ISSN 1330-3651 (Print), ISSN 1848-6339 (Online)
https://doi.org/10.17559/TV-20231127001153
Subject review

Architectural Color Conservation and Renewal Strategies in Historic Urban Areas: An Analysis Based on the Historic City of Macao

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Abstract: As a city with a long history, Macao has valuable resources rich in historical and cultural heritage, which has many historical buildings with unique colors. The color of the architectural environment plays an important role in its conservation and renewal. This study aims to explore strategies for the color conservation and color renewal in the architectural environment of the Historic Centre of Macao. Through the field investigation and analysis of the historic center of Macao, the environmental principles of architectural color conservation were determined, including the conservation and restoration of the original architectural appearance of the historic district, the integrity and richness of the main color of the building, and the control principles of color and other environmental elements. Aiming at the architectural color conservation in Macao's historic urban area, this paper puts forward some strategies, such as determining the architectural color tone, establishing a color database, and giving some suggestions on conservation and renewal, and provides some references and guidance for the renovation and construction of Macao's historic urban area.

Keywords: architectural environment color; conservation; historic district; Macao; renewal strategy

1 INTRODUCTION

As one of the world cultural heritages, the Historic Centre of Macao has unique historical and cultural value, and its architectural color is an important part of the city's characteristic style, which is of great significance for the conservation and inheritance of Macao's history and culture. With the continuous advancement of urbanization in Macao, the architectural environment of the historic urban area is facing a series of challenges and problems. According to the positioning of Macao's future development in the Master Urban Plan for the Macao Special Administrative Region (2020 - 2040), the cultural and historical characteristics of a sustainable city have become an important part of urban development and construction during the planning period. There are also scholars who have analysed the study of urban colour in Macao: Tong Qiaowei (2004) carried out an in-depth study of urban colour and pavement in Macao, and this paper starts from the colour of the urban architectural environment to make up for the gap in the study of the colour of Macao's historical buildings [1] .To this end, this paper takes the Historic Centre of the Macao Peninsula as the research object, which puts forward corresponding conservation and renewal strategies through the study of the architectural environment color in the Historic Centre of Macao. We should not only make full use of the opportunities of urban development, but also pay attention to the protection and sustainable development of Macao's local architectural colors. In this way, the unique charm of the architectural environment is maintained to achieve the dual goals of urban development and world cultural heritage protection. Therefore, it is of great practical value and theoretical significance to discuss the protection and renewal of the architectural environment color in the historic city of Macau.

2 ARCHITECTURAL OVERVIEW OF MACAO HISTORIC CENTRE

2.1 Architecture of Macao Historic Centre

The Historic Centre of the Macao Special Administrative Region has been inscribed on the UNESCO World Heritage List since 2005. The Historic Centre of Macao is home to China's oldest Western-style architectural heritage, a historic district inhabited by the Portuguese in the early days, which gathers part of the core area of the Old City. For the Historic Centre of the Macao Peninsula, the historical and cultural heritage of the intersection of Eastern and Western cultures for more than 400 years, with historical architectural landscapes, natural landscapes, street landscapes, etc., cultural characteristics and historical significance are all unique world historical and cultural heritage, especially the historical buildings of the Historic Centre of the Macao Peninsula.

The Historic Centre of Macao is located within the Macau Peninsula, which covers an area of 1.32 square kilometers. At present, the Historic Centre of Macao is divided into historical buildings and buffer zones, covering 22 historical buildings connected together (Fig. 1).

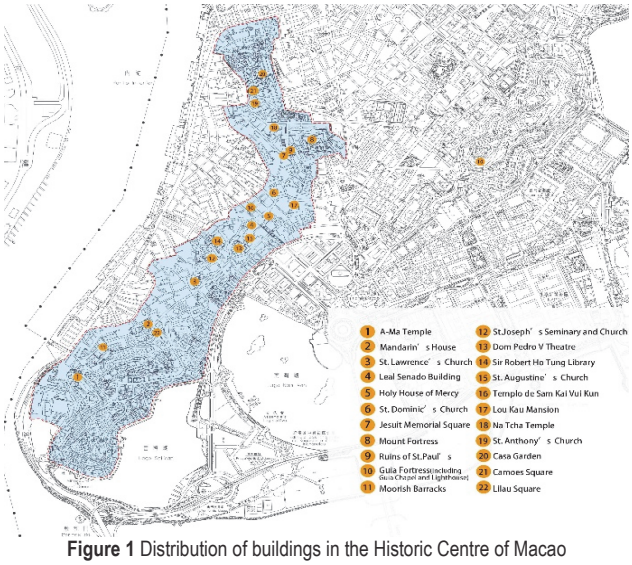

Figure 1 Distribution of buildings in the Historic Centre of Macao

It represents different historical periods and cultural backgrounds, and the architectural colors and styles are more unique and diverse, which is showing the rich architectural colors and historical styles of Macao. The colour of the buildings is a key issue in the planning of historic cities, and the Macao SAR Government and

UNESCO have been committed to protecting and preserving these buildings so that they can be preserved and passed on.

2.2 Research Status of Architectural Color in Historical Urban Areas

In terms of architectural color-related research, some countries and domestic regions have carried out research on it, such as the color restoration of historic districts in Turin, Italy [2]. French scholar Jean Philippe Lenclos proposed that color geography promoted the process of urban color research in the world [3] and Japan through the formulation of the "Tokyo Urban Color Plan". In China, Shenzhen, Guangzhou and Shanghai have also carried out relevant practical research and analysis in the aspects of color conservation of the architectural environment, modern residential architectural color, and the evolution and renewal strategy of architectural color in the old city, such as scholars Guo Hongyu (2017) [4], Shen Lu (2020) [5], Bian Wenjuan (2021) [6] and other scholars. They have respectively conducted research on urban architectural color through computer learning technology and visual comparison method [7]. As one of the World Heritage Sites, the Historic Centre of the Macao Peninsula, the color conservation, and renewal planning of the architectural environment in the area [8], as well as the degree of restoration and integrity of the buildings in the Historic District, are the key elements for the conservation and continuation of the World Heritage buildings in the Historic Centre of Macao.

A number of scholars have conducted academic research on the architectural colours of historical cities through project practice. Zhu, Xiaoyu (2023) [9], et al. in Fuzhou City, Fujian Province, China, have visually compared the architectural colours of the Nan Hou Street through colour swatches and inputted the colour data of the samples to obtain the corresponding colour information, so as to construct the architectural colour atlas, and to propose the strategies of protection and renewal. In Guangzhou, Suzhou and Xiamen, Guo Hongyu (2009) [10] adopt a colour control strategy that is both hierarchical and hierarchical in the degree of control, delineate three levels of control zones, and formulate the recommended chromatograms and colour planning guidelines to provide accurate and efficient colour references for the cities. Through the above case studies, the author further verifies and explores the applicability of the Mensel system using the Mensel system colour card in the context of Macau's historic buildings as a specific research object.

3 RESEARCH METHODS

3.1 Study Object- Macao Peninsula Historic Centre

As the core area of the Macao Special Administrative Region, the Historic Centre is one of the most well-preserved, attractive and largest combination of Chinese and Western architecture in Macao. At the same time, it is also the main residence of Macao residents, and the streets, lanes and internal buildings present a strong historical atmosphere, which also inherit Macao's unique culture and traditions. According to the future development of the Macao SAR Government, it is positioned as the most important historical and cultural heritage reserve in the Macao Peninsula, and the conservation and renewal of its historical architectural colors has become an important task guiding the development of urban planning.

3.2 On-Site Investigation of Architectural Colors in Historic Urban Areas

At present, the Historic Centre of Macao has preserved buildings with historical conservation value, including A-Ma Temple, Port Authority Building, Man's House, St. Lolenzo Church, St. Joseph's Seminary and Holy Church, Gangding Theatre, Ho Tung Library, St. Augustine's Church, Home Affairs Office Building, 3rd Street Hall (Kwan Tai Temple), Mercy House Building, Lobby, Lo Ka House, Rose Hall, Ruins of St. Paul's, Na Ta Temple, Fortress, St. Anthony's Church, Oriental Foundation Sites, Guia Fort, Apa Well Front, Gangding Front and Senado Square. This paper classifies and summarizes the color styles of historical buildings through street scene images and visual comparison (Fig. 2), which selects 22 historical building samples for color comparison, extracts the data of the main color, auxiliary color and decorative color of historical buildings through the color management platform of Qiantongcai [11] , and explores the intrinsic correlation of their color attributes, which has reference and guidance value for the conservation and renewal and development of subsequent historical buildings.

3.3 Excavate the Color and Style Characteristics of Historical Buildings

The natural environment and characteristics of Macao's historical buildings in different historical periods show their unique color features, which is an important factor in continuing the context of the architecture of the historic district and shaping the architectural heritage, and it is also the key to the color conservation of the architectural environment in the context of urban renewal.

The colors and features of Macao's historic buildings reflect the fusion of Chinese and Western cultures. There are many European-style buildings in the Historic Centre of the Macau Peninsula, such as Baroque churches and official residences [12]. These buildings usually adopt light-colored facades such as white, beige and light yellow (Fig. 3), which presents the elegance and solemnity of Western-style architecture. In addition, we can also see traditional buildings of the Ming and Qing dynasties, such as temples and official residences, which often adopt bright colors such as red, green, and blue (Fig. 4), showing the unique charm of traditional Chinese architecture. During the Portuguese colonial period, Macau’s architecture was more diverse, with both European-style architecture and traditional Chinese architectural influences. The colors of these buildings are often softer, such as light pink, light blue, and light green, showing the warmth and romance of Portuguese colonial architecture [13].

Figure 2 Sample survey on the color status of buildings in the Historic Centre of Macao (Image source: self-drawn by the author)

Figure 3 Building façade with light color tone

Figure 4 Traditional building façade in bright tones

After summarizing the collected color data of the architectural environment in the preliminary research sample, the color analysis plug-in of CorelDraw software was first used to extract the example maps and color composition networks of different color systems, brightness and purity (Fig. 5) in order to achieve the visualization of architectural colors. In the color composition network, it can be seen that the circle size indicates the proportion of its color in the historical building. The circles are closer, the color concentrated more, the opposite is scattered. The connection is to indicate the connection between the two colors in the architectural color, and the thick details of the line indicate the matching relationship between the two colors and the number of times they are used [13]. Here, the main colors, auxiliary colors and decorative colors in the architectural environment and the interrelationship with other factors of the environment are sorted out, and the color and style characteristics of the architectural environment of the historic district of Macao are excavated, which provides guidance and support for the implementation of color conservation in the architectural environment of the historic urban area in the later stage.

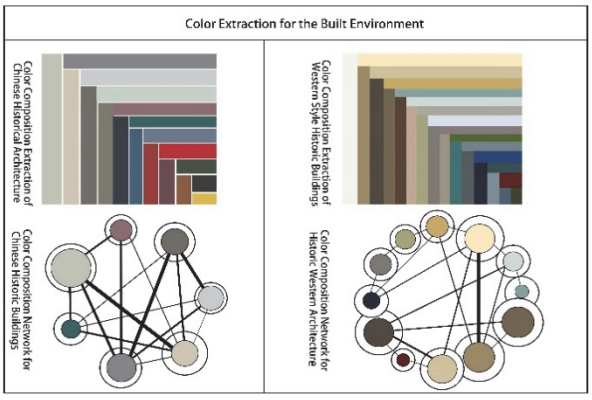

Figure 5 Extraction of color composition of Chinese historical buildings and Western-style historical buildings (Image source: self-drawn by the author)

4 CURRENT SITUATION OF ARCHITECTURAL COLOR IN THE HISTORIC CENTRE OF MACAO

4.1 Analysis of Architectural Color Characteristics in Historic Urban Areas

In the early stage, through the sampling, induction and extraction of architectural color samples in the Historic Centre of Macao, and considering the main color "genes" of the architectural color samples in the Historic District, the Musel color values and ontology attributes of the main color, auxiliary color and decorative color of 22 historic buildings were obtained respectively (Fig. 6), showing the unique urban color style of the architectural color of the Historic Centre of Macao.

According to the actual architectural pictures and the color value of Muncell, the main color of Chinese architecture is mainly green brick, lime brick, granite, and the material of the auxiliary color is expressed as stone and wood, with gray tones. The decorative color is made of window frame material, commonly used ochre red, dark green, and dark gray, while the main color and auxiliary color of Western-style building mainly use special paint, Granite and tiles to highlight the Portuguese style of special architecture. In terms of the color of the façade of the building, the color of Chinese architecture is regular and orderly, and the proportions are appropriate [14]. The main color structure of Western-style architecture mainly revolves around the color matching of two colors, such as medium yellow and white, light yellow and white, pink green and white, etc., and the color characteristics are eye-catching.

Figure 6 Munsell chromatography, a historic building in the Historic Centre of Macao (Image source: self-drawn by the author)

4.2 Comparative Analysis of Color Hue and Chroma Data of Buildings in Historical Urban Areas

Based on the above Munsell chromatographic data of historical buildings, the ColorTell colour management system is used to the hue-chroma distribution map of the main color [15], auxiliary color and accent color of Chinese architecture and Western architecture color was drawn (Fig. 7), and the comparison of the number and types of Chinese and Western architectural colors was discussed, and the color laws and problems at the "gene" level of historical architectural color were summarized.

As can be seen in the hue - colour map, the main tone of Chinese architecture mainly focuses on chroma (N), reflecting the calm and calm environment of the building. In addition, the auxiliary colors of Chinese architecture are concentrated in low chroma and medium brightness yellow (5Y) and red (5R), reflecting a warm sense of atmosphere. In addition to the absence of chroma (N), the dotted colors are also distributed in the four-color ranges of reddish yellow (Y R) - Chartreuse (G Y) - blue (B) - purple (P), which have a complementary effect between the colors, reflecting the color rules of Chinese architecture in the Historic Centre of Macao. The main color of Western-style buildings is distributed in six color intervals: red (R) - yellow (Y) - reddish yellow (Y R) - Chartreuse (G Y) - blue (B) - royal purple (PB), and it can be seen from the color distribution map that the auxiliary colors of Western-style buildings have the highest frequency and the highest chroma of high chroma yellow (5Y, 10Y), followed by royal purple (2.5 PB) with low brightness and high chromaticity. The decorative colors of Western-style architecture use warm yellow (Y), greenish yellow (GY) and reddish yellow (Y R) as the base color, which not only unifies the color of the architectural environment but also echoes the base color.

Through the comparison of the Munsell chromatographic data of Chinese-style architecture and Western-style architecture, the overall color of Chinese-style architecture is warm and has the characteristics of traditional culture, and it also follows the law of Munsell color matching, that is, the area proportion is small and the color is strong; on the contrary, the area proportion is relatively weak. Western-style buildings are rich and diverse in the use of colors, mostly for the main color of the two colors, and the auxiliary color and the accent color are mostly the color of cold and warm contrast.

In addition, the comprehensive distribution of hue-chroma of Chinese and Western-style buildings is compared and analyzed (Fig. 8), and it can be seen that the main color of Chinese and Western-style buildings and the distribution range of Chinese and Western-style architectural accent colors coincide the most, while the hue

display of Western-style buildings is more personalized, resulting in low overlap of some distribution ranges.

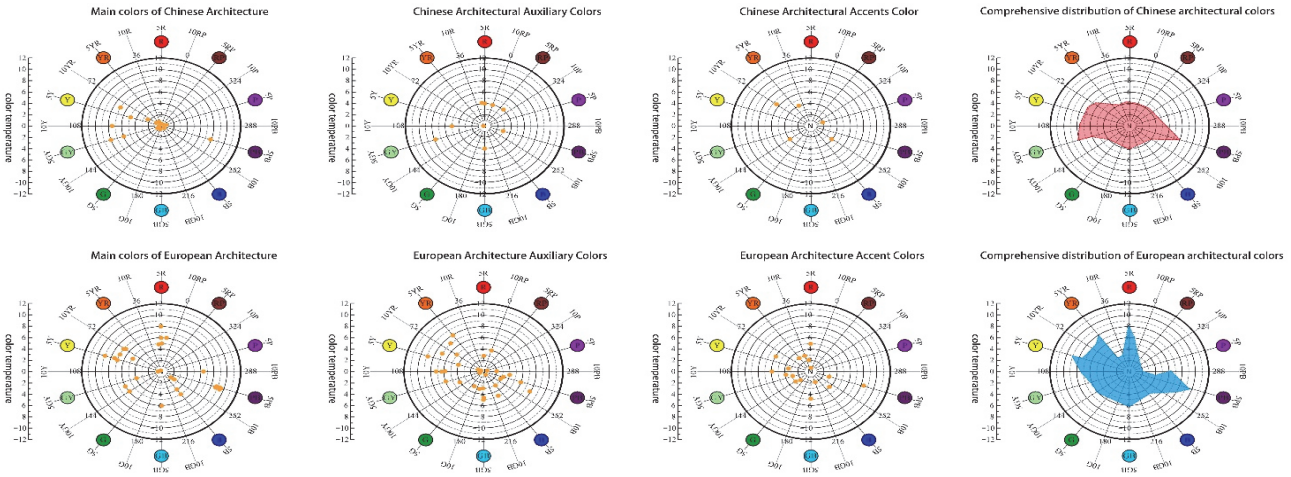

Figure 7 Hue-chroma distribution map of historic buildings in the Historic Centre of Macao (Source: Self-drawing)

Among them, the Chinese buildings in the Historic Centre of Macao are concentrated in dark gray, greenish yellow and dark red tones, while the main colors, auxiliary colors and decorative colors of Western-style buildings are diversified, such as warm yellow, blue - purple, green - yellow and yellow - red, etc., all of which are concentrated and have a growing trend.

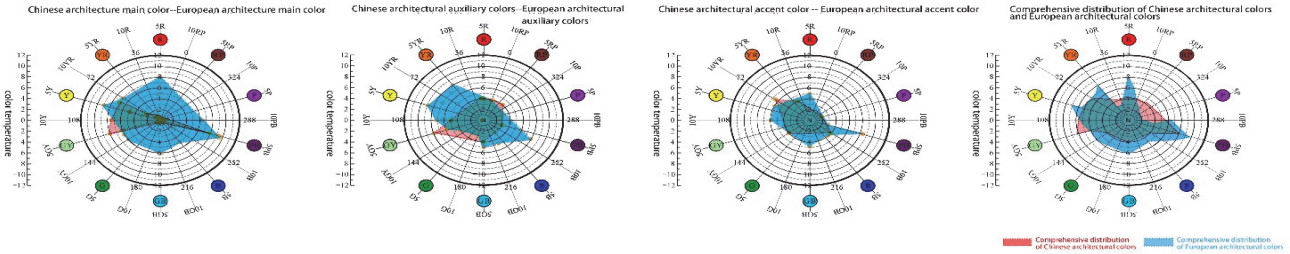

Figure 8 Comparative analysis of hue-chroma distribution in Chinese and Western-style buildings (Image source: self-drawn by the author)

4.3 Comparative Analysis of Architectural Color Brightness Data in Historic Urban Areas

According to the data collected from 22 historical architectural color samples, the brightness of the main color, auxiliary color and accent color of Chinese and Western-style buildings was compared and analyzed (Fig. 9), and the following can be concluded from the figure: First, the main color of Chinese buildings shows medium to high brightness, and the fluctuation range is relatively stable, while some of the Western-style buildings have low brightness, and the main color of Western-style buildings is medium to high brightness. Second, the auxiliary color of Chinese buildings is of medium to low brightness, and trough oscillations appear. The function of Chinese buildings in the historical urban area has a certain impact on the brightness of architectural colors. Western-style buildings have obvious difficulties, all showing a "W" trend. Third, the brightness of the embellishment color of Chinese and Western-style buildings is between medium- low brightness and medium-high brightness, showing stable oscillation, and the contrast characteristics of brightness of Western-style buildings are relatively similar.

Chinese architecture uses traditional lime bricks and decorative paintings as decorative colors, so the whole is in a medium to high brightness, while Western-style buildings in the Historic Centre of Macau have Portuguese architectural decorative characteristics, and some of them are embellished by decorative moldings and tinted glass and other materials. Therefore, the architectural color in the historical urban area has changed from medium and high brightness, low chroma dark and light gray tones to green-yellow, blue-green, yellow-red brightness contrast, high chroma diversified tones, although the color is chaotic and disorderly, and there are problems such as chroma without characteristics, but in the aesthetic level of Chinese architectural color and architectural decoration design, it still maintains the continuation and inheritance of architectural elements and colors.

In summary, the above analysis results are summarized, and the current situation of architectural color in the historic district of Macao is extracted. The essence of the architectural color problem in the historic district lies in the color ratio between Chinese and Western-style buildings, and the importance and conservation needs of architectural color in the historic district are evaluated. Finally, this summary adopts the Mensel colour system to analyse the chromaticity and lightness of the colours of the samples it collects, to extract the characteristics of the colours of the Chinese and Western buildings, to point out the characteristics of the traditional and modern buildings, and to hopefully preserve the decorative elements and colour

beauty of the Chinese and Western buildings in the Historic District itself.

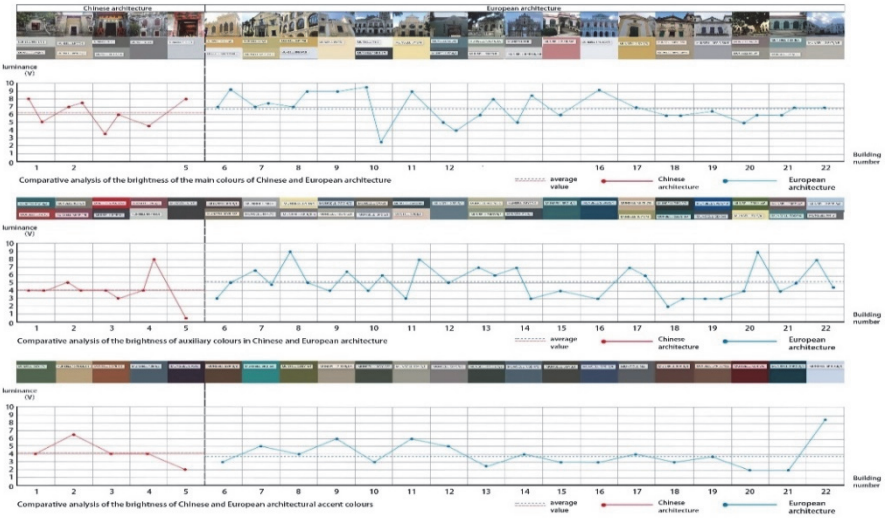

Figure 9 Comparative analysis of color brightness of 22 samples of Chinese and Western-style architecture (Image source: self-drawn by the author)

5 DETERMINE THE PRINCIPLES OF COLOR CONSERVATION IN THE ARCHITECTURAL ENVIRONMENT

Based on the comparative analysis of color sample data in the early stage, the principles of color conservation of Chinese and Western architectural environments in the Historic Centre of Macao are clarified, which has guiding significance for its subsequent practice of architectural color conservation and renewal.

5.1 Principles for the Conservation and Restoration of the Original Architectural Appearance of Historic Urban Areas

It is an effective measure to preserve the original appearance of local architecture and the living habits and ways of life of residents by continuing the architectural context, architectural culture, and life form around the historic urban area, and restoring the architectural heritage with historical value through the color conservation of the architectural environment. Through the study of the conservation and restoration principles of historic urban buildings, it aims to protect and continue the historical context of the building, rather than the copying of history and culture, maintain the historical inheritance and coherence of architectural colors, and create an urban living environment with regional characteristics and cultural characteristics.

5.2 The Integrity and Richness of the Building Main Color

While paying attention to the creation of the overall architectural environment color, we should also pay attention to the richness of the landscape content in the area, and fully consider the harmonious color matching with neighboring buildings and landscape things in the color relationship, emphasize the continuity of urban architecture, and create the overall environmental effect of the city. Therefore, through the research on the conservation and renewal strategy of the main color of the building, the color design of the architectural environment should not only pay attention to the integrity and richness of the color, but also consider the color beauty of the building, aiming to create a rich and diverse architectural color environment.

5.3 Control Principles of Color and other Environmental Elements

By studying the relationship between color and other environmental elements, the aim is to achieve the harmony and unity of architectural color and the surrounding environment. In the color conservation and update of the architectural environment, it is not only simple to use the beautiful color combination in the building standard color card, but also to consider the relationship factors of three environmental colors, such as the overall comprehensive consideration and control of three environmental factors such as the relationship between the form of the building itself and the relationship between culture and color, the harmonious and coordinated relationship between the color of other environmental facilities in the architectural environment, and the color relationship between the natural environment and the man-made environment.

6 COLOR UPDATE STRATEGIES FOR THE ARCHITECTURAL ENVIRONMENT

6.1 Optimization and ADJUSTMENt of the Main Color of the Architectural Environment

Through the color study of the architectural environment of the Historic Centre of Macao, the architectural environment color is the core of urban renewal with renewal and conservation as the core. At the same time, the original main color is continued and retained in the planning and design, such as the conservation of historical and cultural heritage in the urban area. Chinese-style buildings should retain and use traditional architectural colors: light gray brick color, camel color, inherit the charm of traditional Chinese architectural colors [16]. While Western-style buildings

use warm yellow, blue purple, colors such as yellow and red present the hues preferred by Western modern design, expressing the beauty of the diversity and symbiosis of Western modern architectural colors. The color of the architectural environment is optimized and adjusted by controlling the overall color and correcting the existing control methods such as architectural noise, so that the color of the architectural environment is continued and updated in material and form, so as to ensure the historical inheritance of the architectural color and maintain the uniqueness of the architectural color.

6.2 Refinement and Harmonization of Auxiliary Colors and Accent Colors of the Architectural Environment

At present, the auxiliary colors in the color genes of the architectural environment in the Historic Centre of Macao are rich and diverse, and the collision of Chinese and Western-style architectural colors in the area has led to the problem of extensive renewal of urban architectural colors. How to control its architectural color through minimal intervention, so that the auxiliary color of the building plays a prominent and flatter role in the environmental visual effect, it is an important part to consider in the process of urban renewal. In addition, the decorative colors in the color genes of Macao's architectural environment play a decorative and finishing role. Accent colors are usually colors used to highlight architectural details or decorative elements, making the building more vivid and interesting. Through the principles and methods of architectural color renewal in the historic urban area, this paper aims to achieve a balance between architectural color renewal and conservation.

At the same time, based on the color status of the architectural environment in the Historic Centre of Macao, the proportion of colors (main color, auxiliary color, decorative color) is harmonized according to the Munsell color spectrum as the basis. This paper avoids overemphasizing the main color of the architectural environment and reduces the proportion relationship of the main color. It also increases the auxiliary proportion of the architectural environmental color, which can be used for transition. The color structure getting stabilized, the proportion of bright color to the strong decorative color reduces through the standardization of the Munsell chromatography. The color ratio of Chinese and Western architecture is finely reconstructed, and the auxiliary color and the decorative color are harmonized, which is conducive to the precise control of the color style of historical buildings. In general, the auxiliary color adopts a hue that harmonizes with the main hue and moderate changes in brightness and chromaticity, so that it cannot only coordinate with the main hue but also enrich the architectural level and achieve a decorative effect.

6.3 Recommendations and Conservation Strategies for the Application of Colour in the Built Environment

Based on the colour system of the Monselle chromatography, combined with the traditional Chinese building materials and the Portuguese style of architecture, the streetscape of the Historic Centre of Macao is created with the characteristics of Macao's colours. According to the current situation of architectural colours in Macao's historic district, it is recommended to adapt the colour chromatograms of Chinese and Western architectural environments in the historic district (Tab. 1).

Table 1 Recommended colour spectrum of the built environment in the Historic Centre of Macao (Source: Self-drawing)

causality	form	sex	luminance	luminosity
primary colour	Chinese architecture	Low colour	3 ~ 8	1 ~ 4
	Western architectural	5.0R~5.0YR ~ 5.0GY ~ 5.0B~5.0PB	4 ~ 9	1 ~ 7
secondary colour	Chinese-style architecture	5.0Y~5.0R	4 ~ 7	1 ~ 4
	Western architectural	5.0Y~10Y	3 ~ 9	1 ~ 6
spot colour	Chinese-style architecture	5.0YR~5.0GY	4 ~ 6.5	1 ~ 3.5
		5.0B~5.0P		
	Western architectural	5.0Y~5.0GY	2 ~ 6	1 ~ 4
		5.0R~5.0YR		

In terms of the attributes of the environmental colours, the main, auxiliary and accent colours of the Chinese architectures are concentrated in the low chromaticity, 5.0Y ~ 5.0 R, and 5.0YR~5.0 GY respectively; the luminance is concentrated in the ranges of - 3 ~ 8, 4 ~ 7, 4 ~ 6.5; the range of chromaticity is in the range of 1 ~ 6.5; and the range of colour degree of all three is between 1 ~ 4. It can be seen that the distribution of the colour degree is more concentrated, all of them are mainly in the middle and low colour degree; while the distribution of the luminance degree is more scattered, mainly in the middle and high luminance degree; the three main colours, auxiliary colours, and accent colours of the Western-style architecture are within the colour interval of 5.0 R ~ 5.0 YR ~ 5.0 GY ~ 5.0 B ~ 5.0P B; the luminance degree of the three colours is concentrated in 4 ~ 9, 3 ~ 9, and 2 ~ 6; the colour degree of the three colours is in the range of 1 ~ 7. The colour scale of all three is in the range of 1 ~ 7. In the practical application of the colour of the architectural environment in the Macao Historic Centre, the colour of the architectural environment should be based on the original colour of the building to select the appropriate main colour, retaining the original colour of the building as the main focus, and for the colour damage or the need to repair the building, the colour can be selected through the recommended chromatography; and secondly, to give the embellishment of the colour with the building colours to create the required colour. It is hoped that this colour spectrum of the architectural environment can provide a basis for the planning, adjustment and renewal of the architectural colour environment of the Historic Centre of Macao, so as to achieve the effect of overall harmony and unity.

7 CONCLUSION

The color protection and renewal of the architectural environment in historic urban areas is a complex and persistent systematic study. The special research on the color of historical buildings is seldom carried out at the micro level. The research involves multi-field and interdisciplinary content. From the perspective of preservation and renewal of historic urban areas, this study discusses the internal relationship between the colors of the Chinese and Western architectural environments, and scientifically analyzes the sample data with the help of

Munsell chromatography. This paper focuses on the adaptation of the architectural environment colors to the development and changes of the urban environment, so as to promote the protection and renewal practice of the colors of the Chinese and Western architectural environments. In the future, we will further pay attention to the development history and planning guidelines of the buildings in the historic urban area of the Macao Special Administrative Region, popularize the research and practice of the color protection and renewal of the architectural environment in the historic urban area, and provide some scientific basis and guidance for the transformation of other historic urban areas.

When researching the colour of the built environment, architects and planners may ignore the true judgement of the colour of the buildings due to the insufficiency of their subjective feelings. Different people in different environments can perceive different architectural colours, so we hope that future work on the study of architectural environment colours in historical urban areas should be carried out by combining computers and people in two ways, combining rationality and sensibility, quantitative and qualitative, to improve the study of architectural environment colours [17].

Acknowledgment

The work was supported by the State Key Lab of Subtropical Building Science, South China University of Technology (2022ZD06).

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