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Research on the Evaluation of Green Construction of Prefabricated Buildings based on Cloud Matter-element Model

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Abstract

The evaluation index system of green construction of prefabricated buildings was constructed by analyzing its characteristics. The cloud theory is used to establish a cloud object element model for the evaluation of green construction of prefabricated buildings, and the membership degree of each index is determined through the relationship between cloud droplets and clouds in cloud theoryThe evaluation level of the index generated by the cloud generator. This new idea is conducive to promoting the sustainable development of prefabricated buildings. In recent years, prefabricated buildings have gradually become a new development trend in the construction industry due to the characteristics of industrial manufacturing, information management, and environmentally friendly construction. In the construction stage, the process is complex, the energy and resource consumption is concentrated, and the green construction with "green environmental protection" as the core concept is of far-reaching significance for promoting the green and low-carbon development of China's economy and society. In recent years, prefabricated buildings have gradually become a new development trend in the construction industry due to the characteristics of industrialized manufacturing, information management, and environmentally friendly construction. It is an urgent problem to study a set of evaluation systems suitable for the green construction of prefabricated buildings, measure their resource and environmental friendliness in the construction stage, and then scientifically plan the development of prefabricated buildings. Based on the literature and project research, this paper summarizes the shortcomings of the green construction evaluation system of prefabricated buildings, and defines the connotation of greenness and defines the components of prefabricated buildings in combination with the characteristics of the whole process of prefabricated building construction, so as to provide a theoretical basis for the construction of the subsequent index system. Based on the analysis of the typical green building evaluation system, relevant standards and specifications, and the methods of literature research, 52 measurement indicators were preliminarily selected, and finally the green degree measurement index system containing 6 criterion layers and 31 measurement indicators was finally determined. According to the different characteristics of quantitative and qualitative indicators, quantitative methods are given, and the grading standards are determined. Finally, the green degree measurement model of cloud matter element theory was constructed, and the index system and calculation model of the design were used to standardize the work process. The green measurement system of prefabricated building construction designed in this paper includes six attribute factors: environmental protection, material saving and material resource utilization, water conservation and water resource utilization, energy conservation and energy utilization, land saving and land protection and sustainable development management, which can fully reflect the connotation of construction greenness. This paper verifies the scientificity and rationality of the proposed construction greenness measurement method, which has reference value for the improvement of the evaluation system of prefabricated buildings in China.

Keywords

Green Construction; Cloud Matter-element Model; Prefabricated Buildings; Construction Greenness Cloud Element Model.

1. Background and Significance

1.1. Background

At present, China is in the process of urbanization, and the construction industry is facing "bottlenecks" in many fields such as land, energy, population, and environmental carrying capacity, and the traditional urbanization development model of "high investment, high consumption and high emissions" is difficult to sustain. The construction process involves many parties, the process is complex, and the consumption of resources and energy is concentrated, which has a serious impact on the environment, which is an urgent need to build an ecological civilization. In recent years, prefabricated buildings have been greatly satisfied with their characteristics of component prefabrication, construction industrialization, management informatization, energy conservation and environmental protection, and have become a new development direction of the construction industry.

1.1.1. Construction Resources and Energy Consumption are Huge

With the acceleration of China's urbanization process, energy consumption in the building sector continues to grow. Statistics show 1,

In 2020, the country's total energy consumption was 4.98 billion TCE, of which 2.27 billion tons were consumed as a highly polluting fuel, coal. According to the "China Building Energy Consumption Research Report (2022)" 0 the total energy consumption of the whole process of building buildings in China in 2020 has been reached 45.5% of the country's total energy consumption.

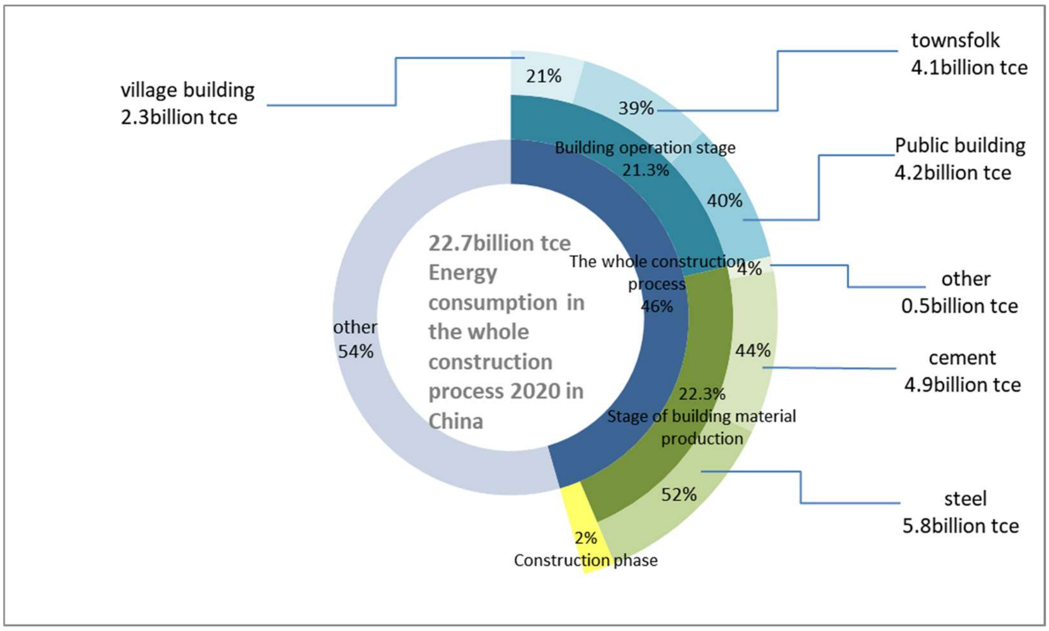

Figure 1. Energy consumption of buildings in China in 2020

In the in-depth analysis of the national energy consumption data in 2020, the carbon emission boundary of the whole process of building was delineated, and three key stages of building material production, construction and operation were proposed, that is, the energy consumption of building materials manufacturing during the production, construction and

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operation of building materials was 11.1100 million tons of standard coal, accounting for 22.3% of total energy consumption; The energy consumption in the construction stage is 90 million tons of standard coal, accounting for only 1.9% of the total energy consumption; The energy consumption of buildings during the operation period is 1.06 billion tons of standard coal, which is about 21.3%. Among them, the carbon emissions in the production stage of building materials refer to the energy consumption and carbon emissions involved in the whole production process (including upstream raw materials) of building materials consumed by the construction industry in the current year, which covers all aspects of housing construction and infrastructure projects. Through the comprehensive consideration and analysis of carbon emissions in these three stages, we can more accurately understand the impact of the construction industry on national energy consumption and carbon emissions, and provide scientific basis and strategic guidance for future sustainable development.

1.1.2. Energy Conservation, Emission Reduction and Green Development

In 2020, China's carbon emissions in the construction and construction sector reached 5.08 billion tons, accounting for 50.9% of China's carbon emissions. Overall, the carbon emissions of the entire process in the construction industry in 2020 were basically the same as in 2019. As can be seen from this chart, the proportion of energy consumption and carbon emissions in the operation stage of China's buildings is roughly the same, both of which are about 20%, but the proportion of carbon emissions from building materials in the whole country is far greater than that of energy consumption, which shows that building materials are still the largest part of emissions. The "14th Five-Year Plan for the Development of Building Energy Conservation and Green Buildings" [2]proposes that the construction of green cities should be based on the actual situation of building energy conservation and green buildings in China. To determine the development goals and key tasks of green and low-carbon cities, it is necessary to clarify the development goals and main tasks of green and low-carbon cities in combination with the work of building energy conservation and green buildings, realize the large-scale development of high-star green buildings, and promote ultra-low energy consumption and zero-carbon buildings in China's buildings, the green transformation of renewable energy buildings, the promotion of renewable energy buildings, the promotion of prefabricated buildings, and the improvement of regional building energy efficiency, so that the development of building energy conservation and green buildings in China has reached a new height.

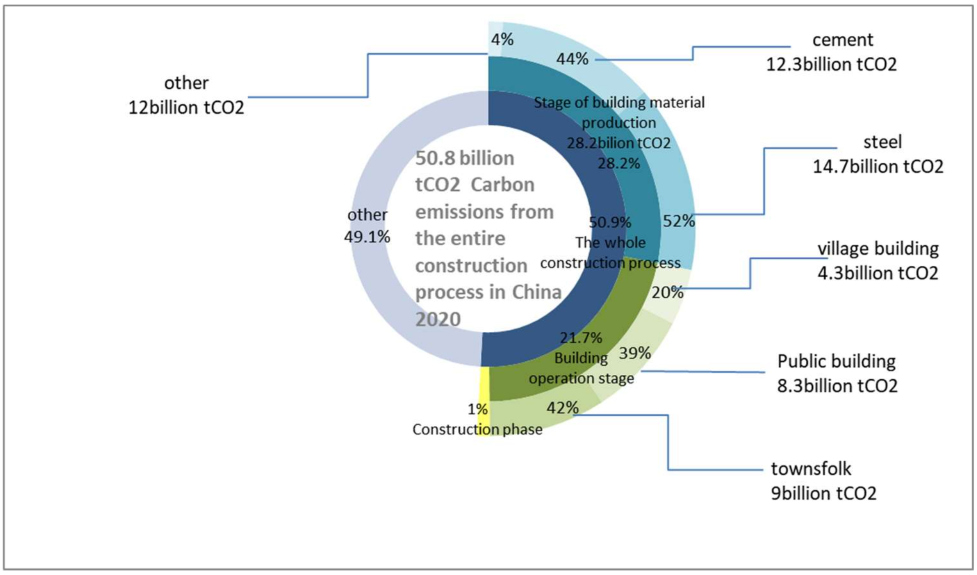

Figure 2. Proportion of carbon emissions from energy consumption in China's construction process in 2020

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1.1.3. Prefabricated Buildings have Become a New Development Trend

As the traditional cast-in-place production mode gradually exposes the problems of high resource and energy consumption, low production efficiency, and low level of quality and safety assurance, prefabricated buildings have been widely recognized and favored by the society by virtue of their convenient construction, fast progress, good component quality, energy conservation and environmental protection. According to the "14th Five-Year Plan for the Development of the Construction Industry" issued by the Ministry of Housing and Urban-Rural Development, in the new period of the "14th Five-Year Plan", China will focus on the preliminaryForm a modern construction industry development institutional framework, and gradually improve the construction market operation mechanism, basically improve the project quality and safety assurance system, so that the level of construction industrialization, digitalization and intelligence has been significantly improved, and promote the transformation of the construction industry from "big to strong".

The planning requirements clearly state that it is necessary to vigorously develop prefabricated buildings in order to improve the comprehensive benefits of prefabricated buildings. On this basis, a prefabricated reinforced concrete structure system suitable for various forms of buildings is proposed. This development direction will further promote the innovation and application of prefabricated buildings, and enhance its status and influence in the construction field. By introducing prefabricated building technology, we can effectively solve the problems faced by traditional cast-in-place production methods, improve resource utilization efficiency, improve production efficiency, ensure building quality and safety, and achieve the goal of energy conservation and environmental protection. The development of prefabricated buildings will inject new impetus into the transformation and upgrading of China's construction industry, and promote the construction industry to move towards a greener, smarter and more sustainable direction.

1.1.4. The Evaluation System of Green Construction Needs to Be Improved

At present, China's green construction evaluation system needs to be further improved and perfected. The existing "Green Building Evaluation Standard" GB/T 50378-2019 [4]which added green construction evaluation content on the basis of construction projects, was officially implemented on December 1, 2020. In this standard, the evaluation of green construction mainly includes five aspects, namely energy saving, water saving, material saving, environmental protection and comprehensive utilization of resources. However, the index system in the standard has not been systematically optimized and improved for the green construction characteristics of prefabricated buildings. For example, the standard divides the evaluation indicators of green construction into a three-level index system, but does not classify the evaluation indicators. The characteristics of green construction of prefabricated buildings are the industrialization and assembly of the construction process, and its energy-saving and environmental protection characteristics also have a greater impact on the environment. However, the index system in the standard only considers the impact on the environment during the construction process, and ignores the impact of the prefabricated building on the environment during the construction process. Therefore, it is particularly important to establish a targeted, systematic and comprehensive green construction evaluation system for prefabricated buildings.

Therefore, prefabricated buildings are a new form of China's new urbanization construction, and the idea of green construction is truly implemented in its construction, which is of great significance to promote the green and low-carbon development of China's economy and society. In the context that "green construction" has become an inevitable choice and is regarded as a new development direction, how to measure and evaluate it is an urgent problem to be solved.

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1.2. Research Implications

On the one hand, the establishment of a green measurement system for prefabricated building construction is helpful to enrich the evaluation system of prefabricated buildings, promote the formulation of development mechanisms and evaluation standards, and promote the development and application of prefabricated buildings. On the other hand, a measurement index system is established from the five dimensions of environmental protection, energy resources, construction management, technological innovation and social coordination to measure the greenness of prefabricated buildings and provide a basis for decision-making. Through actual project investigation and quantitative analysis of data, the benefits of environmental protection, information management, technology application and industrial promotion in the whole process of prefabricated building construction are evaluated, and the benefits brought by information management methods to the green construction of prefabricated buildings are studied, so as to promote the promotion and application of prefabricated buildings in the market.

2. Literature Review

At present, the research on green construction evaluation mainly focuses on green building and green construction evaluation, and there are relatively few related studies in the construction stage of prefabricated buildings. Foreign scholars study the environmental friendliness in the construction process of prefabricated buildings from the perspectives of environmental protection, resource conservation, energy consumption, resource utilization efficiency, pollution reduction and economic benefits. From the perspective of the whole process of prefabricated building production and construction, domestic scholars have constructed a corresponding evaluation index system.

2.1. Research Status of Green Construction and Green Building Evaluation System

In recent years, with the popularization of the concept of sustainable development, green construction has begun to be widely used in construction projects, which has also promoted the construction industry to enter a new development directionGreen construction embodies the idea of "harmony between man and nature" in China's traditional culture, and achieves the goal of environmental protection.

In order to better implement the green construction of construction projects, there are three main versions of the national standards for green building assessment that have been implemented in China: "Green Building Evaluation Standard: GB/T50378-2006" [5] and "[5]GB/T 50378-2014" [6]and Green Building Evaluation Standards: GB/T50378-2019 [4]]. The two standards, promulgated in 2006 and 2014, were based on the "four sections and one environmental protection".Based on the international green building evaluation system, this concept only restricts green buildings from the perspective of construction, and does not consider the needs and aspirations of project stakeholders. In this regard, the "Green Building Evaluation Standard: GB/T50378-2019" [4] issued in [4]from the perspective of "people-oriented". Based on the concept of sustainable development, the performance of building greenness is considered in the first place, and the green building design is evaluated from six aspects: building safety and durability, health and comfort, convenient life, resource saving, environmental livability, improvement and innovation, which further enriches the content of green building design and improves the performance requirements of green building design.

The General Office of the State Council clearly pointed out in the "Guiding Opinions on Vigorously Developing Prefabricated Buildings" that the current construction methods are still

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mainly cast-in-place structures, and the proportion and standardization of prefabricated building construction are still low.

Some countries have conducted in-depth and extensive research on prefabricated buildings, and scholars He Wang, Yin-qi Zhang, Weijun Gao, and Soichiro Kuroki [8].It is believed that prefabricated building is a modern architectural form based on the green concept and different from the traditional construction method, which needs to be combined and corresponded, which is a manifestation of the sustainable development strategy. These research results provide strong support for us to better understand prefabricated buildings.

Merve Anaç; Gulden Gumusburun Ayalp et al. [9] also argue that prefabricated construction is a new construction technology that has many advantages over traditional construction methods, but also has some limitations that make it challenging. Prefabricated buildings can effectively shorten the construction cycle, reduce labor and improve efficiency. However, Yanhui Sun, Jun Wang, Jeremy Wu [10] et al. argue that there are potential limitations to prefabricated buildings, and the use of modular buildings is still relatively rare. According to these scholars, "there is a lack of coordination and communication between stakeholders", "rising costs", "lack of government support", and "lack of experience and expertise.""Lack of building codes and standards", "low level of supply chain integration" and "complexity of connectivity" are the main obstacles to the development of prefabricated buildings. The development of the prefabricated building industry must be coordinated with a number of related industries, requiring huge investment, a long recovery cycle, and the quality and safety are difficult to be accepted and recognized by the public, and there are still many obstacles to the development of prefabricated buildings.

2.2. Research Status of Greenness Measurement Methods

In 2018, Long Shan, Zhang Yunning, and Ouyang Hongxiang [11] proposed a cloud-matter-element evaluation modelThe subjective and objective weighting analytic hierarchy process and entropy weight method were used to calculate the comprehensive weight of each index. On this basis, a green evaluation method based on green index was proposed. Finally, through a case study, it is proved that this method can effectively solve the problems of randomness, discreteness and uncertainty in green assessment, and provides a new way for the green assessment of prefabricated buildings. In November 2020, Wang Qiankun, Nian Chunguang, and Deng Qinli [12] from the School of Civil Engineering and Architecture of Wuhan University of Technology believed that in deepening design, material supply, industrial production and construction, transportation and installation, etc., the idea of sustainable and green development should be implemented to ensure the quality of the projectUnder the premise of quantity, cost, speed and safety, we should realize green development, low-carbon environmental protection and resource recycling, that is, to achieve reasonable conservation of energy resources, promote the coordinated development of national economic and social benefits, improve the economic benefits of commodities with innovative science and technology, and promote the construction of smart cities with management talents. They pointed out that this project comprehensively considers five aspects, including energy conservation, environmental protection, construction management, technological innovation, and social collaboration, to build a green evaluation model of C-OWA operator-cloud matter element, and introduce "environmental greenness" into the whole process of prefabricated construction.

In view of the above problems, this paper draws on the relevant theories and practical experiences of green building and green construction, and constructs an index system of green construction of prefabricated buildings from the aspects of resource conservation, environmental protection, and management level. On this basis, the cloud theory, matter-element analysis and other methods are used to construct a green measurement model for

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prefabricated building construction, in order to provide a new idea for the evaluation of greenness in the construction stage of prefabricated buildings.

In terms of the connotation of greenness, scholars at home and abroad have provided good ideas for the greenness of prefabricated building construction, which provides a reliable basis for the subsequent construction of the green measurement index system. Most of the current studies have conducted simple analyses and have not been tested theoretically. In terms of index weights, due to the influence of expert knowledge level and judgment extremes, a more scientific and reasonable weighting method should be studied in the calculation of greenness. At present, the evaluation methods of the calculation model are not the same, but it is difficult to balance the quantitative and qualitative indicators, and it is of great significance to find a more concise calculation method for prefabricated construction.

3. An Evaluation Model for Green Construction of Prefabricated Buildings based on the Cloud Matter-element Model was Established

3.1. The Evaluation System of Green Construction of Prefabricated Buildings was Established

Table 1. Sustainable evaluation index system of prefabricated building construction

Target layer	Criterion layer A	Criterion layer B	Indicator layer C
Sustainability evaluation of prefabricated building construction	Environmental Protection A_1	Fugitive Dust Control B_1	Spray equipment dust reduction C_1
			On-site import and export dust suppression facilities C_2
		Construction waste B_2	Classified collection of construction and centralized stacking of C_3
			Construction waste recycling rate/% C_4
		Effluent discharge B_3	Drainage ditch arrangement C_5
			Rainwater and sewage diversion and discharge C_6
		Light pollution B_4	Light blocking measures for night welding operations C_7
			Prevent strong light from leaking C_8
		Noise control B_5	Noise/dB C_9
			Noise reduction measure C_{10}
	Material saving and material resource utilization A_2	Material selection and controlB_6	Recyclable material reuse rate/% C_{11}
			Surfaces and tiles are pre-typeset C_{12}
			Formwork and scaffolding turnover times C_{13}
		Resource Recycling B_7	Proportion of water consumption from non-traditional water sources to total water consumption/% C_{14}
			Degree of resource recycling C_{15}
	Water Conservation and Water Utilization A_3	Water Conservation B_8	Rationality of water supply and drainage system at the construction site C_{16}
			Allocation rate of water-saving appliances in office area and living area/% C_{17}
		Water resource utilization B_9	Foundation pit precipitation storage uses C_{18}
			Recycling water plant C_{19}
	Energy Conservation and Energy Utilization A_4	Energy Saving & Energy Temporary electrical facilitiesB_{10}	Energy-saving electrical facilities should be C_{20}
			Rationality of temporary electricity consumption C_{21}
		Machinery and equipment B_{11}	Low-energy, high-efficiency equipment technology application C_{22}
			C_{23} technical maintenance and management of equipment
		Saving land B_{12}	Construction land rate per unit building area/%C_{24}
			Rationality of traffic road layout C_{25}
	Land Conservation and Land Resource Conservation A_5	Protected land B_{13}	Soil erosion measure C_{26}
			Post-construction vegetation restoration measures C_{27}
	Sustainability Management A_6	Technological innovation and efficiency B_{14}	Promote the application of technology C_{28}
			Construction Technology Innovation C_{29}
		Health B_{15} for practitioners	Construction and living office area layout C_{30}
			Labor work intensity C_{31}

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Compared with traditional cast-in-place buildings, prefabricated building construction is more standardized, energy-saving and environmentally friendly. The state attaches more and more importance to green, low-carbon and sustainable development, and the requirements for the degree of prefabricated green buildings are also increasing. Extract and analyze the high-frequency indicators in typical green building evaluation systems, relevant standards and specifications, and literature research. A total of 52 measurement indicators were preliminarily selected, and based on the questionnaire survey, the factor analysis method was used to screen and classify the green degree measurement indicators, and finally the green degree measurement index system containing 6 criterion layers and 31 measurement indicators was finally determined. This is shown in the table below.

3.1.1. Determination of the Green Construction Grade Standard Cloud for Prefabricated Buildings

Cloud theory and matter-element analysis can express complex problems in simple language, and carry out qualitative and quantitative transformation of language according to different situations. This method determines the cloud model between the evaluation object and the standard, and then uses mathematical methods to deal with the ambiguity and randomness between multiple evaluation objects. According to the different value ranges of each parameter in the cloud model, the cloud model can be divided into four basic types: continuous cloud model, normal cloud model, and random cloud model. Matter-element analysis is a method to study the quantitative relationship between physical quantities. The so-called element of matter refers to any thing or phenomenon, which can be called a matter element if and only if it corresponds to a certain object or phenomenon. The matter-element analysis method first needs to determine a set of correlation functions between the objects to be evaluated and the target, and then determine the similarity between the target and the objects to be evaluated according to the functions, and then find the comprehensive correlation degree of the evaluation object, and divide the evaluation level according to the comprehensive correlation degree. In this paper, the sustainability of prefabricated building construction is taken as the target layer element, which includes six first-level sustainability evaluation indicators. The first-level sustainability evaluation index is divided into second-level indicators, and the second-level indicators include their own third-level indicatorsL

$$Ri=(N,\ Ci,\ vi)=\begin{bmatrix} N & C1 & v1 \\ & C2 & v2 \\ & \dots & \dots \\ & Cn & vn \end{bmatrix} \tag{1}$$

where: is the index $Ci(i=1,2,\ldots,31)$ layer matter element of the evaluation object; $vi(i=1,2,\ldots,31$ is Ci the corresponding magnitude.

The basic idea of the cloud-matter-element model is as follows: firstly, the relationship between the thing to be evaluated and the standard set is described as a definite cloud droplet; Then, according to the correlation function between the cloud droplet and a corresponding standard set, the correlation degree between the evaluation object and the standard set is obtained by the cloud generator. By reviewing the literature and combining engineering practice, 31 indicators were selected from six aspects: environmental protection, material saving and material resource utilization, water conservation and water resource utilization, energy conservation and energy utilization, land saving and land protection and sustainable development management, as the green measurement indicators of prefabricated building construction. With reference to relevant standards and expert opinions, the sustainability of

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prefabricated building construction is divided into three levels, namely; Poor sustainability, average sustainability, sustainability. The comprehensive construction experience obtains the sustainability evaluation index boundaries that are consistent with the construction characteristics of prefabricated buildings. It is shown below:

Table 2. Sustainability evaluation index system of prefabricated building construction

index	Hierarchical boundaries		
	Poor sustainability	Generally sustainable	Sustainable
Spray equipment dust reduction C_1	[40,60)	[60,80)	[80, 100)
On-site import and export dust suppression facility C_2	[40,60)	[60,80)	[80, 100)
Classified collection of construction and centralized stacking of C_3	[40,60)	[60,80)	[80, 100)
Construction waste recycling rate/% C_4	[10,20)	[20, 30)	[30,60)
Drainage ditch arrangement C_5	[40,60)	[60,80)	[80, 100)
Rainwater and sewage diversion and discharge C_6	[40,60)	[60,80)	[80, 100)
Light blocking measures for night welding operations C_7	[40,60)	[60,80)	[80, 100)
Prevent strong light from leaking C_8	[40,60)	[60,80)	[80, 100)
Noise/dBC_9	[70,65)	[65,60)	[60,55)
Noise reduction measure C_{10}	[40,60)	[60,80)	[80, 100)
Recyclable material reuse rate/%C_{11}	[20,40)	[40,70)	[70, 100)
Surfaces and tiles are pre-typeset C_{12}	[40,60)	[60,80)	[80, 100)
Formwork, scaffolding turnover times C_{13}	[0,5)	[5,10)	[10,50)
Proportion of water consumption from non-traditional water sources to total water consumption/%C_{14}	[10,20)	[20,30)	[30,50)
Degree of resource recycling C_{15}	[40,60)	[60,80)	[80, 100)
Rationality of water supply and drainage system at the construction site C_{16}	[40,60)	[60,80)	[80, 100)
The allocation rate of water-saving appliances in office area and living area/%C_{17}	[55,70)	[70,85)	[85, 100)
Foundation pit precipitation storage uses C_{18}	[40,60)	[60,80)	[80, 100)
Recycling water plant C_{19}	[40,60)	[60,80)	[80, 100)
Energy-saving electrical facilities should be C_{20}	[40,60)	[60,80)	[80, 100)
Rationality of temporary electricity consumption C_{21}	[40,60)	[60,80)	[80,100)
Low-energy, high-efficiency equipment technology application C_{22}	[40,60)	[60,80)	[80, 100)
C_{23} technical maintenance and management of equipment	[40,60)	[60,80)	[80,100)
Construction land rate per unit building area/%C_{24}	[9,7)	[7,5)	[5,3)
Rationality of traffic road layout C_{25}	[40,60)	[60,80)	[80,100)
Soil erosion measure C_{26}	[40,60)	[60,80)	[80, 100)
Post-construction vegetation restoration measures C_{27}	[40,60)	[60,80)	[80,100)
Promote the application of technology C_{38}	[40,60)	[60,80)	[80, 100)
Construction Technology Innovation C_{29}	[40,60)	[60,80)	[80,100)
Construction and layout of living office area C_{30}	[40,60)	[60,80)	[80, 100)
Labor work intensity/C_{31}	[30,25)	[25,20)	[20,15)

According to the derivation of the cloud-matter-element function, we obtain the standard cloud model for the sustainability evaluation of prefabricated building construction, as shown in the following table.

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Table 3. Sustainability evaluation index system of prefabricated building construction

index	Poor sustainability	Generally sustainable	Sustainable
C_1	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_2	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_3	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_4	(15,1.667,0.1)	(25,1.667,0.1)	(45,5,0.1)
C_5	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_6	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_7	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_8	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_9	(67.5,0.833,0.01)	(62.5,0.833,0.01)	(57.5,0.833,0.01)
C_{10}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{11}	(30,3.333,0.2)	(55,5,0.2)	(85,5,0.2)
C_{12}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{13}	(2.5, 0.833, 0.01)	(7.5, 0.833, 0.01)	(30, 3.333, 0.01)
C_{14}	(15, 1.667, 0.1)	(25, 1.667,0.1)	(40, 3.333, 0.1)
C_{15}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{16}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{17}	(62.5, 2.5, 0.2)	(77.5, 2.5, 0.2)	(92.5, 2.5, 0.2)
C_{18}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{19}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{20}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{21}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{22}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{23}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{24}	(8, 0.333, 0.01)	(6, 0.333, 0.01)	(4, 0.333, 0.01)
C_{25}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{26}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{27}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{28}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{29}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{30}	(50,3.333,0.2)	(70,3.333,0.2)	(90,3.333,0.2)
C_{31}	(27.5,0.833,0.01)	(22.5,0.833,0.01)	(17.5,0.833,0.01)

3.2. Determination of the Weight of the Evaluation Index of the Green Construction Grade of Prefabricated Buildings

The indicator layer contains both quantitative and qualitative indicators, and I collect information about the indicators and determine the standard membership of each indicator. Since the weight of each index cannot be determined, and the membership degree of the index cannot be directly calculated through the numerical value, the weight of each index is calculated by using the expert scoring method. According to the expert score, and combined with the construction characteristics of the prefabricated building and the research situation, the experts determine the standard membership degree of each index in the index system. By establishing a cloud matter-element model, each index is linked to the corresponding score, and the qualitative and quantitative are combined to objectively and truly reflect the overall performance of each index in green construction. After collating and analyzing the data, I finally obtained the weight table of the sustainability evaluation index of prefabricated building construction.

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Table 4. Sustainable evaluation index system of prefabricated building construction

target layer	Criterion Layer A	Weight relative to the target layer	Criterion layer B	Weight relative to the parent metric	Indicator layer C	Weight relative to the parent metric
feign match style build build give work can hold continue sex appraise price	A_1	0.2	B_1	0.0625	C_1	0.0300
					C_2	0.0325
			B_2	0.0497	C_3	0.0300
					C_4	0.0197
			B_3	0.0386	C_5	0.0189
					C_6	0.0197
			B_4	0.0182	C_7	0.0093
					C_8	0.0089
			B_5	0.0310	C_9	0.0171
					C_{10}	0.0139
	A_2	0.2	B_6	0.1509	C_{11}	0.0593
					C_{12}	0.0426
					C_{13}	0.0490
			B_7	0.0491	C_{14}	0.0233
					C_{15}	0.0258
	A_3	0.2	B_8	0.0942	C_{16}	0.0635
					C_{17}	0.0307
			B_9	0.1058	C_{18}	0.0404
					C_{19}	0.0654
	A_4	0.2	B_{10}	0.1019	C_{20}	0.0596
					C_{21}	0.0423
			B_{11}	0.0981	C_{22}	0.0770
					C_{23}	0.0211
	A_5	0.1	B_{12}	0.0616	C_{24}	0.0356
					C_{25}	0.0260
			B_{13}	0.0384	C_{26}	0.0250
					C_{27}	0.0134
	A_6	0. 1	B_{14}	0.0627	C_{28}	0.0240
					C_{29}	0.0387
			B_{15}	0.0373	C_{30}	0.0100
					C_{31}	0.0273

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4. Calculation of Comprehensive Relevance and Determination of Evaluation Grade

After the evaluation index system and grade division criteria are determined, the evaluation indicators are normalized, the qualitative concepts are quantified by cloud theory, the grades of each index are divided, the weight of each index is determined, and the evaluation level of the index is generated by the cloud generator. The C-OWA operator and cloud theory are used to empower each indicator.

4.1. Comprehensive Relevance Calculation

The correlation degree of the measurement index is calculated by calculating the actual value of the measurement index i (i=1,2,3) and the normal cloud correlation degree of the J-level green standard. Wijis the comprehensive weight of the index corresponding to the table, and the sum of n times is taken as its correlation degreeKij.

$$Kij = \sum_{i=1}^{n} WijKj(Ci) \tag{2}$$

The correlation degree between the object element of the target layer and the construction sustainability is determined, and the correlation degree of the target layer is obtained by Kijthe correlation degree of WijIJ and the sum of n timesGij.

$$Gij = \sum_{i=1}^{n} WijKij \tag{3}$$

4.2. Determination of Evaluation Grades

Determine the level of sustainability to which each element belongs:

$$Z = \max\{Gij\}\, j \in (\text{Lesssustainable, generallysustainable, sustainable}) \tag{4}$$

The level of sustainability of the available elementsZ.

At the same time, based on the cloud matter-element model, the correlation degree between the indicators in the greenness measurement system can be determined, and the evaluation results are divided into six levels, which further improves the evaluation system.

5. Summary and Improvements

5.1. Summary

Through the research on the evaluation method of prefabricated building construction, this paper summarizes the green evaluation method of prefabricated building construction based on cloud theory, and obtains the following conclusions:

In terms of index screening, the original index data was processed in the form of questionnaire survey and factor analysis, and the green degree measurement index system containing 6 criterion layers and 31 indicators was finally determined. Different quantitative methods were used for the quantitative and qualitative indicators of greenness evaluation, and the corresponding formulas were used to empower them. The cloud-matter-element theory is used to construct the green measurement model of prefabricated building construction, which overcomes the disadvantages of subjective empowerment to a certain extent and improves the objectivity and scientificity of the evaluation results. The greenness evaluation method is applied to the engineering example, and good results are obtained. In terms of the selection of comprehensive evaluation methods, through comparative analysis, the comprehensive evaluation methods using cloud theory are finally determined. The comprehensive evaluation method is different from the analytic hierarchy process and the entropy method, and the comprehensive evaluation method of cloud theory overcomes the subjectivity and one-sidedness of weight determination to a certain extent, and combines qualitative and quantitative indicators. At the same time, cloud theory can effectively avoid the problems of incomplete data and uncertainty, and can be applied to the comprehensive evaluation of complex systems.

5.2. Improvements:

The greenness evaluation method was not optimized. For example, in the process of data processing, the randomness and ambiguity of the evaluation index data are not fully considered, resulting in inaccurate results. In the empirical analysis using this method, the measured data of the prefabricated building project is used as the index weight value, but there is still a certain gap between the conclusions and the measured results according to the actual engineering cases.

The evaluation index system and the evaluation method of green construction of prefabricated buildings designed in this paper are only a preliminary exploration. By analyzing the main factors influencing the green construction of prefabricated buildings, an evaluation index system and evaluation model based on the cloud matter-element model were constructed. From the analysis results, the evaluation results of the method are reasonable and feasible. In the future, more in-depth and comprehensive research can be carried out at all stages of prefabricated buildings.

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