

Study on Environmental Assessment of the Outdoor Landscape of Chengdu Taikoo Li Commercial Block

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Keywords: block landscape space; environmental assessment; fuzzy analytic hierarchy process.

Abstract: The landscape space of Chengdu Taikoo Li historic district after renovation is the research object of this paper. From the three aspects of landscape node space, path sequence space and overall space, this paper uses the fuzzy analytic hierarchy process to construct a comprehensive evaluation system and evaluates the outdoor landscape environment of this block. The evaluation result is excellent. But the outdoor space still has room to improve in terms of sequence cohesion, the dynamic and static changes of nodes in sequence and the comfort level of landscape facilities in node space.

1. Introduction

With the rapid development of urban construction, the historic commercial blocks in the old city cannot meet the needs of the new era in business, human settlements and citizens' urban life. It is inevitable to change them. Whether the reconstructed historic blocks can take people's needs into account has become the focus of attention. The Taikoo Li commercial block is located in Daci District and built with the Daci Temple scenic spot as its center. It is located in the gap between the Daci Temple scenic spot and the commercial circle of Chunxi Road. The plot is concave toward the Daci Temple; it covers an area of 70800 m², and is connected with the Chunxi Road Business Circle. With an area of more than 250,000 m², the renovated Taikoo Li has retained the style of ancient buildings in Western Sichuan. It is an open and low-density block. The commercial street is a commercial complex that integrates cultural heritage, creative and fashionable urban life and sustainable development, and brings together international luxury brands, fashionable clothing brands and well-known restaurants at home and abroad. Its special surroundings and atmosphere are doomed to be inclusive. From the perspective of feeling, it has won people's praise. However, there is no objective and comprehensive evaluation on such an environment which can explain why the place is excellent. From the perspective of environmental psychology, this paper intends to use the Fuzzy Analytic Hierarchy Process to construct an evaluation index system to objectively evaluate the node space, the path sequence space and overall space of the Taikoo Li, as well as the advantages of the landscape space environment of this block. The paper also establishes a scientific evaluation system for the post occupancy evaluation of historical blocks after reconstruction.

2. Research Methods and Contents

2.1 The analytic hierarchy process

Problems of landscape environmental assessment are listed hierarchically through the "target (T), criterion (C) and index (Cx)" system. All factors at different levels are compared in pairs from the perspective of importance degree. Then a matrix is constructed.^[1] Then, according to the actual situation of the Taikoo Li Commercial District, the content of index layer (Cx) is determined through the expert investigation method (Delphi method).^[2] The consistency of the matrix is tested by comparing the importance of two indexes at each level. The importance of indexes is determined by experts. The consistency test formula is $CR = \frac{\lambda_{\max} - n}{n - 1}$, in which n is the matrix circumference

while λ_{\max} is the maximum of the characteristic root of the matrix. Finally, the YA-AHP software is used to calculate the weights of indexes at all levels; the weight actually refers to the importance of indexes at all levels of the criterion layer.^[3]

2.2 Fuzzy comprehensive evaluation method

Fuzzy comprehensive evaluation method is a kind of evaluation method which transforms qualitative evaluation into quantitative evaluation based on fuzzy mathematics. It is often combined with the analytic hierarchy process.^[4] After establishing the evaluation system and determining the weights of factors in the outdoor landscape environment of Taikoo Li Commercial Block, the evaluation questionnaire is designed with the grades of “excellent, good, medium and poor” for each index. Then the evaluation questionnaires are distributed to pedestrians in Taikoo Li Commercial Block in the form of questionnaire survey. Finally, the evaluation data of each level index are counted, and the fuzzy evaluation matrix of each level is established.

$$R_{Cx} = \begin{Bmatrix} R_{C1} \\ R_{C2} \\ R_{C3} \\ \dots \\ R_{Cx} \end{Bmatrix} = \begin{Bmatrix} R_{C11} & R_{C12} & R_{C13} & \dots & R_{C1X} \\ R_{C21} & R_{C22} & R_{C23} & \dots & R_{C2X} \\ R_{C31} & R_{C32} & R_{C33} & \dots & R_{C3X} \\ \dots & \dots & \dots & \dots & \dots \\ R_{Cx1} & R_{Cx2} & R_{Cx3} & \dots & R_{CxX} \end{Bmatrix}$$

Then multiply with the weight vectors $W = \{W_x\}, (x = 1, 2, 3, \dots, x)$ of each level. By using the cloud computing software of matrix multiplication, the comprehensive evaluation vectors of each level $B = W * R$ are calculated. The comprehensive evaluation vectors are calculated toward the target level. Finally, the comprehensive evaluation vectors correspond to each other should be $B = (\text{excellent, good, medium, poor})$. Then the principle of the membership degree of maximum numerical value is calculated. The largest value of one factor is the located in the evaluation result.

3. Research Results and Analysis

3.1 Determining the index system of the analytic hierarchy process

By analyzing the outdoor landscape environment of Taikoo Li block through the spatial structure of “point-line-surface”, the target layer (T) of the comprehensive evaluation system is “comprehensive evaluation of the outdoor landscape environment of the commercial block”; the criterion layer (C) includes “node space”, “path sequence” and “overall environment”. According to the actual situation of the Taikoo Li Commercial Block, the content of index layer (Cx) is determined through the expert investigation method. Then the evaluation index system is constructed and the weights of each layer are determined (Table 1). When determining the weights of the criterion layer to the target layer, following facts should be considered. Pedestrians have the most cognitive experience in node spaces; most pedestrians do not experience all nodes in the sequence, and it is more difficult to recognize the overall environment. Therefore, the importance of the sequence level is next to that of the node level, and the importance of the overall level is next to that of the sequence level. When determining the weight of the index layer to the corresponding criterion layer, the node space level is dominated by C_{15} attraction and C_{16} comfort, followed by C_{14} activity richness and C_{11} domain sense. The boundary effect and closure are the least important. The sequence space level is dominated by C_{21} , D/H experience, C_{24} landscape facilities distribution on sequence as well as dynamic and static changes, C_{22} virtual and real transformation as well as opening and closing changes on both sides of the path, followed by C_{25} the radiation radius of node distributed on sequence. C_{23} , the change of gray space is the least important. For the overall environmental level, C_{33} , the richness of function and C_{34} , the stimulation of landscape environment to senses are the most important, followed by C_{32} , the richness of culture elements and C_{31} , the openness and closeness of the overall space. The last factors are C_{35} , the restriction of environment

on behavior and C_{36} , the distance of interpersonal communication.

Table 1. Evaluation System and Weight for the Outdoor Landscape Space of Commercial Blocks

target layer	criterion layer	weight	index hierarchy, C_x	weight
Comprehen-sive evaluation on the outdoor landscape space of the commercial block	Node space, C_1	0.6738	Spatial scale and domain sense, C_{11}	0.1214
			Spatial closure, C_{12}	0.0494
			Boundary effect and security sense, C_{13}	0.077
			Human flow density and activity richness, C_{14}	0.219
			Residence time and spatial attractiveness, C_{15}	0.2499
			Distribution density and comfort level of landscape facilities, C_{16}	0.2833
	Path sequence, C_2	0.2255	D/H ratio and path experience, C_{21}	0.2848
			Virtual and real transformation as well as opening and closing changes on both sides of the path, C_{22}	0.1521
			Change of gray spatial distribution on path, C_{23}	0.0933
			Distribution distance of landscape nodes as well as Dynamic and static changes, C_{24}	0.2909
			Changes of nodes with cohesive force on path, C_{25}	0.1789
	Overall environment, C_3	0.1007	Opening and closing of spatial pattern, C_{31}	0.1341
			Richness of cultural images in blocks, C_{32}	0.2027
			Richness of outdoor functional space, C_{33}	0.2895
			Sensory stimulation intensity of landscape facilities, C_{34}	0.2413
			The restriction of environment on behavior, C_{35}	0.0759
			Interpersonal distance, C_{36}	0.0565

Results of the weight consistency test shows, 1) Criteria layer to the target layer: $CR = 0.0825 < 0.1$ 2) Index layer to criteria layer: node space $CR = 0.0647 < 0.1$; sequence space: $CR = 0.0785 < 0.1$; the overall space: $CR = 0.0942 < 0.1$.

3.2 Fuzzy comprehensive evaluation

3.2.1 Establishment of grading standards

On the basis of the established evaluation system and weights for the outdoor landscape space of commercial blocks, the “excellent, good, medium and poor” grading of various indexes are specified (Table 2). Some indexes, such as “cultural image richness of blocks, C_{32} ” are qualitative indexes which cannot be quantified. They are influenced by the subjective feeling of individual pedestrians. The evaluation grades and standards of these indexes are only used as reference. The results are mainly reflected by the form of questionnaire survey and based on the visual evaluation of pedestrians.

Table 2. Grades of Evaluation Indexes and Reference Criteria

Index	Grades of Evaluation and Reference Criteria			
	excellent	good	medium	poor
C ₁₁	D/H≤3	3≤D/H≤4	4≤D/H≤5	D/H≥5
C ₁₂	0.33≤L virtual /L real ≤1, have certain gray spaces and shade angles	0≤L virtual /L real ≤0.33	1≤L virtual /L real ≤3	L virtual / L real ≥3
C ₁₃	There are gray spaces and tea houses at the boundary	There are grays spaces and tea houses at the boundary; these places are well used	There is no grey space or teahouse at the boundary	The boundary area is not utilized.
C ₁₄	Over 4 hours a day, the density of people can reach 4.11 people /100m ²	Over 4 hours a day, the density of people can reach 4.11 people /100m ²	Over 2 hours a day, the density of people can reach 4.11 people. /100m ²	The density of people cannot reach 4.11 people /100m ² over the whole day
C ₁₅	Duration of stay ≥10sec, the area in which residence can happen is 0.3-0.5 times of the place without residence behavior.	Duration of stay ≥10sec, the area in which residence can happen is 0.1-0.3 times of the place without residence behavior.	Duration of stay ≥8sec	Duration of stay ≤8sec
C ₁₆	Distribution density of landscape facilities can reach 8 facilities /100m ²	Distribution density of landscape facilities can reach 5 facilities /100m ²	Distribution density of landscape facilities can reach 3 facilities /100m ²	Distribution density of landscape facilities cannot reach 3 facilities /100m ²
C ₂₁	Continuous D/H changes; the values vary greatly	Continuous D/H changes; the values vary greatly	Continuous D/H changes; the values vary slightly	No continuous D/H changes;
C ₂₂	L virtual /L real ≥0.3;	0.1<L virtual /L real ≤0.3;	0<L virtual /L real ≤0.1;	L virtual /L real =0
C ₂₃	Continuous “D gray /D street” changes; the values vary greatly	Continuous “D gray /D street” changes; the values vary greatly	Continuous “D gray /D street” changes; the values vary slightly	No continuous “D gray /D street” changes
C ₂₄	Nodes distribution between 25m - 80m, with reasonable density and transformation from dynamic to static spaces	Nodes distribution between 25m - 110m, with reasonable density and transformation from dynamic to static spaces	Nodes distribution between 25m - 110m, with reasonable density and a little transformation from dynamic to static spaces	Nodes distribution ≥110m, the density is not reasonable; there is no transformation from dynamic to static spaces
C ₂₅	Number of nodes with radiation radius on sequence ≥5	3≤Number of nodes with radiation radius on sequence < 5	1≤Number of nodes with radiation radius on sequence <3	Number of nodes with radiation radius on sequence<1
C ₃₁	Low density and orderly opening and closing of block space.	Block space is low-density and has certain openness and closeness.	The block space is crowded; the opening and closing degree is general.	Block space congestion; poor opening and closing.
C ₃₂	The block has a rich historical context and is remembered by pedestrians.	The block has a rich historical context.	The block has rich cultural elements.	No memorable historical or cultural elements.
C ₃₃	Business-oriented, with cultural, educational and leisure functions ≥5	3 ≤ Business-oriented, with cultural, educational and leisure functions <5	2≤ Business-oriented, with cultural, educational and leisure functions <3	Only have business function
C ₃₄	Landscape facilities score: 5.0 (best stimulation)	Landscape facilities score: 3.0 - 5.0 (normal stimulation)	Landscape facilities score: 5.0 - 7.0 (excessive stimulation)	Landscape facilities score: less than 3.0 (inadequate stimulation)
C ₃₅	Only weather can constrain behaviors; the constraint is small	Weather and space can constrain behaviors; the constraint is small	Weather and space can constrain behaviors; the constraint is small	Weather and space can constrain behaviors; the constraint is relatively great
C ₃₆	Keeping intimate distance: 0.5 - 1.24m or social distance: 1.24 - 3.72m	Keeping personal distance: 0.5 - 1.24m or social distance: 1.24 - 3.72m	Keeping social distance: 1.24 - 3.72m or public distance: more than 3.72m	Keeping personal distance: 0.5 - 1.24m or public distance: more than 3.72m

3.2.2 Results of spatial evaluation at different levels according to questionnaires

100 evaluation questionnaires are distributed to pedestrians in Taikoo Li District, and 92 valid questionnaires are collected. Finally, the evaluation data of indexes at different levels are collected in the form of percentage (Table 3).

Table 3. Score Statistic for the Questionnaire of Evaluating Spaces at Different Levels in the Taikoo Li Block

criterion layer	index	Number of respondents who chose the item			
		excellent	good	medium	poor
Node space, C_1	Spatial scale and domain sense, C_{11}	59	33	0	0
	Spatial closure, C_{12}	41	51	0	0
	Boundary effect and security sense, C_{13}	66	26	0	0
	Human flow density and activity richness, C_{14}	76	16	0	0
	Residence time and spatial attractiveness, C_{15}	34	58	0	0
	Distribution density and comfort level of landscape facilities, C_{16}	63	29	0	0
Path sequence, C_2	D/H ratio and path experience, C_{21}	40	52	0	0
	Virtual and real transformation as well as opening and closing changes on both sides of the path, C_{22}	71	21	0	0
	Change of gray spatial distribution on path, C_{23}	63	29	0	0
	Distribution distance of landscape nodes as well as Dynamic and static changes, C_{24}	0	0	43	49
	Changes of nodes with cohesive force on path, C_{25}	0	0	60	32
Overall environ-ment, C_3	Opening and closing of spatial pattern, C_{31}	76	16	0	0
	Richness of cultural images in blocks, C_{32}	68	24	0	0
	Richness of outdoor functional space, C_{33}	53	39	0	0
	Sensory stimulation intensity of landscape facilities, C_{34}	75	17	0	0
	The restriction of environment on behavior, C_{35}	58	34	0	0
	Interpersonal distance, C_{36}	20	72	0	0

3.2.3 Evaluation results at all levels

The evaluation vectors of index layer to criterion layer are: node space $B_1 = (0.5518 \ 0.3389 \ 0 \ 0)$, which belongs to the excellent degree; sequence space $B_2 = (0.3059 \ 0.2243 \ 0.2530 \ 0.2168)$, which belongs to the excellent degree; the whole space $B_3 = (0.6849 \ 0.3151 \ 0 \ 0)$, which belongs to the excellent degree. The evaluation vector of criterion level to target level is: outdoor landscape environment $B_t = (0.5098 \ 0.3107 \ 0.0571 \ 0.0489)$, which belongs to the excellent degree.

4. Conclusion

To sum up, this paper establishes a comprehensive evaluation index system of outdoor landscape environment of the Taikoo Li commercial block in Chengdu through the analytic hierarchy process method with the structure of “the target layer, the criterion layer and the index layer”. By calculating the weight of indexes, it is found that the importance of node space is higher than that of the sequence space, while the importance of sequence space is higher than that of the whole space. Secondly, the specific index of each spatial level is optimized. The reference standard of “excellent,

good, medium and poor” is formulated, and the outdoor landscape space of Taikoo Li block is comprehensively evaluated through the method of fuzzy comprehensive evaluation. Finally, the conclusion that the comprehensive evaluation of the outdoor landscape space of Taikoo Li commercial block is “excellent” is drawn, which shows that the reconstructions of the Taikoo Li block are relatively successful. However, there are still some improvements in its space, such as the comfort degree of landscape facilities, as well as the dynamic and static changes of sequences. It is necessary to further optimize the space to meet the needs of users, so as to achieve the purpose of better serving the people.

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