Evaluation of the Garden Road Landscape of the Classical Gardens -- Taking the Classical Gardens in Hangzhou as Example

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Abstract. The garden road is an important element in the garden. Its aesthetic value directly affects the comprehensive value of the whole landscape. In order to explore a better evaluation model and to improve the landscape, the study uses Scenic Beauty Estimation method (referred as SBE method) and multiple linear regression comprehensive analysis to conduct the scenic beauty evaluation of the photographs of the Hangzhou classical garden road landscape. It has extracted 19 landscape elements to analyse and build predictive models. This helped to extract factors that affect the road views, summarize garden road building technologies, including plant arrangement, material selection, form building and other construction techniques, and thus provide a theoretical basis for garden road landscape construction.

1. Introduction
As one of the important elements in the garden, the garden road is called the "blood vessel" of the garden, which plays the role of guiding tourists, connecting scenic spots and dividing regions. Different forms of the road not only can create a variety of landscape, but also can enhance the artistic conception of the garden. At present, the research on classical gardens in China is mainly about plant landscape, spatial pattern, artistic conception and history [1-4], and the evaluation of garden road is rare. The researcher Gulirong [5] etc. have done a lot of investigation on the landscape garden road from the form, function and the pavement, Yangli-xia [6] has analyzed the function structural elements of road from the aesthetic view. This article is mainly used the landscape evaluation method which is recognized as effective method in physical and psychological way to evaluate Hangzhou classical garden road [7], and explore the differences between groups of different professional background, aesthetic taste and the significant factors influencing the garden road aesthetic feeling and aesthetic trend of garden road, so as to provide reference for modern landscape construction road.

2. Research Overview
Hangzhou, located in the northern part of the southeast coast of China, which has an obvious microclimate influenced by mountain and water area, and also has prominent regional characteristics.
As early as the Southern Song Dynasty, there were notes about the classical gardens in Hangzhou [8]. Hangzhou, home of many typical Chinese classical gardens, is deeply influenced by local traditional culture, lifestyle and construction techniques, forming a garden art form rich in local characteristics.

3. Research methods

3.1. Evaluation Photo Selection

In this paper, the object of study of road landscape in the Hangzhou west lake scenic area, Guo's villa, Qu yuan prescribed by ritual law, Hangzhou flower nursery, Lingyin temple, YueWang temple and six typical of Xiling printing society and the biggest tourist classical garden of a comprehensive field investigation. In addition, a total of 1912 photos of road in the classical gardens were taken as the basis for the evaluation of scenic beauty of the park. Exclusion including light, tourists, after repeated interference such as landscape photos, coarse selected about 243 revetment scenery photos, and in ensuring that the selected landscape photos are on the basis of typical significance. In order to avoid sample too big cause the visual fatigue for judge, this study finally select only 89 photos of typical model and used to construct the landscape.

3.2. Scenic beauty evaluation method

SBE method is also called the Scenic Beauty evaluation method, the evaluation results is influenced by the characteristics of landscape and aesthetic dimension of respondents, which is applied in the assessment of landscape as most effective method [9-11]. Various studies have shown that there is no significant difference between on-site and in-house evaluations among different types of evaluators and that there are corresponding provisions regarding the number of photographs, the conditions of the filming method [12]. According to a unified standard, it is ensured that the landscape photographs used are based on the same basis, and the evaluation results based on public opinion have high reliability [13].

Judging the SBE value was taken by Slide [14]. Before judging, make some brief explanations to the judge, not to disclose the details that may affect the judgments. After browsing the photos to the audience again, the official judgments were started and the two films were shown for 10 seconds [15], during the photo scoring, according to the order of playback in the photo beauty rating table corresponding column "√". The scale of the response was 7 points (that is, they were liked, liked, liked, averaged, not liked, disliked, liked very much, and the corresponding scores were 3, 2, 1, 0, -1, -2,-3). In order to reflect the relationship between the evaluation value of landscape beauty and the landscape elements affecting the photos, the landscape factors included in all the evaluation photos are classified and classified, and at the same time, it is ensured that the number of samples is more than 2 times the number of landscape elements [16].

Differences in attitude toward life between judges of different cultural backgrounds were not statistically significant, while the young college students of landscape appreciation tend to show the pursuit of beauty, with little utility [17-18], and different professional students of the same landscape evaluation results are highly consistent [19]. In order to highlight the response to modern garden road landscape visual aesthetic feeling, this study choose undergraduate and graduate students (including professional and non-professional students) as evaluation objects, and parts of teachers and to standardize the evaluation value.

3.3. Landscape factor decomposition

According to the aesthetic characteristics of the park, 19 landscape elements that affect the beauty of the park are extracted and the landscape elements are divided into different categories according to the same standard. In class decomposition, landscape information contained in each park landscape image should be taken into full consideration to ensure that all the landscape photos participating in the assessment have the landscape information and should ensure that the number of samples is greater than two times the number of landscape elements.
Table 1. Elements decomposition of roadscape revetment

| Number | Element                          | Category | Category | Category | Number |
|--------|---------------------------------|----------|----------|----------|--------|
|        |                                 | 1        | 2        | 3        | 4      |
| X1     | Plant color                      | 1        | 2        | 3        | >3     | 4      |
| X2     | Vegetation contrast              | obvious  | unconspicuous |         |        |
| X3     | Plant Storey                     | 1        | 2        | 3        | 4      | 4      |
| X4     | Plant Shape                      | Developing type | Convergent type |        |        |
| X5     | Plant Coverage                   | <0.4     | 0.4~0.6  | 0.6~0.8  | >0.8   | 4      |
| X6     | Plant Space                      | <1/3     | 1/3~2/3  | >2/3     |        | 3      |
| X7     | Road Width                       | 0.6~0.8  | 0.8~1.2  | ≥1.2     |        | 3      |
| X8     | Road Form                        | Straight | Curvy    | Inharmonious |        |
| X9     | Furniture                        | None     | Exist    | Harmonious |        |
| X10    | Road Fence                       | None     | Exist    | Harmonious |        |
| X11    | Vision Depth                     | Shallow  | Medium   | Deep     |        | 3      |
| X12    | Vision Area                      | Broad    | Narrow and undirected | Narrow and directed |        |
| X13    | Paving Combination               | 1        | 2        | ≥3       |        | 3      |
| X14    | Paving Material                  | Brick    | Stone    | Wood     | mix    | 4      |
| X15    | Paving Color                     | Light    | Medium   | Dark     |        | 3      |
| X16    | Paving Type                      | Block    | Medium   | Patch    |        | 3      |
| X17    | Overall Coordination             | Well     | Medium   | Inharmonious |        |
| X18    | Wild Degree                      | Urbanization | Normal | Rustic  |        | 3      |
| X19    | Highest Branch                   | <1.2     | 1.2~2    | 2~3      | ≥3     | 4      |

3.4. Data processing and modeling

There are certain differences in the aesthetic scale between different judges. In order to eliminate or reduce this difference, the aesthetic value of the judgement is standardized [19].

\[ Z_{ij} = \frac{(R_{ij} - R_j)}{S_j} \]

In the formula, \( Z_{ij} \) is the normalized value (referred to as standardized value) of the scenic value of the landscape i by the judge j, \( R_{ij} \) is the scenic value of the j judge on the i landscape, \( R_j \) is the j judge's average, \( S_j \) is the standard deviation of the scenic value of the j judge on a certain type of landscape.

A total of 100 evaluators were issued with a total of 100 evaluation response tables, and eight invalid tables were removed. The effective response table was 92 and the effective recovery rate was 92%. The invalid reaction table is mainly manifested as the following characteristics: (1) For a class of obvious difference, the value of landscape response is the same, that is, the standard deviation of the landscape is equal to zero. (2) Repeated evaluation appeared in the evaluation. (3) The evaluation was less than the actual number of photos.

Standardizing the response values of each landscape photograph, computing the average, getting the beauty of each picture. Based on the values of the scenic beauty of each photo as the dependent variable, the model was established by "multiple linear regression" to explore the relationship between the scenic beauty of the garden road and the elements. In the process of modeling, some less important...
factors are gradually eliminated, and the factors that contribute more are retained as independent variables of various landscape models. In modeling process, fully consider the multiple linear relationship between the independent variables, try to make the model variables have good independence, give priority to retain accountability and interpretability good factor, try to reduce the number of modeling factors. Finally, the larger contribution to the dependent variable factor is preserved, as a landscape model of the independent variable, to establish evaluation model, and using the R2 test, F test, t test of regression model to test to verify the validity of the regression model.

4. Results and Analysis

4.1. Beauty degree evaluation result
To survey 100 evaluators, received 100 valid questionnaire responses received. The data was standardized to obtain the beauty of each landscape photograph. The evaluation results are shown in Table 2.

| Serial number | SBE | Serial number | SBE | Serial number | SBE | Serial number | SBE | Serial number | SBE | Serial number | SBE |
|---------------|-----|---------------|-----|---------------|-----|---------------|-----|---------------|-----|---------------|-----|
| 1             | 0.328| 13            | 0.377| 25            | 0.604| 37            | -   | 0.024| 49            | 0.395| 61            | -   | 0.110| 73            | 0.055|
| 2             | 0.201| 14            | -   | 0.367| 26            | 0.545| 38            | -   | 0.339| 50            | -   | 0.260| 62            | 0.508| 74            | 0.147|
| 3             | 0.119| 15            | -   | 0.195| 27            | 0.256| 39            | -   | 0.386| 51            | -   | 0.284| 63            | -   | 0.310| 75            | 0.059|
| 4             | 0.231| 16            | 0.209| 28            | 0.021| 40            | 0.202| 52            | -   | 0.556| 64            | -   | 0.100| 76            | 0.121|
| 5             | -   | 0.302| 17            | -   | 0.104| 29            | -   | 0.272| 41            | -   | 0.582| 53            | -   | 0.415| 65            | 0.036| 77            | -   |
| 6             | -   | 0.357| 18            | -   | 0.165| 30            | -   | 0.297| 42            | -   | 0.131| 54            | -   | 0.046| 66            | 0.530| 78            | -   | 0.308|
| 7             | 0.081| 19            | 0.294| 31            | 0.170| 43            | 0.875| 55            | 0.139| 67            | 0.444| 79            | -   | 0.653| |
| 8             | -   | 0.147| 20            | 0.418| 32            | -   | 0.099| 44            | 0.681| 56            | 0.057| 68            | -   | 0.101| 80            | -   | 0.257|
| 9             | -   | 0.387| 21            | 0.263| 33            | 0.189| 45            | 0.135| 57            | -   | 0.551| 69            | -   | 0.282| 81            | -   | 0.030|
| 10            | 0.089| 22            | 0.188| 34            | 0.642| 46            | -   | 0.188| 58            | 0.442| 70            | 0.407| |
| 11            | 0.021| 23            | 0.143| 35            | 0.670| 47            | -   | 0.495| 59            | -   | 0.188| 71            | -   | 0.332| |
| 12            | 0.318| 24            | 0.204| 36            | 0.534| 48            | 0.006| 60            | -   | 0.016| 72            | 0.119| |

Using multiple linear regression modeling, the author first performed 7 operations on the selected 19 projects. According to the results of the operation, the T-test was performed on the partial correlation coefficients. The items with insignificant differences and partial correlation coefficients were removed, and then the remaining items were left. The next category continues to operate, and so on. The result of the operation is as follows (Table 3).

4.2. Landscape model establishment
The 19 decomposition elements are modeled by multivariate linear regression. Finally screening 13 landscape elements as Plant color number, Plant level, Plant shape, Road width, Road form, Vegetation space share road form, Furniture and vision scope, Combination of pavement, Pavement material branch, Overall coordination, Open degree, and the Highest branch as factors influencing the comprehensive beauty of landscape garden road modeling. The model is:
\[ SBE = -0.687 - 0.129X_{11} - 0.01X_{12} + 0.036X_{14} + 0.594X_{31} - 0.038X_{34} + 0.018X_{44} - 0.06X_{42} + 0.11X_{61} + 0.038X_{62} - 0.109X_{71} + 0.019X_{73} - 0.253X_{15} - 0.084X_{32} - 0.132X_{34} + 0.114X_{42} + 0.059X_{93} - 0.003X_{12} + 0.09X_{12} + 0.067X_{13} + 0.014X_{133} - 0.084X_{14} - 0.043X_{43} - 0.008X_{44} + 0.621X_{71} + 0.32X_{72} + 0.292X_{133} + 0.045X_{141} + 0.061X_{152} + 0.15X_{181} - 0.06X_{193} + 0.052X_{194} \]

### Table 3. Comprehensive evaluation modeling result of roadscape revetment

| Item Number | First operation | Second operation | Third operation | Fourth operation | Fifth operation | Sixth operation | Seventh operation |
|-------------|-----------------|------------------|----------------|-----------------|----------------|-----------------|-------------------|
| X1          | 0.065           | 0.508            | 0.075          | 0.594           | 0.077          | 0.610           | 0.077             | 0.647           | 0.078          | 0.673           | 0.072          | 0.630           | 0.072             | 0.583           | 0.072             | 0.594           |
| X2          | -0.28           | 0.215            | -0.028         | 0.224           | -0.031         | 0.244           | -0.031           | 0.247           | -0.031         | 0.251           |
| X3          | 0.337           | 0.347            | 0.2918         | 0.347           | 0.348          | 0.2971          | 0.349             | 3.000           | 0.351          | 3.049           | 0.362          | 3.176           |
| X4          | 0.127           | 0.127            | 0.099          | 0.126           | 0.124          | 0.1060          | 0.122             | 0.991           | 0.122          | 0.996           | 0.122          | 1.005           |
| X5          | 0.022           | 0.022            | 0.022          | 0.022           | 0.022          | 0.022           |                  |                | 0.022          | 0.022           | 0.022          | 0.022           |
| X6          | 0.048           | 0.048            | 0.381          | 0.052           | 0.412          | 0.064           | 0.515             | 0.066           | 0.530          | 0.063           | 0.515          | 0.067           | 0.550           |
| X7          | 0.202           | 1.608            | 0.213          | 0.171           | 0.216          | 1.753           | 0.215             | 1.794           | 0.217          | 1.805           | 0.228          | 1.920           |
| X8          | 0.238           | 1.917            | 0.238          | 1.933           | 0.238          | 1.947           | 0.242             | 1.993           | 0.243          | 2.023           | 0.247          | 2.068           | 0.247             | 2.084           |
| X9          | 0.191           | 1.521            | 0.191          | 1.533           | 0.200          | 1.621           | 0.200             | 1.630           | 0.200          | 1.645           | 0.199          | 1.654           | 0.199             | 1.664           |
| X10         | 0.035           | 0.272            | 0.035          | 0.274           | 0.031          | 0.242           | 0.025             | 0.209           |                  |                |                |                |
| X11         | -0.024          | -0.180           | -0.024         | -0.192          | -0.025         | -0.198          |                  |                |                |                |                |
| X12         | 0.071           | 0.603            | 0.078          | 0.618           | 0.076          | 0.605           | 0.075             | 0.599           | 0.076          | 0.615           | 0.077          | 0.624           | 0.081             | 0.688           |
| X13         | -0.156          | 1.234            | -0.167         | 1.330           | -0.166         | 1.337           | -0.166             | 1.349           | -0.165         | 1.352           | -0.166         | 1.371           | -0.170             | 1.413           |
| X14         | 0.125           | 0.981            | 0.127          | 1.005           | 0.127          | 1.012           | 0.124             | 1.000           | 0.126          | 1.024           | 0.127          | 1.041           | 0.135             | 1.115           |
| X15         | 0.024           | 0.185            | 0.024          | 0.193           | 0.027          | 0.211           | 0.039             | 0.310           | 0.037          | 0.300           | 0.032          | 0.259           |
| X16         | 0.000           | 0.002            |                  |                |                |                |                  |                |                |                |                |
| X17         | 0.233           | 1.870            | 0.233          | 1.886           | 0.232          | 1.893           | 0.235             | 1.933           | 0.244          | 2.026           | 0.242          | 2.025           | 0.240             | 2.023           |
| X18         | 0.135           | 1.065            | 0.135          | 1.074           | 0.136          | 1.098           | 0.134             | 1.086           | 0.133          | 1.081           | 0.141          | 1.158           | 0.142             | 1.175           |
| X19         | 0.327           | 2.703            | 0.327          | 2.725           | 0.330          | 2.773           | 0.332             | 2.815           | 0.335          | 2.866           | 0.336          | 2.899           | 0.344             | 2.999           |

### Table 4. Overview evaluation model of Chinese classical garden revetment landscape

| Model | R    | R²   | Adjust R² | Standard estimation error |
|-------|------|------|-----------|---------------------------|
| 1     | .724a| .524 | .223      | .321                      |

### Table 5. Variance analysis of Chinese classical garden revetment landscape evaluation model

| Model | Quadratic sum | df | Mean square | F   | Sig. |
|-------|----------------|----|-------------|-----|------|
| Regression | 5.543          | 31 | .179        | 1.739 | .041a|
| Residual  | 5.038          | 49 | .103        |       |
| Total    | 10.591         | 80 |             |       |

As can be seen from Table 4, the complex correlation coefficient R of this model is 0.724, indicating that the linear relationship between the landscape factor and the predictor of preference value in this model is relatively strong. The established regression prediction model Better. The residual variance S2 value is 0.103, indicating that this model has a very high prediction accuracy; from the analysis of variance table 5, it can be seen that the calculated F=1.739, the corresponding p<0.05, and the t-test of the complex correlation coefficient R is performed. The probability of regression model is 0.041, less than the significance level of 0.05, it means that the analysis of the linear model is established, indicating that the model of these landscape categories and preference values have a significant correlation between the linear model can be established. Therefore, this model can be used as a prediction model for the landscape beauty of classical garden roads.
4.3. Landscape model results analysis

Table 6. Various category scores of Chinese classical garden revetment landscape evaluation model

| Item  | Category | Coefficient value | Range | Contribution rate % |
|-------|----------|-------------------|-------|---------------------|
| X1    | 1        | -0.129            | 0.119 | 5.7                 |
|       | 2        | 0                 | 0.119 |                      |
|       | 3        | -0.01             | 0.119 |                      |
|       | 4        | 0.036             | 0.119 |                      |
|       | 1        | 0.594             | 0.119 |                      |
| X3    | 2        | 0                 | 0.632 | 30.3                |
|       | 3        | -0.038            | 0.632 |                      |
|       | 4        | 0.018             | 0.632 |                      |
| X4    | 1        | 0                 | 0.06  | 2.9                 |
|       | 2        | -0.06             | 0.06  |                      |
|       | 1        | 0.11              | 0.06  |                      |
| X6    | 2        | 0.038             | 0.148 | 7.1                 |
|       | 3        | 0                 | 0.148 |                      |
|       | 1        | -0.109            | 0.148 |                      |
| X7    | 2        | 0                 | 0.128 | 6.1                 |
|       | 3        | 0.019             | 0.128 |                      |
|       | 1        | -0.253            | 0.128 |                      |
| X8    | 2        | -0.084            | 0.169 | 8.1                 |
|       | 3        | -0.132            | 0.169 |                      |
| X9    | 2        | 0.114             | 0.055 | 2.6                 |
|       | 3        | 0.059             | 0.055 |                      |
|       | 1        | -0.003            | 0.055 |                      |
| X12   | 2        | 0.09              | 0.093 | 4.5                 |
|       | 3        | 0                 | 0.093 |                      |
|       | 1        | 0.067             | 0.093 |                      |
| X13   | 2        | 0                 | 0.053 | 2.5                 |
|       | 3        | 0.014             | 0.053 |                      |
|       | 1        | -0.084            | 0.053 |                      |
| X14   | 2        | 0                 | 0.076 | 3.6                 |
|       | 3        | -0.043            | 0.076 |                      |
|       | 4        | -0.008            | 0.076 |                      |
|       | 1        | 0.621             | 0.076 |                      |
| X17   | 2        | 0.32              | 0.329 | 15.8                |
|       | 3        | 0.292             | 0.329 |                      |
|       | 1        | 0.045             | 0.329 |                      |
| X18   | 2        | 0.061             | 0.016 | 0.8                 |
|       | 3        | 0                 | 0.016 |                      |
|       | 1        | 0.15              | 0.016 |                      |
|       | 2        | 0                 | 0.016 |                      |
| X19   | 3        | -0.06             | 0.21  | 10                  |
|       | 4        | 0.052             | 0.21  |                      |

The following rules can be seen from the comparison of the regression coefficients of various categories: (1) as for the color quantity of plants in garden plants, the judges have a preference of three or more plants for three or more plants. (2) The plants with abundant planting level, coronal development and small space occupancy can effectively improve the scenic beauty of the road. (3) The cultivation of plants on both sides of the road will create a certain local field of interest which can increase the perception of the beauty of the garden path. (4) The higher the branching degree of woody plants on both sides of the garden road, the more it can improve the scenic beauty of the road. (5) The
general preference of tourists has a certain curve and is suitable for people's road form. (6) The narrow and unguided garden path can stimulate the curiosity of visitors, and can enhance the scenic beauty of the road. (7) The proximity of the original wood to the wood and the overall environment of the road can also affect the beauty of the road. From the model under the same project class purpose regression coefficient of the floating range, and the contribution percentage can be seen in the model of the project: plant level on the classical garden road landscape contribution is the largest, up to 30.3%. The other elements sort by contribution, respectively: Overall Coordination, Highest Branch, Road Form, Plant Space, Road Width, Plant color, Vision Area, Paving Materials, Plant Shape, Furniture, Paving Combination, Wild Degree. Among them, the contribution rate of the overall Coordination and the highest branch was more than 10.0%.

5. Conclusion and Discussion
The author uses the beauty degree judgment method to evaluate the beautiful scenery of Hangzhou Xihu Classical Garden Road landscape, comprehensive evaluation and analysis of multiple quantitative methods, and establish a prediction model of landscape beauty of the garden road. The results show:

(1) Using the SBE method to evaluate the beauty of the landscape of Chinese classical garden gardens and construct a scenic beauty model, the prediction equation is:

\[
SBE = -0.687 - 0.129X_{11} - 0.01X_{13} + 0.036X_{14} + 0.594X_{31} - 0.038X_{33} + 0.018X_{34} - 0.06X_{42} + 0.11X_{51} + 0.038X_{62} - 0.109X_{71} + 0.019X_{73} - 0.253X_{81} - 0.084X_{82} - 0.132X_{93} + 0.114X_{94} + 0.059X_{95} - 0.003X_{121} + 0.09X_{122} + 0.067X_{131} + 0.014X_{133} - 0.084X_{141} - 0.043X_{143} - 0.008X_{144} + 0.621X_{171} + 0.32X_{172} + 0.292X_{173} + 0.045X_{181} + 0.061X_{182} + 0.15X_{191} - 0.06X_{193} + 0.052X_{194}
\]

(2) Plant Storey, Plant color, Plant Shape, Plant Space, Road Width, Road Form, Furniture, Vision Area, Paving Combination, Paving Material, Wild Degree, Overall Coordination, Highest Branch, the 13 factors can be used as the leading factor influencing the comprehensive beauty of Chinese classical garden landscape. In the modern landscape garden road landscape design should first consider the morphological characteristics of plants, seed selection and tall and straight trunk clear tree based on plant landscape of native tree species are chosen as more as possible, pay attention to protect local biodiversity. It is necessary to take into account the coordination of plant landscape and garden road environment and the factors that directly influence landscape beauty of garden path, such as plant color, canopy and vegetation space occupancy. Garden road in the form of design also is particularly important, spacious clean avenue can bring the feeling of bright and clean, zigzag path of deep, have artistic conception can cause the curiosity of tourists, all for landscape garden road. In the selection of the paving form of garden road, the choice of natural tile can enhance the artistic conception and charm of the landscape, so that visitors can feel the ancient and ancient colors of classical gardens during the tour. Meanwhile, the roadside placement of writing facilities can also increase the landscape quality of the landscape.

(3) Scenic beauty evaluation method is very important to optimize landscape quality. Through the sample evaluation study of classical garden landscape garden road to provide theoretical basis for the modern garden landscape garden road construction has a certain practical significance, but still need to make more wide range of sampling investigation and study, make the evaluation results more reasonable. As a whole, the landscape of garden road cannot be fully reflected by individual independent landscape factors, and the combination of factors can not be fully quantified. The evaluation of scenic beauty has higher requirements on the selection of landscape factors, and it should pay special attention to the selection of landscape factors and the rationality of the mutual quantitative combination in the evaluation study.
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