic system with large key space and chaotic dynamics performance, and combined it with a cloud model to construct a more complex random sequence as a keystream to solve the chaotic periodicity problem [15]. Qian J et al. developed an R-packet tranSurv and estimated the phase dependent truncation under One model of the survival function is a structural transition model that relates potential quasi-independent truncation times to observed dependent truncation times and event times [16]. Muhic M et al. developed a staged business model innovation model related to the adoption and continued use of cloud outsourcing, and the model identifies three business model innovation stages by characterizing specific capability types. The model was experimentally demonstrated to help better understand the evolution of dynamic capabilities and the evolution of cloud sourcing companies and cloud-based business model innovation [17]. Cui et al. proposed a cloud model-based risk assessment method for the ambiguity and stochastic nature of qualitative and quantitative knowledge transformation in the risk assessment process, which was experimentally demonstrated to fully consider risk itself and the uncertainty in the inference process [18].

In summary, there are few examples of the entropy power method, network analysis, and the integrated optimization application of cloud conversion model in safety evaluation, and the same lack of experience in constructing safety indicators for assembled buildings, so the study constructs the EW-ANP model to make up for the shortage of related studies.

CONSTRUCTION OF EW-ANP SAFETY ASSESSMENT MODEL FOR ASSEMBLED BUILDING CONSTRUCTION

Selection of construction safety assessment indexes based on network analysis method

Due to the diverse safety influencing factors and complicated construction procedures of assembly building construction, its safety assessment indexes need to meet the principles of comprehensiveness, practicality and dynamism. Therefore, the research constructs the safety assessment index system of assembly building construction firstly, the construction safety indexes are screened out by text mining method, the network construction reports and accident causes are analyzed by Text Miner tool, the high-frequency words in the reports are summarized work, and the Text Miner software is used to clean up the word-sense relationship and summarize the accident causes and high-frequency words to ensure the safety assessment index system is comprehensive comprehensiveness as well as practical and reasonable [19]. Secondly, the network analysis method was used to determine the subjective weights of safety evaluation indexes, and the relationship between construction safety factors was initially judged based on the questionnaire survey, and the safety indexes derived from the text mining method were correlated with the comprehensive construction safety factors derived from the questionnaire to determine the hierarchical relationship and importance ranking between the indexes. The network structure model and judgment matrix of the network analysis method are used to divide the main criteria and secondary indicators, and their unweighted matrix is shown in equation (1).

$$X_{ic} = \begin{pmatrix} x_{i1}(\mathrm{c1}) & x_{i1}(\mathrm{c2}) & \dots & x_{i1}(cn) \\ x_{i2}(\mathrm{c1}) & x_{i2}(\mathrm{c2}) & \dots & x_{i2}(cn) \\ \dots & \dots & \dots & \dots \\ x_{in}(\mathrm{c1}) & x_{in}(\mathrm{c2}) & \dots & x_{in}(cn) \end{pmatrix} \tag{1}$$

In equation (1), X_{ic} is the unweighted evaluation factor index matrix, x_{ij} is the normalized eigenvector of the j evaluation factor of the i level decision criteria, and cn is the influence factor. Next, the weights are coupled with the matrix and multiplication is performed to derive the weighting matrix, and the weighting formula is shown in equation (2).

$$W = \bar{X}_{ic} = a_{ic} X_{ic} (i = 1, 2..., n; c = 1, 2..., n) \tag{2}$$

In equation (2), W indicates the weighting matrix, $\bar{X}_{ic}$ indicates the weighting result of the evaluation factor index matrix, and a_{ij} indicates the weight of the j evaluation factor of the decision criteria at the i level. After the weights are obtained, the network structure model is used to rank the importance of the indicators, and four first-level indicators are derived, including personnel indicators, equipment indicators, environmental indicators, and policy indicators. In the process of assembly building construction, the occurrence of safety accidents is accompanied by the injury of construction personnel and the loss of material equipment. Among the personnel indicators, those that have an impact on the safety factors of the construction process of building projects include the degree of operational standardization of construction personnel, the management experience of management personnel, the awareness of safety standardization of construction personnel and the completion of their safety training. Among the indicators of equipment and things, they include the degree of strict factory security inspection of materials, frequency of regular inspection of equipment safety, number of simulations of equipment component assembly, and fixed measures of equipment component installation and transportation. The specific index system is shown in Figure 1.

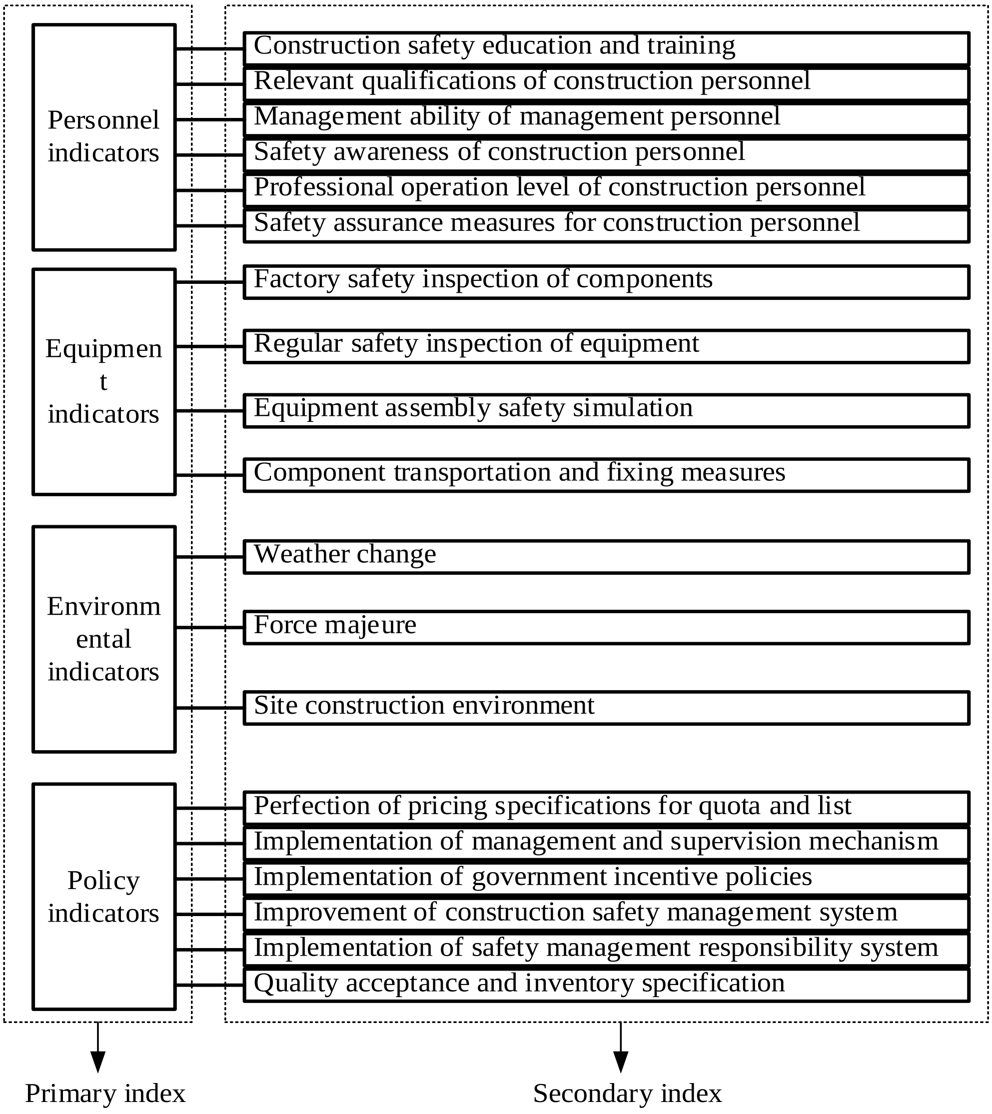


Fig. 1 – Safety evaluation index system of prefabricated building construction

As can be seen from Figure 1, in addition to personnel indicators and equipment indicators, the safety evaluation index system of the assembly building project also includes two first-level indicators of environmental factors and policy factors, and a total of 19 second-level indicators. The environmental indicators include weather changes, force majeure level construction environment conditions such as temperature, humidity and ventilation, while the policy indicators include six secondary indicators such as the specification of quality acceptance inventory, the perfection of pricing specification of quotas and lists, the implementation of safety management responsibility system, the perfection of construction safety management system, and the implementation of government incentive policies. Therefore, the study derived the above safety evaluation index system for assembly building construction based on the correlation analysis of text mining and questionnaire survey, which can comprehensively identify the safety factors in the construction process from four perspectives: human, material, environment and policy.

Construction of safety assessment model of assembly building construction by entropy power method and ANP

After constructing the safety evaluation index system of assembly building construction, the study determined the objective weights of the indexes by entropy weight (EW) method. Since the entropy weight method has the advantages of clear data processing, reduction of the influence of subjective factors and clear operation steps, the objective weights of the entropy weight method and the subjective weights of the network analysis method are combined [20]. Firstly, the interval range of indicator data is unified by the extreme criteria method to enhance the comparability of the model, and its formula is shown in equation (1).

$$x'_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \tag{3}$$

In equation (3), equation (1) $\max x_{ij}$ denotes the maximum value of the initial data of the indicator in the influence factor ; i j $\min x_{ij}$ denotes the minimum value of the initial data of the i indicator in the influence factor ; j x_{ij} denotes the initial data of the i indicator in the influence factor ; j x'_{ij} denotes the normalized data of the i indicator in the influence factor j . After standardizing the indicator values, the data are normalized and the entropy value of the risk indicator is calculated based on the standardization matrix with the formula shown in equation (4).

$$E_i = -K \sum_{j=1}^{m} P_{ij} \ln P_{ij} \tag{4}$$

In equation (4), the indicator E_i denotes the weight of the factor i , K is the Boltzmann constant, $K = 1/\ln m$, m denotes the sample size, and P denotes the number of indicators whose calculation formula is shown in equation (5).

$$P_{ij} = \frac{y_{ij}}{\sum_{i=1}^{m} y_{ij}} \tag{5}$$

In equation (5), y_{ij} denotes the normalized indicator value after normalization, and the variance coefficient of risk indicator $g_i = 1 - E_i$ can be calculated based on the entropy value of risk indicator, and the entropy weight of risk indicator of variance coefficient can be derived, and its mathematical expression is shown in equation (6).

$$WO_i = \frac{g_i}{\sum_{i=1}^{n} g_i} \tag{6}$$

After the objective weight is calculated, the subjective weight is calculated through network analysis, and the CR value is introduced to judge the consistency of the weight matrix. Modify the matrix until the CR value meets the consistency requirements, multiply the rows of the influencing factors of the optimized matrix, and square the results n times to obtain the matrix vector. Normalize the subjective weight of the indicator. The method of network analysis to calculate the subjective weight is shown in formula (7).

$$W_i = \frac{\sqrt[n]{\prod_{j=1}^{n} b_{ij}}}{\sum_{i=1}^{n} \sqrt[n]{\prod_{j=1}^{n} b_{ij}}} \tag{7}$$

In equation (7), b_{ij} is the initial weight of the influencing factors of the weight matrix. Finally, according to the subjective weight coefficient $W = [W_1, W_2, ..., W_n]$ and the objective weight coefficient $WO = [WO_1, WO_2, ..., WO_n]$, the comprehensive weight of the index is derived, and its calculation formula is shown in equation (8).

$$WC_j = \frac{W_i WO_i}{\sum_{1}^{n} W_i WO_i} \tag{8}$$

After deriving the comprehensive weights, the probabilistic statistical cloud model is used to analyze each safety index of construction by feedback and calculate the comprehensive safety score. Using the cloud model of fuzzy mathematics in the quantitative conversion of qualitative generators reflect the natural language in the safety evaluation questionnaire, first determine the evaluation criteria grading, the formation of the standard cloud, the mathematical model is shown in equation (9).

$$\begin{cases} E_x = \dfrac{\max x + \min x}{2} \\ E_n = \dfrac{\max x + \min x}{6} \\ H_e = f \end{cases} \tag{9}$$

In formula (9), E_x indicates the evaluation expectation value, which is the qualitative concept quantification point of the evaluation results, and its calculation method is to take the absolute center of the maximum and minimum values of the security score. E_n is the rating entropy value, which indicates the randomness and fuzziness of the evaluation model, and the larger the entropy value is, the fuzzier the qualitative concept month of the evaluation results. Finally, H_e is the super entropy, which indicates the randomness of the entropy value and reflects the discrete nature of the evaluation results, and f is a constant. After the standard cloud is determined, the evaluation cloud is calculated, and the evaluation data is produced according to the secondary index i , whose model is expressed as equation (10).

$$\begin{cases} E_x u_i = \dfrac{1}{n}\sum_{q=1}^{n} x_q \\ E_n u_i = \dfrac{1}{n}\sqrt{\dfrac{\Pi}{2}}\sum_{q=1}^{n}\left|x_q - E_x u\right| \\ H_e u_i = \sqrt{\left|S^2 - E_n^2 u\right|} \end{cases} \tag{10}$$

In equation (10), $E_x u_i$ is the evaluation expectation value of indicator i , x_q is the q th rating under the second level indicator, $E_n u_i$ is the rating entropy value of the indicator, $H_e u_i$ is the super entropy of the indicator rating, and S^2 is the variance of the sample to absolute center distance of the indicator. Finally, the evaluation results are calculated according to the evaluation cloud and the integrated weight, and the mathematical model is expressed as shown in equation (11).

$$\begin{cases} E_X = \sum_{i=1}^{m} WC_i E_x u_i \\ E_N = \sqrt{\sum_{i=1}^{m} WC_i E_n^2 u_i} \\ H_E = \sum_{i=1}^{m} WC_i H_e u_i \end{cases} \tag{11}$$

In equation (11), E_X , E_N , and H_E denote the comprehensive evaluation results of the secondary index i , respectively. In the comprehensive evaluation result, the comprehensive result of the evaluation cloud is valid when the similarity between the evaluation cloud and the standard cloud is large. According to the above research method, the operation flow of the summarized EW-ANP model is shown in Figure 2.

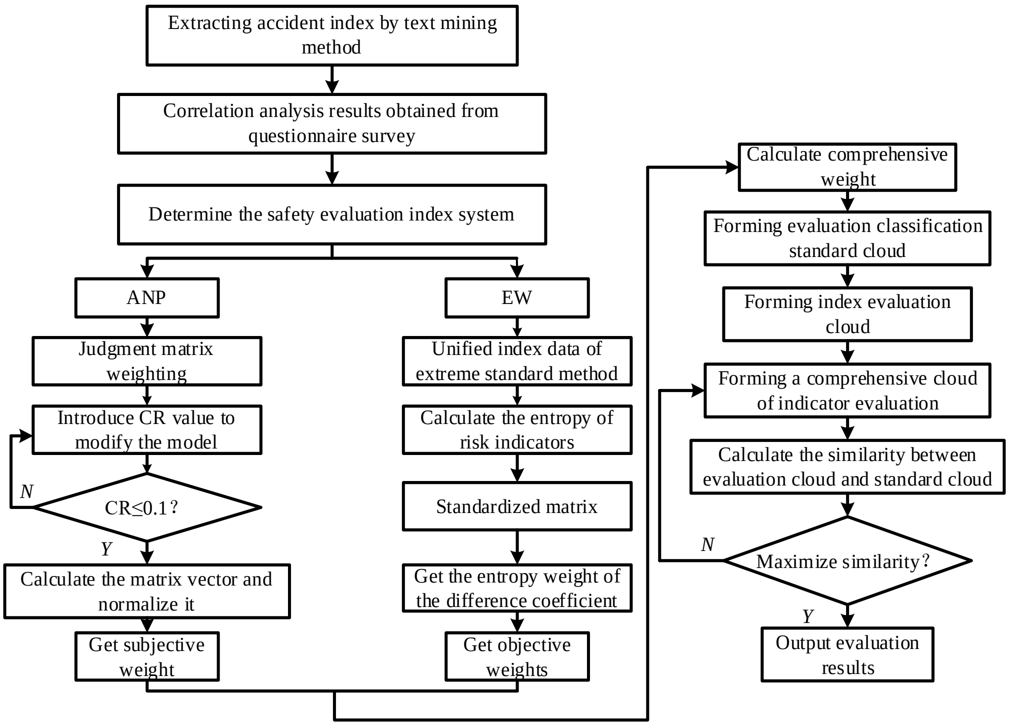


Fig. 2 – Ew-ANP model operation flow chart

From Figure 2, it can be seen that the optimization of this study to construct the safety evaluation index system lies in the modification of CR values introduced in the subjective weight matrix and the comparison of the maximum similarity of quantitative scores to qualitative transformation of the cloud conversion algorithm. The subjective weights determined by ANP and the objective weights determined by the entropy weighting method yield the comprehensive weights, and finally the evaluation cloud and the standard cloud are derived using the cloud model (Shuai Li, 2019) [21]. The research method was constructed to ensure the validity of the safety evaluation indexes and the accuracy of the safety assessment of the construction of assembled buildings.

PRACTICAL STUDY OF THE EW-ANP SECURITY ASSESSMENT MODEL

Analysis of EW-ANP index algorithm in high-rise residential construction

In order to verify the practical performance of the EW-ANP safety indicator assessment model constructed by the research method, the study selected a high-rise residential assembly construction project in a city as an example. The subjective weights of the safety index system constructed by the text mining method in this experiment relied on the expert survey method to complete, and the personnel distribution of 205 experts practicing in the construction industry who participated in this experiment is shown in Figure 3.

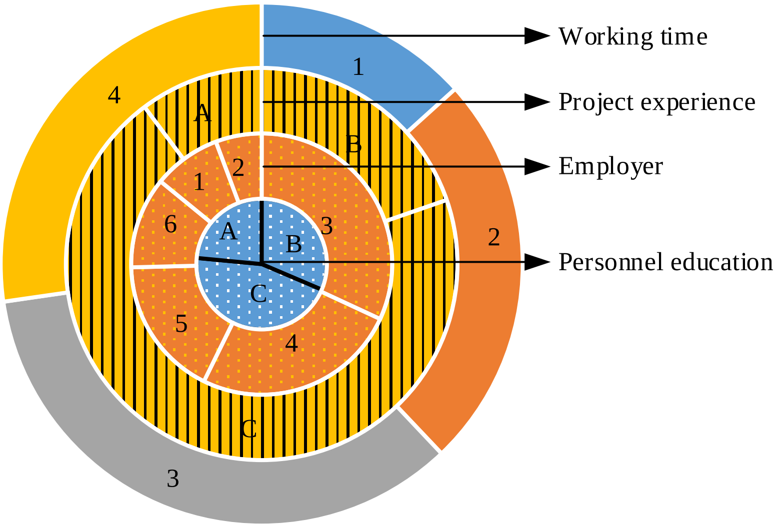


Fig. 3 – Distribution of experts participating in the questionnaire

In Figure 3, from the outer ring to the inner ring, the length of time in the field, construction project experience, organization in the field, and education level of the 2000 experts are indicated respectively. Outer ring 1 indicates the number of people who have been in the field for less than 1 year, accounting for 13.3%, outer ring 2 indicates the number of people who have been in the field for 2-4 years, accounting for 24.6%, outer ring 3 and outer ring 4 indicate the number of people who have been in the field for 5-10 years and more than 10 years, accounting for 34.8% and 27.3%, respectively. The outer ring A indicates the number of personnel involved in construction projects more than 10, accounting for 10.2%, the outer ring B and outer ring C respectively white man involved in construction projects 0-1 and 2-10, the number of people accounted for 19.7% and 70.1%. Inner ring 1-6 indicate BIM consulting units, build manufacturers, construction units, construction units, and design units and residential service units, respectively, and the number of people accounted for 8.4%, 5.7%, 31.9%, 25.4%, and 11.3%. The inner rings A, B and C denote specialist degree, bachelor's degree and graduate degree, respectively, and the number of people accounted for is 31.4%, 45.1% and 23.5%, respectively. The weights of 19 secondary indicators and 4 level 1 indicators were derived from the experts' questionnaires as shown in Table 1.

Tab. 1 - Subjective weight of safety index system for prefabricated buildings

Primary index	Secondary index	Number	Subjective weight of secondary indicators	Subjective weight of primary indicators
Personnel index evaluation	Construction safety education and training	c1	0.1482	0.2818
	Relevant qualifications of construction personnel	c2	0.1736	
	Management ability of management personnel	c3	0.1705	
	Safety awareness of construction personnel	c4	0.1673	
	Professional operation level of construction personnel	c5	0.1834	
	Safety assurance measures for construction personnel	c6	0.1570	
Equipment index evaluation	Factory safety inspection of components	c7	0.2312	0.0827
	Regular safety inspection of equipment	c8	0.1865	
	Equipment assembly safety simulation	c9	0.3193	
	Component transportation and fixing measures	c10	0.2630	
Environmental index evaluation	Weather change	c11	0.3259	0.2141
	Force majeure	c12	0.3418	
	Site construction environment	c13	0.3323	
Evaluation of policy indicators	Perfection of pricing specifications for quota and list	c14	0.1921	0.4214
	Implementation of management and supervision mechanism	c15	0.1643	
	Improvement of construction safety management system	c16	0.1752	
	Implementation of safety management responsibility system	c17	0.1625	
	Quality acceptance and inventory specification	c18	0.1493	
	Implementation of government incentive policies	c19	0.1566	

As can be learned from Table 1, the subjective weights of the four Level 1 indicators of personnel, equipment, environment, and policy indicators are 28.18%, 8.27%, 21.41%, and 42.14%, respectively. The results indicated that the policy indicators and personnel indicators had the highest weighting, and the number of secondary indicators within both level 1 indicators was 6. Among the personnel indicators, the professional operation level of construction personnel has the highest weight, with a value of 0.1834; the safety education and safety training of construction personnel has the lowest weight, with a weight of 0.1482. Among the equipment indicators, the assembly safety simulation of construction equipment has the highest weight, with a value of 0.3193; the regular safety inspection of equipment has the lowest weight, with a weight of 0.1865. Among the environmental indicators, force majeure Among the environmental indicators, force majeure has the highest weight, with a value of 0.3418; weather changes have the lowest weight, with a value of 0.3259. Finally, among the normal indicators, the highest weight, with a value of 0.1921, is given to the situation of perfecting the fixed list pricing specifications, and the lowest weight, with a value of 0.1493, is given to the situation of quality acceptance and inventory specifications. The calculation results are shown in Figure 4.

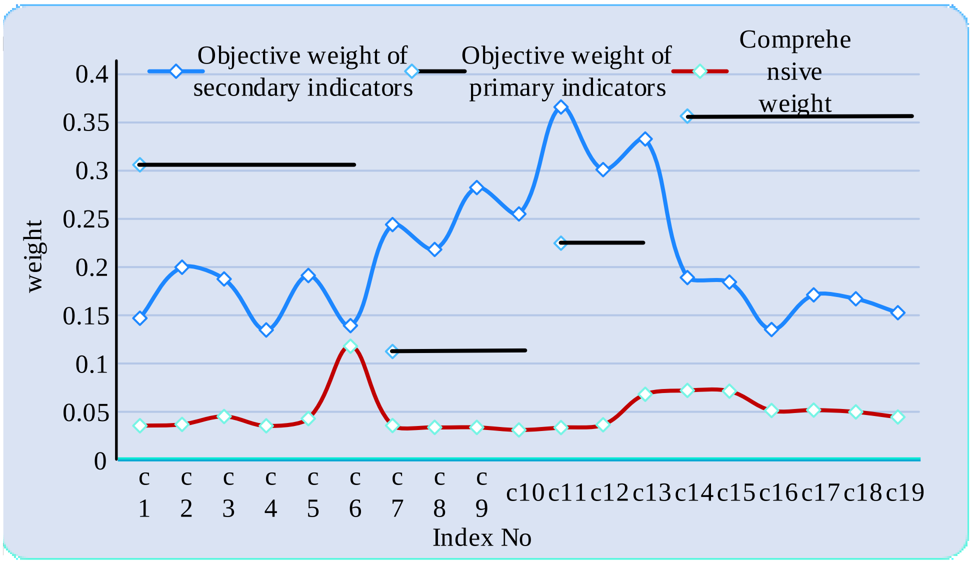


Fig. 4 – Objective weight of safety index system for prefabricated buildings

As can be seen from Figure 4, the subjective weights of the four Level 1 indicators of personnel indicators, equipment indicators, environmental indicators, and policy indicators are 30.61%, 11.25%, 22.48%, and 35.66%, respectively. Compared with the subjective weights, the objective weights of personnel indicators, equipment indicators and environmental indicators have increased, and the increase is within the range of 1%-3%, indicating that the calculation results of the subjective and objective weights are relatively unified, while the objective weight of policy indicators among the level 1 indicators has decreased by 6.48% compared with the subjective weights, indicating that the introduction of objective weights has effectively increased the applicability and effectiveness of the model. The overall evaluation index of assembly building construction safety is set as Bn, and the four first-level indicators of personnel, equipment, environment and policy indicators are set as B1, B2, B3 and B4, then the results of the subjective weight validity test of the index system are shown in Figure 5.

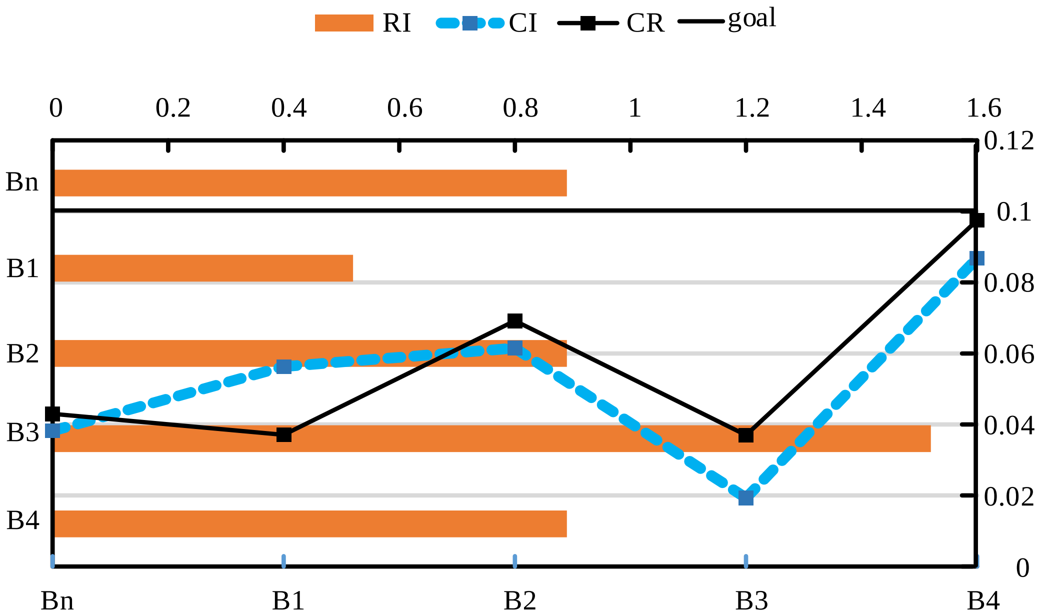


Fig. 5 – Introduction of CR value of subjective weight of index system and modification results of weight matrix

As can be seen from Figure 5, the CR values of the overall consistency tests of the index system are all less than 0.1, and the consistency test results of the overall weights of the safety evaluation indexes of assembly building construction are 0.043, and the consistency test results of the subjective weights of the four primary indexes of personnel indexes, equipment indexes, environmental indexes, and policy indexes are 0.0371, 0.0692, 0.037, and 0.0975. The CR values of indicator weights are all less than 0.1, indicating that the results of subjective weight calculation are true and valid, and have reliability in the safety evaluation of assembly building construction.

Simulation experiment of EW-ANP model for safety assessment in high-rise residential construction

According to the actual situation of the high-rise construction project and the feedback from experts, the safety evaluation level of the assembly building construction is divided into five levels: dangerous, mildly dangerous, generally safe, relatively safe and very safe. The specific evaluation criteria cloud for construction are shown in Table 2.

Tab. 2 - Standard cloud model for safety evaluation of high-rise building construction projects

Evaluation criterion	Scoring range	Ex	En	He
Danger	[0,40]	20	6.67	0.5
Mild hazard	[40,60]	50	3.33	0.5
General safety	[60,75]	67.5	2.5	0.5
Relatively safe	[75,90]	82.5	2.5	0.5
Very safe	[90,100]	95	1.67	0.5

The calculated standard cloud model for construction safety of building projects is shown in Table 2, and the intervals of safety scores for the five safety evaluation levels are 0-40 for dangerous, 40-60 for mildly dangerous, 60-75 for generally safe, 75-90 for relatively safe, and 90-100 for very safe. After deriving the standard cloud model, 10 experts who participated in the questionnaire were invited to rate the 19 secondary indicators of the high-rise construction project as shown in Figure 6.

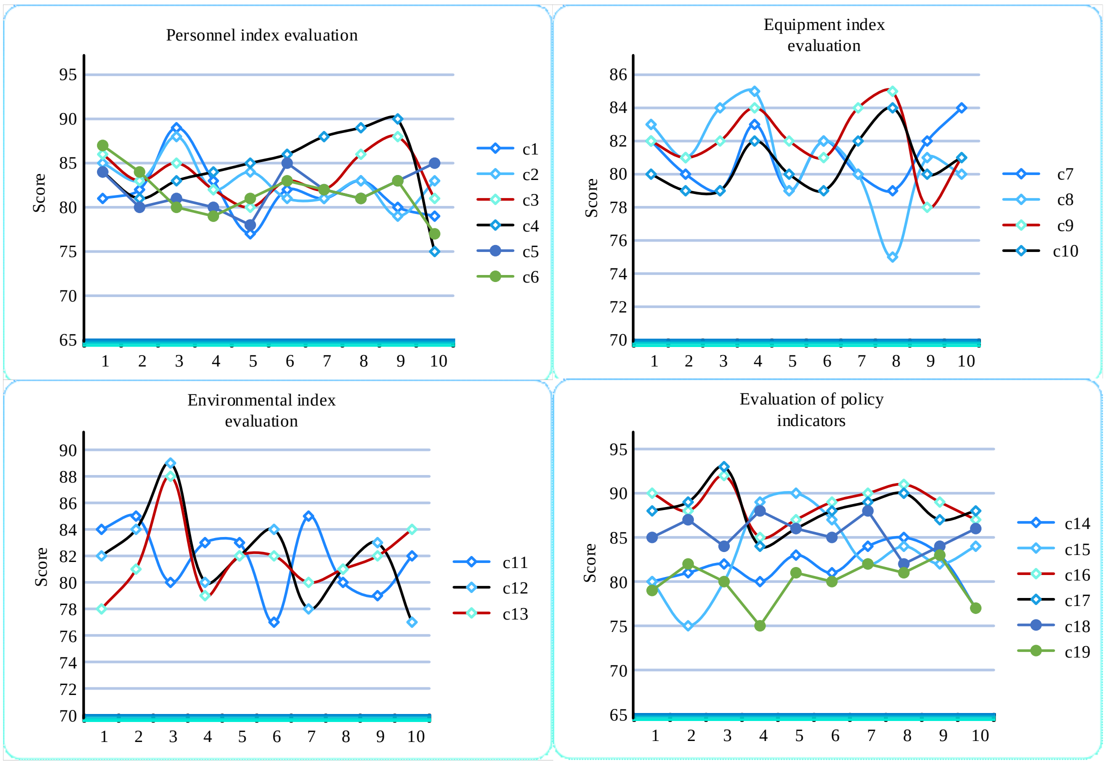


Fig. 6 – Experts' scores on 19 secondary indicators of high-rise building construction projects

As can be seen from Figure 6, the average ratings of 19 safety indicators of building construction projects by 10 experts are in the range of 81-84, with the minimum rating of 75 and the maximum rating of 93, which exist in the indicators of regular safety inspection of equipment and the indicators of implementation of safety management responsibility system, respectively, and the evaluation cloud model of building construction is derived according to the ratings, as shown in Table 3.

Tab. 3 - Evaluation cloud model of building construction

Index No	E_x u	E_n u	H_e u
c1	81.7	2.632	1.7405
c2	82.9	2.1557	0.9813
c3	83.6	2.657	1.1004
c4	84.5	3.8853	1.9548
c5	81.9	2.3813	0.8528
c6	81.7	2.632	1.5031
c7	81	1.88	0.5586
c8	81	2.5066	1.128
c9	82	1.7546	0.9598
c10	80.6	1.6544	0.2566

c11	81.8	2.8074	1.0633
c12	82	3.008	1.5836
c13	81.7	2.3813	0.7728
c14	81.6	2.256	0.0629
c15	83.3	4.3866	0.4749
c16	88.8	2.1306	0.5474
c17	88.2	2.0554	1.2264
c18	85.5	1.888	2.8826
c19	80.2	2.8826	1.5558

Based on the above standard cloud model, the average expert score and the median distance score within the evaluation cloud model were calculated to derive the similarity between the two, and the similarity results are shown in Figure 7.

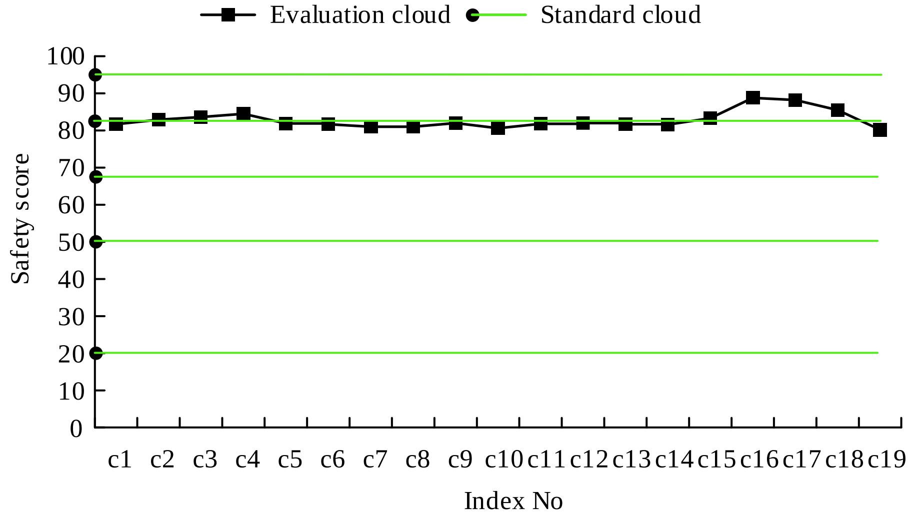
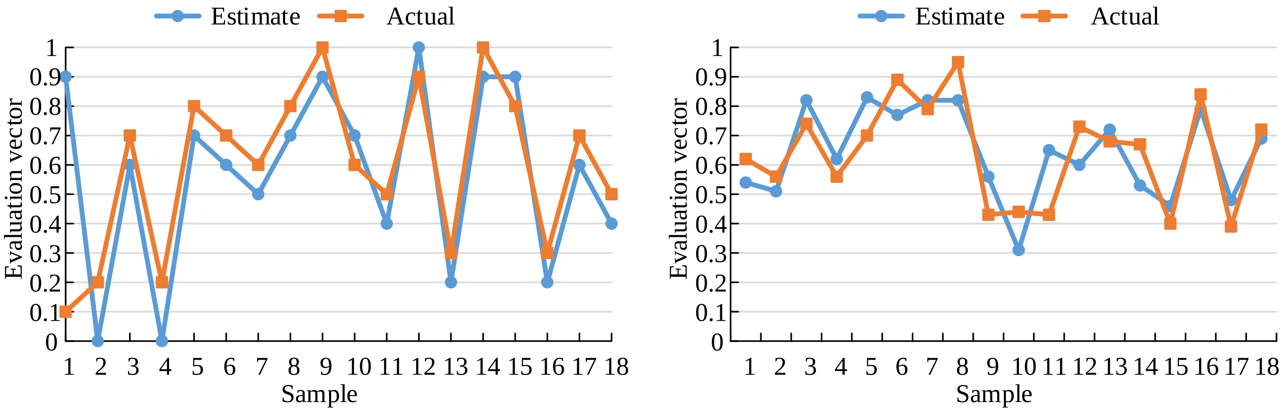


Fig. 7 – Comparison of similarity between building safety standard cloud and evaluation cloud

As can be seen from Figure 7, the rating fold of the evaluation cloud is closest to the straight line of the comparative security evaluation level in the standard cloud, and the similarity calculation results in the similarity between the evaluation cloud model and the five security levels of the standard cloud model in the order of 0.0094, 0.0691, 0.257, 0.772, and 0.3341.Finally, the subjective and objective weight evaluation model proposed in this study is compared with the traditional data survey weight evaluation model for evaluation vectors, and the specific results are shown in Figure 8.



（a）Evaluation and prediction of traditional subjective and objective weight matrix

（b）Evaluation and prediction of optimizing subjective and objective weight matrix

Fig. 8 – Comparison of evaluation matrix vector between traditional method and optimization method

It can be seen from Figure 8 that in the weight matrix of the subjective and objective weight safety evaluation model of prefabricated buildings constructed in this study, the fluctuation range and error of the evaluation prediction value are smaller than those of the traditional evaluation methods. The experimental data show that the error between the predicted value of the optimized model and the actual safety evaluation vector is between 0.05-0.1, while the error of the traditional method is between 0.1-0.15. The experimental results show that the safety evaluation model is more accurate in the safety measurement of prefabricated buildings.

CONCLUSION

Through the calculation and algorithm analysis of the subjective and objective weights of the high-rise building project, the study concluded that the subjective and objective weight gap of the three secondary indicators is within the range of 1%-3%, and the subjective and objective weight gap is 6.5% only in the policy indicators, and the experiment shows that the calculation results of the subjective and objective weights corroborate each other and compensate each other, which can effectively improve the reliability of the index construction. At the same time, the CR value was introduced to analyze the consistency of the weights of the model, and the results showed that the consistency of the subjective weights of the four first-level indicators of personnel, equipment, environment and policy indicators were 0.0371, 0.0692, 0.037 and 0.0975, indicating that the construction of the subjective weight matrix has validity. In addition, the study analyzed the evaluation performance of the cloud conversion model by example, and concluded that the similarity of the five safety levels of the evaluation cloud model and the standard cloud model are 0.0094, 0.0691, 0.257, 0.772, 0.3341 in order, and the maximum similarity is 0.772, which indicates that the safety index of the example project of high-rise building is evaluated as relatively safe. The shortcoming of this experiment is that the empirical examples were selected as random results, and other influencing factors such as the geographic location of the dwelling were not considered enough.

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