Research on Model of Urban Architecture Color and Character Based on Color Science

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Abstract

With the development of social economy, people’s living standards are increasing, and the degree of their aesthetic demands is getting higher and higher. In order to meet people’s diverse aesthetic needs, the modeling and color of urban architecture become more novel, which promotes the development of construction industry in China. However, it also leads to the urban color landscape in disorder, thus having a certain negative effect on the overall style of the city. Moreover, the character of a city is formed by its external image and cultural heritage, and the color matching of the city has a direct impact on its overall temperament. Therefore, major cities in China have carried out extensive research on the color of urban architecture. However, a lot of research on architectural color in China is still in its infancy as its late start. Therefore, it is of great significance for the overall development of a city to reinforce the quantitative research on urban architectural color and combine it with the urban character to promote their coordinated development.

Keywords: Color Science, Urban Architectural Color, Urban Character.

1. RESEARCH OVERVIEW

1.1 Research background

From the perspective of color psychology, color plays a guiding role on people’s psychology. As the external environment of people’s life, the city with its color has a profound impact on its image and people’s living level. Foreign cities have a long history and high level of development. As early as the 1960s, the research on urban color had been made and important achievements had been obtained. For example, it is clearly stated that beige and gray are major architectural colors in Paris in the Urban Landscape Management Regulations of Paris, France; a vast majority of buildings are subject to the architectural color style, which also makes the Paris boast a stronger artistic atmosphere to became one of the most elegant cities. In addition, many tourist cities along the Mediterranean Sea also have been designed into a colorful appearance, which produces a stunning effect with the natural landscape environment. It is also proved that in foreign countries, urban architectural color has been closely integrated with the urban culture to form a unique urban character. However, urbanization in China is developing at a rapid rate, but the time is relatively shorter, and the urban color was firstly studied in the 1980s, which also results in that the urban architectural color in China is in a mess and difficult to manage, thus greatly affecting the development level of cities in China. Therefore, in-depth research should be carried out on the color of urban architecture, so as to develop the color of urban architecture for urban character and enhance the construction and development level of cities in China.

1.2 Literature review

At present, there are still more gaps in the research on urban architectural color in China, mainly reflected in two aspects: on one hand, different environments such as daylight color temperature and its spectral characteristics will have a certain impact on the observation of architectural color; and there is a certain attenuation law on the color in different atmospheric environment. On the other hand, as lack of quantitative data for observation and research on the urban architectural color, the conclusion obtained is difficult to play a guiding role. Moreover, the method for use of observation tools related to urban architectural color is less studied, and there is a problem of misuse of measurement instruments (Ji et al., 2010). At present, the major problem of urban architectural color in China is that the cities are generally in a lack of main color, most of which are divided in accordance with a certain area, but no standard has been proposed for the main color of the city. At the same time, for some of the historic cities, the ancient architecture is combined with new buildings around without necessary transition,
thus leading to abruptness of architectural color. In addition, there is still no unified standard for architectural color. Each building is designed in accordance with the standards of the designers without integration with the surrounding environment. Therefore, chaotic color appears occasionally (Dong et al, 2013). In the choice of urban architectural color, on one hand, it needs to reflect the background role of architectural color to avoid overwhelming; on the other hand, it should correspond to the cultural environment of the city. For example, for some cities rich in historical and cultural heritage, the green bricks and gray tiles could serve as main colors. Ancient architecture is an important manifestation of urban history and civilization, which can make people feel deep cultural heritage of the city. In the context of urbanization, ancient architecture can be constructed into a location like pedestrian streets to fulfill its value and thus become an important urban commercial center, and making people appreciate the rich cultural heritage through the construction of trams and other equipment with nostalgic atmosphere (Chen and Liu, 2016).

2. THEORETICAL BASIS OF URBAN ARCHITECTURAL COLOR BASED ON COLOR SCIENCE

2.1 Physical theory of color

In an actual object, when the light is irradiated to the object, a part of the light is directly absorbed by the object, while the other part of the light is reflected by the form of electromagnetic waves, and absorbed by the observer. Therefore, the color is essentially reflected by electromagnetic waves of the light with different wavelengths, which is an important physical phenomenon. Thus, the three key elements for color generation are light, actual object and observer (Jia et al, 2012). The principle of color generation is shown in Figure1:

![Figure1. Principles of Color Generation](image)

In addition, color will have a certain impact on people’s psychology. Color psychology is a subject specialized in researching the impact of color on people’s psychology. Although the subject has not yet included in the scope of psychology, the color indeed has a certain impact on people’s psychology. For example, the decoration of the fast-food restaurant is mainly yellow. The color can make customers feel happy and open appetite, but also feel like a long time, which is not conducive to waiting for others (Ding and Liu, 2012).

The architectural color is mainly determined by the building materials and coatings. However, in the actual observation, the inherent color of the building under different environments will produce some deviation, which is mainly affected by three factors, namely the spectral reflection characteristics of materials, spectral power distribution of incident light and spectral sensitivity of human eyes. From the point of view of architectural color, attention should be paid to the color of building surface, that is, the color of the finish materials on the choice of building materials. The finish materials are divided into two types; one is part of the structural material, such as concrete, which can play a load-bearing role (Yang et al., 2012); the other more focuses on the role of fencing, such as glass. There are two categories of finish materials for building; one is made from the things that exist in nature itself through a certain processing such as wood and stone; the other is manually manufactured metal, glass and other materials. Due to the lower productivity in the past, it was difficult to transport building materials for long distances. Therefore, distinctive building materials were used in various regions. Under the background of rapid social development, the regional characteristics brought by building materials continue to decrease, which plays a role in promoting the development of the construction industry, and causes the phenomenon of serious homogeneity now (Li and Zhou, 2012).
2.2 Mechanism of color generation and influence factors

The color of a real object is divided into two categories; the first is the object color. The main reason for color generation of the object is the different wavelengths of electromagnetic waves generated by the reflection of light. Therefore, the color is not the inherent property of the object. It is to absorb a part of color light and reflect the other part of the color light under irradiation, and the reflected color light is the object color of the material that can be observed (Li, 2011). The second is the inherent color, that is, the color fed back by the object in the sunlight. In different light and atmospheric environment, the color of object will produce a certain difference. Therefore, only under the irradiation of standard daylight, the color fed back by the object is the most stable (Li, 2011). The relationship between object color and light source spectrum is shown in Figure 2:

![Figure 2](image)

**Figure 2.** The Relationship Between Object Colors and Spectral Officials

It can be seen from the above figure that the normal sunlight (including white, green, blue and red light) projected on a object without absorption of green light will reflect the green light. Therefore, the object itself is green. If only red light is projected on an object that does not absorb green, it will produce black light, thus reflecting that different light will have a great impact on the color of the object.

![Figure 3](image)

**Figure 3.** The Effect of Different Backgrounds on Color

Figure 3 shows the difference of the same gray square under black and white background. Among them, the graysquare under black background gives the impression that it is lighter, and the gray square under the white background makes people feel it is deeper, which reflects the color of object will have a greater difference under different color background. In addition, the change in brightness, distance and media will have a different degree of effect on the color of the same object.

2.3 Color measurement and evaluation

2.3.1 CIE standard color system

CIE standard color system is a form widely used for quantitative description of the color, and its core idea is to mix three primary colors of red, yellow and blue according to a certain proportion to evaluate the quantitative method for composition of any color. Since any kind of color light is made of monochromatic light, the spectral tristimulus value of monochromatic light can be used to obtain the spectral tristimulus value of the three primary colors.
In the CIE standard chromaticity system, several standard values have been explicitly given, and only the spectral reflectance factor $\beta(\lambda)$ of object color stimulus needs to be measured. It is more difficult to measure $\beta(\lambda)$ and the procedure is complex. In 1971, several $\beta(\lambda)$ reference standards were provided in the CIE standard chromaticity system, but these standards were deduced under perfectly ideal premise without consideration of the loss in actual environment. Therefore, $\beta(\lambda)$ can be determined in the measurement by comparing with other values under the constraints of the actual situation.

2.3.2 CIEL $^* a^* b^*$ color difference method

The CIELAB color space, the Euclidean distance $\Delta E$ of two color points compared also refers to the color difference of the two colors. It is assumed that the two-color points are $(L_1, a_1^*, b_1^*)$ and $(L_2, a_2^*, b_2^*)$, and the color difference is expressed as $\Delta E_{ab}^*$, we can obtain the equation of color difference:

$$\Delta E_{ab}^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

(2)

where:

$$\Delta L^* = L_1^* - L_2^*$$

$$\Delta a^* = a_1^* - a_2^*$$

$$\Delta b^* = b_1^* - b_2^*$$

(3)

It is assumed that the lightness index is $L^*$ in the color space, we can obtain:

$$L^* = \begin{cases} 116(Y/Y_n)^{1/3} - 16, & Y/Y_n > 0.008856 \\ 903.3(Y/Y_n), & Y/Y_n \leq 0.008856 \end{cases}$$

(4)

Under the same brightness, the following equation can be obtained through the distance from the origin (0,0) to $(a^*, b^*)$ in the coordinate system, namely saturation $C_{ab}^*$:

$$C_{ab}^* = \left[(a^*)^2 + (b^*)^2\right]^{1/2}$$

(5)

High hue is

$$h_{ab} = \tan^{-1}(b^*/a^*)$$

(6)

It can be obtained from the above equation that in a plane of the same brightness, $+a^*$ symbolizes the red parameters, and the higher the value is, the higher the degree of red is; $-a^*$ symbolizes the green parameters, and the higher the value is, the higher the degree of green is; $+b^*$ symbolizes the yellow parameters, and the higher the value is, the higher the degree of yellow is; $-b^*$ symbolizes the blue parameters, and the higher the value is, the higher the degree of blue is (Li et al., 2014). The equation of color difference is as follows:
\[ \Delta E_{ab}^* = \left[ (\Delta L^*)^2 + (\Delta C_{ab}^*)^2 + (\Delta H_{ab}^*)^2 \right]^{1/2} \]

where it contains the brightness difference, saturation difference and hue difference. Therefore, according to the above equation, the equation of hue difference is as follows:

\[ \Delta H_{ab}^* = \left[ (E_{ab}^*)^2 - (\Delta L)^2 + (\Delta C_{ab}^*)^2 \right]^{1/2} \]

There is a positive relationship between hue angle and hue difference. When the hue angle is increased, the hue difference is positive, and when the hue angle is reduced, the tone difference is negative (Liu and Zhang, 2014).

3. INTEGRATION DEVELOPMENT OF URBAN ARCHITECTURAL COLOR AND URBAN CHARACTER

3.1 Choice of the main color of a city

The main color of a city is the basis of the urban architectural color, and the choice of the main color has a direct impact on urban culture and character performance. On one hand, the main color of a city should be consistent with that of current buildings in the city to avoid bad chain reaction caused by larger difference of main colors. On the other hand, as there are many cities with a long history in China, larger difference between the main color of urban architecture and traditional architecture or culture will produce abrupt color in the city, so that it is difficult to play a role of coordinated development. According to the survey, the city with an area of more than 4 million square kilometers will be monotonous with a single main color. Therefore, more appropriate main colors should be selected according to the different partitions. 2-3 main colors should be selected in accordance with the partitions for the city with an area of 1 to 4 million square kilometers, and single architectural color is more suitable to the smaller city with an area of 100 million square kilometers. At the same time, the top three colors are light blue, light green and milky white according to the questionnaire of main color in a city. In addition, many residents select other colors as they consider that the main color with light tone lacks of angry, and they are more inclined to the lake blue, green and other colors. They generally do not fully understand the color and do not know that the main color of a city only serves as a background. Thus, gorgeous color will take the position of the original things (Sun and Sun, 2015).

3.2 Color design plan for residential area

Residential area is the main part of urban construction, and it occupies a large proportion of a city. Therefore, the color design of residential area is also a key part in the design of urban architectural color. Reasonable color design of residential area not only can enhance the living experience of the surrounding residents, but also have important significance on the overall level of development of the city. However, it is more difficult to design the color of residential area. If the color of each building is consistent in a large residential area, it will cause a sense of monotony, and even seriously affect the overall design and planning of residential areas. Meanwhile, if the color of the building varies and is no interrelated, it will make a mess. Therefore, the overall color of each building can be consistent, while the balcony and windows can be embellished with different colors, which can effectively enhance the color design level of residential buildings, and improve the aesthetic level of residential buildings.

In addition, the level of greening also reflects the design level of the residential area. For some buildings which are of unreasonable color style but cannot be removed, strengthening the level of greening of the surrounding buildings can effectively play the role of shielding, and improve the air quality of the surrounding areas, thus having great significance on enhancing the living standards of residents (Yang and Mei, 2015).

3.3 Color design plan for business district

Commercial area and residential areas are essentially different. Residential area adopts a duller color to enhance the housing quality of residents. More novel and beautiful buildings are designed in the Commercial area in order to attract the attention of consumers, thus stimulating consumers’ desire to buy. Nevertheless, the architectural color in commercial area cannot be designed too free. For the design of commercial building, attention should be paid to combine with the surrounding environment, on this basis, and then decoration can be made through the personalized design or auxiliary color. The use of auxiliary colors should not be limited but no
more than 60% in principle (Jiao, 2015).

3.4 Color design plan for leisure area

The leisure area is different from the commercial and residential area, which is less restrictive to the environment or scope and only limited within the buildings. It is closely related to urban greening, air quality, atmospheric environment and weather. Therefore, the natural environment is also an important direction for color design of leisure area to a certain extent. Therefore, the building in leisure area is not only combined with the main color of the city, but also realizes the harmony with nature and unity. The color should be duller, on one hand to avoid conflicting with color of nature and the main color of the city, on the other hand to avoid reflecting the main color of the city (Qian, 2013).

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