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Research paper

Research on suitability evaluation of prefabricated steel structure technology

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Abstract: To evaluate the application degree of the prefabricated steel structure technology in Gathering Station, particularly in small-scale permanent buildings for comprehensive duty rooms and integrated warehouses in the oil and gas field, an evaluation system for the applicability indicators of prefabricated steel structure technology is established from four perspectives: economic factors, environmental factors, social factors, and technical factors. The unascertained measure theory is introduced in this evaluation system. The G1-entropy weight method is utilized to calculate the combined weight of each indicator, and the applicability level of prefabricated steel structure in the gathering and transmission station is quantified and evaluated using the unascertained measure function, ensuring a scientific and effective determination of the applicability level. Finally, an analysis example is presented, focusing on a prefabricated steel structure shift apartment project in Guangyuan. The application study of this engineering example demonstrates that the unascertained measure model can be used to evaluate the applicability level. The evaluation results align with the actual situation, thus verifying the reliability and practicality of the aforementioned applicability degree evaluation method. Furthermore, it provides a reference for the application of prefabricated steel structure technology in similar scenarios.

Keywords: prefabricated steel structure, gathering station, applicability evaluation, combination empowerment, unascertained measure

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1. Introduction

Prefabricated building technology represents an innovative and efficient approach to construction. As the construction industry progresses towards greater industrialization, there is an increasing emphasis on achieving environmentally friendly and sustainable development practices. Compared to traditional reinforced concrete structure design and construction, steel structure design offers advantages of less area, wider coverage, higher construction efficiency, and lower environmental pollution. This is particularly relevant in densely populated and medium-sized cities and towns with limited resources, making it an inevitable choice for China's current economic development. However, the traditional construction mode in China faces numerous problems, especially in terms of environmental damage. The rapid rise of prefabricated steel structure buildings, guided by national reform trends and relevant supporting policies, not only addresses the issue of excess steel production in China, but also offers the benefits of low carbon emissions and environmental protection. In the long term, this trend promotes the harmonious development of humanity, nature, and architecture, and holds significant potential for widespread application.

2. Research status of prefabricated buildings

In terms of the development of steel structure buildings, the research and application of prefabricated buildings in China has experienced a 30-year gap compared to foreign countries. This has resulted in differences in design theory, research outcomes, and construction practices. Different social factors have led countries to develop their own standard systems and prefabricated technologies with national characteristics. Currently, most developed countries in Europe have established a mature and comprehensive industrial chain in the field of prefabricated buildings. Japan has widely adopted PC (Precast Concrete) technology in various sectors and was one of the first countries to achieve large-scale production of housing, standardizing the prefabricated industry. In the United States, steel structure has become the mainstream choice, and the building production process has matured with the application of BIM technology. The country is also exploring a more low-carbon and environmentally friendly building development path. Developed countries like Singapore and Sweden have also achieved a high level of development in prefabricated buildings. In China, with the accumulation of project experience and the promotion of scientific research, many related standards for prefabricated buildings have been introduced. Local applicability systems have been researched, and leading industry enterprises have gradually developed their own system achievements, with prefabricated concrete structures being the most prominent. Although the steel structure system has been implemented according to certain standards and specifications, it still has a long way to go before achieving true industrialization.

The existing research on the development of prefabricated buildings primarily focuses on the aspects of economy [1–3], progress control [4,5], and low-carbon and environmental protection aspects [6,7]. By examining actual cases, research on cost comparison and influencing factors, as well as standardized design and assembly technology progress, it is possible to enhance the economic and environmental benefits and promote large-scale implementation [8]. The application of BIM technology enables information integration and project management throughout the entire life cycle [9]. Prefabricated buildings are considered a crucial pathway to the sustainable development of the construction industry due to their advantages in resource conservation and pollution reduction [10, 11]. Under appropriate conditions, the prefabricated building technologies can modernize the process of building new housing and contribute to the mitigation of the urban crisis [12]. However, existing research lacks applicability analysis regarding the implementation of prefabricated structures in different fields, which hinders the ability to provide enterprises with a decision-making basis for evaluating the value of prefabricated schemes. In particular, there is a lack of a mature evaluation system for innovative applications in oil and gas field gathering and transmission stations.

3. Construct the technical applicability evaluation system of prefabricated steel structure

3.1. The construction of the evaluation indicator system

Through the site investigation, we found that the buildings in the oil and gas field gathering and transmission station are less prefabricated structures, and most of them are small-scale permanent buildings such as comprehensive duty room and integrated warehouse. Due to the particularity of prefabricated steel structure technology applied to gathering and transmission stations, we initially identified the factors that influence its technical applicability through literature research and field research. The 25 factors that influence the technical applicability of prefabricated steel structures are primarily derived from four aspects. The factors listed in Table 1 are not exhaustive, but they represent the main factors considered in this study [13–18].

Table 1. Identified the suitability evaluation indicators of the prefabricated steel structure technology in the gathering and transmission station

Factors	**Number**	**Evaluating indicator**
Economic factors A1	A11	Material selection and market price changes
	A12	Pre-preparation cost
	A13	Transportation costs of prefabricated component
	A14	Production, hoisting, and installation costs of prefabricated components
	A15	Annual energy consumption cost during the use period
	A16	Maintenance cost
	A17	Construction cycle
	A18	The residual value of component parts

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Factors	Number	Evaluating indicator
Environmental factor A2	A21	Water saving benefits
	A22	Energy saving benefits
	A23	Land saving benefits
	A24	Material saving benefits
	A25	Carbon emission benefits
Social factors A3	A31	laws and regulations
	A32	Transformation and upgrading of production modes
	A33	Promote industry development
Technical factors A4	A41	Assembly rate
	A42	Standardization and modular degree of components
	A43	Split and deepening the design level of prefabricated components
	A44	Site management personnel and skilled worker-level
	A45	Quality and performance of the construction equipment
	A46	Application level of BIM technology
	A47	Design changes and component rework
	A48	Reliability of component production and connection technology
	A49	Seismic performance and impact resistance performance

3.2. Classification of applicability level of prefabricated steel structure technology

To effectively determine the evaluation level for the applicability of prefabricated steel structure technology, the evaluation space is divided into four levels (I, II, III, and IV) based on references to relevant literature, evaluation standards for prefabricated buildings, and associated data evaluation standards for prefabricated steel structures. Specifically, a score below 2 is classified as level I, scores ranging from 2 to less than 4 are classified as level II, scores ranging from 4 to less than 6 are classified as level III, and scores of 6 or above are classified as level IV. These four levels correspond to low applicability, general applicability, relatively high applicability, and high applicability, respectively. This represents the overall evaluation space $R = (R_1, R_2, R_3, R_4)$. Specific data can be found in Tables 2 and 3.

Table 2. Classification of quantitative indicators of suitability

Evaluating indicator	**Pre-preparation cost (yuan/m^2)**	**Transportation costs of prefabricated components (yuan/m^2)**	**Production, hoisting, and installation costs of prefabricated components (yuan/m^2)**	**Annual energy consumption cost during the use period (yuan/m^2)**	**Maintenance cost (yuan/m^2)**
IV(R_4)	< 8	< 10	< 800	≥ 160	< 2
III(R_3)	8 – < 14	10 – < 20	800 – < 1000	150 – < 160	2 – < 4
II(R_2)	14 – < 20	20 – < 28	1000 – < 1200	140 – < 150	4 – < 6
I(R_1)	≥ 20	≥ 28	≥ 1200	< 140	≥ 6
Evaluating indicator	Construction cycle	The residual value of component parts (yuan/m^2)	Water saving benefits (yuan/m^2)	Material saving benefits (yuan/m^2)	Land saving benefits (yuan/m^2)
IV(R_4)	≥ 35%	≥ 90	≥ 4	≥ 2	≥ 60
III(R_3)	30% – < 35%	50 – < 90	3 – < 4	1.5 – < 2	50 – < 60
II(R_2)	25% – < 30%	30 – < 50	2 – < 3	1 – < 1.5	40 – < 50
I(R_1)	< 25%	< 30	< 2	< 1	< 40
Evaluating indicator	Energy saving benefits (yuan/m^2)	Carbon emission benefits (yuan/m^2)	Assembly rate		
IV(R_4)	≥ 20	≥ 4	≥ 70%		
III(R_3)	10 – < 20	3 – < 4	60% – < 70%		
II(R_2)	5 – < 10	2 – < 3	50% – < 60%		
I(R_1)	< 5	< 2	< 50%		

Note: Pre-preparation cost – The cost increase per square meter of prefabricated steel structure buildings compared to cast-in-place concrete buildings, mainly increases the cost of detailed design; Transportation costs of prefabricated components – The cost increase per square meter of prefabricated steel structure buildings compared to cast-in-place concrete buildings, according to the transport distance of 200 km; Production, hoisting and installation costs of prefabricated components, Maintenance cost – The cost increase per square meter of prefabricated steel structure buildings compared to cast-in-place concrete buildings; Annual energy consumption cost during the use period, Carbon emission benefits – Prefabricated steel structure buildings reduce costs per square meter compared to cast-in-place concrete buildings; Construction cycle – Accelerated progress in comparison between prefabricated steel structure buildings and traditional buildings; Residual value of component parts – The difference in cost recovery between steel structure buildings and reinforced concrete buildings at the end of their service life; Water saving, material saving, land saving, energy saving, carbon emission benefits – Steel structure buildings reduce costs compared to reinforced concrete buildings.

Table 3. Classification of qualitative indicators of suitability

Evaluating indicator	IV(R_4)	III(R_3)	II(R_2)	I(R_1)
A11	Steel quality is good, and the price is low	Steel quality is relatively good, and the price is normal	Steel quality is general, and the price fluctuates at a higher point	Steel quality is poor, and prices continue to grow
A31	Greatly promote	General push	Lower push	Hindering development
A32	High	Relatively high	Relatively low	Low
A33	High	Relatively high	Relatively low	Low
A42	High	Relatively high	Relatively low	Low
A43	High	Relatively high	Relatively low	Low
A44	High	Relatively high	Relatively low	Low
A45	Construction equipment has high quality and advanced performance	Construction equipment has relatively high quality and relatively advanced performance	Construction equipment has relatively low quality and general performance	Construction equipment has low quality and backward performance
A46	Horizontal and efficient	Normal level	General level	Low level
A47	The scope of design change is small, and the component rework is less	The scope of design change is relatively small, and the component rework is relatively less	The scope of design change is relatively large, and the component rework is relatively much	The scope of design change is large, and the component rework is much
A48	High reliability	Relatively high reliability	Relatively low reliability	Low reliability
A49	Good seismic performance and good impact resistance	Relatively good seismic performance and relatively good impact resistance	General seismic performance and general impact resistance	Poor seismic performance and poor impact resistance

4. Comprehensive evaluation model based on the unascertained measure function

4.1. Determine the ordered segmentation class of the evaluation space

In the applicability of prefabricated steel structure technology to gathering stations, the evaluation indicator is divided into n dimensions to form the dimension space $X = (X_1, X_2, \cdots, X_n)$. Each dimension space has m evaluation indicators, and the evaluation indicator set is $V = (V_1, V_2, \cdots, V_m)$. If the applicability evaluation level space is $R = (R_1, R_2, \ldots, R_s)$, then the kth rating R_k is the level value of x_{ij}; If $k+1$ is higher than k, it is recorded as $R_{k+1} > R_k$. If $R_1 > R_2 > \ldots > R_s$ or $R_1 < R_2 < \ldots < R_s$, $R = (R_1, R_2, \ldots, R_s)$ is an orderly segmentation class of the evaluation level space.

4.2. Determine the single indicator unascertained measure matrix

This paper considers the characteristics of the selected indicators and the difficulty of practical application and decides to use the simple calculation, high recognition, and widely used linear method to construct the unascertained measure function. The measure function is a piece-wise function, let $a_{ij}(j = 1, 2, \ldots, m)$ be the boundary point of the definition domain, and $a_{i1} < a_{i2} < \ldots < a_{im}$. Each indicator measure value μ_{ijk} of the evaluation dimension X_i is obtained from the single indicator measure function $\mu(x_{ij} \in R_k)(i = 1, 2, \ldots, n; j = 1, 2, \ldots, m; k = 1, 2, \ldots, s)$, called $(\mu_{ijk})_{m\times s}$ as the single-indicator measure rating matrix.

4.3. Determine the multi-indicator comprehensive measure matrix

If $\mu_{ik} = \mu(X_i \in R_k)$ represents the membership degree of the evaluation object X_i to the k level and μ_{ik} meets $0 \le \mu_{ik} \le 1$, $\mu_{ik} = \sum_{j=1}^{m} \omega_j \mu_{ijk} (k = 1, 2, \ldots, s)$, multiply the weight value of each indicator ω and the corresponding single indicator unascertained measure matrix $(\mu_{ijk})_{m\times s}$ step by step, and the multi-indicator comprehensive measure matrix can be obtained finally.

$$\mu_{ik} = \sum_{j=1}^{m} \omega_j \mu_{ijk} = (\mu_{i1}, \mu_{i2}, \cdots, \mu_{is}) \tag{4.1}$$

4.4. Determine the evaluation level and sort of evaluation objects

The confidence recognition criterion is used to judge the rank result in the unascertained measure theory. Let λ be the confidence degree ($\lambda \ge 0.5$, usually $\lambda \ge 0.6$ or $\lambda \ge 0.7$). If $R_1 > R_2 > \ldots > R_s$, the technical applicability level of prefabricated steel structure is considered to be S_0, that is, the evaluation level is R_{S_0}.

$$S_0 = \min |s : \sum_{k=1}^{s} \mu_{ik} > \lambda, \quad i = 1, 2, \cdots, n \tag{4.2}$$

Let $R_1 > R_2 > \ldots > R_s$, the value of R_k is Z_k, then $Z_k > Z_{k+1}$, and

$$O_{xi} = \sum_{k=1}^{s} Z_k \mu_{ik}, \; i = 1, 2, \ldots, n, \quad I = 1, 2, \ldots, n \tag{4.3}$$

O_{xi} is the unascertained importance of the assessed object, and $O = (O_{x1}, O_{x2}, \cdots, O_{xs})$ is the vector of the unascertained importance. The applicability level of the assessed object is ranked according to the value of O_{xi}.

5. Engineering application

The project is a shift apartment building that serves as a representative example of prefabricated buildings used in the oil and gas field gathering and transmission station located in Guangyuan City, Sichuan Province. It has a building area of 805.41 m^2 and a total construction area of 3053.44 m^2. The floor area ratio is 3.79, while the greening rate is 20.1%. The main above-ground part consists of 4 floors, with no underground floors. The building has a height of 15.6 meters and a designated service life of 50 years. It is classified as a multi-storey residential building with a steel frame structure. The design of the building takes into consideration various usage needs, including office spaces, entertainment areas, and living spaces.

5.1. Determine the weight of the technical application applicability evaluation indicator

In order to effectively take into account the subjective will of experts and the objectivity of indicators, the weight determined by the G1 method and entropy weight method is combined, and the division integration with simple calculation and high accuracy is selected to calculate the combined weight. The G1 method, also known as the order relationship analysis method, is an improvement of the hierarchical analysis method (AHP). The γ_k assignments and the meanings of the values are shown in Table 4. All indicators in this study are forward indicators, with no positive processing. Then calculate the specific gravity P_{ij} of x_{ij}, and the smaller the difference of indicator value, the larger the entropy value. Finally, we get the entropy weight W_j of the indicator X_j. The calculation process is illustrated in Equations (5.1) through (5.4).

$$W'_{cn} = \left(1 + \sum_{k=2}^{n} \prod_{i=k}^{n} \gamma i\right)^{-1}, \quad k = n, n-1, \ldots, 2 \tag{5.1}$$

$$W'_{Ck-1} = \gamma_k W'_{Ck}, \quad k = n, n-1, \ldots, 2 \tag{5.2}$$

$$W_j = \frac{1 - ej}{\sum_{j=1}^{n} (1 - ej)} \tag{5.3}$$

$$W_i = \frac{W'_i W''_i}{\sum_{i=1}^{m} W'_i W''_i} \tag{5.4}$$

Table 4. γ_k assignment reference table

γ_k	Assignment description
1.0	Indicator $x^{\cdot}_{k-1}$ has the same importance as indicator $x^{\cdot}_k$
1.2	Indicator $x^{\cdot}_{k-1}$ is slightly more important than indicator $x^{\cdot}_k$
1.4	Indicator $x^{\cdot}_{k-1}$ is quite more important than the indicator $x^{\cdot}_k$
1.6	Indicator $x^{\cdot}_{k-1}$ is much more important than indicator $x^{\cdot}_k$
1.8	Indicator $x^{\cdot}_{k-1}$ is extremely more important than indicator $x^{\cdot}_k$
1.1, 1.3, 1.5, 1.7	The ratio of indicator $x^{\cdot}_{k-1}$ to indicator $x^{\cdot}_k$ is between the two levels of importance

e_j – entropy value; γ_k – the relative ratio of importance between adjacent evaluation indicators $x^{\cdot}_{k-1}$ and $x^{\cdot}_k$; W'_{Ck-1} and W'_{Ck} – the weight of the adjacent evaluation indicators $x^{\cdot}_{k-1}$ and $x^{\cdot}_k$; W'_i – subjective weights determined by the G1 method; W''_i – objective weights determined by the entropy weight method; the value range of k is $\{k|k = n, n-1, \ldots, 2\}$.

To ensure the accuracy of the evaluation results, assemble a team of ten experts, including two experts from the engineering consulting company, three experts from the construction unit, one expert from the government department, two experts from the construction department, and two teachers from universities. First, 10 experts were invited to participate in the survey. Based on their own work experience and professional knowledge, these experts ranked the relative importance of each applicability evaluation indicator according to the requirements of the G1 method and assigned rational values. Subsequently, the ten experts were invited to form an expert team. These experts evaluated the project process equipment, health environment, organization and management level, and other relevant information, taking into account the actual operation in the process of energy saving test report, national standards, and their own experience. They provided objective scores using entropy data calculation. The calculated weight of each evaluation indicator is presented in Table 5.

Table 5. Combination weight of the evaluation indicators determined based on the entropy weight method

One-level metric	**Subjective weight of the G1 method w'**	**Objective weight of entropy weight method w''**	**Assemble weight**	**Two-stage metric**	**G1 method subjective weight w'**	**Objective weight of entropy weight method w''**	**Assemble weight**
A1	0.2909	0.1955	0.2269	A11	0.1370	0.1370	0.1231
				A12	0.1434	0.1434	0.0940
				A13	0.1160	0.1160	0.0748
				A14	0.1827	0.1827	0.3210

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One-level metric	**Subjective weight of the G1 method w'**	**Objective weight of entropy weight method w''**	**Assemble weight**	**Two-stage metric**	**G1 method subjective weight w'**	**Objective weight of entropy weight method w''**	**Assemble weight**
A1	0.2909	0.1955	0.2269	A15	0.1294	0.1294	0.1372
				A16	0.0851	0.0851	0.0543
				A17	0.1406	0.1406	0.1175
				A18	0.0658	0.0658	0.0782
A2	0.2497	0.4356	0.4340	A21	0.1651	0.1651	0.0870
				A22	0.2157	0.2157	0.4022
				A23	0.1679	0.1679	0.1009
				A24	0.2055	0.2055	0.1773
				A25	0.2458	0.2458	0.2326
A3	0.2318	0.2472	0.2287	A31	0.3554	0.3554	0.4318
				A32	0.3194	0.3194	0.2845
				A33	0.3252	0.3252	0.2837
A4	0.2276	0.1217	0.1105	A41	0.1397	0.1397	0.1216
				A42	0.1527	0.1527	0.1909
				A43	0.1443	0.1443	0.1674
				A44	0.0999	0.0999	0.1023
				A45	0.0833	0.0833	0.1142
				A46	0.0726	0.0726	0.0608
				A47	0.0773	0.0773	0.0432
				A48	0.1280	0.1280	0.1094
				A49	0.1023	0.1023	0.0903

5.2. Evaluation calculation of the unascertained measure

5.2.1. Construct a single-indicator measure function

Assuming 10 experts with equal weight, a 10-point system is utilized. The data statistical analysis method of removing the highest and lowest scores and then averaging is used to obtain the data for each item. Finally, the values of each evaluation indicator A11–A18, A21–A25, A31–A33, and A41–A49 are as follows: 3.66, 14.00, 18.00, 1200.00, 150.00, 4.12, 0.33, 54.00, 3.02, 10.07, 55.60, 1.65, 5.60, 5.70, 5.94, 5.95, 0.60, 3.98, 4.40, 3.94, 5.34, 4.44, 5.81, 5.68, 4.66. The specific measurement function is shown in Fig. 1.

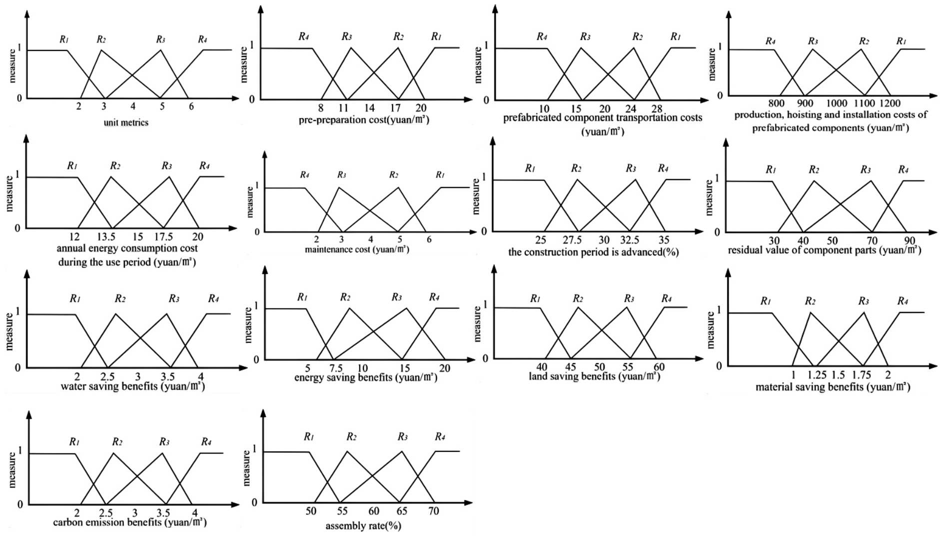

Fig. 1. The single-indicator measure function for each qualitative indicator and quantitative indicator

5.2.2. Establish a single indicator unascertained measure matrix

Taking the economic benefit of the first level indicator A1 and A11, A12, A13, A14, A15, A15, A16, A17 and A18, the single indicator evaluation matrix for each dimension is obtained by using the unascertained measure function of the single indicator and the evaluation level of each evaluation indicator.

$$(\mu_{1jk})_{8\times4} = \begin{bmatrix} 0.00 & 0.67 & 0.33 & 0.00 \\ 0.00 & 0.50 & 0.50 & 0.00 \\ 0.00 & 0.33 & 0.67 & 0.00 \\ 1.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.50 & 0.50 & 0.00 \\ 0.00 & 0.56 & 0.44 & 0.00 \\ 0.00 & 0.00 & 0.80 & 0.20 \\ 0.00 & 0.47 & 0.53 & 0.00 \end{bmatrix} \qquad (\mu_{2jk})_{5\times4} = \begin{bmatrix} 0.00 & 0.48 & 0.52 & 0.00 \\ 0.00 & 0.66 & 0.34 & 0.00 \\ 0.00 & 0.00 & 0.88 & 0.12 \\ 0.00 & 0.20 & 0.80 & 0.00 \\ 0.00 & 0.00 & 0.00 & 1.00 \end{bmatrix}$$

$$(\mu_{3jk})_{3\times4} = \begin{bmatrix} 0.00 & 0.00 & 0.30 & 0.70 \\ 0.00 & 0.00 & 0.06 & 0.94 \\ 0.00 & 0.00 & 0.05 & 0.95 \end{bmatrix} \qquad (\mu_{4jk})_{9\times4} = \begin{bmatrix} 0.00 & 0.50 & 0.50 & 0.00 \\ 0.00 & 0.51 & 0.49 & 0.00 \\ 0.00 & 0.30 & 0.70 & 0.00 \\ 0.00 & 0.53 & 0.47 & 0.00 \\ 0.00 & 0.00 & 0.66 & 0.34 \\ 0.00 & 0.28 & 0.72 & 0.00 \\ 0.00 & 0.00 & 0.19 & 0.81 \\ 0.00 & 0.00 & 0.32 & 0.68 \\ 0.00 & 0.17 & 0.83 & 0.00 \end{bmatrix}$$

5.2.3. Multiple indicators are not indeed known to measure

The comprehensive evaluation vector of the first-level indicator is determined based on the combination weights from previous calculations. The comprehensive evaluation vector for economic, environmental, social, and technical factors is expressed as A1, A2, A3, and A4, respectively.

One-factor measure vector of economic factors A1:$A1 = \omega_1 \cdot \mu_{1jk} = \begin{bmatrix} 0.32 & 0.30 & 0.36 & 0.02 \end{bmatrix}$

One-factor measure vectors of environmental factors A2:

$$A2 = \omega_2 \cdot \mu_{2jk} = \begin{bmatrix} 0.00 & 0.34 & 0.41 & 0.25 \end{bmatrix}$$

One-factor measure vector of social factors A3:$A3 = \omega_3 \cdot \mu_{3jk} = \begin{bmatrix} 0.00 & 0.00 & 0.16 & 0.84 \end{bmatrix}$

One-factor measure vector of technical factors A4:$A4 = \omega_4 \cdot \mu_{4jk} = \begin{bmatrix} 0.00 & 0.29 & 0.56 & 0.15 \end{bmatrix}$

The multi-indicator unascertained measure matrix of this project:

$$A = \begin{bmatrix} A1 \\ A2 \\ A3 \\ A4 \end{bmatrix} = \begin{bmatrix} 0.32 & 0.30 & 0.36 & 0.02 \\ 0.00 & 0.34 & 0.41 & 0.25 \\ 0.00 & 0.00 & 0.16 & 0.84 \\ 0.00 & 0.29 & 0.56 & 0.15 \end{bmatrix}$$

Therefore, the measured vector μ of the evaluation object is:

$$\mu = \omega \cdot A = \begin{bmatrix} 0.07 & 0.19 & 0.37 & 0.37 \end{bmatrix}$$

5.2.4. Confidence criteria identify the suitability level

Take confidence $\lambda \geq 0.6$, calculated according to Equation (4.2), expand from small to big, $0.32 + 0.20 = 0.62 > 0.6$, that is, the applicability level is level II. From large to small, $0.02 + 0.36 + 0.30 = 0.68 > 0.6$, the applicability level is level II. Based on the two evaluation results, the application applicability level of the prefabricated steel structure technology in the oil and gas field gathering and transmission station is level II, that is, the applicability is high. Similarly, the applicability level of each level indicator is calculated as shown in Table 6.

Table 6. Dimensions and comprehensive evaluation levels

Project name	**Economic factors A1**	**Environmental factors A2**	**Social factors A3**	**Technical factors A4**	**Overall merit**
Prefabricated steel-frame shift apartment	II	III	IV	III	III
Level definition	general applicability	relatively high applicability	high applicability	relatively high applicability	relatively high applicability

Comparing the four first-level indicators horizontally, Due to $R_4 > R_3 > R_2 > R_1$, let $Z_4 = 4$, $Z_3 = 3$, $Z_2 = 2$, $Z_1 = 1$, calculate the unascertained importance of the applicability of the four first-level indicators according to Equation (4.3). The unascertained importance of economic factors was $O_{x1} = 0.32 \times 1 + 0.30 \times 2 + 0.36 \times 3 + 0.02 \times 4 = 2.08$, and the remaining three first-level indicators were $O = (O_{x1}, O_{x2}, O_{x3}, O_{x4}) = (2.08, 2.91, 3.84, 2.86)$.

5.3. Analysis of evaluation results

According to the data on economic factors of the prefabricated steel structure shift apartment project, when $S_0 = 2$, the judgment data is slightly greater than 0.6, indicating that there is a need for improvement in the economic factors of the project. In the process of applying and developing prefabricated building technology, further research and application are required to enhance the economic factors. In order to enhance the overall application level of the prefabricated technology in the entire project, it is crucial to prioritize and improve it. In terms of social factors, when $S_0 = 4$, the judgment data is significantly higher than 0.6, suggesting that the social factors brought about by the prefabricated steel structure technology are highly significant. The emergence and development of prefabricated steel structures hold great importance in the construction industry and will have a profound impact on the adjustment and expansion of China's building product structure. In the future, there is potential for bold expansion and exploration in the field of prefabricated buildings.

The results indicate that the level of applicability of the prefabricated steel structure technology adopted in this project is level III, which means that the applicability is relatively high and the technology is actively being adopted, aligning with the actual situation. Based on the unascertained importance vector, the order of applicability for the application of prefabricated steel structure technology in oil and gas field transport station shift apartments is as follows: social factors > environmental factors > technical factors > economic factors. Secondary indicators such as policies and regulations, energy saving, and carbon emissions have higher weights in the applicability evaluation. The policy for the development and application of prefabricated steel structure technology is significantly promoted due to its advantages in green environmental protection, which aligns with the construction goals of the transport station shift apartment project. However, the applicability of economic factors is low. Considering that the prefabricated steel structure technology started late and has had slow development and limited practice in our country, it is necessary to focus on the prefabricated steel structure policy and market, as well as the latest research results, in order to strictly control the entire project's life cycle, seize development opportunities, and overcome industry bottlenecks.

6. Conclusions

In the study, we introduce the evaluation model of unascertained measure and construct the applicability indicator evaluation system for prefabricated steel structure technology in the oil and gas fields. This is done based on 25 evaluation indicators that consider economic, environmental, social, and technical factors. The applicability level is then determined. Using the prefabricated steel structure shift apartment project as an example, we assess the rationality and applicability of the checking model. The engineering example application study demonstrates that the unascertained measure model can be used to evaluate the applicability level of the prefabricated steel structure project, which is found to have an overall applicability level of "high applicability". These evaluation results align with the actual situation. Through analysis and evaluation, we can target and promote the improvement of regional or specific projects related to prefabricated construction technology.

The study provides a reference for the rapid development of the prefabricated construction industry in China. Other countries can still derive value from this study by making appropriate adjustments and optimizations to the evaluation system, particularly in countries and regions that are seeking efficient, environmentally-friendly, and economically viable construction solutions. Additionally, China has engaged in energy cooperation with other countries under the Belt and Road initiative, such as Central Asia, the Middle East, and Africa. There is also significant potential for further promotion and cooperation in China's oil and gas field surface construction standards. Given the current level of development and promotion of prefabricated steel structure technology, it is necessary to develop a more comprehensive and accurate measurement method, establish a measurement function that is widely applicable, and further enhance the universality of the evaluation model. This will enable the evaluation model to be more effectively applied in practical evaluation work.

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