Evaluation on functional Importance of Regional Landscape Elements of Highway

Yuwen Wang¹, Shaobing Pan¹, Xianwei Wei², Haifeng Jiang², Zhiqiang Liu² and Minmin Yuan²*

¹ Guangdong road and bridge construction development co., Ltd. Guangzhou, 510632, China
² Research institute of Highway, MOT, Beijing, 100088, China
* E-mail: ccmmyuan@qq.com

Abstract. Highway regional landscape elements are an important part of highway landscape, which can play an attractive exploration of the unique landscape effect. The infiltration of regional landscape elements of expressway can make drivers and tourists experience the local conditions and customs in the region through which they pass, and also enable the staff of the Department to understand the local economic characteristics and bring business opportunities to the economic development of the region. This paper uses analytic hierarchy process to rank the importance of five regional factors. The results show that representativeness and influence are the two most important factors.

1. Introduction
The multi-factor evaluation decision-making problem has a wide theoretical and practical background [1]. Many methods to solve the multi-factor decision-making problem need information about the weights of factors, so how to determine the weights is one of the keys of evaluation decision-making. At present, there are many methods to determine the weight, such as experience scoring method, two-to-two comparison method, analytic hierarchy process, ratio method, eigenvector method, least square method, principal component analysis method, multi-objective optimization method and so on. In this study, the analytic hierarchy process was used to determine the weight of each factor [2-3].

2. Analytic Hierarchy Process
Analytical Hierarchy Process (AHP) divides various factors in complex problems into interrelated and orderly levels to make them organized. It combines data, expert opinions and analysts' subjective and objective judgments directly and effectively. It quantitatively expresses the relative importance of each level, and then uses mathematical methods to determine the relative important weights of all elements in each level. Analytic Hierarchy Process (AHP) is an effective method to transform semi-qualitative and semi-quantitative problems into quantitative calculation. It can make people's thinking process hierarchical and compare various related factors layer by layer, providing quantitative basis for analysis, prediction, decision-making or control of the development of things [4].

The basic principle of analytic hierarchy process (AHP) is that according to the nature and objective of the problem, according to the interaction of factors and membership relationship, hierarchical clustering and combination, experts can get the combined weights of relative importance order of each factor in the model by calculating the weights of relative importance of each factor synthetically.
according to individual judgment of objective reality. Analytic hierarchy process (AHP) is used to determine the weight of evaluation index. The main steps are as follows [5]:

2.1. Constructing Hierarchical Matrix
On the basis of in-depth analysis of practical problems, the relevant factors are divided into several levels according to different attributes. The factors at the same level are subordinate to the factors at the upper level, and at the same time dominate the factors at the lower level or are affected by the factors at the lower level. The top level is the target level, usually with only one factor [6]. The bottom level is usually the scheme or object level. There can be one or more levels in the middle, usually the criteria or indicators level. When there are too many criteria (e.g. more than 9 criteria), the sub-criteria layer should be further decomposed.

2.2. Constructing Judgment Matrix \( P \)
By comparing the relative importance of each element at the same level with that of the criteria at the upper level, a two-two comparison judgment matrix is constructed [7,8]. It is assumed that there are \( n \) factors influencing the quality of ecological environment, constituting a set 
\[ C = \{ \text{Influences}, \text{Representativeness}, \text{Dissemination}, \text{Identification}, \text{Expressiveness} \} ; \]

According to the hierarchical structure model, two or two comparison judgment matrices are constructed respectively.

\[ A = \left( a_{ij} \right)_{n \times n} . \]

The matrix should satisfy the following conditions:
\[ a_{ij} > 0, \]
\[ a_{ij} = \frac{1}{a_{ji}}, \quad i \neq j, \]
\[ a_{ii} = 1, \quad i = 1, 2, 3, \ldots, n \]

The scale values in Judgment matrix \( A \) are given according to Saaty's scale method of 1-9 and its reciprocal as the measure scale. The scale is shown in Table 1.

| Scale | Meaning |
|-------|---------|
| 1     | Represents two factors that are of equal importance. |
| 3     | The former is slightly more important than the latter. |
| 5     | The former is more important than the latter. |
| 7     | The former is strongly more important than the latter. |
| 9     | The former is extremely more important than the latter. |
| 2, 4, 6, 8 | Representing 1, 3, 5, 7, 9 Neighboring Judgements |
| Reciprocal of value | The latter is more important than the former. |

Table 1. Meaning of Factors in Judgment Matrix

2.3. Ranking importance
According to the judgment matrix, the eigenvector \( w \) corresponding to the maximum eigenvalue \( \lambda_{\text{max}} \) is obtained. The formula is as follows.
\[ P w = \lambda_{\text{max}}. \]
2.4. Consistency test and criteria
Whether the weight distribution obtained above is reasonable or not, we need to check the consistency of the judgment matrix and use the formula.

\[ CR = \frac{CI}{RI} \]

Where

- \( CI \) - Random Consistency Ratio of Judgment Matrix
- \( RI \) - The general consistency index of the judgment matrix is given by the following formula.

\[ CI = \frac{\lambda_{max} - n}{n - 1} \]

\( RI \) is the average random consistency index of judgment matrix. The \( RI \) values of judgment matrices of order 1 to 9 are shown in the table 2 below.

| n  | 1  | 2   | 3    | 4    | 5    | 6    | 7    | 8    | 9    |
|----|----|-----|------|------|------|------|------|------|------|
| RI | 0  | 0   | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 |

When the CR of the judgment matrix \( P \) is less than 0.1 or \( \lambda_{max} = n \), it is considered that the judgment matrix has satisfactory consistency. Otherwise, it is necessary to adjust the elements of the judgment matrix to make it have satisfactory consistency.

3. Importance Recognition
According to the functional characteristics of regional elements, this paper regards influence, representativeness, dissemination, identification and expressiveness as the core basic indicators of regional elements importance identification, uses the analytic hierarchy process to get the evaluation index and its weight, and studies the method of determining the importance of regional elements selection in the process of expressway landscape design.

3.1. Establishing Hierarchical Model
Representativeness, identification, dissemination, influence and expressiveness are the core basic indicators of the importance identification of regional elements. Evaluation structure model is seen in table 3.

| Content                                    | Indicators                  |
|--------------------------------------------|-----------------------------|
| Recognition of the Importance of Regional Elements in Expressway | influences A1               |
|                                            | representativeness A2       |
|                                            | dissemination A3            |
|                                            | identification A4           |
|                                            | expressiveness A5           |

This paper adopts 35 experts scoring method, through comprehensive evaluation of expert questionnaires and factor weight scoring tables, the comparative judgment matrix of evaluation factors at different levels is constructed.

We invite experts from relevant fields to grade and evaluate the five indicators to be evaluated and get the judgment matrix \( A \).
3.2. Importance Recognition
The obtained eigenvector \( w \) is normalized to rank the importance of each evaluation factor.

\[
A = \frac{1}{4} \begin{bmatrix} 1 & 1/2 & 4 & 3 & 3 \\ 2 & 1 & 7 & 5 & 5 \\ 1/3 & 1/5 & 2 & 1 & 1 \\ 1/3 & 1/5 & 3 & 1 & 1 \end{bmatrix}
\]

Therefore, we can get the weight value of evaluation index.

\[
w = \left( 0.261 \ 0.481 \ 0.049 \ 0.099 \ 0.109 \right).
\]

So we can get the result of the weight of index system of regional element importance recognition in table 4.

| Index     | Weight |
|-----------|--------|
| Influences| 0.261  |
| Representativeness | 0.481  |
| Dissemination | 0.049  |
| Identification | 0.099  |
| Expressiveness | 0.109  |

4. Conclusion
As a common spiritual activity, spiritual behavior and spiritual materialized product of local people's life and production, regional elements are transformed into abstract regional elements. It is of great significance for expressway landscape design to incorporate visual expression into landscape upgrading design. In this paper, we use analytic hierarchy process (AHP) to measure the five characteristics of highway to measure the importance of regional elements. Through calculation, representativeness and influence are the two most important characteristics of regional elements.

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