buildings

MDPI

Article

Structural Materials, Ventilation Design and Architectural Art of Traditional Buildings in Guangdong, China

Yingqiu Song [1] and Chenyue Liao [2,*]

[1] Faculty of Education, Shenzhen University, Shenzhen 518060, China; songyq@szu.edu.cn
[2] Guangdong Provincial Key Laboratory of Durability for Marine Civil Engineering, College of Civil and Transportation Engineering, Shenzhen University, Shenzhen 518060, China
* Correspondence: liaochenyue2020@email.szu.edu.cn

Abstract: Due to its special geographical conditions, Guangdong has absorbed the essence of the Central Plains Han culture and characteristics of foreign cultures, resulting in architecture in which traditional buildings exhibit unique regional cultural connotations. The architectural design is adapted to the needs of nature and ecology and the arts and humanities. This paper investigates the technical process of using local materials to obtain structural materials. Traditional Guangdong buildings use patios, cold alleys and doors as well as windows in a comprehensive manner to create an energy-saving and environmentally friendly ventilation design, which was analyzed here. In addition, we study the floor plans and artistic characteristics of traditional buildings in different regions of Guangdong. Traditional Guangdong buildings realize the harmonious coexistence of humans and nature, as well as embody the concept of sustainable development. Traditional buildings integrate benefits and efficiency while condensing the surpassing wisdom and rich experience of craftsmen from ancient times to the present. Thus, it is worthwhile to research the connotation of traditional buildings to develop modern architectures.

Keywords: traditional buildings; structural materials; ventilation design; architectural art

Citation: Song, Y.; Liao, C. Structural Materials, Ventilation Design and Architectural Art of Traditional Buildings in Guangdong, China. *Buildings* **2022**, *12*, 900. https://doi.org/10.3390/buildings12070900

Academic Editor: Tiago Miguel Ferreira

Received: 11 June 2022
Accepted: 22 June 2022
Published: 25 June 2022

1. Introduction

Traditional buildings are an important type and the most authentic source of Chinese architecture. Such architecture not only reflects the unique production method, custom and aesthetics of each ethnic group but also the experience of people using local materials and making the best use of their local circumstances. Such architecture can be seen as a time-space bridge for Chinese people, as they review history while looking forward to the future. At the same time, for many Chinese ethnic groups, it represents a spiritual home and a place to which the soul of the departed can return. Traditional buildings in any location display cultural regionality, which is a comprehensive reflection of national histories, cultural backgrounds and regional characteristics [1,2].

Guangdong is also known as Lingnan. It is a long, narrow region between the Nan Mountains and the South China Sea with high altitudes in the north and low land in the south. China is a country with many mountains, and across the nation, these mountains are the watersheds of the large rivers. The Nan Mountains are watersheds of the Yangtze River and the Pearl River. Lingnan is in southern China, surrounded by the winding Nan Mountains in the north and the vast South China Sea in the south. The Nan Mountains are the most important mountains in northern Guangdong and traverse northern Guangdong, Hunan, Jiangxi and northeastern Guangxi. Because of the rise of the Nan Mountains, Guangdong and the Central Plains are separated. Thus, Guangdong is referred to as Lingnan or Lingwai in Chinese history. The Lingnan culture has also preserved the long and splendid Chinese culture extending from the Han Dynasty. Based on the unique geographical environment and historical conditions, Lingnan culture has continuously

absorbed and integrated Central Plains culture and overseas culture in its developmental process, gradually forming its own unique features. With the changing times, the development of science and technology as well as productivity, and the exchanges between Lingnan's architectural culture and that of foreign cultures and cultural practices, Lingnan culture is characterized by openness and compatibility, which are fully reflected in Lingnan dwellings. Traditional buildings in Guangdong can be approximately divided into three styles: Cantonese dwellings, Hakka dwellings and Chaoshan dwellings. These styles belong to three major cultural circles: Cantonese culture of the Pearl River Delta and surrounding areas, Chaoshan culture of the eastern coastal areas of Guangdong and Hakka culture of northern Guangdong.

As evidenced by the annual average temperature from 2016 to 2020, Guangdong Province experiences high temperature and humidity. The annual average temperature is 22.5 °C, and the average annual rainfall from 2016 to 2020 was 1387.3 mm (Figure 1). In this study, we analysed the characteristics of traditional residential structural materials from the perspective of comprehensive climatic conditions and local natural resources. The analysis revealed the connection between structural materials and the natural environment in Guangdong Province. Despite the availability of other relatively complex and expensive technologies, traditional buildings in Guangdong generally utilize natural ventilation. The ventilation system is coordinated through three elements: patios, cold alleys, and doors and windows. The method and principles of natural ventilation in traditional buildings are based on the regional cultural characteristics of Guangdong Province and are reflected in the architectural art of Hakka buildings in northern Guangdong, Cantonese buildings in central Guangdong and Chaoshan buildings in eastern Guangdong. The structure of the article is shown in Figure 2.

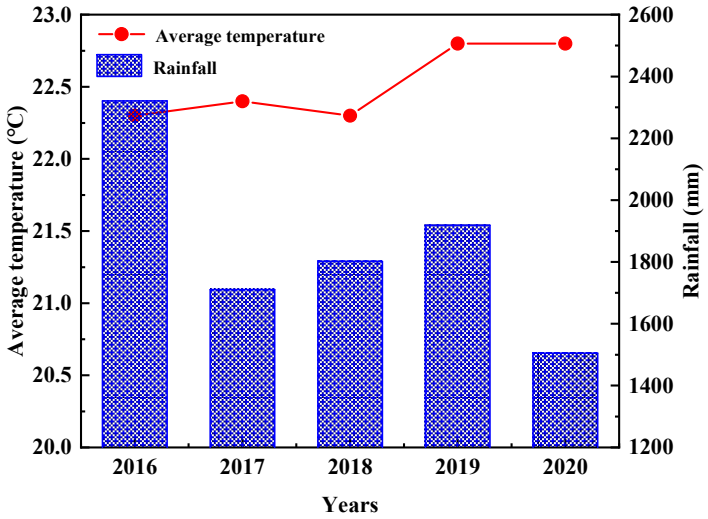

Figure 1. Climate characteristics of Guangdong Province from 2016–2020. (Adapted from ref. [3]).

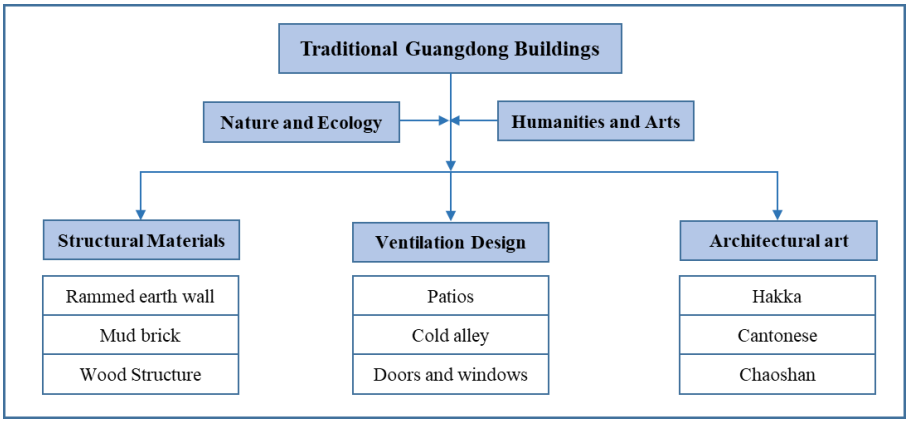

Figure 2. Structure of the article.

2. Structural Materials of Traditional Buildings in Guangdong

Guangdong is located in the tropics, near the northern limit of the Tropic of Cancer and belongs to the subtropical monsoon climate region of East Asia. There are abundant natural resources in the region that can be used as building materials, such as red sandstone, various types of clay and river pebbles. Red sandstone is red, dark red or brown and rich in oxides. It has good moisture resistance, low hardness and low mining technology requirements. Its usefulness was recognized early by Lingnan's inhabitants, and the material is widely employed in residential building walls, foundations, column foundations, door beams, etc. During the late Ming and early Qing dynasties, red sandstone was used less. Because of advances in mining technology and transportation, granite with high strength has been widely used. In Guangdong Province, the mostly yellow silty clay or loam soil is soft and rich with good viscosity. Rice straw is often added to such soft soil to make raw earth bricks. In addition, supplementary materials are added to the soft soil and the outcome is rammed directly to form a wall. Guangdong Province is rich in forest resources, and the river network extends vertically and horizontally. There are many water systems, such as Zhenshui, Jinjiang, Wushui, and Lianjiang, originating from the Five Ridges. There are large and small pebbles along the river, all of which provide useful construction material for buildings.

In certain ancient Hakka villages in northern Guangdong, ordinary traditional buildings are constructed with cheap, readily available materials, that is, the soil. The practice of constructing rammed-earth buildings and mud-brick buildings can be observed. "Banzhu" is a method of building walls by stamping earth between board frames. It represents a common technology for constructing traditional Chinese walls. The production process is shown in Figure 3. First, a mould is made with wooden boards or bamboo pieces at the position of the wall, and then, river stones, yellow mud and grass roots are mixed. The mixture is poured into the mould and compacted layer by layer. After a few days, the outer mould is removed, forming a rammed earth wall. It is time-consuming to build this type of wall, but such walls are very solid and durable. Obtaining material from local sources for buildings is a typical approach [4–7]. The method for constructing mud-brick buildings is similar to that used for rammed earth buildings (Figure 4). An appropriate quantity of river sand is mixed into field mud, and then dry straw is added as an aggregate to increase the strength. Water is added, and then the mass is mixed into a paste and compacted into a block using a pre-sized wooden form. After slowly drying, the mass can be demoulded and stacked to form a sturdy wall. Regardless of which construction method is adopted, earthen walls are generally plastered with a layer of loess or white ash on the surface to protect the inner and outer walls. However, this layer can easily fall off. With the development of craftsmanship, adobe bricks were gradually transformed into fired bricks. The outer walls of the buildings were constructed with blue bricks, and the surfaces were mostly fair-faced walls or whitewash.

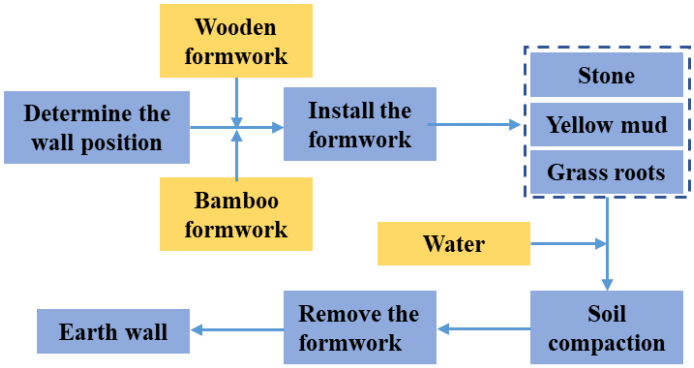

Figure 3. Rammed earth wall production process.

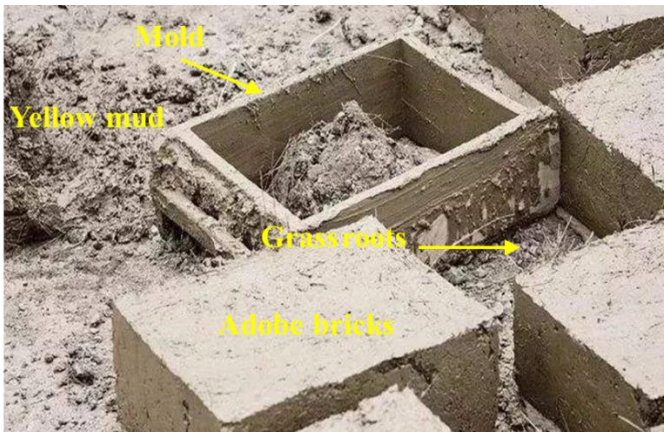

Figure 4. Mud brick materials.

For example, the materials of traditional buildings exhibit regional characteristics in Donghuping, Shixing and northern Guangdong. As shown in Figure 5, the wall foundation is mainly red sandstone, which has a good moisture-proofing effect and can prevent rainwater from soaking the wall. Wealthy families often directly use stone masonry to construct the wall foundation, which can keep the building dry. Such walls mainly use yellow clay bricks bonded with lime–glutinous rice slurry, which ensures higher strength and more water resistance compared with pure lime mortar. This is because the glutinous rice slurry influences the carbonization reaction of calcium hydroxide, which changes the morphology characteristics of calcium carbonate grains and limits the growth space of particles. Thus, the microstructure of glutinous rice lime mortar is better. The use of this material can significantly improve durability and keep a structure stable for hundreds of years. The yard floor is paved with cobblestones, a simple construction process that allows rainwater to quickly penetrate the soil. The upper part of the building is a black–grey roof, and the lower part is plastered with yellow bricks and white ash. The combination of deep black and sharp white in the building, with simple, earthy yellow in the middle, represents the integration of heaven and earth.

Guangdong Province has rich forest resources that can be used as high-quality building materials. The wood types commonly used in this area include fir, pear, teak, nanmu and camphor. During construction, Chinese fir is mainly used for framing, and camphor and fir are mostly used for the carved components [8]. Chinese fir is a light material and offers many advantages, such as a straight grain, easy processing, good elasticity, toughness, insect resistance and corrosion resistance. Building components made of Chinese fir generally remain straight and are not easily deformed by the thermal expansion and contraction caused by the alternating heat and cold as well as the changes in internal and external dry and wet conditions. The characteristics of Chinese fir, which can be soft or hard and bend or stretch, make it an ideal construction material [9]. The typical brick–mixed-

wood structure with Chinese fir beams, terracotta roof, and masonry walls are common in Lingnan Cantonese buildings. This mix continues to be used today and can often be seen in the roof trusses of traditional buildings.

Figure 5. Structural materials of traditional buildings in Donghuping, Shixing.

Among the structural materials of traditional buildings in Guangdong, adobe or rammed earth yellow mud walls without decoration appear simple and elegant. The wall foundation is made of river pebbles, whereby large pebbles are piled up, and small pebbles are used to fill in the gaps. The white plaster used for stitching is waterproof, firm, delicate and orderly. The red sandstone strip stone doorframe and the log-coloured wooden components are concise and plain. Viewed from a distance, buildings with rows of scattered grey roofs and yellow mud walls contrast with the blue sky and white clouds. Buildings using local materials are completely integrated with nature, creating an unpretentious yet vibrant beauty.

3. Ventilation Design of Traditional Buildings in Guangdong

Most areas in Guangdong have a tropical marine climate. Buildings mainly use ventilation to dissipate heat rather than enclosures to prevent heat from entering the room. There are two types of natural ventilation: wind pressure ventilation and hot pressure ventilation. The two methods function according to different principles (Figure 6). Wind pressure ventilation occurs through a change in spatial scale, which causes uneven air density on the windward and leeward sides of the building and thus a pressure difference. Hot pressure ventilation operates through temperature changes and uses the height of the air inlet and outlet, causing an uneven density of indoor and outdoor air, leading to the exchange of cold and hot air. These two ventilation modes are flexibly used in traditional Guangdong buildings. There are various methods of ventilation in such buildings, including patios, cold alleys, doors and windows. In ancient times, because of the low indoor living environment and the labour intensity of people, the heat that required removal was much less than that of modern buildings. Due to the rationality of the thermal environment's design, natural ventilation can basically meet the requirements of indoor heat dissipation [10,11].

In the ventilation system of traditional buildings, patios play the role of organizing and connecting (Figure 7). For example, Hakka buildings are generally larger in scale and have better enclosures. To ventilate and find contact with nature, people have formed a pattern of combining virtual and real buildings by adding yards and patios [12–14]. However, the indoor thermal environment can still be dark and humid and suffer from unfavourable ventilation. In the ancient towns of Chayang and Songkou, Hakka settlements in northern Guangdong, most of the buildings have three to four floors to make full use of the land. Such multistory strip-shaped dwellings are characterized by a single patio, and the bottom floor is very deep, reaching 20 m to 30 m. Compared with that of the traditional Hakka partial multilayer unit, the ventilation of the overall multilayer unit is more complicated.

As the core ventilation and lighting component, the size and location of the patio have an important impact on the living environment of the entire unit. If the patio is too small, the indoor lighting is insufficient. Additionally, too small an air volume is not conducive to ventilation. During the day, the roof absorbs a large amount of solar radiation, causing the temperature to increase quickly. If the patio is too large, the heat radiation unevenly absorbed by the patio from the roof results in a slow temperature increase. However, large patios can absorb solar radiation to heat the air near the ground during certain periods so that the temperature difference between the upper and lower patios is small. Finally, the thermal pressure ventilation is weakened [15]. Therefore, the size of the patio must be designed to make the air volume sufficiently large. In addition, the temperature difference between the patio mouth and the patio ground air should be increased as much as possible.

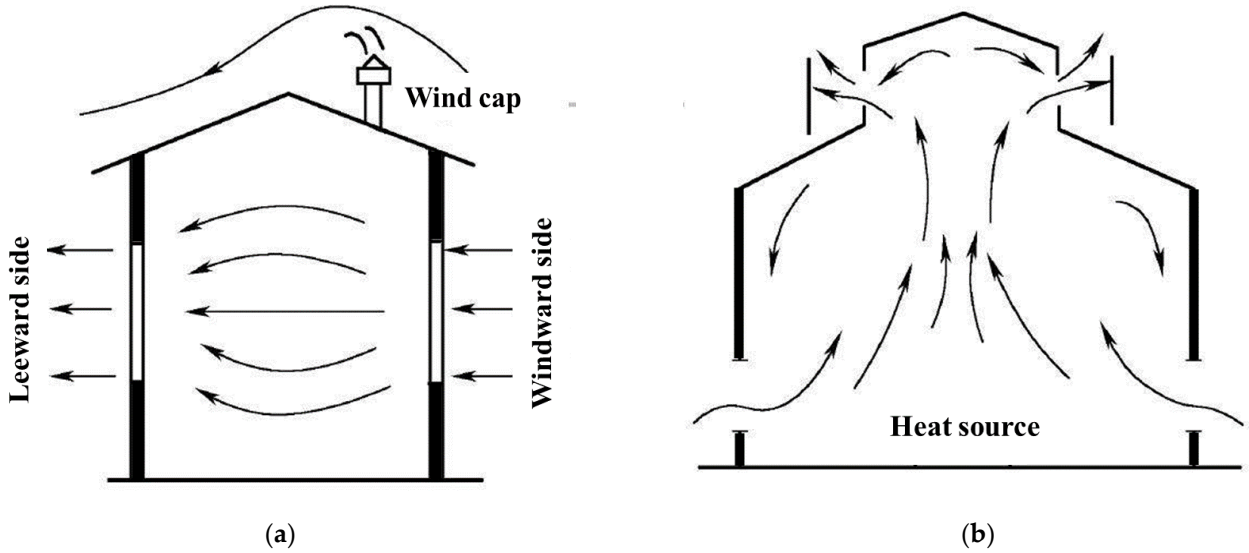

Figure 6. The two principles of natural ventilation. (**a**) Wind pressure ventilation; (**b**) hot pressure ventilation.

Figure 7. The patio in the traditional building.

The cold alley is another common ventilation design element in traditional buildings and plays a role in improving the thermal environment [16]. A cold alley is a relatively narrow alley formed by the arrangement and combination of buildings or, alternatively, a small corridor left on one side of a building. It is an air duct with a small cross-sectional area. The wind pressure decreases as the wind speed increases, and the warmer air of each room connected to the cold alley is removed. Then, the cooler air enters the rooms and fills them, thus ventilating them. The patios of ordinary courtyard buildings are usually

only affected by wind pressure. Adding cold alleys can create the effect of heat pressure. As shown in Figure 8, in Zhan Garden, Zhongshan, there is a shadow area formed by the building on one side of the roadway, and a temperature difference will form in the roadway, thereby creating hot pressure ventilation. Certain buildings have three-entry courtyards, and the ventilation effect is poor. In such cases, adding an alley on one or both sides of the courtyard is beneficial. This type of roadway not only solves the problem of traffic and fire prevention but also adapts to climatic conditions and achieves a good ventilation effect [17]. This effect is strongly related to directional orientation. As shown in Figure 9, the heat resources from the hall, rooms and kitchen are transported to the cold corridor and then concentrated to the patio. The cold corridor and the patio work synergistically for efficient ventilation. Because the dominant wind direction in Lingnan is southeast or south, most roadways run north to south to provide good ventilation.

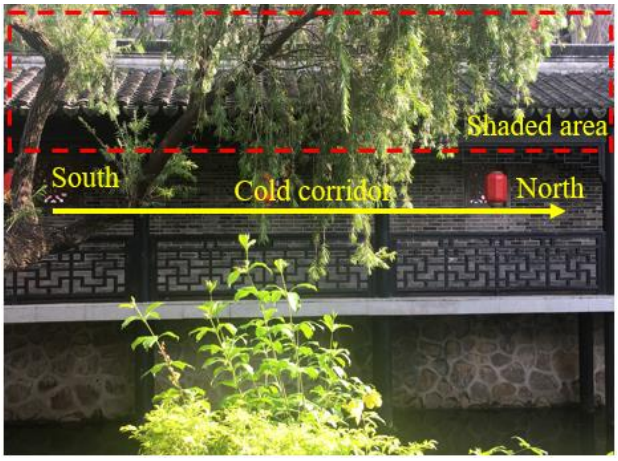

Figure 8. Cold corridor of Zhan Garden in Zhongshan.

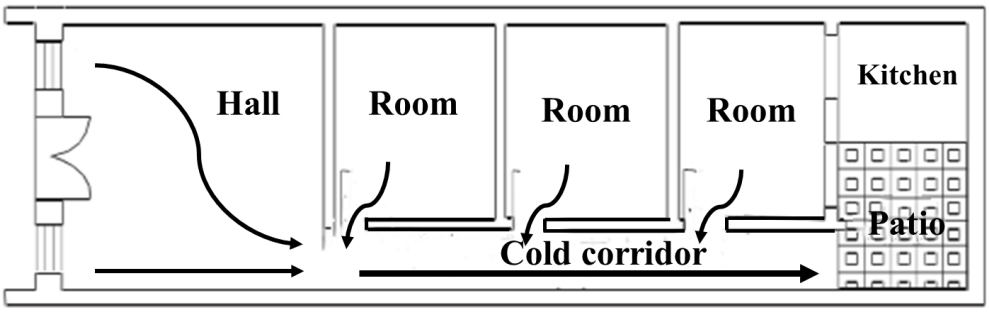

Figure 9. The ventilation design of traditional buildings in Guangdong.

Properly designed doors and windows support good ventilation (Figure 10). For example, certain doors are made of movable lattice fans with two upper and lower sections, while others are use floor lattice fans in the opening part of the second floor. The lower section of the lattice fan is fixed by a transparent wooden railing to ensure safety. When the grid fan is turned on, the wind blows in from the top and bottom to create convection, and the air volume can be doubled. Another type of door, a transparent wooden gate, is generally added outside the gate in houses in the coastal and central regions of Guangdong. When the weather is hot, the inner gate can be opened, and the wooden gate can be closed, which is beneficial for ventilation and security. In addition, to ensure proper observation of the feng shui of such buildings, the wooden gates are decorated with different gossip patterns in the Chaoshan area. The main indoor partitions are the upper and lower transparent fir partitions, and the guardrail in front of the roof is a transparent bottle-shaped porcelain railing. All these devices reduce ventilation resistance and are conducive to airflow as well as even distribution.

(**a**) (**b**) (**c**)

Figure 10. Doors and windows of traditional buildings in Guangdong.

4. Architectural Art of Traditional Guangdong Buildings

4.1. Hakka Traditional Buildings

The Hakka people who moved to Guangdong gathered at the junction of North Mountain and South Mountain. Their survival and development were based on adhering to their original cultural characteristics while integrating the advantages of the local indigenous culture into their living customs, language, totem worship, residential buildings and into other material and spiritual aspects of their culture. As one of the districts with the most prominent Hakka ethnic features, the Meizhou area is rich in typical traditional cultural elements of Hakka [18]. The Dragon House, as shown in Figure 11, which exhibits the regional characteristics of the Hakka building, is the most popular architectural style among the Hakka buildings in northern Guangdong. The distribution of the Dragon House is centred on the Hakka-inhabited hinterland in Xingning, Meixian, Guangdong. It has also spread into the surrounding areas, including the Dong River Basin and the Pearl River Estuary [19,20]. This building style displays good structural characteristics in harmony with the laws of nature and is amenable to good sustainable development [21–23].

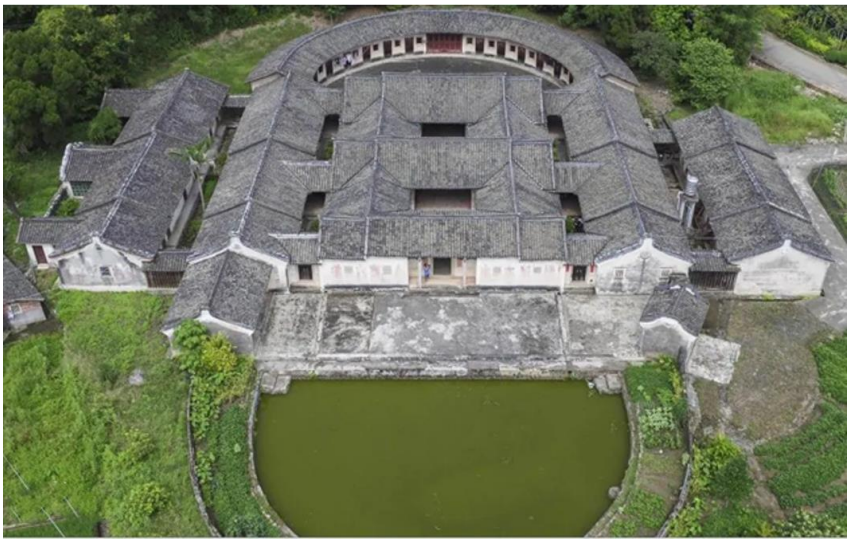

Figure 11. The Dragon House.

The overall layout of the dragon house is a closed shape (Figure 12). In terms of overall shape, the dragon house is similar to a tai chi figure. The main body of the dragon house is the main room, which is an extension of the two halls–two horizontals and the three halls–two horizontals. At the back of the main room, a half-moon-shaped enclosure connects with the tops of the horizontal rooms on both sides. The main house is located

in the middle, and there are two halls with two horizontal rooms surrounded by one dragon, three halls with two horizontal rooms surrounded by one dragon, four horizontal rooms surrounded by one or two dragons, and six horizontal rooms surrounded by three dragons. Certain such structures are surrounded by as many as five dragons. Most Dragon houses are constructed near mountains. The entire building spans the space between the hillside and the flat ground, forming a double-arch curve with a low front and a high back and with two sides of low and medium height. Buildings are stacked on top of one another, as viewed looking forward from the highest point behind the house; it is an open landscape [24].

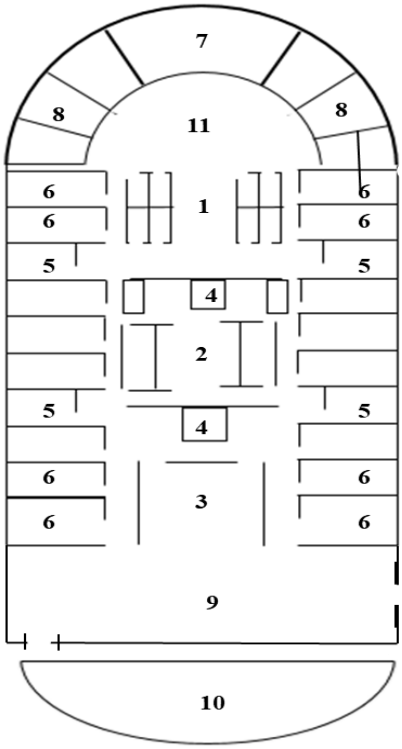

Figure 12. Dragon House floor plan. 1—Upper Hall; 2—Middle Hall; 3—Lower Hall; 4—Patio; 5—Hengwu Hall; 6—Hengwu Room; 7—Dragon Room; 8—Enclosed Room; 9—Heping; 10—Pond; 11—Flower Tire.

In terms of construction materials, the foundation is made of stone. The high platform is built to bear the weight of the upper wall and isolate the damp air. The walls are almost rammed earth walls adapted to the local weather that is warm in winter and cool in summer. They are durable and solid, economical and environmentally friendly. Generally, the roof is tiled, which is conducive to drainage. The structure is mainly the wooden frame, and the wall is directly used to bear the load. It has the characteristics of simple craftsmanship, good seismic performance and clear structural logic. The Dragon House shaped the basic pattern of the patio-center and the unit type, and the halls are connected by the patio. The architecture with good space permeability and meets the requirements of ventilation and lighting (Figure 11). As shown in Figure 13, the interior of the Dragon House is bright and spacious. The relationship between humans and nature is well coordinated in the dense living environment.

Figure 13. The interior of the Dragon House.

Judging from the basic shape of the dragon house, the open-air section between the main body of the building and the walls is a semicircular "flower tire". The shape is like a pregnant woman's slightly bulging belly, which corresponds to the "five-party dragon god" that symbolizes the birth gate of women under the lower abdomen, indicating that the dragon and the phoenix are born, and the descendants will be long-lived. In addition to the basic functions of irrigation and fire safety, the pond in front of the house has the special meaning of gathering wealth [25]. The ancestral hall is the heart of the Dragon House. In addition to its function as a space in which to worship ancestors, it serves for welcoming relatives and banqueting with guests. It can also serve as a place for the tribe to pass on traditional beliefs and customs and for spiritual belief and emotional sustenance [26,27].

In terms of interior decoration and cultural connotation, woodcarvings and paintings complement one another, and the decorative components can be quite exquisite. Sculptural elements decorated with relief, openwork or a combination of techniques are mostly used in beams, columns, doors, windows and railings but also in other places. The content of the carving and painting is elaborate, and the themes are mainly myths and customs, flowers, animals, and figures. Realistic and decorative techniques are used to express various objects and reflect different meanings. The latter include children, blessings, wealth, good luck, fertility and prosperity, and other auspicious symbols. The main shapes are bats (a homonym for blessing), dragons, phoenixes, pomegranates (meaning children) and several others. On the beams, words and phrases appear, such as "hundreds of sons and grandchildren" or "peace and wealth". The words are painted with pigments made of natural plants or minerals, with bright and firm colouring [28]. Such decoration reflects the Hakka people's pursuit and yearning for a better life while exhibiting the valuable inheritance of the local culture and its compatibility with the traditional culture of the Central Plains and foreign cultures.

4.2. Traditional Cantonese Buildings

The Cantonese area is the Pearl River Delta area around Guangzhou in the central part of Guangdong Province. The Cantonese people who live here are characterized by speaking the Cantonese dialect, and their language, religion, customs, moral values, social organization, and economic characteristics are similar. The Cantonese area has the largest area and the largest population in Guangdong Province. Since ancient times, it has been the most developed economy and the most important representative area of Lingnan culture. "Cantonese architecture" generally refers to the traditional architecture in the area in which the Han people live, and the style is an important branch of Lingnan architecture. While retaining its own regional characteristics, it constantly absorbs and digests foreign cultural influences. The fusion of architectural culture and decorative techniques expresses the compatibility and diversity of Cantonese architecture based on practicality and commerce.

The layout of Cantonese buildings is in line with Chinese symmetrical beauty, and their exquisite decoration makes their appearance sophisticated, elegant and solemn.

Like the Lingnan people, Cantonese buildings are open and innovative, inclusive, enthusiastic and cheerful, pragmatic and truth-seeking. Chen Clan Temple (1888–1894) in Guangzhou, also known as Chen Clan Academy, was constructed during the late Qing Dynasty. Because of its prominent regional cultural characteristics and aesthetic orientation, it is referred to as the "Cantonese Architecture Model". It is famous for its large scale and gorgeous decoration. The temple is a relatively well-preserved and representative example of folk architecture of the late Qing Dynasty in Guangdong. As shown in Figure 14, the main body of Chen Clan Temple follows the traditional layout of axisymmetric and clear primary and secondary elements of ritual architecture [29], and in the comb-style layout, the Lingnan characteristics are interspersed. Most of the temple buildings are single-story wooden structures. Lingnan is in the subtropical and tropical region with short winter and long summer, and the climate here is hot. The buildings in the Lingnan region are usually single-story wooden structures, so the shapes in the architecture are transparent and open, simple and light. The walls can be able to reduce fire risk, and also called the "horsehead wall" in the Chen Clan Temple. Besides, the outer walls made of blue bricks are high, and the interior rooms and halls are mostly connected by corridors. Most of the ventilation structures are shown in Figure 15. Removable lattice fans are used to ventilate the hall. In this way, halls, patios, and corridors are integrated together to form a large space that is outside, closed and open inside. This is the inheritance and development of the traditional features of a Lingnan architectural plane and space layout. It is beneficial for creating a good enclosure for the courtyard space. Furthermore, corridors are usually arranged between two buildings or two viewing points and become an important means of spatial connection and space division. It not only provides a sheltered place for keeping the interior shady all year round but also as the traffic connection. In short, corridors play an important organizational role in the arrangement and viewing of the landscape.

Figure 14. The Chen Clan Temple.

The solemn and grand architecture is integrated with eye-catching and elegant artistic elements, and the attention to detail calmly provides a bright yet subtle visual experience. All of the exquisitely elaborated decorations, such as roof ridges, cornices, doors and windows, patios, walls, steps, corridors, courtyards and interior furnishings, reflect the pursuit of perfection in details (Figure 14). Chen Clan Temple represents a collection of various artistic expressions and absorbed foreign classic decorative methods that integrate various techniques, such as stone carving, wood carving, brick carving, grey sculpture, pottery sculpture, copper and iron casting, and colour painting, all of which are commonly known as the Seven Wonders of Chen Clan Temple (Figure 16) [30]. Woodcarving represents a large proportion of the architectural decoration of Chen Clan Ancestral Hall, which can be described as "no wood without carving". All the wooden structures in the building use the

two techniques of relief and engraving. The artistry completely preserves the folk culture of the Lingnan area at the time the building was erected and condensed the surpassing wisdom and rich experience of craftsmen from ancient times to the present. For example, let us describe the twelve large double-sided engraved screens at the rear of the temple's Juxian Hall, whose wood texture is on full display. The composition is strict and orderly, and skilled and vigorous carving is used to create vivid characters and complex scenes. The application of the scatter perspective technique enables plane woodcarving to evoke a three-dimensional sense of hierarchy. Another example is the niche cover of the three-entry lobby—another masterpiece of meticulous carving. It is tall and luxurious, and carved with a great number of dragons and phoenixes, figures and flowers; it is the largest Qing Dynasty woodcarving remaining in Guangdong [31]. In front of Chen Clan Temple is a pair of stone lions with peaceful demeanours (Figure 17). The male lion is stepping on a stone ball and looks proudly into the distance, symbolizing power. The lioness holds a cub in her paws, symbolizing the prosperity of the family. The smooth stone ball in the mouth of the male lion was carved whole using the engraving technique. It can rotate freely without falling out of the lion's mouth. The four sides of the stone base under the lions are engraved with auspicious patterns, such as "Carp Leaping over the Dragon Gate", "Danfeng Chaoyang" and "Lion Playing Ball", with high relief techniques.

(**a**) (**b**) (**c**)

Figure 15. Ventilation structures at Chen Clan Temple. (**a**) The Horsehead Wall. (**b**) The Corridor. (**c**) The High Wall.

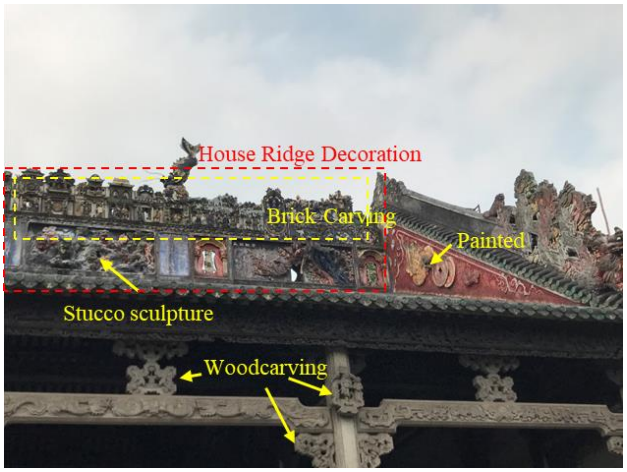

Figure 16. Artistic elements at Chen Clan Temple.

Figure 17. The male lion at Chen Clan Temple.

Grey sculpture is a unique outdoor decorative art found in Guangdong buildings. Its design is highly particular and has distinct layers and elaborate symbolism. It is mainly distributed on the roof and roof ridge (Figure 18). Because of its special decorative aspects, the production is relatively difficult. Thus, the grey sculpture of Chen Clan Temple represents the highest level of folk grey sculpture technology [32]. On the ridge of the nine halls of Chen Clan Temple, there are eleven pottery sculpture ridges. Each has a double-sided figure and flower ridge, tall in extent, rich in layers and complicated in decoration, with numerous characters and extensive scenes. It is a representative work of ceramic ridge art of the late Qing Dynasty. The ridge decoration is broadly divided into left, middle and right sections according to the decorative theme. A middle section is a group of large-scale theme opera scenes, the left and right sides are subtheme opera scenes, and the left and right ends are large figures or round dragon and phoenix sculptures.

(**a**) (**b**)

Figure 18. Pottery sculpture ridges at Chen Clan Temple.

Cantonese buildings also reflect an open attitude towards certain foreign architectural forms and elements. They neither refuse to cultivate the native tradition nor blindly reject foreign architecture. However, through rational examination, Cantonese architecture boldly absorbs and learns from both sources. The artistic features noted above are in fact inspired by Baroque architecture [33–35]. For example, the corridor of Chen Clan Temple changes the traditional column style and adopts Western-style cast-iron columns. To highlight the theme pattern of the railings and reduce the cumbersome feeling of the platform stone railings, the stone balcony railings in front of Juxian Hall are made of cast-iron flowers.

Sixteen exquisite and carefully designed cast-iron railings are carved into patterns such as "Dragon and Phoenix, Jade Book, Kirin", "Nine Fish Diagram", "Three Sheep Qitai", and "Cloud Dragon Spitting Pearl". The grey–white and elegant stone railings and the dark-toned cast-iron railings complement one another, contrasting harmoniously in terms of their prominent themes, which enhances the decorative effect of the railings and has a poetic and picturesque beauty. This achievement established a precedent for the combination of stone and iron carvings in Guangdong.

4.3. Chaoshan Traditional Buildings

The Chaoshan area is located in the eastern coastal area of Guangdong, surrounded by mountains on three sides and facing the sea on the other, with a unique geographical location. Traditional Chaozhou culture was developed through the integration of three main elements: the ancient "Baiyue" indigenous culture, the Central Plains Han culture brought by immigrants from the southern Central Plains ruled by past dynasties, and the culture born in the late Ming and early Qing dynasties and extending to the present "Spirit of the Sea" [35]. People who live by the sea must be more adaptable than inland farmers, and whether for navigation or commercial purposes, fishermen require colourful emblems. Therefore, Chaoshan buildings tend to use random, dynamic and luxurious colour decorations [36], which introduce the gorgeous Nanyang style into Chaozhou folk decoration.

There are many styles of traditional buildings with symbolic names in Chaoshan, such as Sima Trailer, Four Points Gold, and Xiahu. As an example, we describe Four Points Gold, a unique residential building with Chaoshan characteristics (Figure 19). The layout is shown in Figure 20. The building is named for a room shaped like the word "gold" on each of its four corners. In the old days, only wealthy families could build such structures. The architectural pattern of Four Points Gold resembles that of the courtyard building in Beijing. There are generally fences around the walls, and wells are drilled inside the fences. There are "wall bellies" on the left and right sides of the gate. Passing through the gate, one enters the front hall. The rooms on both sides are referred to as the front room. Across from the gate is an empty patio. There is a room on each side, one of which serves as a kitchen and the other as a firewood room. Behind the patio is the back hall, also known as the hall, which is occupied by the earth force, important for ancestor worship. There is a large room on each side, which are the bedrooms for the elders [37]. The windows of a Four Points Gold building generally do not open to the outside but, rather, only to the inner courtyard. This is because "wealth" accumulates in the patio from the gate or the sky and then "sucks" into the house through the doors and windows of each room. If a window opens to the outside, the house leaks air, and the "wealth" leaks out [38]. Four Points Gold buildings are connected and symmetrical, while the courtyard in the atrium is small and square. The layout is based on the old system, established prior to the Song Dynasty, with the gate centred in the middle and south on the central axis. The Four Points Gold building of Chaoshan retains the shape and layout of the Quadrangle in the Song Dynasty, which is very similar to the Quadrangle appearing in Wang Wei's Figures of Wangchuan of the Tang Dynasty [37].

In the early days, the Chaoshan people mixed the clay sandy soil with water, stirred it to soften and added straw as rebar. Pouring the wet soil into a mold to pressurize and harden, and drying it to make "Thokakchhu" (Figure 21). The Thokakchhu Wall is poor in terms of integrity and durability, so few of them remain. Since then, the brick walls became popular in the Central Plains, and gradually evolved their own building systems. Because there are many people but less land in Chaoshan, land resources are extremely valuable while burning bricks require good soil. To avoid competing with agriculture for land, the Chaoshan people utilize grey sands, shell ash and shell to make rammed earth walls (Figure 22). Thus, the brick materials have not been widely adopted in traditional Chaoshan architectures. Calcining shells to obtain the shell ash with high strength and cohesive force and can resist the erosion of sea wind. During the process of repeatedly mixing and stirring,

shell ash can be added in a certain proportion or mixed with brown sugar water and rice pulp. After curing, the mixture is layered into the mold for compaction. The quality of the rammed earth wall depends on the content of water. If the water is less, the viscosity of the rammed earth wall is poor, and it is difficult to ram. The rammed earth wall with much moisture is easy to ram, but it is also easy to shrink and crack after drying. The experienced craftsmen built rammed earth walls made of shell lime sand with high strength and quality. Thus, the traditional Chaoshan buildings are still intact after hundreds of years of wind and rain.

Figure 19. Four Points Gold buildings.

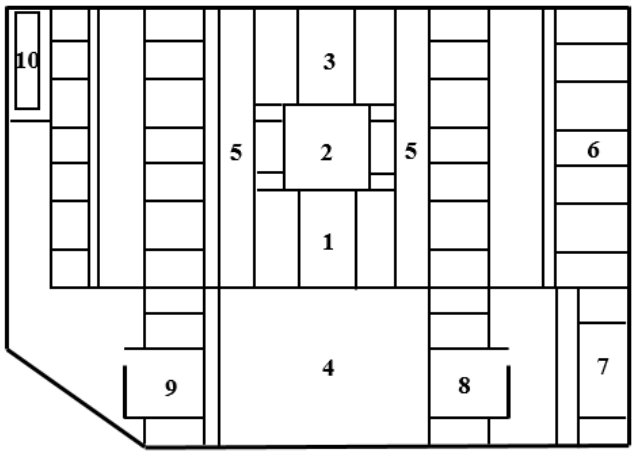

Figure 20. Floor plan of the Four Points Gold building. 1—Front Hall; 2—Patio; 3—Back Hall; 4—Qiancheng 5—Huoxiang; 6—Upper Book Hall; 7—Lower Book Hall; 8—Eastern Gate; 9—Western Gate; 10—Toilet.

The architectural decoration of Chaoshan residential buildings is extensive and profound, and there are many types. The most prominent and most important features are the gatehouse, roof and hall. Many decorative techniques are used, including wood carving, stone carving, and murals. The most popular and unique technique is Chaoshan carving. Most of the decorations on the girders are paintings, and the themes are highly diverse. There are a variety of painting techniques, including using ink and black lacquers. It is precisely because of these special techniques that Chaoshan buildings are resplendent [39]. The interior decoration also includes wood and stone carvings and other decorations, adding to the beauty of the buildings.

Figure 21. The "Thokakchhu" Wall.

Figure 22. The rammed earth wall.

The climate in the Chaoshan area is hot and rainy (Figure 23). The annual average temperature is 23.2 °C, and the annual rainfall is approximately 1300 to 2000 mm, mostly concentrated from April to September. The salt content of the air in the region is high due to its proximity to the sea. Under such climatic conditions, decorations (such as the grey sculptures and paintings on the roofs of early buildings) are easily damaged, and craftsmen must focus on corrosion resistance and sturdiness. Seeking to prevent the roof decoration from being eroded by wind, rain and salt, artists were inspired by Jiaozhi pottery, which originated south of Five Mountains, Guangdong. They began to investigate and develop decorative components similar to Jiaozhi pottery, creating the porcelain inlay process, which continues to be used (Figure 24). For example, there are five different signs representing gold, wood, water, fire and soil on the ridge end of the gable. The five-star ridge decoration, gable, eaves, and other roof sections are all inlaid with porcelain. Inlaid porcelain is a type of folk art and a craft handed down from Chaoshan. The term refers to the use of variously coloured porcelain pieces inlaid in the form of various three-dimensional images on the main roof parts, such as the gables and eaves. These images include flowers and plants, birds and animals, insects and fish, as well as other natural imagery. The shapes are very expressive, and some mix the imaginary with the genuine. The inlaid porcelain not only resists erosion by wind, rain and salt but also becomes even more splendid after being exposed to rain and the sun because of the characteristics of the ceramic material [40]. The craft of inlaying porcelain was adapted to the climate characteristics of Chaoshan without losing decorative value. Therefore, it remains widely used in Chaoshan architecture and was included in the national intangible cultural heritage list in 2011.

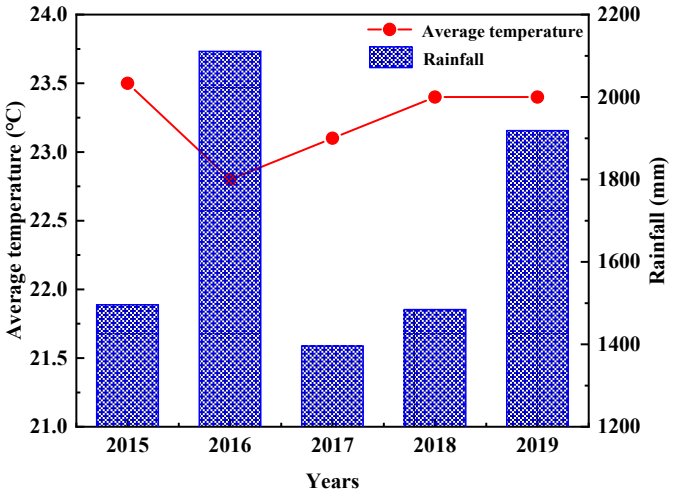

Figure 23. Shantou climate characteristics in five recent years.(Adapted from Ref. [3]).

(**a**) (**b**)

Figure 24. The inlaid porcelain of the Four Points Gold building.

5. Conclusions

Guangdong culture is based on the indigenous culture of South Vietnam. It adopts the essence of the Central Plains culture and that of the surrounding regional culture. After a long period of absorption, integration, innovation and sublimation, a unique cultural system emerged, one that is unique in terms of Chinese architectural art.

(1) Most of the structural materials of traditional buildings are produced from local materials. Full use of the rammed earth wall and mud-brick are made of local clay, stone and red sandstone to meet the moisture-proofing requirements of buildings. At the same time, it can better realize the unity of man and nature. Besides, due to the abundant local forest resources, the Cantonese traditional building presents a typical brick-wood mixed structure.

(2) To adapt to the hot climate in Guangdong, the ventilation requirements of traditional buildings are relatively high. The buildings comprehensively use patios, cold alleys, doors and windows for ventilation. The positioning of the ventilation facilities effectively ensures indoor-outdoor air exchange. The patios make the traditional building form a pattern of combining virtual and real. The cold corridor not only solves the ventilation problem but also meets the requirements of traffic and fire prevention. The more interesting and diversified doors and windows enrich the architectural aesthetics.

(3) The architectural art of traditional buildings in Guangdong is based on pragmatism, openness, tolerance, environmental protection and sustainability. Hakka architecture, as

represented by Hakka earthen buildings, displays rich and typical Hakka characteristics and regional Hakka traditional cultural elements. Cantonese traditional buildings condense the cultural essence of Chinese and Western architecture, reflecting the integration of Chinese and Western styles. The buildings of the Chaoshan area focus on decoration because of the influence of the marine culture. The decorative themes are mostly marine, Teochew Opera stories and life scenes and reflect the local preference for strong colours.

Author Contributions: Conceptualization, Y.S.; writing—review and editing, C.L.; writing—original draft preparation, Y.S.; visualization, C.L. All authors have read and agreed to the published version of the manuscript.

Funding: The work described in this paper was fully supported by Shenzhen city science and technology project (RKX20140603152808827).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Cetin, S.; Gokarslan, A.B. Sustainable architecture in Rurm Yayla settlements. *Open House Int.* **2014**, *39*, 14. [CrossRef]
2. Abdelmonem, M.G.; Selim, G. Architecture, memory and historical continuity in old Cairo. *J. Archit.* **2012**, *17*, 163–189. [CrossRef]
3. Chinese National Climate Center. Available online: http://www.ncc-cma.net/cn (accessed on 13 May 2022).
4. Villacreses, J.P.; Granados, J.; Caicedo, B.; Torres Rodas, P.; Yepez, F. Seismic and hydromechanical performance of rammed earth walls under changing environmental conditions. *Constr. Build. Mater.* **2021**, *300*, 124331. [CrossRef]
5. Arslan, M.E.; Emiroglu, M.; Yalama, A. Structural behavior of rammed earth walls under lateral cyclic loading: A comparative experimental study. *Constr. Build. Mater.* **2017**, *133*, 433–442. [CrossRef]
6. Bui, T.T.; Bui, Q.B.; Limam, A.; Maximilien, S. Failure of rammed earth walls: From observations to quantifications. *Constr. Build. Mater.* **2014**, *51*, 295–302. [CrossRef]
7. Bui, Q.B.; Morel, J.C.; Reddy, B.V.V.; Ghayad, W. Durability of rammed earth walls exposed for 20 years to natural weathering. *Build. Environ.* **2009**, *44*, 912–919. [CrossRef]
8. Ma, N. A preliminary study on the building materials of traditional residential buildings in Qingyuan area. *Guangdong Build. Mater.* **2021**, *37*, 76–78.
9. Chun, Q.; Van Balen, K.; Pan, J.W. Flexural Behavior of Typical Chinese Traditional Timber Stitching Beams. *Int. J. Archit. Herit.* **2015**, *9*, 1050–1058. [CrossRef]
10. Moonen, P.; Dorer, V.; Carmeliet, J. Evaluation of the ventilation potential of courtyards and urban street canyons using RANS and LES. *J. Wind Eng. Ind. Aerodyn.* **2011**, *99*, 414–423. [CrossRef]
11. Refrigerating and Air-Conditioning Engineers. *American Society of Heating Thermal Environmental Conditions for Human Occupanc American Society of Heating*; Refrigerating and Air-Conditioning Engineers: Peachtree Corners, GA, USA, 2017.
12. Driss, S.; Driss, Z.; Kammoun, I.K. Numerical simulation and wind tunnel experiments on wind-induced natural ventilation in isolated building with patio. *Energy* **2015**, *90*, 917–925. [CrossRef]
13. Driss, S.; Driss, Z.; Kammoun, I.K. Computational study and experimental validation of the heat ventilation in a living room with a solar patio system. *Energy Build.* **2016**, *119*, 28–40. [CrossRef]
14. Yao, X.B.; Dewancker, B.J.; Guo, Y.; Han, S.; Xu, J. Study on Passive Ventilation and Cooling Strategies for Cold Lanes and Courtyard Houses—A Case Study of Rural Traditional Village in Shaanxi, China. *Sustainability* **2020**, *12*, 8687. [CrossRef]
15. He, X. Quantitative Analysis and Modern Application of Natural Ventilation in Strip-Shaped Residential Buildings in Fujian and Guangdong. Master's Thesis, Tianjin University, Tianjin, China, 2012.
16. Sung, U.J.; Eum, J.H.; Son, J.M.; Oh, J.H. Planning Strategies of Wind Corridor Forests Utilizing the Properties of Cold Air. *Land* **2021**, *10*, 607. [CrossRef]
17. Xie, H. Guangdong Traditional Architecture from the Perspective of Natural Ventilation. *Hous. Technol.* **2007**, *27*, 30–33.
18. Tao, J.; Chen, H.S.; Zhang, S.W.; Xiao, D.W. Space and Culture: Isomerism in Vernacular Dwellings in Meizhou, Guangdong Province, China. *J. Asian Archit. Build. Eng.* **2018**, *17*, 15–22. [CrossRef]
19. Shenzhen Museum (Ed.) *Hakka Enclosed Houses*; Cultural Artifacts Publishers: Beijing, China, 1999.
20. Shenzhen Museum (Ed.) *Hakka Enclosed Houses in Guangdong and Hong Kong*; Cultural Artifacts Publishers: Beijing, China, 2001.
21. Cattaneo, T.; Giorgi, E.; Flores, M.; Barquero, V. Territorial Effects of Shared-Living Heritage Regeneration. *Sustainability* **2020**, *12*, 8616. [CrossRef]

22. Luo, Y.; Zhong, H.P.; Ding, N.; Ni, P.P.; Xu, Y.Y.; Peng, X.Q. Bond-Slip Mechanism of Rammed Earth-Timber Joints in Chinese Hakka Tulou Buildings. *J. Struct. Eng.* **2021**, *147*, 04021037. [CrossRef]
23. Ueda, M. A Preliminary Environmental Assessment for the Preservation and Restoration of Fujian Hakka Tulou Complexes. *Sustainability* **2012**, *4*, 2803–2817. [CrossRef]
24. Yang, S. A Study on the Architectural Heritage of the Hakka Surrounded Dragon House in Meixian County and Its Evaluation. Ph.D. Thesis, Guangdong University of Technology, Guangdong, China, 2017.
25. Lowe, K.D. Heaven and Earth-Sustaining Elements in Hakka Tulou. *Sustainability* **2012**, *4*, 2795–2802. [CrossRef]
26. Porretta, P.; Pallottino, E.; Colafranceschi, E. Minnan and Hakka Tulou. Functional, Typological and Construction Features of the Rammed Earth Dwellings of Fujian (China). *Int. J. Archit. Herit.* **2022**, *16*, 899–922. [CrossRef]
27. Xiong, R.; Du, H.M. The Construction of Traditional Residential Houses in Jiangxi-The Characteristics and Culture of Hakka Enclosed Houses in Southern Gansu. *Young Writ.* **2013**, *14*, 173–174.
28. Zheng, D.Y. Reflections on Traditional Architecture: Taking Hakka Weilong House as an Example. *Beauty Times City* **2018**, *2018*, 10–11. (In Chinese)
29. Faure, D.; Bo, Y. *Emperor and Ancestry: State and Lineage in South China*; Jiangsu People's Publishing House: Nanjing, China, 2009.
30. Sansonetti, A.; Andreotti, A.; Bertasa, M.; Bonaduce, I.; Corti, C.; Facchin, L. Territory and related artworks: Stuccoworks from the lombard lakes. *J. Cult. Herit.* **2020**, *46*, 382–398. [CrossRef]
31. Zhang, F. Analysis of the Decorative Arts of Chen Clan Temple in Guangzhou—One of the Research Series of Traditional Ancestral Temple. *Masterpieces of Nature* **2020**, *2020*, 16–19. (In Chinese)
32. Wu, Y. The influence of Lingnan culture on the architectural decoration of Chen Clan Temple. *Art Sci. Technol.* **2021**, *34*, 205–206.
33. Salvado, N.; Buti, S.; Clemente, C.; Beltran, V.; Cinque, G.; Juanhuix, J. Microanalytical study of luster glazed gilding and silvering from Baroque altarpieces. *Pure Appl. Chem.* **2018**, *90*, 477–492. [CrossRef]
34. Bartz, W.; Kierczak, J.; Gasior, M.; Zboinska, K. Analytical overview of different Baroque plastering techniques applied in the post-Cistercian abbey in Lubiaz (South-Western Poland). *J. Cult. Herit.* **2017**, *28*, 37–47. [CrossRef]
35. Pan, Y.; Zhuo, X.; Shi, Y. 100 Years of two villages: Study of modernization of rural settlements in Chaoshan area. *South Archit.* **2015**, *1*, 71–78.
36. Zheng, H. Analysis of the characteristics of wooden colored paintings in Chaozhou, Guangdong. *South. Archit.* **2014**, *2014*, 62–70.
37. Huang, X.; Gu, Y.Y. Revisiting the spatial form of traditional villages in Chaoshan, China. *Open House Int.* **2020**, *45*, 297–311. [CrossRef]
38. Xiao, L. Research on Chaoshan Traditional Community Architecture. Master's Thesis, Shantou University, Shantou, China, 2010.
39. Chu, C.Y. Analysis of the Architectural and Cultural Characteristics of Chaoshan Residential Buildings. *Shenhua* **2016**, *2016*, 119.
40. Liu, C.; Yao, X.Y.; Yang, M.Y. Analysis of decorative features and functions of traditional architectural elements in Chaoshan, eastern Guangdong. *Urban Archit.* **2016**, *18*, 218–219.