Study on the Evaluation and Countermeasures of Green Construction of Construction Projects

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Abstract. In recent years, with the advancement of urbanization in China, the management idea of infiltration of green construction in the construction process can not meet the needs of the industry development. Comprehensive and systematic green construction planning, development and application of green construction technology will be a new driving force to promote the sustainable development of the construction industry. Construction scheme and process standardization, site facilities standardization, construction measures industrialization, site environment garden, site management information is the main focus of our action. Evaluate the construction project of green construction, is not only beneficial to the promotion of green construction, can timely find the deviation appeared in the process of project implementation, guarantee the project of the construction of the economic benefits, social benefits and ecological benefits, will also be able to provide reference and guidance significance for other similar project, improve the level of future overall implementation of the construction project and environmental benefits.

Keywords: Construction project; Green construction; Sustainable development; Environmental benefits.

1. Construction principles of green construction evaluation index system

The green construction evaluation of construction projects needs to collect a lot of data and information, and the collected information is integrated and processed, and finally a comprehensive analysis result is obtained. Therefore, we should not only follow the scientific principle of the green construction evaluation index system, but also establish the green construction evaluation system scientifically and orderly on the basis of the existing principles. The principles of constructing the evaluation index system are as follows:

1.1 Systemic

The index factors of the green construction evaluation index system of construction projects should be considered from all aspects, and the evaluation index factors should be very representative. The objective, fair and comprehensive scientific evaluation of green construction should be carried out, so as to lay a solid theoretical foundation for the construction of a sustainable, stable and efficient green construction evaluation model.

1.2 Dynamic

The whole life cycle of a construction project is a dynamic process. Based on the basic theoretical principles and dynamic principles of green construction evaluation, the green construction of a project is evaluated by considering relevant indicators with dynamic and temporal characteristics.

1.3 Significance

The selection of evaluation indicators should ensure the irreplaceability and particularity of the indicators in the project. Since there are many evaluation indicators of the project, the factors that have a great influence on the green construction of the construction project should be selected as the main evaluation indicators in the selection process.

1.4 Operability

There are many indicators that affect the green construction of construction projects, including quantifiable and unquantifiable indicators. In order to ensure the objectivity and fairness of the evaluation results, the project index system should be determined based on the principle of operation.

2. Construction of evaluation index system

At present, the research on green construction evaluation of construction projects has organically integrated the development of construction enterprises and environmental protection, and finally formed a situation of comprehensive and coordinated development of nature and society. Green construction is closely related to the rational utilization of resources, the management of construction enterprises, the implementation of construction technology, the investment of construction costs and the impact on the environment in the whole project implementation process. If only one or several factors are taken into consideration in the evaluation process of green construction of construction projects, it may lead to the phenomenon that the actual situation of the project cannot be fully reflected due to the single selection of indicators, which is also one of the most obvious drawbacks in the evaluation index system at this stage. This paper takes this as the reference basis, and makes innovative evaluation on the rational utilization of resources, management of construction enterprises, implementation of construction technology, investment of construction costs and impact on the environment as the main content.

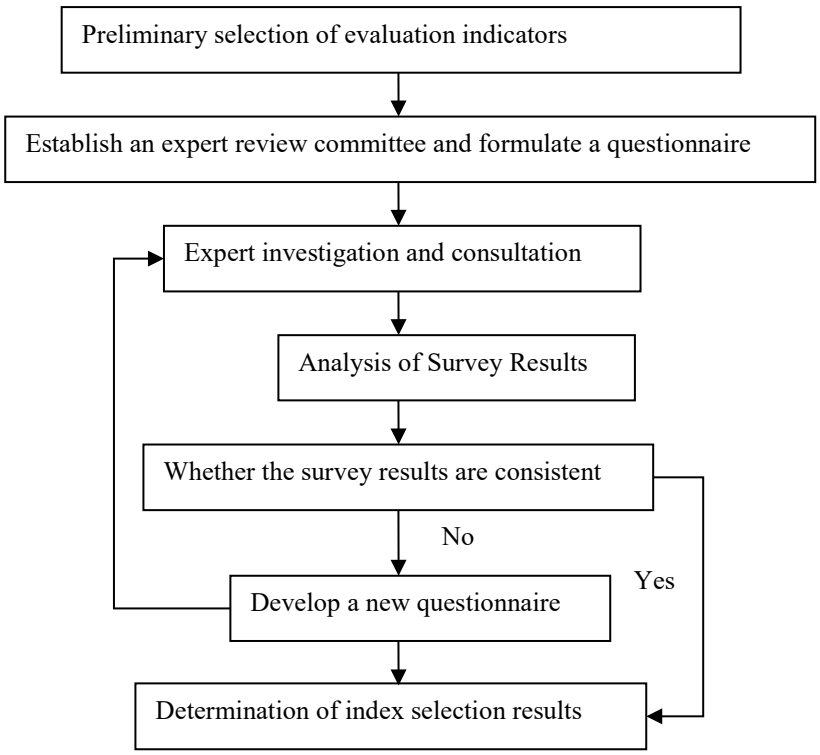


Fig. 1 Flowchart of the Delphi method

The specific evaluation index can be selected according to the experience of similar project evaluation in the past, or the qualitative index can be quantified by some mathematical methods. The experience selection method mainly summarizes the influential factors by the professionals in the field according to the individual in the implementation process of the actual project, and makes a finer screening of the obtained factors. The disadvantages of this method are mainly that the degree of subjective influence is large, and the objectivity of the factors is low. When using principal component analysis method and other relevant mathematical methods to screen indicators, it mainly quantifies the importance of index factors to reduce the influence of people's subjective factors on the

selection of indicators, but this method lacks the subjective analysis of logical relations among complex factors. In this article, therefore, the selection of evaluation index system in use in the process of Delphi method, this method first by the results of expert opinion after sorting, inducing and summarizing the results obtained will be feedback to the expert, so repeatedly, until the final experts agree the results, the method avoids the single by the empirical method and research method of index selection of disadvantage, the implementation of the specific process as shown in figure 1.

Based on the principles of green construction evaluation index system construction and Delphi method, this paper constructs the evaluation index system, and finally divides the evaluation index factors of green construction into three levels for research and analysis. Firstly, the target layer is the green construction evaluation of the construction project. Secondly, the criterion layer includes the rational utilization of resources, the management of construction enterprises, the implementation of construction technology, the investment of construction costs and the impact on the environment. Finally, the second-level indicator layer is divided into 20 specific indicator factors according to the actual situation of the five criterion layers, including the rational utilization of water resources and building materials in the rational utilization of resources, as shown in Table 1.

Table 1. Table of green construction evaluation index system of construction project

Target layer	Rule layer	Index layer
Green construction evaluation of construction projects	Rational use of resources B1	Rational use of water resources X1
		Rational use of building materials X2
		Rational use of land resources X3
		Rational use of energy X4
	Management of construction enterprises B2	Green construction education and training X5
		Construction unit environmental protection system establishment X6
		Personnel safety and health X7
		Construction site coordination and management X8
	Implementation of construction techniques B3	Green construction planning scheme X9
		Introduction of green construction technology and environmental protection equipment X10
		Application of new construction techniques X11
		Development of green construction materials X12
	Construction cost input B4	Development of green construction cost plan X13
		Investment in green construction measures X14
		Expenses for environmental pollution control X15
	Impact on the environment B5	Dust pollution control X16
		Noise pollution control X17
		Sewage discharge control X18
		Construction waste disposal X19
		Control of light pollution X20

3. Construction of green construction evaluation model for construction project

In this study, the study of green construction evaluation of construction projects adopts AHP-fuzzy analysis method, combining quantitative and qualitative analysis, to solve the related problems of green construction evaluation of construction projects.

3.1 The characteristics of AHP-Fuzzy comprehensive evaluation method

Analytic hierarchy Process (AHP) is a practical evaluation method of multi-criteria decision making. Because it can make various factors related to complex problems more organized and clearer,

it is favored by researchers. The fuzzy comprehensive evaluation method makes a reasonable classification of the quality of each index factor. In the best way to solve the fuzzy, difficult to quantitative analysis of the problem. The effective combination of the two methods makes the analysis result convincing.

3.2 Construction of evaluation model based on AHP-Fuzzy

①Construct judgment matrix

To determine the weight, several experts with relevant professional knowledge background will be invited to give scores, and the indicators to be evaluated will be compared pairwise, and 1-9 scale method will be adopted.

Table 2. 1-9 scaling method

scale	meaning
1	The i and j elements are equally important
3	I is slightly more important than j
5	I is obviously more important than j
7	I is more important than j
9	I is more important than j
2、4、6、8	Between the two values

②The weight of each factor index was calculated and the consistency was checked

Judgment matrix $B=\begin{pmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \cdots & \cdots & \cdots & b_{3n} \\ b_{m1} & b_{m2} & \cdots & b_{mn} \end{pmatrix}$,

Normalization deals with the column vectors of the judgment matrix $\overline{b_{ij}}=\frac{b_{ij}}{\sum_{i=1}^{m} b_{ij}}$;

Add the above judgment matrices $\overline{W_{ij}}=\sum_{j=1}^{n}\overline{b_{ij}}$;

Normalize the processing matrix and calculate the eigenvectors of the judgment matrix $\lambda_{max}=\sum_{i=1}^{n}\frac{(BW_i)}{nW_i}$;

Conduct a consistency check $CI=\frac{\lambda_{max}-n}{n-1}$,

Calculate consistency ratio $CR=\frac{CI}{RI}$, When the value of CR is less than 0.1, it indicates that the judgment matrix meets the consistency test standard and obtains that it has consistency.

③Make a comprehensive evaluation

The words V ={good, better, medium, average, poor} of the evaluation object are established, namely, the evaluation level, and each level can correspond to a fuzzy subset.The set of assigned comments is V={95,85,75,65,55}.

The established comment set is used to evaluate a single factor by experts, and the fuzzy evaluation matrix R of each factor in the index layer is obtained. The judgment matrix of each evaluation factor index Cij can be expressed as:

$$R=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1j} \\ r_{21} & r_{22} & \cdots & r_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ r_{i1} & r_{i2} & \cdots & r_{ij} \end{bmatrix}$$

The rij represents the membership degree of the evaluation index bij.

The weight results of each index are correlated with the fuzzy matrix $B_{Ri} = R_i \times W_i$, and the evaluation result BRi of a single index is obtained.

Through the conversion of the whole evaluation result and weight, the formula can be obtained $T = W \times B_R$.

Using the data T obtained in the previous step and the corresponding score of the comment set score to calculate $Score = T \times V^T$.

4. Evaluation analysis of construction project hotel construction based on fuzzy comprehensive evaluation method

4.1 The establishment of fuzzy relation matrix

The survey objects of this paper include government staff, scholars in universities, staff of digital communication companies, and the public, etc. A total of 350 questionnaires were sent out, and 280 valid questionnaires were obtained. After sorting out the scores of the importance of each index, the following judgment matrix can be obtained after multiple selection.

$$B=\begin{pmatrix} 1 & 4/7 & 3/5 & 2/5 & 5/8 \\ 7/4 & 1 & 5/8 & 7/3 & 2/5 \\ 5/3 & 8/5 & 1 & 9/4 & 7/3 \\ 5/2 & 3/7 & 4/9 & 1 & 1/5 \\ 8/5 & 5/2 & 3/7 & 5 & 1 \end{pmatrix}; B_1=\begin{pmatrix} 1 & 1/3 & 5/8 & 7/3 \\ 3 & 1 & 7/4 & 4 \\ 8/5 & 4/7 & 1 & 6 \\ 3/7 & 1/4 & 1/6 & 1 \end{pmatrix}; B_2=\begin{pmatrix} 1 & 3/2 & 1/3 & 3/7 \\ 2/3 & 1 & 2/5 & 3/8 \\ 3 & 5/2 & 1 & 1/6 \\ 7/3 & 8/3 & 6 & 1 \end{pmatrix}$$

$$B_3=\begin{pmatrix} 1 & 9/5 & 3/5 & 7/4 \\ 5/9 & 1 & 5/3 & 8/5 \\ 5/3 & 3/5 & 1 & 2/5 \\ 4/7 & 5/8 & 5/2 & 1 \end{pmatrix}; \quad B_4=\begin{pmatrix} 1 & 3/5 & 7/4 \\ 5/3 & 1 & 8/3 \\ 4/7 & 3/8 & 1 \end{pmatrix}; \quad B_5=\begin{pmatrix} 1 & 7/5 & 8/3 & 4/5 & 3/2 \\ 5/7 & 1 & 7/5 & 4/7 & 2/5 \\ 3/8 & 5/7 & 1 & 3/5 & 5/9 \\ 5/4 & 7/4 & 5/3 & 1 & 7/4 \\ 2/3 & 5/2 & 9/5 & 4/7 & 1 \end{pmatrix}$$

4.2 Weight and membership degree determination

Tab 3. Summary table of index weights at all levels

Rule layer	Weight	Index layer	Weight
Rational use of resources B1	0.1742	Rational use of water resources X1	0.2132
		Rational use of building materials X2	0.3103
		Rational use of land resources X3	0.3133
		Rational use of energy X4	0.1632
Management of construction enterprises B2	0.1953	Green construction education and training X5	0.1734
		Construction unit environmental protection system establishment X6	0.1132
		Personnel safety and health X7	0.1723
		Construction site coordination and management X8	0.5411
Implementation of construction techniques B3	0.2366	Green construction planning scheme X9	0.2841
		Introduction of green construction technology and environmental protection equipment X10	0.1798
		Application of new construction techniques X11	0.2565
		Development of green construction materials X12	0.2796
Construction cost input B4	0.2133	Development of green construction cost plan X13	0.4286
		Investment in green construction measures X14	0.3256
		Expenses for environmental pollution control X15	0.2458
Impact on the environment B5	0.1806	Dust pollution control X16	0.1576
		Noise pollution control X17	0.1322
		Sewage discharge control X18	0.1289
		Construction waste disposal X19	0.3166
		Control of light pollution X20	0.2647

Through the calculation of relevant calculation formulas, it can be obtained that all indexes have passed the consistency test. The weight of each factor index is summarized in Table 3 as follows.

In this paper, a total of 300 questionnaires were sent out and 264 valid questionnaires were obtained. The membership results were summarized in the following table.

Table.4 Summary table of membership

Rule layer	Index layer	Comment set				
		Excellent	Good	Medium	General	Poor
Rational use of resources B1	Rational use of water resources X1	0.1875	0.3431	0.3571	0.1117	0.0006
	Rational use of building materials X2	0.0873	0.2467	0.2595	0.3298	0.0767
	Rational use of land resources X3	0.0678	0.1735	0.3436	0.3448	0.0703
	Rational use of energy X4	0.2972	0.2728	0.2272	0.1465	0.0563
Management of construction enterprises B2	Green construction education and training X5	0.433	0.327	0.143	0.0531	0.0439
	Construction unit environmental protection system establishment X6	0.107	0.273	0.312	0.2521	0.0559
	Personnel safety and health X7	0.2175	0.1435	0.3696	0.1081	0.1613
	Construction site coordination and management X8	0.2446	0.2563	0.2095	0.235	0.0546
Implementation of construction techniques B3	Green construction planning scheme X9	0.0545	0.1466	0.2253	0.3445	0.2291
	Introduction of green construction technology and environmental protection equipment X10	0.2066	0.1475	0.3674	0.1075	0.171
	Application of new construction techniques X11	0.2175	0.1435	0.3696	0.1081	0.1613
	Development of green construction materials X12	0.059	0.3761	0.221	0.2092	0.1347
Construction cost input B4	Development of green construction cost plan X13	0.1345	0.0905	0.2026	0.5274	0.045
	Investment in green construction measures X14	0.0815	0.0728	0.2132	0.4763	0.1562
	Expenses for environmental pollution control X15	0.1058	0.084	0.2265	0.5005	0.0832
Impact on the environment B5	Dust pollution control X16	0.126	0.1795	0.2425	0.3163	0.1357
	Noise pollution control X17	0.0567	0.1242	0.2316	0.4363	0.1512
	Sewage discharge control X18	0.0991	0.0728	0.1964	0.5867	0.045
	Construction waste disposal X19	0.091	0.0728	0.1908	0.5285	0.1169
	Control of light pollution X20	0.1323	0.1052	0.129	0.4885	0.145

4.3 Analysis of evaluation results

According to the result of membership degree of each index above, it can be calculated by fuzzy comprehensive evaluation formula $T = W \times R$.

$$B_{R1} = W_1 \times R_1$$

$$= \begin{pmatrix} 0.2132 & 0.3103 & 0.3133 & 0.1632 \end{pmatrix} \times \begin{pmatrix} 0.1875 & 0.3431 & 0.3571 & 0.1117 & 0.0006 \\ 0.0873 & 0.2467 & 0.2595 & 0.3298 & 0.0767 \\ 0.0678 & 0.1735 & 0.3436 & 0.3448 & 0.0703 \\ 0.2972 & 0.2728 & 0.2272 & 0.1465 & 0.0563 \end{pmatrix}$$

$$= \begin{pmatrix} 0.1316 & 0.2353 & 0.2750 & 0.2316 & 0.0497 \end{pmatrix}$$

$$B_{R2} = W_2 \times R_2 = \begin{pmatrix} 0.2570 & 0.2510 & 0.2372 & 0.1835 & 0.0713 \end{pmatrix}$$

$$B_{R3} = W_3 \times R_3 = \begin{pmatrix} 0.1249 & 0.2101 & 0.2867 & 0.2034 & 0.1749 \end{pmatrix}$$

$$B_{R4} = W_4 \times R_4 = \begin{pmatrix} 0.1102 & 0.0831 & 0.2119 & 0.5041 & 0.0906 \end{pmatrix}$$

$$B_{R5} = W_5 \times R_5 = \begin{pmatrix} 0.1040 & 0.1050 & 0.1887 & 0.4798 & 0.1226 \end{pmatrix}$$

$$R = \begin{pmatrix} B_{R1} & B_{R2} & B_{R3} & B_{R4} & B_{R5} \end{pmatrix},$$

$$T = W \times R = \begin{pmatrix} 0.1923 & 0.2019 & 0.2056 & 0.2095 & 0.2077 \end{pmatrix}$$

According to the formula, the green construction evaluation score of construction projects is calculated as follows:

$$S = T \times V^T$$

$$= \begin{pmatrix} 0.1923 & 0.2019 & 0.2056 & 0.2095 & 0.2077 \end{pmatrix} \times \begin{pmatrix} 95 & 85 & 75 & 65 & 55 \end{pmatrix}^T = 75.89$$

According to the calculation, the green construction evaluation value of the construction project is 75.89, which is above the medium level, indicating that there is still some room for improvement in the green construction of the construction project. At the same time, the score of rational utilization of resources is 70.915 points, the score of management of construction enterprises is 79.389 points, the score of implementations of construction technology is 74.068 points, the score of input of construction cost is 71.181 points, and the score of impact on environment is 70.880 points.

5. Countermeasures for green construction evaluation of construction projects

5.1 Establish resource conservation standards

Material saving and material resource utilization: reasonably arrange material entry plan and production and processing control, reduce material loss rate, and actively promote and apply the "Four New" plan; Achieve steel loss rate of less than 2.5%; The loss rate of concrete is less than 1.5%, the average turnover of traditional formwork is more than 6 times, and the turnover rate of tool-type standardized equipment is more than 80%. Water-saving and water resources utilization: the allocation ratio of water-saving appliances for domestic use shall reach 90%, and the water consumption per ten thousand yuan of output value shall be controlled within 6t; Land saving and construction land protection: BIM5D technology is used for layout, reasonable optimization of temporary land area, and full use of the original road, site, etc.

5.2 Prepare the green construction plan

Before the enterprise organizes the green construction, that is, the organization prepares the project green construction plan, the construction plan has made the specific description to each work. Green construction plan preparation and construction organization design preparation synchronization, around the "four sections and one environmental protection" to develop green construction measures, at the same time, the application of new technology, new materials were refined.

5.3 Strengthen environmental protection measures

Sound dust control measures, such as: commercial concrete and ready-mixed mortar on site, minimize dust. To prevent water pollution, such as: the construction site sewage discharge to meet

the national standard "sewage comprehensive discharge standard" requirements. Prevent construction noise pollution, such as: the site noise emission shall not exceed the national standard "construction site boundary noise limit" (GB12523-2011) provisions. Limit light pollution measures, such as: during night construction, reasonable adjustment of light irradiation direction, ensure that the site construction surface has enough light conditions, reduce the interference to the surrounding residents.

5.4 Strengthen green construction management

Establish and improve the green construction management system. Set up a green construction leading group with the project manager as the first responsible person and the project management personnel as members. Clear green construction management goal: fully embodies the "green construction" concept, adhere to the office courtyard, overlay facilities standardization, standardization site layout, construction scientific management, work out a clear regularization of the "five" standard, to protect the environment of production site and the surrounding environmental protection, prevent pollution of the environment, beautify the construction environment, saving the resources available.

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