

## Research on Architectural Design Technology of Macau World Heritage Building Mandarin's House in Response to Hot and Humid Climate

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**ABSTRACT:** The climate of Lingnan determines the form of the building. As a well-preserved representative building in the world cultural heritage of Macau with the characteristics of Lingnan architectural style, the Mandarin's House reflects the architectural design of the subtropical zone and the humid and hot climate of Macau, which is worthy of later analysis, study and research application.

**Keywords:** Mandarin's House, architectural design technology, Macau World Heritage Building, traditional buildings, response to climate

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## INTRODUCTION

The Mandarin's House was built in around 1881. The entrance to the Mandarin's House compound is through a gate-way, which is oriented to the northeast and located on António da Silva Lane. This is a two-storey structure 13 metres wide and 7.9 metres deep, which is independent of the main building cluster. It has projecting roof eaves, windows on the upper floor and an arched entrance gateway on the lower floor. The eave boards are painted with typical Chinese decorative motifs, while the ceiling of the entrance hallway features Western plaster decorations. A shrine of the Earth God is set into one of the walls in the hallway. A flight of granite steps leads down from the entrance through the hallway into the compound at a lower level. The individual entrances to the series of houses in the compound are all oriented in the same direction, facing northwest. The different orientation of the main entrance and the house entrances distinguishes the Mandarin's House from the typical Chinese dwelling. A continuous spacious forecourt fronts the series of houses, in the middle of which is a gateway leading into a large courtyard that separates the master's quarters from the servants' quarters and the outer garden.



Figure 1. Mandarin's House (Image Source: <https://banbi.tw/mandarin-house/>)

Located in the inner part of the compound are the master's quarters, which consist of two traditional enclosed courtyard houses of three bays in width and three halls in depth, separated by a drain. The buildings are built on foundations of granite slabs, and the friezes on the external walls are decorated with relief ornamentations sculpted from clay. Like the entrance to the compound, the surrounding walls of each house entrance are recessed from the main wall plane. A granite frame around the house entrances further emphasizes its importance as the gateway into the house. The interior layout of



the houses is in accordance with traditional design, except that the main living room is located on the upper floor of the main hall instead of the usual ground floor. The main hall is of timber post-and-beam construction.



Figure 2. Mandarin's House (Image Source: <https://banbi.tw/mandarin-house/>)



Figure 3. Mandarin's House (Image Source: <https://banbi.tw/mandarin-house/>)





Figure 4. Mandarin's House (Image Source: <https://banbi.tw/mandarin-house/>)



Figure 5. Mandarin's House (Image Source: <https://banbi.tw/mandarin-house/>)

Although the Mandarin's House is a traditional Chinese building in form, it features a combination of Chinese and foreign elements in its details. The Chinese tectonics is expressed in the roof, the house super-structure, the building



materials and the painted and relief ornamentations on the friezes, the pattern of the windows, and the design details of the main entrances and the traditional timber sliding shutters. Western and other foreign influences are evident on some of the interior ceilings, the archway over the door and window openings, the architrave along the roof eaves, the mother-of-pearl window panels of Indian origin and the plasterwork on the external walls.

## RAINPROOF DESIGN

### *Window rain protection*

Many places in the main building of the Mandarin's House have adopted the design of shutters, which also shows the characteristics of Western-style decoration. The slats of the shutters are horizontal wooden strips, and the middle is composed of an iron rod shaft. Pushing the iron shaft upwards, that is, when the shutters are parallel, is conducive to the ventilation of the house; when the iron shaft is pulled down, the shutters sag about 30 Angle, forming a large number of seamless small slopes, which is conducive to the drainage of rainwater and protects the house from rain splashing.



Figure 6. Window rain protection (Image Source: <https://banbi.tw/mandarin-house/>)

### *Roof rain protection*

The Mandarin's House is divided into the servant room area and the master room area in terms of the relationship between master and servant, both of which are the typical sloping roof design of Lingnan architecture. Surrounded by the sea on three sides, Macau has direct sunlight twice a year,

strong radiation and strong evaporation. It has the characteristics of rich heat, sufficient water vapor, high temperature and rainy climate. It belongs to the subtropical marine monsoon climate and also has the characteristics of tropical climate. The average annual temperature is about 22.3 °C , the annual temperature difference varies from 11 to 14 °C. Therefore, there is a slope design for the roof to facilitate the drainage of rainwater.

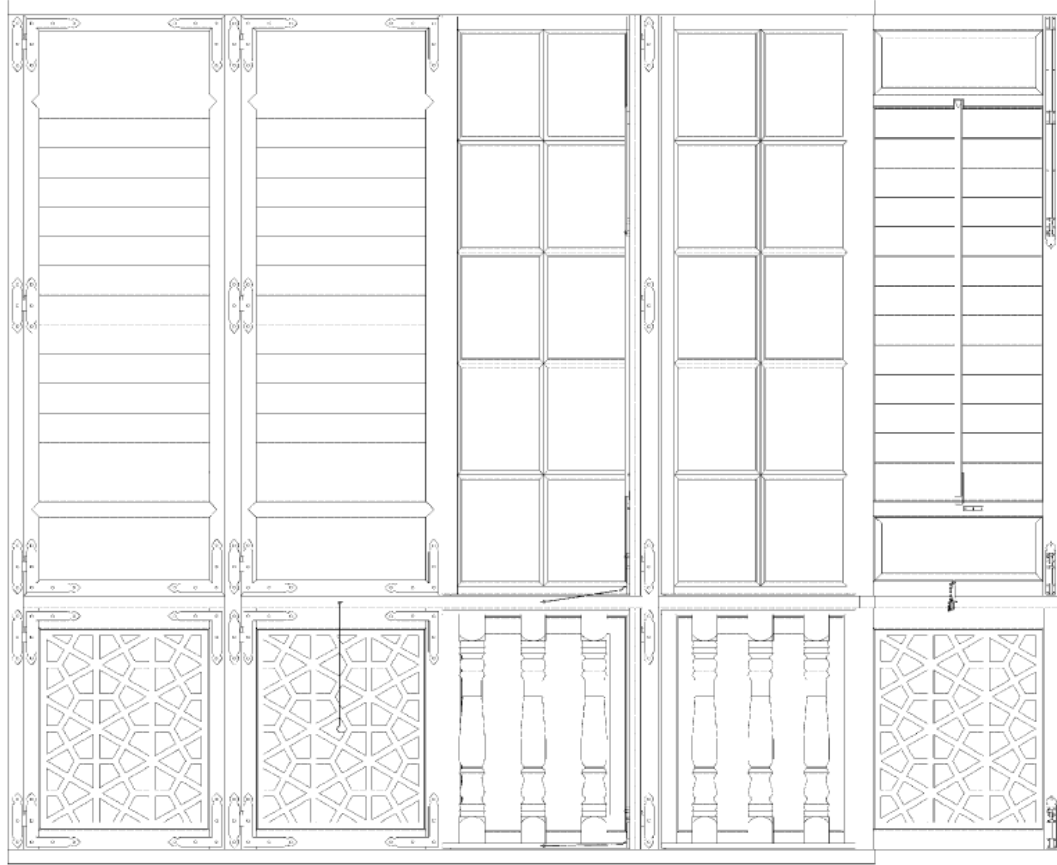


Figure 7. Design details of the Mandarin's House (Image Source: The Historic Monuments of Macau)

However, the roof is usually relatively gently sloped, unlike the larger slopes in Jiangsu and Zhejiang. Originally, the Pearl River Delta region has a lot of rain, so the roof is designed to be steeper, which is more conducive to the drainage of rainwater. However, in order to prevent the typhoon from blowing on the roof and reduce the wind-receiving area of the roof, the roof is designed to be gentle to protect the roof.

#### *Rainproof eaves*

It can be seen from the entrance of the main building area from Rongludi, the Mandarin's House, that the roof tiles on the eaves and the dripping design of the eaves are more protruding than the original building. At the same time, the roof has a roof-pressing design, which not only prevents rainwater from dripping directly into the house, but also prevents the coastal waters from dripping directly into the house. A typhoon hit the area.



Figure 8. Window rain protection (Image Source: <https://banbi.tw/mandarin-house/>)

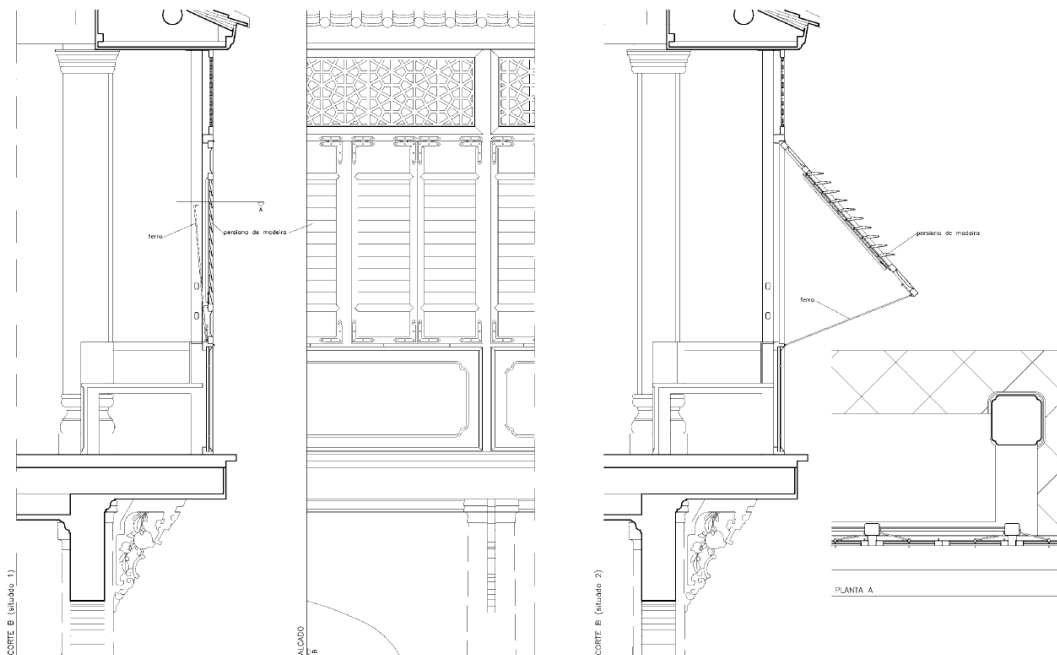


Figure 9. Design details of the Mandarin's House (Image Source: The Historic Monuments of Macau)



## THERMAL INSULATION DESIGN

### *Insulation of tile roof*

Like other typical Lingnan traditional dwellings, the Mandarin's House adopts a thermal insulation design on the roof, that is, the double-layer tile roof is laid, which blocks the heat from the sun directly hitting the roof and makes the house cool.

### *Wall insulation*

The outer wall of the Mandarin's House is less exposed to the sun than the roof. The smooth surface of the terrazzo blue bricks is conducive to reflecting long-wave radiation from the street floor and the buildings opposite.

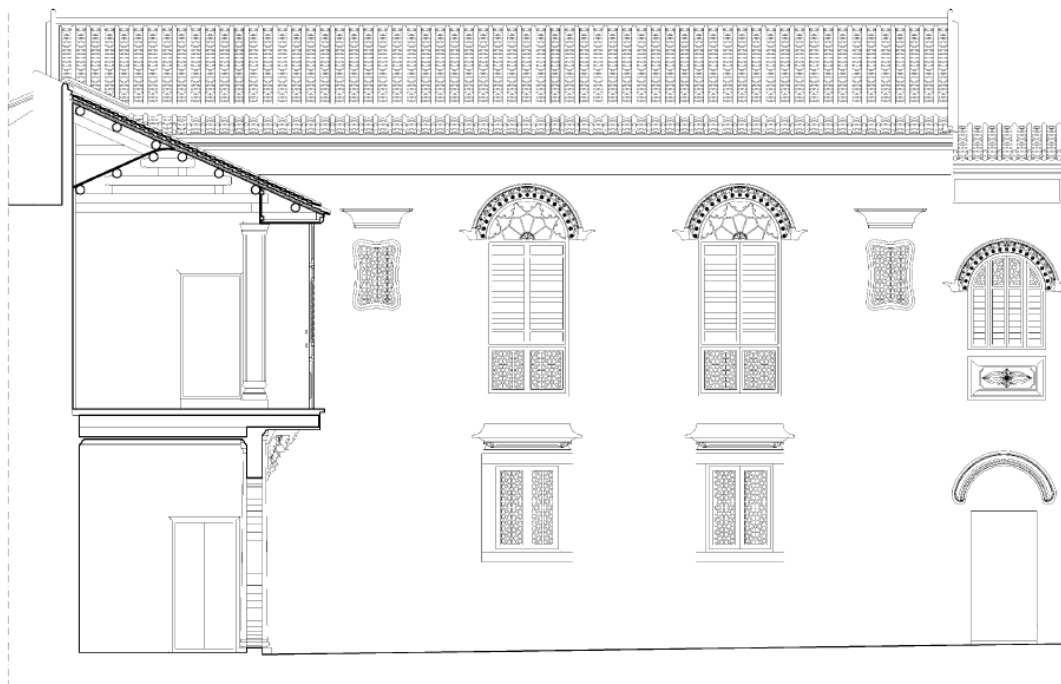


Figure 10. Section of patial building (Image Source: The Historic Monuments of Macau)

## DISCUSSION AND CONCLUSION

### *Problems of Restoration of Historic Buildings*

According to the site visit, the Mandarin's House did not pay attention to the design of natural ventilation in the house during the renovation process, and due to the convenience of management, some secondary windows that are not open to tourists on the second floor of the main building were sealed. In the long run, it is not only unfavorable. If the building is ventilated, it is easy to cause dust accumulation in the house. If it is not taken care of for a long time, the space will easily smell musty, which is not conducive to the "free breathing" of the building.



### *Summary*

Lingnan Architecture has experienced a long period of precipitation and a series of historical and technical experiences. In the past without modern technology air conditioners or awnings, natural brick and wood structures can still be used for heat insulation, ventilation, shading, and rain protection. Etc., worthy of the name, is a typical case of green building. In the process of repairing, we should pay more attention to learning the essence of the ancients' architectural technology, and to be familiar with the function and application of its design, and only pay attention to its protection during the repairing process.

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### **REFERENCES**

- Chen, Y. (2019, June). Research on the Development of the Style of Lingnan Homestead in Macau – Taking Mandarin's House as an Example. In 2019 International Conference on Architecture: Heritage, Traditions and Innovations (AHTI 2019) (pp. 251-257). Atlantis Press.
- Cao, J., Chen, Y., & Guo, Y. (2021). Characteristics and application of regional building materials in Lingnan area: a case study of Casa da Cheang in Macau. In E3S Web of Conferences (Vol. 284, p. 05003). EDP Sciences.
- Chen, Y. (2019, November). The Development of Decorative Art in Lingnan House Garden in Macau – Taking Lingnan Oyster Shell Window and Manchuria Window as Examples. In 3rd International Conference on Art Studies: Science, Experience, Education (ICASSEE 2019) (pp. 479-484). Atlantis Press.
- Li, B., Guo, W., Liu, X., Zhang, Y., Russell, P. J., & Schnabel, M. A. (2021). Sustainable Passive Design for Building Performance of Healthy Built Environment in the Lingnan Area. *Sustainability*, 13(16), 9115.
- Liang, X. Y. Q. S. (2007). Architectural Thoughts of Xia Changshi and Their Impacts on Lingnan Modern Architecture. *Time+ Architecture*.
- Schnabel, M. A. (2021). Sustainable Passive Design for Building Performance of Healthy Built Environment in the Lingnan Area.
- Sun, L. P. (2013). The sun-shading technologies of the existing traditional dwellings in China. In *Advanced Materials Research* (Vol. 689, pp. 163-166). Trans Tech Publications Ltd.
- Tang, X. X. (2014). Three Adaptabilities of the Traditional Vernacular Architecture of the Han Nationality in Lingnan. In *Applied Mechanics and Materials* (Vol. 644, pp. 5109-5112). Trans Tech Publications Ltd.

- Wei, J., Yu, F., & He, J. (2012). Optimal Design Based on Computer Simulation for Improving Thermal Comfort in the Passage Space around Arcade Buildings in a Hot and Humid Climate. In *Advances in Electronic Commerce, Web Application and Communication* (pp. 327-334). Springer, Berlin, Heidelberg.
- Xue, S., & Xiao, Y. (2016). Study on the outdoor thermal comfort threshold of Lingnan Garden in summer. *Procedia Engineering*, 169, 422-430.
- Yan, L., & Chen, Y. (2021, April). Stained Glass in Lingnan Historic Buildings and Its Application in Manchuria Windows. In *Journal of Physics: Conference Series* (Vol. 1885, No. 3, p. 032052). IOP Publishing.
- Yan, L., & Chen, Y. (2021, May). Study of Roof Tiles in Lingnan Traditional Buildings and Roof Drainage Technologies. In *IOP Conference Series: Earth and Environmental Science* (Vol. 768, No. 1, p. 012151). IOP Publishing.
- Zeng, Z., Li, L., & Pang, Y. (2017). Analysis on climate adaptability of traditional villages in Lingnan, China--World Cultural Heritage Site of Majianglong Villages as example. *Procedia Engineering*, 205, 2011-2018.
- Zheng, L., & Chen, Y. (2021, May). The protection process and measures of Macau's heritage buildings. In *IOP Conference Series: Earth and Environmental Science* (Vol. 783, No. 1, p. 012120). IOP Publishing.