Application of Electric Energy Saving Light Source and Light Emitting Diode in the Landscape of Buildings under Optical Spectroscopy Theory

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Abstract. How to reflect energy conservation and environmental protection in the landscape of high-rise buildings is a hot topic of current research. How to use environmentally friendly materials to show the charm of high-rise building landscape is the main content of this article. Based on the colour samples of the high-rise building landscape, the thesis uses environmental protection and energy-saving light sources to simulate the lighting of the building colour samples in the laboratory. This article realizes the quantitative research on the colour authenticity performance of colour paintings under commonly used LEDs in high-rise building landscapes, and provides a reliable basis for the selection of LEDs in colour painting lighting design.

Keywords: Green environmental protection, energy-saving materials, energy-saving light source materials, high-rise building landscape.

1. Introduction
In the context of rapid social and economic development, people's living standards are constantly improving, and higher requirements are placed on urban gardens and landscapes. In order to meet people's requirements, designers introduced lighting control systems in the garden landscape, embellished the garden environment, and made the garden landscape more beautiful [1]. This article is supported by the National Natural Science Foundation of China project "Quantitative Research on Colour and Light Emotion in Artificial Light Environment". By simulating typical light sources of landscape lighting under laboratory conditions, colour light lighting simulation experiments are carried out on typical high-rise building colour cases, and the case studies Subjective evaluation and scientific analysis of the application effect of shades are carried out, so as to obtain preliminary conclusions based on the emotional expression of shades of architectural colours.

2. The effect of traditional light source spectrum on landscape objects
When designing landscape lighting, it is necessary to deeply understand the colour of the light source and the colour of the object, so that the effect of the lighting design can be estimated in the early stage [2]. For architectural landscape lighting, high-pressure sodium lamps, metal halide lamps, LEDs and other light sources are usually used, while some low-power light sources with monochromatic spectrum are mostly used as landscape decorations.
The so-called light source colour refers to the colour of the light source itself, which is usually described by a colour table or colour temperature. The so-called object colour refers to the colour emitted by light shining on the object. In daily applications, the colour of the object under natural light (daylight) is usually used as the standard, which is called the inherent colour. The effect of landscape lighting is determined by the colour of the light source and the colour of the object. Due to the phenomenon of metamersim, the use of intuitive colour description will still be biased [3]. A more accurate description or representation is to use its corresponding spectrum. The interaction of the spectrum directly affects the effect of the lighting design. Figure 1 shows the colour of the daylight source and the corresponding spectral reflectance curve of a certain object.

Different buildings or landscapes have very different surface materials and their spectral reflectance curves are also different. In order to conduct spectral research, a sample of objects (green spectral reflectance curve) is selected as the research object. Natural light spectrum, as well as typical high-pressure sodium lamp, metal halide lamp, LED light source spectrum and various monochromatic spectrum light sources are used as illumination light sources, among which metal halide lamps and LED light sources are all white light sources.

3. Interaction between monochromatic spectrum and landscape

Monochromatic light usually refers to a light source with a smaller full width at half maximum and higher saturation. In architectural landscape lighting design, monochromatic light is usually used as auxiliary lighting. Designers need to pay attention to the application scene and atmosphere. Reasonable application of colour light sources can play a role in contrasting the atmosphere, on the contrary, unreasonable application will cause distortion of the display of the architectural landscape, and the effect will be poor. Figure 2 shows the spectrum of the monochromatic light reflected from the corresponding object. It can be seen from the figure that the spectrum of the monochromatic light is relatively narrow. When the monochromatic light interacts with objects in the architectural landscape, it is also in a narrow range of wavelengths [4]. Figure 3 shows the colour of the monochromatic light source and the corresponding light source illuminating the object colour. It can be seen from the figure that the object colour of the architectural landscape object illuminated by the monochromatic light is very close to the light source colour of the monochromatic light, which makes the building There is a huge difference between the display form of the landscape and the display under natural light, and it cannot truly show the essential characteristics of the landscape. Only monochromatic light is used in the architectural...
landscape, and the architectural landscape can only be displayed as the light source colour, which cannot give people a good visual experience. The reproduction effect is poor, therefore, the monochromatic light can only be used as auxiliary light in the lighting of the architectural landscape, and it can also be used when reshaping the landscape.

Figure 2. Monochromatic spectrum light source and the reflected spectrum of the object

Figure 3. Monochromatic light source colour and light source illuminating object colour

4. The influence of the spectral reflectance curve of landscape objects

By setting the change of the spectral reflection curve of the landscape object, the colour change law of the object after the light source is illuminated is studied. From the object's spectral reflectance curve to the iso-energy spectral reflectance curve, five gradually changing spectral reflectance curves are set respectively. Spectral reflectance curve 1, 2, 3, 4, 5 chromaticity and the corresponding chromaticity change under traditional light source illumination. When the spectral reflectance curve is an equal energy spectral reflectance curve, the colour of the object under the illumination of the light source is consistent with the colour of the light source. When the spectral reflectance curve gradually changes more and more, the interaction between the light source spectrum and the object becomes more obvious [5]. Due to the yellowish light colour of the high-pressure sodium lamp, the corresponding object colour
is in the yellowish area after its interaction with the landscape; while the white light metal halide lamp and LED illumination, the corresponding object colour is relatively close to the reference chromaticity.

5. Calculation and analysis of colour shift threshold of high-rise building colour painting

5.1. Threshold definition

"Suprathreshold sensation" uses a psychological scale to measure the quantitative relationship between a change in a stimulus and the psychological change it causes. For the "sensation threshold" threshold, it can be divided into two categories: one is the absolute sensory threshold, which is used to measure the minimum stimulus that can just cause detection; the other is the difference threshold, which is used to measure the difference that can just cause the difference [6]. The smallest amount of difference felt. In the experiment, due to more or less changes in the surrounding environment, the subject’s physical and mental conditions, etc., the measured sensory threshold is not a single value, but multiple stimuli of different intensities. In order to accurately define the threshold limit, people define the threshold limit as follows: For an absolute threshold, it is defined as the stimulus that 50% of the times can cause sensation and 50% of the times cannot cause the sensation; for the difference threshold, it is defined as 50% of the times can cause different sensations, and 50% of the times cannot cause different sensations. The threshold is determined by defining 50% of the stimulus, which is called the operational definition of the threshold.

5.2. Threshold calculation method

According to the operational definition of the threshold, it is known that the threshold is the magnitude of the stimulus caused by 50% of the times. However, in actual operation, it is difficult to have a stimulus whose judgment times are exactly 50%. Therefore, two judgment times closest to 50% are generally used for calculations based on mathematical linear interpolation.

In 1949, Coran first proposed the straight-line interpolation method, which effectively transformed the nonlinear programming problem with constraints into unconstrained programming problems. For nonlinear programming

$$\min f(x)$$

$$s.t. \begin{cases} c_i(x) = 0, \; i = 1, 2, \ldots, m \\ c_j(x) \leq 0, \; j = m + 1, \ldots, n \end{cases}$$

(1)

The linear interpolation function is defined as:

$$p(x) = \sum_{j=m+1}^{n} \max\left\{ 0, c_j(x) \right\}^\alpha + \sum_{i=1}^{m} |c_i(x)|^\beta$$

(2)

Among them, $\alpha, \beta > 0$. The corresponding penalty optimization problem (FP) is

$$\min f + ap(x)$$

$$s.t. \; x \in R^n$$

(3)

Where $\alpha > 0$ is the penalty parameter. Let (FP) be $p(x, \alpha)$, we can know by analysis: For a sufficiently large $\alpha$, the optimal solution $x(\alpha)$ of the problem $p(x, \alpha)$ belongs to the feasible region of the original problem (NP), then for any feasible point $\bar{x}$ of the problem (NP), we have:
\[ f(x(\alpha)) = p(x(\alpha), \alpha) = \min_{x \in \mathbb{R}^n} p(x, \alpha) \leq p(\bar{x}, \alpha) = f(\bar{x}) \]  

(4)

Through this equation, we find that as long as we choose a larger \( \alpha \), we can find the optimal solution to the constrained optimization problem by solving an unconstrained optimization problem. However, in actual calculations, it is difficult to determine the appropriate size of \( \alpha \), so it is usually to select a monotonically increasing penalty parameter sequence \( \{\alpha_k\} \), and find the optimal solution to the constrained optimization problem by solving a series of unconstrained optimization problems. This is the origin of the name SUMT.

In order to ensure the convergence of the linear interpolation function, \( \alpha_k \to \infty \) is required. However, when the value of \( \alpha_k \) is large, solving the unconstrained minimum value of the penalty function often becomes very difficult, because the Hessian matrix of the penalty function will show ill-conditioned characteristics as \( \alpha_k \) increases. In order to overcome this morbidity, we usually use the following two methods:

One is to appropriately select or determine the way \( \alpha_k \) changes. In order to strike a balance between the convergence of the algorithm and the exact solution. Empirically, we can set \( \alpha_i = 1 \) or \( \alpha_i = \max(10^{-2}, |f^*|/100) \), where \( f^* \) is an estimate of the constrained minimum, and then make \( \alpha_k \) increase by a constant multiple of \( c \). The usual method of \( c \) is \( \sqrt[3]{10} \), 4 or 10. In order to accelerate the convergence of the penalty function method, the so-called extrapolation technique is very effective. In 1990, Fiacco and McCormick proposed: In the exterior point function method, given a value of the penalty parameter \( \alpha = 1/r \), the unconstrained minimum point of \( p(x, 1/r) \) can be obtained, so the minimum point can be regarded as \( \alpha \) or equivalent \( r \). The function of, remember \( x(1/r) = x(1/r) \). When \( r \to 0 \), \( x(1/r) \) tends to the optimal solution of the constraint problem.

5.3. Calculation of Colour Shift Threshold for Colour Painting

According to the setting of the subjective evaluation test questionnaire, "colour shift is particularly not obvious" is -3 points, "colour shift is not obvious" is -2 points, "colour shift is less obvious" is -1 points, "colour shift is normal" is 0 points, "colour shift is obvious" is 1 point, "colour shift is particularly obvious" is 2 points, and "colour shift is particularly obvious" is 3 points. When the subjective evaluation score is \( \geq 1 \), the 50% threshold value obtained is the threshold value of the colour shift of the colour painting. The calculation results are shown in Table 1.

| Frequency/ (score percentage %) | 4/91.252 | 9/175.379 | 13/205.571 | 20/218.603 |
|--------------------------------|----------|-----------|-----------|-----------|
| -3                             | 0(0)     | 0(0)      | 0(0)      | 0(0)      |
| -2                             | 0(0)     | 0(0)      | 0(0)      | 0(0)      |
| -1                             | 3(15)    | 1(5)      | 0(0)      | 0(0)      |
| 0                              | 12(60)   | 6(30)     | 4(20)     | 2(10)     |
| 1                              | 3(15)    | 7(35)     | 7(35)     | 4(20)     |
| 2                              | 2(10)    | 6(30)     | 8(40)     | 9(45)     |
| 3                              | 0(0)     | 0(0)      | 0(0)      | 5(25)     |
| Percent \( \geq 1 \) (%)       | 25        | 65        | 75        | 90        |
According to whether the colour difference corresponding to each parameter LED is below the threshold limit, the applicable range of power and colour temperature is divided, and the results after screening are summarized. The summary results are shown in Table 2 below:

| Colour painting LED colour temperature | LED power |
|---------------------------------------|-----------|
| Red 3000k/4000k                       | 4W        |
| Green 3000k/4000k/5000k/6000k         | 4W/9W/13W |
| Blue 4000k/5000k/6000k                | 4W        |
| Black 3000k/4000k/5000k/6000k         | 4W/9W/13W/20W |
| White 3000k/4000k/5000k               | 4W        |
| Yellow 3000k/4000k/5000k              | 4W        |

6. Conclusion
In the actual architectural landscape design, the choice of light sources is wider, because human perception may not always be able to accurately feel small changes. However, if the design lighting uses a large deviation, it will cause a poor overall rendering effect. It is unacceptable for people. When designing architectural landscape lighting, designers generally consider using natural light to truly display landscape objects. When landscape objects are required to show different effects from the daytime, they can consider using monochromatic light as the main light.

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