BIM Impact Assessment of Landscape Architecture Design

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Abstract. In order to determine the influence degree of building information model (BIM) on the stage of landscape architecture design, firstly, this paper analyzes the influencing factors of the application of BIM in landscape architecture design based on the theory of balanced score card (BSC), and then establishes the hierarchical evaluation model of BIM influence degree by using analytic hierarchy process (AHP). Finally, realizes the quantitative evaluation of BIM influence degree. The research results show that based on the level evaluation model of BIM influence degree, the transformation from qualitative analysis to quantitative evaluation of BIM application in landscape architecture design stage is realized, which proves the feasibility and practicability of BIM application in landscape architecture design stage.

Keywords: Building information model, Balanced score card, Analytic hierarchy process, Landscape architecture design

1 Introduction
With the advent of the information age, the construction industry is gradually getting rid of the traditional two-dimensional CAD working mode, BIM, as an information and digital means, will have a significant impact on landscape engineering design.

Although there are many achievements in the research of BIM application [1,2], it is necessary not only to study the realization degree and target orientation of BIM application itself, but also to analyze the key factors affecting BIM implementation process [3,4]. There are still many bottlenecks in the effective integration of BIM and landscape architecture engineering design, and there are still many obstacles in the research and application of BIM [5].

Based on the characteristics of landscape architecture engineering, this paper studies the influence degree of BIM in the design stage of landscape architecture engineering, so as to lay a theoretical foundation for the goal oriented application of BIM.
2 Construction of BIM Impact Evaluation Index System Based on BSC in Landscape Architecture Design Stage

2.1 BSC
BSC is a comprehensive performance evaluation system proposed by Robert Kaplan and David Norton in 1992, which takes into account all factors affecting the performance of enterprises [6]. Its core idea is to combine the multi-dimensional factors and evaluate the evaluation content comprehensively.

Based on the basic theoretical framework of BSC, this paper establishes three dimensional conditions for BIM application in landscape architecture design stage, as shown in Figure 1. This lays a theoretical foundation for the analysis of BIM design influencing factors.

![Fig1. Analysis of three dimensions affecting BIM application](image)

2.2 Analysis of Influencing Factors in BIM Design of Landscape Architecture Based on BSC

2.2.1 BIM design objective dimension. (1) Ecological factors. The introduction of ecological principles into landscape architecture design is an inevitable trend in the design stage. Therefore, ecological factors are one of the goals of BIM design. (2) Time factor. Due to the complexity of landscape architecture engineering, the design of drawings based on CAD will face the problems of large quantities, complex engineering technology, etc., which lead to the delay of design time. Therefore, one of the goals of BIM application is to shorten the design time. (3) Economic factors. Because of the huge amount of information in garden construction projects, the design stage is the key period that affects the economic cost. Economy saving is the great value of BIM design.

2.2.2 BIM application time dimension. In order to further clarify the impact of BIM on the design stage, this paper studies the impact of BIM on the three stages of scheme design, preliminary design and construction drawing design.

2.2.3 BIM application point dimension. Collaborative design based on BIM solves many problems in CAD design. In this paper, the main application points of BIM are sorted out and its auxiliary functions are analyzed, as shown in Figure 2.

![Fig2. Auxiliary path of BIM technology to achieve design objectives](image)
2.3 Determination of the Evaluation Index System of BIM Influence Degree in Landscape Architecture Design

The three dimensions of BIM design and influencing factors are transformed into three levels of evaluation indexes, and the BIM impact degree evaluation index system is constructed, as shown in Table 1.

**Table 1. Evaluation index system of BIM influence degree in landscape architecture design stage**

| B-level index | C-level index | D-level index |
|---------------|---------------|---------------|
| Reduce design time B1; Economize economy B2; Ecological design B3 | Scheme design stage C1; Preliminary design stage C2; Construction drawing design stage C3 | Drawing drawing D1; Rendering roaming D2; Collision detection D3; Precise valuation D4; Automatic calculation D5; Building performance simulation D6 |

3 Evaluation of BIM Influence Degree in Landscape Architecture Design Stage Based on AHP

3.1 AHP

There are many qualitative analysis elements in the evaluation content, and AHP can carry out quantitative analysis on qualitative problems. Therefore, this paper uses AHP to realize the quantitative evaluation of BIM impact.

3.2 Quantitative evaluation of BIM impact

3.2.1 The construction of hierarchy evaluation model based on AHP. According to the above analysis of BIM design influencing factors, the three dimensions of the evaluation index system are transformed into three levels of AHP evaluation model, and the hierarchical evaluation model of BIM impact degree evaluation is constructed, as shown in Figure 3.

![Fig3. Hierarchical evaluation model of BIM impact degree](image)

3.2.2 Construct the comparison judgment matrix. By means of questionnaire survey, relevant experts are invited to grade each evaluation index. In this paper, the data of evaluation results are analyzed and sorted out, and the comparison judgment matrix of the two is as follows:
A

\[
\begin{bmatrix}
1 & 1 & 5 \\
1 & 1 & 3 \\
5 & 3 & 1 \\
\end{bmatrix} \quad B_1 = \begin{bmatrix}
1 & 1 & 1 \\
5 & 4 & 1 \\
3 & 4 & 1 \\
\end{bmatrix} \quad B_2 = \begin{bmatrix}
1 & 1 & 1 \\
5 & 4 & 1 \\
3 & 4 & 1 \\
\end{bmatrix} \quad B_3 = \begin{bmatrix}
1 & 1 & 3 \\
5 & 5 & 3 \\
3 & 3 & 1 \\
\end{bmatrix} \quad C_1 = \begin{bmatrix}
1 & 3 & 1 \\
3 & 5 & 1 \\
5 & 5 & 4 \\
\end{bmatrix} \quad C_2 = \begin{bmatrix}
1 & 3 & 5 \\
3 & 5 & 1 \\
1 & 1 & 1 \\
\end{bmatrix} \quad C_3 = \begin{bmatrix}
1 & 3 & 5 \\
3 & 5 & 1 \\
1 & 1 & 1 \\
\end{bmatrix}
\]

3.2.3 Calculate the weight of each index. (1) Normalization calculation is carried out for each judgment matrix, and the results are as follows:

\[
\overline{A} = \begin{bmatrix}
0.4545 & 0.4286 & 0.5556 \\
0.4545 & 0.4286 & 0.3333 \\
0.9100 & 0.1428 & 0.1111 \\
\end{bmatrix} \quad \overline{B}_1 = \begin{bmatrix}
0.1111 & 0.1379 & 0.0625 \\
0.5556 & 0.6897 & 0.7500 \\
0.3333 & 0.1724 & 0.1875 \\
\end{bmatrix} \quad \overline{B}_2 = \begin{bmatrix}
0.1111 & 0.1379 & 0.0625 \\
0.5556 & 0.6897 & 0.7500 \\
0.3333 & 0.1724 & 0.1875 \\
\end{bmatrix} \quad \overline{B}_3 = \begin{bmatrix}
0.1579 & 0.1489 & 0.2143 \\
0.7895 & 0.7447 & 0.2857 \\
0.0526 & 0.1064 & 0.5000 \\
\end{bmatrix} \quad \overline{C}_1 = \begin{bmatrix}
0.1272 & 0.1041 & 0.2000 \\
0.3814 & 0.3126 & 0.2000 \\
0.0254 & 0.0625 & 0.0400 \\
\end{bmatrix} \quad \overline{C}_2 = \begin{bmatrix}
0.0444 & 0.0244 & 0.0828 \\
0.0889 & 0.0488 & 0.0724 \\
0.3111 & 0.2902 & 0.5794 \\
\end{bmatrix} \quad \overline{C}_3 = \begin{bmatrix}
0.3111 & 0.3902 & 0.5794 \\
0.2667 & 0.2439 & 0.0965 \\
0.2667 & 0.2439 & 0.0965 \\
\end{bmatrix} \quad \overline{C}_4 = \begin{bmatrix}
0.2667 & 0.2439 & 0.0965 \\
0.2667 & 0.2439 & 0.0965 \\
0.0222 & 0.0488 & 0.0724 \\
\end{bmatrix}
\]
The consistency matrix is:

\[ C^3 = \begin{bmatrix} 0.0634 & 0.2884 & 0.1667 & 0.0543 & 0.0543 & 0.1538 \\ 0.0127 & 0.0577 & 0.1250 & 0.0761 & 0.0761 & 0.0513 \\ 0.0158 & 0.0192 & 0.0417 & 0.0543 & 0.0543 & 0.0256 \\ 0.4435 & 0.2885 & 0.2917 & 0.3805 & 0.3805 & 0.3590 \\ 0.4435 & 0.2885 & 0.2917 & 0.3805 & 0.3805 & 0.3590 \\ 0.0211 & 0.0577 & 0.0832 & 0.0543 & 0.0543 & 0.0513 \end{bmatrix} \]

(2) Calculate the weight value of single sorting as follows: The sorting weight value of the first level indicator is:

\[ W = [0.4796 \quad 0.4504 \quad 0.1150]^T \]

The weight value of single sorting of secondary indicators is:

\[ W_1 = [0.1038 \quad 0.6651 \quad 0.2311]^T; W_2 = [0.1038 \quad 0.6651 \quad 0.2311]^T; \]

\[ W_3 = [0.1737 \quad 0.6066 \quad 0.2197]^T \]

The weight value of three-level indicator single sorting is:

\[ W_1 = [0.1757 \quad 0.2867 \quad 0.0398 \quad 0.1121 \quad 0.0968 \quad 0.2889]^T; \]

\[ W_2 = [0.0469 \quad 0.0504 \quad 0.5075 \quad 0.1780 \quad 0.1780 \quad 0.0392]^T; \]

\[ W_3 = [0.1301 \quad 0.0665 \quad 0.0351 \quad 0.3573 \quad 0.3573 \quad 0.0537]^T \]

(3) Consistency test. The consistency test results of each judgment matrix are shown in Tab.2:

| Matrix | A | B1 | B2 | B3 | C1 | C2 | C3 |
|--------|---|----|----|----|----|----|----|
| CR     | 0.0280 | 0.0825 | 0.0825 | 0.0624 | 0.0837 | 0.0795 | 0.0875 |

The consistency ratio of all judgment matrices is less than 0.1. Therefore, the data results are true and effective.

(4) Determine the total sorting weight of hierarchy model. According to the above calculation results, the total ranking weight of all indicators is determined, as shown in Figure 4.

\[ \text{BIM impact assessment} \]

| Reduce design time | Economize economy | Ecological design |
|--------------------|-------------------|-------------------|
| 0.4796             | 0.4054            | 0.1150            |

| Scheme design stage | Preliminary design stage | Construction drawing design stage |
|--------------------|--------------------------|-----------------------------------|
| 0.1119             | 0.6583                   | 0.2298                            |

| Drawing drawing | Rendering | Collision detection | Precise valuation | Automatic calculation | Building performance simulation |
|----------------|-----------|---------------------|-------------------|-----------------------|---------------------------------|
| 0.0805         | 0.0805    | 0.342               | 0.217             | 0.210                 | 0.0704                          |

**Fig4.** Weight chart of BIM impact evaluation index

4 Conclusion

(1) BIM has a great influence on the two goals of saving economy and reducing design time. Therefore, the application of BIM is of great help to the projects with high time cost and economic benefit requirements.

(2) BIM has the most obvious impact on the preliminary design, so we should pay attention to the application of BIM in the preliminary design stage.

(3) In the stage of landscape architecture design, "collision detection" has the greatest impact, followed by "precise valuation" and "automatic calculation". “Drawing drawing”, “render
walkthrough”, and “building performance simulation” have a low impact.

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