ISSN 2618-1568 Vol. 4, Issue 17: 43-48, DOI: 10.25236/FAR.2022.041709

Analysis of Weathering Causes and Maintenance Suggestions of Brick Carving in Cai's Ancient Residence

Jie Chen, Weiqing Li*

College of Arts, Xiamen University, Xiamen, 361005, Fujian, China
**Corresponding author*

Abstract: *Based on the field survey of Cai's ancient residential buildings, this paper finds that the weathering phenomena such as falling off, crisp powder and fading of brick carving decorative components on the exterior wall are mainly caused by environmental factors and marine climate. Based on the distribution and material characteristics of brick carvings in Cai's ancient residence, combined with the analysis of local climate and environmental factors, the author tries to find ways to reduce weathering damage, reasonably repair and maintain brick carving art.*

Keywords: *Cai's ancient residence, Brick carving, Weathering, Maintenance*

1. Introduction

The Cai's ancient residential complex is located in Guanqiao Town, Quanzhou City, Fujian Province.In 2001, it was announced as a national key cultural relics protection unit. In 2008, the " Minnan traditional residential construction techniques" contained in it were included in the national intangible cultural heritage protection list. The complex well preserved the precious Minnan traditional architectural culture, its brick decoration as an important building component, has important historical, artistic, literary and educational value. Due to the influence of multiple factors such as material properties and environmental climate, the brick carving decoration has been obviously damaged by weathering. In recent years, the brick carving art of Cai's ancient buildings has attracted more and more attention and research from the academic circle. Most of them have carried out theoretical discussions on its origin and development, artistic value and application mode, but there are few relevant research results on the mechanism of weathering damage and the countermeasures of restoration and protection. Based on the internal multiple factors and external environmental factors of Cai's architectural brick carving, and combined with its current weathering status, this paper tries to analyze the causes of weathering damage from multiple angles, and tries to explore feasible repair and maintenance methods, in order to provide some reference for the repair and maintenance of Cai's ancient residence[1].

2. The Brick Carving Decoration of Cai's Ancient Residence

2.1. The Distribution of Brick Carving Decoration

The ancient residential buildings of the Cai family consist of 23 complete houses. Brick decorations are distributed on the exterior walls of each house in an orderly manner. The external wall facade has a unique block surface division. The wall distributed symmetrically from the center to the outside in the horizontal direction is called the Pailou plane, the Duikan wall and the mirror wall, and the vertical top-down partition is called the Shuiche block, the top block, the body block, the waist block, the skirt block and the counter plinth (Figure 1). The placement of brick decoration is mainly concentrated in the Pailou plane, the Duikan wall, the body block area of the mirror wall, and the Xiangxian frame of the mirror wall.

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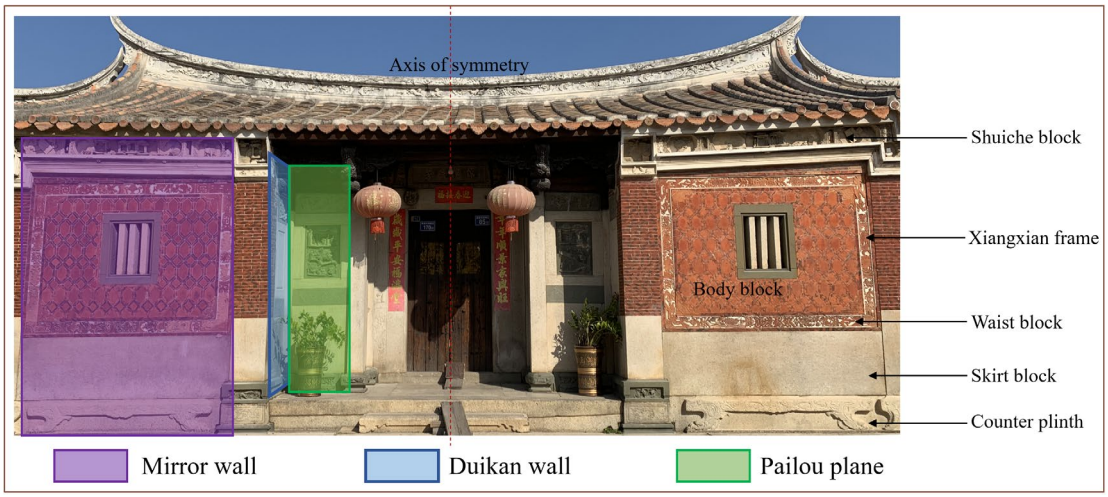

Figure 1: The Wall Partition Structure Diagram

The brick carvings on the *Pailou plane and* the *Duikan wall* are mostly fine relief paintings with rich meanings and large specifications. On the mirror wall, the four corners of the body block and the *Xiangxian* frame are usually auspicious patterns of brick carvings, and the middle section of the *Xiangxian* frame is often embedded with relief carvings of plants or theme stories.

2.2. The Current Situation of Brick Carving Decoration

The weathering impact on the brick carving decoration of Cai's ancient buildings is mainly manifested in the fading, powdering, peeling or cracking of local brick surfaces (Figure 2), or the blurring of brick carving lines, which makes it difficult to identify the patterns, and even many traces of artificial carving and painting. The weathering degree of brick carvings in different locations and types is different, and the brick carvings in mirror wall are the most seriously weathered.

Figure 2: The Weathering Status of Brick Carving

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2.3. The Overview of Decorative Materials for Brick Carving

The clay in southern Fujian is mostly a series of soil composed of laterite, which is the raw material of traditional red brick in southern Fujian. Because the rich iron element in the clay is oxidized into iron ions during the kiln firing, the final brick appearance is bright red. Brick carving used is usually 2 cm thick special specifications tiles, usually according to the size of the decoration position. Minnan brick carving is usually carved with fired finished bricks, and the carved bricks are more susceptible to weathering. On the one hand, the thinner bricks are affected by many processes such as chiseling and polishing, and the design of the picture pattern will also make the brick appear weak and slender structural parts, which makes the carved bricks weaker than the conventional bricks. On the other hand, carving increases the exposure ratio of the brick surface, making water more easily absorbed by the brick. Therefore, the weathering damage of brick carving decorative components is more serious than that of brick walls and stone[2].

The "white ash" used as the substrate of brick carving is made from oyster shell kiln after burning and then processed, which is a traditional building auxiliary material in the local area. The composition of lime is similar to hydrated lime and has strong weathering resistance. However, under the influence of environmental factors, there are still many cracks. The structural combination of brick carving components and lime base makes them interact with each other. The falling off or cracking of one side will often reduce the stability of the other side. In the field survey, it was found that many brick carving components have obvious cracks at the joint of brick carving components and white base (Figure 3).

Figure 3: The Gap between Brick Carving and White Background

3. The Cause of Weathering of Brick Carving

3.1. The Mechanism of Weathering

Many people in the industry have conducted a number of studies on the weathering mechanism of ancient building bricks. Tang Yongjing et al. believe that the larger porosity is an important factor leading to the weathering of ancient brick through the study of the pores of ancient brick. After research, Bai Xianchen et al. believed that the main causes of wall powder and cracking were the thermal and wet conditions of the wall, the migration of underground water and the alternating change of ambient temperature. Generally speaking, weathering of brick is closely related to capillarity phenomenon, that is, external moisture is easy to be sucked and diffused along the inner pores of brick. Then, due to wind, temperature, light and other factors, the water evaporates, and the salt in it forms crystallized salt and stays in the brick. The ambient temperature and humidity change alternately, and the repeated crystallization and dissolution of salt make the pores of the brick expand and contract repeatedly. The cyclic expansive force leads to the gradual disintegration and loose of the brick. In

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addition, $CaCO_3$ in the brick reacts with CO_2 and H_2O to form soluble $Ca(HCO_3)_2$, which makes the brick surface more prone to be washed by rain and fade and fall off. The external water mainly comes from the foundation soil and the atmosphere. For example, the buildings in many areas are built with brick walls, which are easy to absorb the moisture from the foundation soil, making the weathering damage of the wall from the bottom up show a phenomenon from heavy to light. The difference between southern Fujian buildings is that the brick walls below 1 meter are usually built with natural granite bars, which can effectively avoid the erosion of the brick body caused by the moisture of the foundation due to its good moisture insulation. Therefore, weathering of buildings in southern Fujian is mainly caused by subtropical Marine monsoon climate, including multiple factors such as wind direction, temperature, humidity, terrain, distance from the sea and salt spray content in the air.

3.2. The Climate Analysis

The linear distance between Cai's ancient buildings and the southern sea area is about 21KM (Figure 4). According to the latest data from the meteorological network, the rainy season in Guanqiao Town lasts for up to 6 months, with the precipitation up to 190mm. The time when the relative air humidity exceeds 90% is 3 to 4 months. The precipitation, humidity and temperature in winter are significantly different from those in summer (Figure 5). It can be seen from the terrain that the buildings face mountains in the northwest and flat land and sea from the east to the south. Most of the time, the wind direction in the area is mainly the east wind and south wind from the sea. In addition, frequent typhoon disasters in summer bring high humidity, high heat, high salt fog airflow and heavy rainfall. In addition, frequent activities in the seismic zone in this area also make bricks more prone to cracking. The impact of such annual climate change on buildings is obvious.

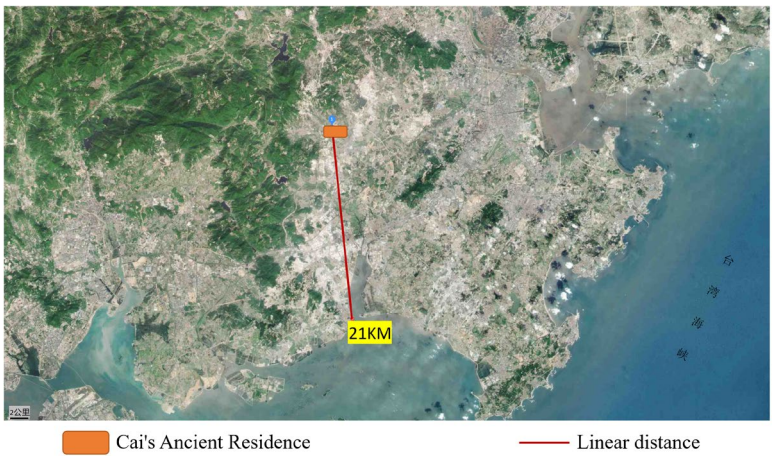

Figure 4: The Topographic Map of Guanqiao Town

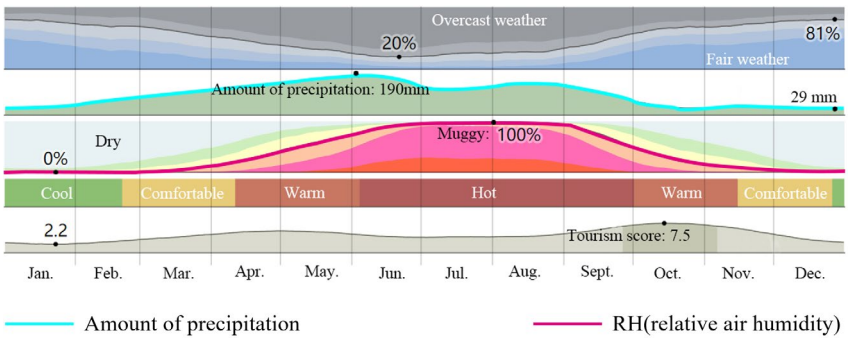

Figure 5: The Climate Analysis Map of Guanqiao Town (2022)

In addition, the high amount of salt mist in the air in this area further aggravates the weathering erosion of the bricks. Salt fog is a salt nucleus existing in the atmosphere and a dispersion system composed of tiny droplets containing chloride, sodium and sulfate ions, usually with a diameter of 5 μ wettable particles below m. The salt fog in the air of coastal cities is mainly generated by the formation and rupture of sea spray and bubbles. Its erosive effect is that the main component chloride is very easy to absorb moisture and become a strong promoter of electrochemical reaction. According to Xu Guobao's research on the atmospheric salt fog content in coastal areas, the average salt fog content per

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cubic meter in the air 20 kilometers from the sea on land is about 0.15 mg. Therefore, for Cai's ancient buildings, the sea breeze from the southeast brings high humidity, high heat and high salt fog flow, while the blocking of the mountain terrain in the northwest makes it easier for the high concentration salt fog flow to gather and settle here[3].

3.3. The Human Factors

Through field investigation, it is found that some brick carving surfaces are also subject to a lot of man-made damage, which makes the wall surface that has already suffered weathering and erosion worse. Some man-made damage occurred before this building group was listed as "Intangible Cultural Heritage" project, and its original components were difficult to recover, so it is unlikely to be repaired For more people to paint and scratch marks, or professional repair methods can be used to remove stains and repair scratches to restore their original shape.

4. The Suggestions on the Maintenance of Brick Carvings in Cai' s Ancient Residence

4.1. To Emphasize Protection Principles and Awareness

According to Article 2 of the Guidelines for the Protection of Cultural Relics and Historic Sites in China, the purpose of the protection of cultural relics is to truly and comprehensively preserve and continue their historical information and all their values. Therefore, the repair and maintenance of brick carvings of Cai's ancient buildings should respect the original structure and materials, and try to retain and reflect the regional characteristics and style of The Times. For example, it is not suitable to use the method of repainting the brick surface for part of the weathered faded, falling off the brick, otherwise it is likely to form secondary damage to the component.

In addition, it is necessary to strengthen the awareness of protecting cultural relics buildings. While developing tourism, it is also necessary to emphasize the importance and social significance of protecting cultural relics buildings to people, establish the consciousness of consciously protecting the architectural environment of Cai's ancient residential buildings, and guide the masses to actively and correctly use the cultural resources of Cai's ancient residential buildings. At the same time, it is also necessary to strengthen supervision, explicitly prohibit and resolutely put an end to illegal acts such as wanton painting, carving, destruction or theft on buildings.

4.2. To Emphasis on Scientific Detection and Analysis

In order to improve the anti-weathering ability of the brick carvings of Cai ' s ancient buildings, it is necessary to pay attention to the relevant scientific detection methods as the basis for maintenance and repair work. Most of the detection of brick weathering is based on visual impression. However, for the physical and chemical changes inside the brick, there is a lack of corresponding detection methods and technical specifications. Therefore, advanced technology can be introduced when necessary. For example, Peking University's Red Mansion in the implementation of the protection project, the introduction of Germany' s Remaz testing technology, the brick body salt analysis and mechanical properties to make quantitative analysis of changes, and then take targeted repair measures.

4.3. To Make a Reasonable Plan

For the protection of bricks that have been powdery, faded or fallen off, new materials can be used for hydrophobic and reinforcement treatment. For example, the brick carving restoration project of the Imperial Garden of the Forbidden City uses CKYH series organic siloxane resin coating, which combines the heat resistance, aging resistance, adhesion, toughness and water resistance of a variety of polymer materials, and has achieved good experimental results in the protection of cultural relics.

Before repairing cracks, it is necessary to carefully investigate their underlying causes. For example, the cracks formed by different factors such as structure, earthquake and bearing capacity are different. On the basis of the reinforced structure, the proportion of raw materials, color and weathering degree shall be studied. The nature and color of the repair materials and the original components shall be verified by experiments, and then the repair glue shall be used to fill the joints[4].

For manually painted handwriting, appropriate tools and neutral detergent with appropriate concentration can be used to gently erase the stains, and then rinse with clean water. During this

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process, secondary pollution of brick surface caused by acid or alkaline detergent should be avoided.

For the brick carving decorative components that have been damaged by human beings, you can try to make a detailed survey of the ancient houses of similar age and type in this region, or visit the inheritors of intangible cultural heritage, try to obtain the original pattern drawings of the fallen parts, and then copy the missing brick carving components by professional technical means, so as to restore the original shape.

In addition, appropriate physical measures can be taken in the environment to reduce weathering hazards to the extent permitted by conditions. For example, in the summer when tourists are scarce, thin-net sunshade sheds can be used in the front space to facilitate storage, which can physically block the high temperature of the hot sun for the wall, thereby reducing the damage of temperature difference to the brick surface.

5. Conclusions

The brick carving decoration component is one of the components which are seriously weathered in Cai's ancient residential buildings. The maintenance and repair work should adhere to the principle of minimum intervention and try to narrow the scope of maintenance to retain the original components. The key is to use appropriate materials to reinforce and hydrophobically treat the brick surface on the basis of theoretical research, and take appropriate measures to minimize the weathering damage, so as to continue its historical and cultural connotation and heritage value more truly and comprehensively.

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