Characteristics and application of regional building materials in Lingnan area: a case study of Casa da Cheang in Macao

Junrui Cao[1,2,*], *Yile* Chen[1], and *Yichenfei* Guo[3]

[1]Macau University of Science and Technology, Avenida Wai Long Taipa Macau, China
[2]Industrial Design Institute, Zhao Qing University, Zhao Qing, China
[3]CIECC, 25 Cheongzhuang West Road, Beijing, China

Abstract. Traditional local material is an important way to express regional architecture. As the most direct carrier to reflect regional characteristics, materials can realize the adaptability of regional architecture to the greatest extent. In this article, through analysis on brick, stone, earth, oyster shell as a representative of the Lingnan area regional traditional materials, material properties, an analysis of the regional characteristics of expression, as a case study of Casa da Cheang details its expression and function of regional material, for Lingnan area offer reference for the development of the regional architecture.

1 Introduction

Regionality is the inherent basic attribute of architecture. The development of regional architecture is restricted by climatic conditions, historical and cultural conditions and technical conditions, etc. Through the perception of architecture, people can quickly know the climate and cultural background of the region where the architecture is located.

As one of the basic elements of architecture, materials used in different regions can not only adapt to the local seasonal conditions to the greatest extent and reflect the local cultural style and features, but also achieve the maximum diversity of buildings. Regionalism emphasizes respect for regional environment, so the physical basis of traditional materials makes it the most direct carrier in the process of architectural expression. Using local materials and adapting to local conditions is the simplest and direct manifestation and externalization of regional architecture.

As for the definition of Lingnan area, the architectural circle divides it into a broad sense and a narrow sense from the perspective of research. Geographically, the south of the five Ridges all become the South of the Five ridges. Therefore, in a broad sense, areas such as Guangdong, Hainan, south of Quanzhou and Zhangzhou in Fujian, and south of Guilin in the east of Guangxi all belong to Lingnan area. In a narrow sense, the Lingnan region mainly refers to the Pearl River Delta region of Guangdong Province, that is, the geographical scope of canton area, including Zhao Qing, Zhanjiang, Hong Kong and Macao. Traditionally, Guangdong culture is the main body of Lingnan culture, and there is no strict distinction

* Corresponding author: 415392373@qq.com

between the two. In practice, the Lingnan region can be concentrated in the most central region, namely the Pearl River Delta region, including Guangzhou, Foshan, Zhao Qing, Shenzhen, Dongguan, Huizhou, Zhuhai, Zhongshan and Jiangmen, as well as Hong Kong and Macao.

Casa da Cheang is located on the side of MAGE street in Macao, facing Lilau Square which is a Lingnan style courtyard house. As a regional building located in Lingnan area, Casa da Cheang embodies the adaptability of Lingnan architecture in all aspects. This paper mainly takes Casa da Cheang in Macau as an example to analyze how Casa da Cheang reflects the regional characteristics of Lingnan area through traditional materials.

2 Types of main traditional materials in Lingnan area

The traditional materials in Lingnan area include wood, earth, brick, tile, bamboo, iron, ash, sand, asphalt, oyster shell, ceramics, Placuna placenta, glutinous rice paste and other special materials. The most commonly used materials are wood, stone, brick and tile. Bricks are divided into blue brick, red brick, mud brick and adobe brick. The stone is divided into volcanic stone, coral stone, etc. Earth is divided into rammed earth, concrete and so on. The unique regional materials are oyster shell, Placuna placenta ceramics and so on. Most of the wood trees come from the humid and hot conditions in the tropics and subtropics of Lingnan region, while oyster shells and sea moon are used because they are abundant in the coastal areas of the Pearl River Delta. The use of these regional building materials can make the building adapt to different climates better, such as humid, rainy, typhoon and other climatic conditions in the South of the Five ridges, so as to ensure its moisture-proof, rain-proof, moth-proof, durability and other characteristics.

3 Bricks

Brick is a kind of traditional material produced by manual labor. According to different firing methods, the traditional brick in Lingnan area can be divided into two categories: no-fire brick and fired brick. The fire-free bricks, including mud bricks, adobe bricks and earthen corner bricks. This kind of bricks is mud or soil, add straw or rice husk, add straw or rice husk to mud or soil, and add water to stir into mud paste, and then carry out different specifications of wooden mold imprint. This kind of bricks is made up of mud or soil and straw or rice husk. And then add water to stir into mud paste. Finally, it can be carried out different specifications of wooden mold imprint [1]. The advantages of this kind of brick are its simply operation process and its environmental material. However, its strength is worse than that of fired brick. Firing bricks is a mixture of clay, soil and sand with water, and then according to a certain shape, fired in a high temperature in a brick kiln, high strength. It also includes blue bricks and red bricks. In Lingnan area, it is hot and humid, with strong air permeability, oxidation resistance and corrosion resistance. Therefore, the existing Lingnan traditional buildings mostly use blue bricks. The buildings in Lingnan area almost use the blue brick from the wall to the local decorative carved patterns, and the external walls has not any decoration. Clay sculpture is commonly used in Lingnan dwellings, and the Casa da Cheang is no exception (Fig.1). Clay sculpture is mainly consisted lime of appropriate amount of river sand, straw, hemp skin and other materials. In coastal areas, shell fired ash is used to replace lime, which is a significant advantage of regional materials and it also can effectively prevent acid erosion from sea breeze. Clay sculpture material should choose high density brick without mixed with sand and low hardness, which is not only easier to carve but also can ensure the durability of Clay sculpture. It also needs to brush around the surface of 3-4 times with boiled tung oil when finished the Clay sculpture. The boiled tung oil can

form a film to protect the brick carving will not be weathered. Specific technology and materials: firstly, using boiled tung oil to brush around Clay sculpture's surface and then connect with tung oil ash which is made of quick lime and tung oil. After that, it is going to get sticky by stirring 5 to 6 hours later. Finally, the clay sculpture surface will take a week to dry out. This kind of protection treatment prevent Clay sculpture from being affected by various adverse harsh weather conditions and spread for hundreds of years.

Fig. 1. The clay sculpture of Casa da Cheang.

4 Lay brick

The basic element of brick masonry is the arrangement of bricks, which includes Stretcher, Header, Row Locker and Soldier (Fig.2). Common traditional bricklaying methods in Lingnan area include all stretchers, one-stretcher-one-header, three-stretchers-one-header, five-stretchers-one -header, seven-stretchers -one-header, nine-stretchers -one -header, etc. According to the type and shape of buildings, palaces, temples, ancestral halls, and other buildings usually have fewer stretchers; Civil and residential buildings tend to have more stretchers. This is closely related to the climatic conditions in Lingnan.

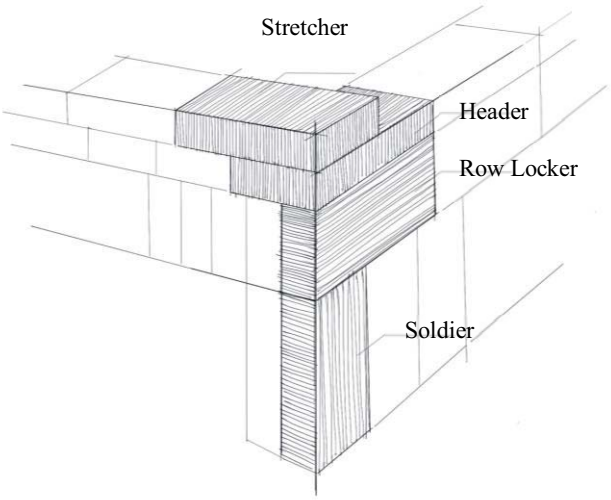

Fig. 2. The way of laying brick.

Taking blue brick as an example, the way of laying bricks generates an air layer between the two layers of wall, the air layer blocks part of the heat outside the wall, and the blue bricks are darker in color and can better absorb heat. Further, more stretchers and fewer headers, which can effectively reduce the gap between bricks, thereby reducing hot air from entering the room from the outside and ensuring indoor comfort. The walls of Casa da Cheang are made of blue bricks, with five-stretchers-one -header. This method can effectively keep heat, insulate and ventilate, and ensure the comfort of the indoor environment. It is also in line with the hot and humid climate of Macao.

5 The method of adobe brick wall

In many areas of Lingnan's traditional dwellings, there are not only adobe bricklaying but also ramming walls, which are mainly straw mud brick." Gold wrapped in silver" is a regional method of laying mud bricks in Lingnan area. Mud bricks are mostly Khaki, they are called "gold", while blue bricks are referred to as "silver". The waterproof performance of adobe brick is poor compared with that of blue brick, and it is easy to cause wall collapses when rainwater leaks. Therefore, the "golden-silver" laying method appears in the dwellings with better economic conditions, that is, the wall with two layers, the inner is adobe bricks, and the outer is blue bricks. This method not only plays a role in preventing moisture but also increases the strength of the wall.

6 Soil

The raw soil is classified according to the processing method which have twelve categories and eighteen construction methods. Among them, rammed earth, adobe bricks, pressed earth bricks, and mud walls are more commonly used. The soil is used as a wall material, which can be rammed into a wall by plate building, or it can be made into adobe bricks to build a wall. Different regions will have different soil selections, material ratio and construction methods which depend on the climate and technical. Basic material used for rammed earth walls is concrete. The raw materials of concrete are loess or red loam, lime, and sand. According to the material ratio and water consumption, it can be divided into dry ramming and wet ramming. In addition, the Lingnan region also has its special formula of concrete, it is made by adding glutinous rice, brown sugar, and egg white to the ordinary concrete. Due to the characteristics of these three ingredients, which are natural binders and curing agents. Even adding a small amount can greatly enhance the toughness of the triad, which becomes very tough and hard after it dries out. It usually uses silt from the sea or river sediment near the offshore area. During the construction process, it needs to remove the large gravel in the sand, and then stir them to promote the evaporation of water until the sand is thick and agglomerated before it can be used for ramming. The solidification walls made of this material are harder and more impermeable because the silt contains fiber and animal carcass protein.

7 Stone

Lingnan area is rich in stone resources, with good water resistance and abrasion resistance. Most of them are red sandstone, duck excrement stone, granite and etc. The choice of stone materials in different areas is based on the principle of local materials. For example, in Guangzhou, red sandstone was used before the Ming Dynasty, and granite was used after the Ming Dynasty, while coral stone is used in great quantities as building materials in the Lei Zhou area. Lingnan area is rich in stone resources, with good water resistance and abrasion

resistance. Most of them are red sandstone, duck excrement stone, granite, etc. The choice of stone materials in different areas is based on the principle of local materials. For example, in Guangzhou, red sandstone was used before the Ming Dynasty, and granite was used after the Ming Dynasty, while coral stone is used in great quantities as a building material in the Lei Zhou area.

In the Moog Garden of Casa da Cheang, we can see the bottom of the Moon Gate is laid with stones (Fig.3). These stones are used to reuse the remaining stone components which had been abandoned, giving play to the good abrasion resistance of the stone and protecting the moon gate. In the corridor of the Casa da Cheang, you can see that the wooden windows are bound with stone (Fig.4), and the lower part of the wall is also protected by stone (Fig.5). The indoor column foundations are also made of stone (Fig.6). These measures can prevent the wooden windows from deforming effectively, and the use of stone wear resistance, water resistance to improve the wall's tolerance and one of which is adapted to Lingnan regional construction material performance.

Fig. 3. The Moon Gate of Casa da Cheang.

Fig. 4. The wood window of Casa da Cheang.

Fig. 5. The Wall of Casa da Cheang.

Fig. 6. The column foundation of Casa da Cheang.

8 Oyster shell material

The coastal areas of Lingnan are rich in shellfish. In addition to being eaten, Oysters and other shellfish can also be used locally as wall materials for window decoration have become one of the unique building materials in Lingnan area. The oyster shell used for the masonry of the wall is generally edible. Its main ingredient is calcium carbonate, which is corrosion-resistant, insect-resistant, and hard in texture. The shells used for oyster shell windows need

large, flat, high-quality shells with good transparency (Fig.7). The oyster shell wall generally plays a role in maintenance and decoration. The light through the oyster shell window is soft, and at the same time, it can ensure the line of sight is blocked, which can protect people's privacy to the greatest extent.

There are two methods for oyster shell walls. One method is to place the convex surface of the oyster shell upward and slightly inclined outward (approximately 45° angle) in a building with a blue brick frame or a wooden frame and use triad mud or lime slurry as cement Material, layer by layer, and finally plaster and level the interior wall; another method is to build the wall with blue bricks, with the convex surface of the oyster shell facing upward, slightly inclined outwards, cement with triad mud or lime slurry, and attach Outside the blue brick wall [2].

Fig. 7. Oyster shell window in Rong Ludi, Casa da Cheang, Macao.

The effective use of Lingnan materials can better reflect the vitality of regional architecture and characteristics. At the same time, it can also help generations to have a better understanding of traditional materials in the future.

References

1. Wansu Zhang, *The Expression of Lingnan Traditional Materials in Contemporary Architecture* (South China University of Technology, 2015)
2. Weijun Chen, *Structure Characteristics and Protection Renewal of Modern Architecture in Lingnan* (South China University of Technology, 2018)
3. Lijuan Zeng, Art Panorama **11**, 94-95 (2019)
4. Yao Wu, *A Study on Architectural Transformation of Early Modern Time in Macau* (Southeast University, 2004)