Research on index system of evaluation of Prefabricated Building Industrialization based on BIM Technology

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Abstract. Firstly, this paper analyzes the functions of the BIM platform, comprehensively considers and extracts the required evaluation index of industrial efficiency of prefabricated buildings, and calculates the weight value. Then, the actual case data extracted on BIM platform was applied, and the fuzzy comprehensive evaluation method was used to evaluate the efficiency of the case. Finally, the structure was calculated and analyzed, so as to obtain the impact results of the prefabricated building industrialization efficiency after the application of BIM platform.

1. Instruction
BIM is the key technology and the best platform in the process of industrial development of prefabricated buildings. It can provide coordinated information in the whole life cycle and provide powerful technical support in the prefabricated building system [1]. As soon as possible, therefore, the study and establish the efficient feasible efficiency evaluation system and evaluation method of prefabricated building industrialization, promote the industrialization of prefabricated building based on BIM, realization of BIM in the application of the prefabricated building design, production and construction process, provide prefabricated building industrialization effectively, is the necessary way to development prefabricated building industrialization.

2. Application of BIM in the industrialization of prefabricated building

2.1. Realize information transmission among participants
In order to improve the industrialization efficiency, it is necessary to strengthen the cooperation between participants and the closeness of each link of the life cycle [2], which requires not only the upgrading of management level and working mode, but also the support of information transmission technology. Therefore, the application of BIM completely meets the needs of the industrialization of prefabricated buildings.

Establish a standardized BIM data definition, management and application model for prefabricated buildings [3]; The BIM platform and application software supporting the prefabricated building system are developed to solve the key problems of information transmission in the design, production and construction of prefabricated buildings. The data docking relationship between the BIM platform and each link is shown in Figure 1.
2.2. Diverse models are presented
The application of BIM enables participants to practice closely together, which depends on the diverse presentation of information models [4]. For example, traditional model, web page and client browsing, and flexible presentation are not only the basis for designers, manufacturers, and builders to work together, but also enable investors, users and maintenance personnel to participate in it.

3. Evaluation system of industrial efficiency of prefabricated building

3.1. Establishment of index system
This article through the literature research combined with the reality, and in view of the 25 expert questionnaires, select an evaluation index industrial efficiency of based on BIM, the importance of judgment matrix is obtained by research [5], and the weight of each index is calculated, as shown in figure 3.
3.2. Selection of evaluation methods

In this study, the fuzzy comprehensive evaluation method was selected according to the characteristics of the evaluation objects, and the membership degree of the evaluation results could be obtained by using this method, which met the comprehensive evaluation needs of the evaluation system for quantitative and qualitative indexes [6].

3.3. Evaluation procedure

(1) The factor set is divided into several disjoint subsets and the weight of each factor is determined. The factor-set U is decomposed into s disjoint $u_i$, which is decomposed into p disjoint $u_{i,j}$.

(2) Determine the rating of comments. According to the actual situation of the evaluation, the evaluation level in this paper $V = \{V_1, V_2, V_3, V_4, V_5\} = \{Excellent, Good, Relatively good, Normal, Poor\}$.

(3) A single factor fuzzy comprehensive evaluation was carried out for each $u_i$.

\[
B_i = A_i \cdot R = \left( a_{i,1}, a_{i,2}, \ldots, a_{i,l} \right)^T \cdot \begin{bmatrix}
    r_{i,1,1} & r_{i,1,2} & \cdots & r_{i,1,m} \\
    r_{i,2,1} & r_{i,2,2} & \cdots & r_{i,2,m} \\
    \vdots & \vdots & \ddots & \vdots \\
    r_{i,p,1} & r_{i,p,2} & \cdots & r_{i,p,m}
\end{bmatrix} = \left( b_{i,1}, b_{i,2}, \ldots, b_{i,s} \right) \quad i=1,2,\ldots,s
\]

(4) The fuzzy comprehensive evaluation of U was carried out. $U_i$ was taken as the comprehensive factor and $B_i$ as the single factor evaluation result, and the membership matrix $R$ was obtained [7].

![Figure 3. Index system of industrial efficiency of prefabricated building.](image)
Then the result of the two-level fuzzy comprehensive evaluation is as follows:

\[ B = A \cdot R = (a_1, a_2, \ldots, a_n) \]

4. Application of evaluation index

4.1. Project overview

China Railway No.1 Residential Plot Real Estate Development Project, this project is the A-1 Plot in Licheng District, Caishi Block, developed by China Railway Real Estate Group Jinan Co., Ltd., with a construction area of 102793.39 square meters. The high-rise area consists of 10 residential buildings and underground garage. The work officially started in October 2017.

The 10 residential buildings all adopt the prefabricated shear wall structure system. Each prefabricated component factory is produced in the factory by the prefabricated factory and transported to the construction site for splicing and installation, and the prefabricated assembly rate reaches over 60%. At the same time, the PKPM-BIM platform is used to implant electronic chips into each component, which can dynamically query the whole process information of the component and realize quality traceability.

4.2. The evaluation results

In this study, 10 experts who participated in the survey conducted statistical analysis on the scoring results of this project. The statistical results of frequency P for each comment set of the evaluation index are shown in Table 1.

| Rule layer | Index layer | Excellent | Good | Relatively good | Normal | Poor |
|------------|-------------|-----------|------|----------------|--------|------|
| Design efficiency | Cooperative design | 1 | 7 | 2 | 0 | 0 |
| | Design quality management | 0 | 9 | 1 | 0 | 0 |
| | Degree of standardization | 3 | 6 | 1 | 0 | 0 |
| | Design simplification | 0 | 1 | 6 | 3 | 0 |

**Table 1.** Statistics of expert rating results in the design stage.

Determine the Set of determinate factors, \( U_1 = \{ \text{Cooperative design, Design quality management, Degree of standardization, Design simplification} \} \).

\( u_1 = \{ \text{Cooperative design} \} = \left[ \begin{array}{cccc} \frac{1}{10} & \frac{7}{10} & \frac{2}{10} & 0 & 0 \end{array} \right] ; \)

\( u_1 = \{ \text{Design quality management} \} = \left[ \begin{array}{cccc} 0 & 9 & 1 & 0 & 0 \end{array} \right] ; \)

\( u_1 = \{ \text{Degree of standardization} \} = \left[ \begin{array}{cccc} \frac{3}{10} & \frac{6}{10} & \frac{1}{10} & 0 & 0 \end{array} \right] ; \)

\( u_1 = \{ \text{Design simplification} \} = \left[ \begin{array}{cccc} 0 & 1 & 6 & 3 & 0 \end{array} \right] ; \)
So we get the fuzzy relation matrix \( R_{11} = \begin{bmatrix} 0.1 & 0.7 & 0.2 & 0 & 0 \\ 0 & 0.9 & 0.1 & 0 & 0 \\ 0.3 & 0.6 & 0.1 & 0 & 0 \\ 0 & 0.1 & 0.6 & 0.3 & 0 \end{bmatrix} \)

Determine the weight of the corresponding factors, \( A_{1} = \{0.139, 0.193, 0.419, 0.249\} \), and the Comprehensive evaluation

\[
B_{11} = A_{11} \cdot R_{11} = \begin{bmatrix} 0.1394 & 0.1930 & 0.4188 & 0.2488 \end{bmatrix} \begin{bmatrix} 0.1 & 0.7 & 0.2 & 0 & 0 \\ 0 & 0.9 & 0.1 & 0 & 0 \\ 0.3 & 0.6 & 0.1 & 0 & 0 \\ 0 & 0.1 & 0.6 & 0.3 & 0 \end{bmatrix}
\]

\[
= \begin{bmatrix} 0.1 & 0.7 & 0.2 & 0 & 0 \\ 0 & 0.9 & 0.1 & 0 & 0 \\ 0.3 & 0.6 & 0.1 & 0 & 0 \\ 0 & 0.1 & 0.6 & 0.3 & 0 \end{bmatrix}
\]

\( B_{11} = \{0.140, 0.547, 0.075, 0.000\} \)

Based on the principle of maximum membership degree, the design efficiency of this project is evaluated as good, and the improvement degree of design efficiency is 20%—30%.

5. Conclusion

Through literature review and expert interviews, this paper this paper analyzes the current situation of prefab industrialization based on BIM, reflects the impact factors and indicators of the efficiency evaluation of prefab building industrialization, determines the weight of indicators by AHP, and then evaluates the case by fuzzy comprehensive evaluation method. Verify the effect of evaluation system in order to promote the development of prefabricated building industry and improve the industrial efficiency of prefabricated building.

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