

Analysis of Diseases and Conservation of Modern Residential Buildings in Macao: A Case Study of the Lou Family's Big House

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Abstract: The Lo Family Building is a typical representative of modern residential architecture in Macao, which has its own characteristics in terms of architectural history, culture, spatial layout and fittings. In recent years, many scholars have been carrying out research on the Lu Family's Great House. At present, there is insufficient research and protection on the disease analysis and architectural protection related issues of the restored Lu Family's Great House. This paper through the literature research, field research methods on the Lu family house specific investigation and research, analysis of existing disease phenomena, concluded that the Zheng family house is currently the main external finishes discolouration, cracking, weathering, plant erosion and human factors and other types of disease, and its characteristics and causes of a brief collation of the analysis; and finally, based on the above materials, put forward the subsequent protection measures. To a certain extent, it provides some new thoughts for the conservation of modern residential buildings in Macao.

Keywords: Architectural Cultural Heritage Protection; Building Disease; Macao Folk Houses.

1. Introduction

The Historic Centre of Macao preserves the essence of Macao's history of over 400 years of Sino-Western exchanges, witnessing the collision and dialogue between Western and Chinese cultures. It is the oldest, largest, best-preserved and most concentrated historic district in China, where Western-style buildings predominate and Chinese and Western-style buildings reflect each other. It has a rich architectural cultural heritage, including the Lu Family Building, a modern residential building in Macau.

Also known as "Golden Jade Hall"[1,2], it is one of Macau's World Heritage Sites and a modern residential building of high artistic value. The architectural structure and construction style are a fusion of traditional Qing Dynasty houses and Lingnan style, while at the same time reflecting Western design concepts and decorative styles. It demonstrates the inclusive character of Macao's culture, reflecting the exchange and fusion between different cultures. In 2019, it was selected for inclusion in the Macao Real Estate Register, assessed as a building of artistic and architectural value, with code AM029. It reveals the intermingling and influence of different cultural elements, and is of great significance to the understanding of Macao's historical evolution and cultural identity.

Modern residential buildings are an important part of Macao's urban development, and these buildings carry Macao's unique historical and cultural significance, thus research on them is of great academic and cultural value. Studies on Macau's modern residential buildings and the Lo Family Building have shown that most of the current studies are based on architectural style [3], historical lineage, artistic analysis and tourism activation and utilisation [4-7], with few studies on architectural diseases and conservation, and the conservation of their buildings requires detailed measures to be considered. Moreover, with the passage of time, different degrees of disease problems have appeared in the Lu Family

Great House, which has a greater impact and needs to be solved urgently. Therefore, an investigation and research on the Lu Family's Great House will also provide more possibilities for the subsequent conservation and restoration of the building, as well as a certain guiding significance for the future conservation and inheritance of Macao's historical and cultural heritage preservation.

2. Overview of Modern Residential Architecture in Macao

The forms and styles of Macao's architecture are influenced by Chinese and Western cultures in a very complex and varied way. Early Macao's architecture was deeply influenced by the traditional Lingnan culture of China, with obvious southern architectural characteristics [4], and to this day, traditional Chinese architecture still accounts for a large proportion of the building, and after the Portuguese colonialism brought about the Western style of architecture, as well as the collision of Sino-Portuguese cultures and the fusion of a variety of architectural styles, so that the architecture covers the Western Classical style, the Portuguese Classical style, Eclectic style, Gothic style, traditional residential style, traditional Chinese temple style, and Suzhou classical garden style.

The architecture of Macao covers nearly 20 styles, including Western Classical, Portuguese Classical, Eclectic, Gothic, Traditional Residential, Chinese Traditional Temple and Suzhou Classical Garden styles [1,8]. The rich architectural heritage of Macao combines the unique flavour of the European style with the traditional charm of the Chinese style, and demonstrates the "architectural museum" style of the city.

Residential buildings are one of the most numerous types of modern residential buildings in Macao, and they are found all over the city. Closely related to people's daily lives, the rapid development, large number and richness of residential buildings reflect the complexity of Macau's modern social development and composition. For most of the modern period,

the Portuguese and Chinese communities developed their own settlements, which, due to fundamental cultural differences, were spatially bounded and had their own developmental and organisational characteristics. As well as in modern residential styles, due to the long period of Portuguese colonial rule, Macao's architectural style has been influenced by Portuguese culture. Some modern residential buildings have retained features from the Portuguese colonial period, such as tiled façades, baroque decorations, balconies and terraces. These buildings usually have bright colours and European flair, reflecting Macao's history as a Portuguese colony. As a place where East meets West, Macao's modern residential architecture reflects a fusion of Chinese and Western styles. Some buildings fuse traditional Chinese architectural elements with Portuguese colonial styles, such as Chinese roofs, red brick walls, window carvings and Portuguese façades. This fusion created a unique Macao architectural style that demonstrates cultural diversity and exchange. Due to the limited land in Macao, modern residential buildings often adopt a narrow and tall building form to maximise the use of limited land resources. These buildings are usually long and narrow, featuring multiple floors and windows to increase the efficiency of space utilisation. Some modern residential buildings have retained traditional architectural elements and decorations, such as wood carvings, stone carvings and colourful paintings. These elements reflect traditional craftsmanship and art and add unique charm and historical significance to the buildings[1,2].

3. Overview of Lu's House

One of the representative works of Macao's modern residential architecture is the Lou Kau Mansion, located at No. 7, Lane Da Tang, in the Historic Centre of Macao (Fig. 1). Built in the 15th year of the Qing Dynasty (1889), it was the former residence of Lou Wah Sau (Lou Kau), a famous merchant of Macao during the late Qing Dynasty, and has a history of about a hundred years [9,10,2].

The outside of the Lou is scenic and the inside of the mansion is luxurious. The Lu family house, also known as the Golden Jade Hall, with an area of about 400 square metres, is a Chinese two-storey building constructed with thick green bricks, gentle and slender, with a delicate layout, which is a typical mansion modelled on the Xiguan Dajia residential style in Guangzhou during the late Qing Dynasty. The overall three-room, three-entry pattern (Figure 2), that is, divided into the foyer, the tea hall (sedan chair) and the main hall, up and down a total of two floors. Among them, there are a number of patios to facilitate ventilation and lighting. The entire building has a permeable space along the entire central axis, with the main hall as the main body of the main room, with a clear and strict central axis, and the outer part of the side hall is Tsingyun Lane, which serves as the access and living support, with clear functional distinction and clear boundaries between inside and outside, which is only separated by a screen [2].

The interior is a fusion of Chinese and Western decorative materials and techniques. The main façade of the Big House has a recessed entrance section, typical of the Chinese style, while the design of the windows, i.e. shutters with semi-circular stained-glass windows, is influenced by Western architecture. The house has two inner courtyards to let in light, and according to feng shui principles, the main entrance has a screen to block out bad chi.

The interior decorations of the house are elaborate,

including brick carvings, grey mouldings, ponchos, hangings and oyster-shell windows, which are common in central Guangdong [9], as well as Western-style false ceilings, Manchurian windows and cast-iron balustrades. The two kinds of characteristic decorations are blended together in one furnace, and the combination of exquisite grey moulding decorations on the windows, which is very interesting, reflecting the unique residential architectural culture of Macao.



Fig 1. Front view of Lu's house

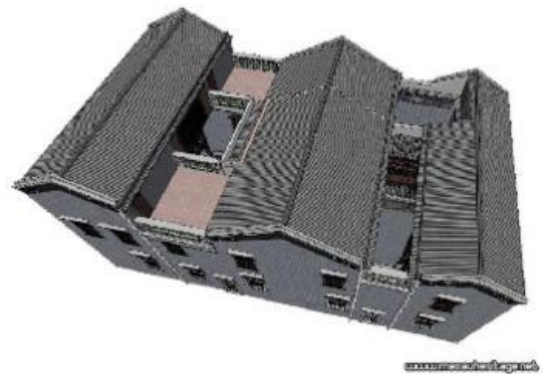


Fig 2. Model of Lu's House

3.1. Status of the Lu Family House

According to the official website of Macao Cultural Heritage, the development of the house is as follows: the Lu Family's Grand House started to be protected and repaired by the government in 2002, and there are problems such as wide repair area, high degree of damage, difficult to verify the repair materials and difficult repair process. In the implementation of the restoration of the big house, in 2007, the Lu family big house restoration construction of Chinese and Western heritage landscape, has completed the building reinforcement, whitewash and other structural engineering and interior decoration, currently continue to carry out the final stage of the restoration of grey plastic, brick carvings and other restoration projects. While in 2017, the inspection and restoration of the roof tiles will be carried out, at which time a workbench will be built on the ground floor, and in 2020, the maintenance and upkeep of the house will still be carried out. With the passage of time, the Lu Family House has suffered from the phenomena of crispy alkali, weathering, peeling and other diseases, which have affected the building's appearance, functional use, and overall safety.

Table 1. Maintenance History of the Lu Family House

time	content
Qing Guangxu 15th year (1889)	Completion of the Lu Family House
1970s	The number of households in Lo's Big House has been increasing, with more than 20 at its peak; the house is dilapidated due to lack of maintenance
July 2002	Cultural Affairs Bureau of the Macao SAR Government starts restoration work of the Lou Family Building
On July 15,2005	The Historic Centre of Macao was inscribed on the World Heritage List by the United Nations Educational, Scientific and Cultural Organisation (UNESCO), and the Louvre is included.
May, 2007	Lu Family House officially opens to the public
September 28,2007	Lu family house restoration to build the landscape of Chinese and Western heritage, has completed the building reinforcement, whitewash and other structural engineering and interior decoration, currently continue to carry out the final stage of the restoration of grey plastic, brick carvings and other restoration projects.
June 16,2015	Type of real estate assessed: Buildings of architectural interest
March 15,2017	Inspection and repair of roof tiles, at which time work benches will be set up on the ground floor
On January 1,2019	The Lou Family's House is listed in the Real Estate Register of Macao as a building of artistic and architectural value, code AM029.
April 15,2020	Repairing the Lo Family Building at No. 7, Tai Tong Lane, Macao, mainly for the maintenance and upkeep of the interior of the building, works are expected to be completed by the end of June

Throughout the restoration history mentioned above, the Lu Family House has undergone salvage protection and key repairs, but its protection has a certain lag, and it is difficult to essentially solve the problems regarding the diseases. As shown in Table 1, in 2007 and 2017, the two protection time span is almost ten years, with the increasing number of tourists, while the protection of Zhengjia Dajia is far from enough only by the way of occasional maintenance, so it is very important to establish a preventive protection system.

3.2. Conservation Significance of the Lo Family House

The Lou's House is not only a residence, but also a museum showcasing the history and culture of Macau. Inside the Grand House are exhibitions showcasing the history, folklore and artefacts of Macau. Visitors can learn about Macau's past and enjoy some valuable exhibitions and artefacts here. To sum up, the Lo Family Building, as one of the representative works, demonstrates the combination of Chinese and Western architectural styles, as well as the richness of Macao's history and culture. It is an important part of Macao's architectural heritage and one of the most important places for tourists to learn about Macao's history and culture. And facing the emergence of architectural diseases, only by taking preventive measures against the diseases and their causes before the damage reoccurs can we avoid large-scale repairs

at a later stage and ensure its sustainable development.

4. Disease Analysis of Lu's House

4.1. Main Destructive Factors

Macao's architectural cultural heritage has more causes of disease, which are mainly categorised into natural and human factors.

4.1.1. Natural Factor

Macao is located on the west bank of the Pearl River Estuary, surrounded by the sea on three sides, with high temperature, high humidity and rainy subtropical monsoon climate characteristics is a typical coastal city. Under the dual influence of sea water and air, Macao is often affected by storm disasters. Coupled with the vulnerability of Macao's disaster prevention system, it is difficult to resist the damage of storm surges, so that buildings are exposed to high humidity for a long period of time, and building materials will inevitably be subjected to moisture infiltration. Prolonged moisture penetration can lead to problems such as wood decay and cracking of masonry materials. In addition, the humid environment provides conditions for the growth of moulds and fungi, making it easy for moulds to grow on the surface of the building, leading to the deterioration of the quality of the building materials and even seriously affecting the structural stability of the building [11].

Ultraviolet radiation is also one of the important factors for building diseases. Macao has sufficient sunshine and will be exposed to direct sunlight twice a year, with high radiation intensity, evaporation intensity, and high humidity temperature all year round. Buildings are exposed to UV rays for a long period of time, and timber and masonry materials are prone to colour fading and surface oxidation. This not only affects the aesthetic appearance of the building, but also leads to possible cracking and breakage of the materials.

Macao is close to the ocean and is exposed to high salt sea air. Salts from the sea such as sodium chloride and calcium sulphate attach to the surface of building materials with the wind, leading to erosion and damage of the masonry materials. The corrosive effect of salts makes the surface of masonry materials flake and break [12]. In addition, the salts in the high-salt sea breeze also have a corrosive effect on metal parts, such as iron and aluminium parts, accelerating the process of corrosion and spalling resulting in salt damage.

4.1.2. Anthropogenic Causes

Due to many local residents, improper maintenance and upkeep can lead to building deterioration. Lack of regular inspections, repairs and maintenance, as well as the use of inappropriate cleaning agents and materials, and the touching of buildings by travellers can lead to damage and disease in building materials.

4.1.3. Disease Types and Their Characterization

The Lu Family Building belongs to the Macao brick and wood architectural cultural heritage, and the building as a whole is composed of masonry and wood, and its architectural structure is composed of wood structure as the main body and masonry as the building enclosure. Therefore, architectural diseases can be analysed from two classifications: wall construction and wood construction [13], and this classification covers the main existing disease phenomena.

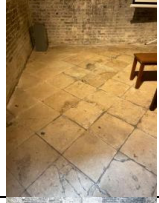
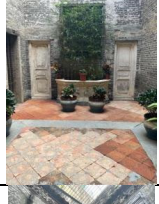
4.1.4. Masonry

Buildings under the combined effect of natural and man-made damages have different types of diseases produced by

different materials; masonry commonly suffers from chalking, discolouration, crispy alkali diseases, etc., while timber

commonly suffers from deterioration, insect pests and diseases.

Table 2. Major Diseases of the Masonry Elements of the Lu Family's House in Macao

Disease status		Location Distribution	Example photos		clarification
1	pellets	The lower part of the exterior surface			As a result of prolonged erosion by moisture
2	Diseases of Whitewash	The lower part of the exterior surface			The wall has suffered serious moisture erosion, after sun exposure precipitated such as calcium carbonate and other inorganic substances. It not only affects the aesthetics of the building, but also easily causes damage to the wall in the long run.
3	Broken weathering	brick wall			Significant deterioration of the wall blocks occurs in wind and sun exposed environments.
4	human-made destruction	Grey plastic			There is a high degree of mutilation and detachment. In addition to early unintentional damage, the author's field contacts revealed that current management is also negligent, resulting in architectural damage.
5	disintegrate	Indoor floor tiles			The floor is in a widespread state of crumbling. Consider age, deterioration of materials, unreasonable repairs and human factors.
		Outdoor floor tiles			
6	shedding	exterior finish			The wall is in a sun-exposed and rain-soaked space. The surface of the wall is mottled and dilapidated.
7	fade	Grey plastic			Long-term exposure to UV radiation may cause colour fading and surface oxidation of the brick material, causing it to lose its original beauty.
8	Microbial growth	corner			Moss in corners, growth of plants or parasites

As Macao's buildings are permanently exposed to high temperature and high humidity in the coastal environment, while creating a good outdoor environment, this environment also causes a series of problems in the buildings, such as cracks in the walls, moulds on the walls, plant erosion, weathering of the outer surface of the walls, and other disease problems, which may lead to the surface of the brick materials starting to chalk and the bricks becoming fragile and brittle if the brick materials themselves are not of good quality or suffer from severe moisture erosion. These problems also accelerate the functional deterioration of traditional residential wall construction. Prolonged exposure to ultraviolet radiation may cause colour fading and surface oxidation of the brick materials, causing them to lose their original aesthetics, while the highly saline sea winds of

Macao may lead to salt deposition and erosion on the surface of the brick materials. This erosion may lead to the deterioration of the quality of the brick material and even surface spalling and breakage [14].

On the other hand, incorrect maintenance during the building maintenance process leads to missing parts of the build and cracking of the walls, which is also related to poor maintenance such as routine inspection and management. Based on the above description, the disease condition of the building is caused by multiple factors, and based on the results of the field study, the diseases of this wall components are mainly classified as wet block, whitish, weathering, plant erosion, cracking, and peeling (Table 2).

4.1.5. Wooden Component

Table 3. Major Diseases of Wooden Elements of the Lu Family's House in Macao

Disease status		Location Distribution	Example photos	clarification
1	fade	Building exterior finishes		Intense radiation ages the wood, with corresponding changes in colour such as fading.
2	flake	Wooden doors and Windows		The surface layer of the wood components in many places showed more serious mottled cracks, severe peeling and low adhesion; in addition, there were discolouration and breakage.
3	pantothenic	Exterior wooden doors, walls		Underneath timber windows with a waterline accompanied by a white powdery substance and wood rot in some locations.
4	Microbial erosion	door, window		Microorganisms such as fungi and algae appear distinctly green. Attached to the underside of wooden doors on outdoor backsides.

Because wood itself is susceptible to external influences, by dry and wet wind and rain, fungal pests and temperature interference; in addition, wood in the process of taking, there will be its own aging and wear and tear. It is susceptible to decay and insect pests. In the natural environment of Macao, many problems have gradually appeared in the wooden components, such as spalling, discolouration, microbial

erosion and the breakage of the wooden components, which affects the safety of the building. The doors and windows of the Louvre are also made of wood, and these are also parts that we need to protect in an important way. However, with the humid climate of Macao, timber is often exposed to high humidity, which makes it susceptible to moisture and leads to decay. In particular, timber that is not properly protected is

susceptible to mould and fungus. The humid environment and humid climate also provide suitable growing conditions for pests. For example, ants and moths may attack wood, leading to structural damage and weakening. Wood tends to expand and contract when exposed to moisture, which can lead to warping, cracking and peeling of the wood. These are potential threats to the building's capacity to heal and also affect the overall aesthetics. Based on the above description, the major diseases of wood components are discolouration, spalling, fading, and microbial erosion (Table 3).

5. Preventive Protection Recommendations

Based on the assessment of the current state of architectural deterioration of the Lu Family Building in Macao, which is a modern civil building, the distribution, characteristics, and preservation status of architectural diseases are clarified, and the preventive conservation measures can be adopted through the analysis of the causes of the diseases, which can prevent and mitigate the existing or upcoming diseases, therefore, the article selects the masonry and timber. Therefore, the article selects some representative diseases of masonry and wood to be explored by preventive conservation measures, including surface staining, salt erosion, and plant diseases.

Firstly, appropriate repairs are carried out on existing problems, using appropriate repair techniques and materials to remediate the existing problems. Secondly, preventive treatment and protection of potentially diseased buildings, as well as preventive monitoring of parts of the building that have not yet suffered serious damage [15].

5.1. Masonry

The first and foremost principle of architectural conservation is to exclude the problem of accidental disasters in buildings. Therefore, for the brick wall surfaces of the Lo Family Building, a detailed inspection is required to ensure the stability of the base walls. Firstly, each brick wall surface is carefully observed and assessed to check whether there are problems such as cracks, detachment and loose bricks. Problematic bricks need to be repaired or replaced in a timely manner to ensure the overall stability of the wall.

Next, brick wall surfaces need to be cleaned to remove dirt and harmful substances from the surface. For different types of pollutants, a typical wall surface can be selected for local feasibility experiments to determine the most suitable cleaning method. Suitable methods such as high-pressure water cleaning, high-temperature water vapour cleaning or cladding cleaning can be used to remove mottled dirt as well as harmful substances from the surface of brick walls [16]. In addition, drainage systems such as downpipes as well as areas such as eaves need to be cleaned and serviced regularly to ensure proper drainage function. At the same time, in order to prevent the external finishes from moisture attack and salt deposition, relevant protective measures such as wall salt drainage can be carried out [17,18].

In addition to the daily basic maintenance work, the relevant departments should also improve the structural monitoring system of the Lu Family House and introduce advanced technology to establish an information-based data platform. Through these initiatives, the pattern of change of disease and the cause of damage of the building can be analysed more systematically and scientifically, providing a more reliable basis for the scientific development of

protection programmes [19]. This can realise the sustainable development of architectural cultural heritage and provide guidance and support for subsequent conservation work.

5.2. Wooden Component

According to the current disease status, for the wooden components of the Lu family house, the first thing that should be done is to carry out a simple cleaning work on the surface. Cleaning tools such as soft-bristle brushes and cotton can be used to remove the impurities attached to the surface in a more gentle way to avoid secondary injuries [20,21] to the wooden components.

Considering the severe aging and mottled and fragile surfaces of the wooden components, suitable protective coatings can be added to protect them from moisture and UV rays. The coatings need to be inspected and appropriate repair measures need to be taken for localised vulnerable areas such as peeling, buckling and cracking. In addition, the pest status of the wooden components needs to be continuously observed and controlled by applying agents when necessary [22-24].

In the long term, in addition to the overall conservation of the Lu Family House, attention needs to be paid to the maintenance of the individual timber pieces. The wood components need to be constantly monitored for problems such as deterioration, armouring, cracking and insect infestation, as well as for microbial attack. If deterioration is present, it should be repaired and recorded in a timely manner to avoid further exacerbating the development of the disease.

In addition, in order to prevent neglect and vandalism of the built heritage, caretaking mechanisms should be put in place to mobilise public awareness of building maintenance and to avoid touching and scratching. Due to the characteristics of wood, fire-fighting equipment and lightning equipment should also be regularly tested and maintained to eliminate potential risks and mitigate the occurrence of diseases, so as to maximise the protection of architectural cultural heritage [25].

6. Conclusion

In this paper, through data collection and field research, we have collated the current status of the diseases of the Lou Family's Grand House, aiming to put forward thoughts on preventive conservation, in order to mitigate the impact of these factors on the Zheng Family's Grand House, to enhance the accuracy and pertinence of architectural conservation, and to avoid salvaging and repairing the building only after its gradual destruction. At the same time, we also found that the current systematic as well as comprehensive architectural pathology research on Macao's architectural cultural heritage is still largely insufficient. The research on the deterioration mechanism of materials and preventive conservation techniques, the perfect daily monitoring mechanism and the sound legal and regulatory system need to be further strengthened. This paper's exploration on the concept of architectural cultural heritage protection aims to promote more scholars to conduct in-depth research on Macao's architectural cultural heritage. We encourage the strengthening of the integration of theory and practice in order to enhance the study of architectural pathology, to explore in depth the mechanism of material deterioration, and to develop more effective preventive conservation techniques. In addition, the establishment of a sound daily monitoring mechanism and the formulation of appropriate laws and regulations will provide important safeguards for the long-

term conservation of Macao's architectural heritage. The conservation of architectural cultural heritage is a long-term and complex task that requires the joint efforts and attention of all parties. Therefore, we look forward to the formation of wider co-operation between the academic and practical fields to contribute more wisdom and strength to the conservation of Macao's architectural cultural heritage.

References

- [1] KANG Anqi, LIU Min. Traditional Houses in Macao: The Architectural and Cultural Values and Inheritance of Lo Ka Uk[J/OL]. Chinese and Foreign Architecture, 2022(4): 29-35. DOI: 10.19940/j.cnki.1008-0422.2022.04.005.
- [2] Zhu Hongyu. An analysis of the characteristics of Chinese and Western architectural art of Lu Family House in Macao[J]. City Residence, 2019, 26(12): 93-96.
- [3] Zhao Qiang. Problems, Countermeasures and Prospects of Scientific and Technological Protection of Macao's Cultural Heritage[J/OL]. Science and Technology Communication, 2021, 13(24): 128-130. DOI:10.16607/j.cnki.1674-6708.2021.24.040.
- [4] Chen Yiyu, Zhang Qi. Exploration and Reflection on the Conservation of Macao's Architectural Heritage[J]. Journal of Anhui University of Architecture, 2020, 28(3): 84-91.
- [5] Chen Yiluo, Zheng Liang. Study on the Restoration Engineering and Materials of Macao's Reformatory Buildings: An Example of the Reformatory at Sha Lei Tau[J]. Beauty and Times (City Edition), 2021(3): 1-4.
- [6] Zhai Leilei, Yu Yanqiao, Xia Haishan. Study on the Conservation Characteristics and Development of Macao's Architectural Heritage[J/OL]. Central China Architecture, 2020, 38(11): 147-151. DOI: 10.13942/j.cnki.hzjz.2020.11.030.
- [7] Ke Hao Ran. An Introduction to the Conservation and Revitalisation of Macao's Architectural Heritage in the 21st Century [D/OL]. Huaqiao University, 2020. <https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CMFD&dbname=CMFD202101&filename=1020324502.nh&v=>.
- [8] Ma Viet, Chen Weixin. Evolution and Alienation of Architectural Styles in Macao[J/OL]. World Architecture, 2009(12): 130-133. DOI:10.16414/j.wa.2009.12.026.
- [9] Chen Yiluo. The development of decorative arts in Lingnan mansion gardens in Macao - the examples of oyster shell windows and Manchurian windows [C/OL]. 2020: 4. https://kns.cnki.net/kcms2/article/abstract?v=78ssZZiLu9b9NjOC-AICrs8H-hs6bPSuQtXqNV9wEBOC6icE54BO67WEaKrFAMUd2uvgnJ4ai_ILv8rdPpyOTtvDukMLKQafMUNVDEOMUB7ZZe-MeZmdFWv7_6de02a&uniplatform=NZKPT&language=gb. DOI: 10.26914/c.cnkihy.2020.015298.
- [10] Feng Jingzhao. A study on the grey plastic decoration of Macao's residential buildings - the example of the Lu Family's Big House [C/OL]. 2022: 7. <https://kns.cnki.net/kcms2/article/abstract?v=78ssZZiLu9ZgLCbdek5INagwhnv6mJg4Q1Dz8cJxBbC5EZ0Xw5oglxcbwirOSL5DLfiVL2BH4klpb4wNIFn452ZIHn1gwChKdqI7bp9pspQsWpcyAso7dD1E-GZ3Zm&uniplatform=NZKPT&language=gb>. DOI: 10.26914/c.cnkihy.2022.018363.
- [11] Chen S, Wang YC, Shen SY, et al. Deterioration and Evidence-Based Research on Damp Diseases of Vernacular Architectural Heritage - An Example of Yu Jia Village, Xintong Township, Hangzhou City, Zhejiang Province[J]. Rural Economy and Technology, 2021, 32(19): 287-289.
- [12] Yang Changming, Liu Ning. Disease analysis of masonry walls of modern buildings in Beijing[J]. China Cultural Relics Scientific Research, 2012(2): 41-44.
- [13] Li Tingshen, Zhang Minghao, Sun Xiaohong. Research on the assessment strategy and identification mechanism of the disease problem of traditional residential houses in Hongcun [J/OL]. Architecture and Culture, 2020(12): 233-235. DOI: 10.19875/j.cnki.jzywh.2020.12.084.
- [14] Zhang S-L. Exploration of preventive protection measures for the red building facade of Peking University based on disease analysis[J/OL]. Architecture and Culture, 2021(8): 90-92. DOI: 10.19875/j.cnki.jzywh.2021.08.033.
- [15] ZHAO Zhifeng, GOU Yingrui, RONG Qingwen. Preventive Conservation Experience and Inspiration of Heritage in Italian Cultural Districts--Taking Valtellina as an Example[J]. Small Town Construction, 2023, 41(8): 40-48.
- [16] Feng Nan. Research on weathering mechanism and protection method of masonry cultural relics under humid environment [D/OL]. Jilin University, 2011. <https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CMFD&dbname=CMFD0911&filename=1011095056.nh&v=>.
- [17] Chen Yiluo, Zheng Liang. Study on Restoration Measures and Preventive Strategies for Historic Buildings in Macao[J]. Urban Housing, 2021, 28(9): 52-54.
- [18] Shen Yu, Liu Song Fu, Cheng Peng. Research on microclimate pathogenesis of wooden heritage buildings along the southeast coast [J/OL]. World Architecture, 2023(9): 114-119. DOI:10.16414/j.wa.2023.09.025.
- [19] Exploration of preventive conservation research on Chinese city walls_Zhang Yifang.pdf [Z].
- [20] Dong Yu. Discussion on the application of preventive protection of cultural relics - Tangshan Museum as an example [J/OL]. Heritage Identification and Appreciation, 2023(20): 52-55. DOI: 10.20005/j.cnki.issn.1674-8697.2023.20.013.
- [21] Zhang Man, Yu Xiaohan, Tang Yuyang, et al. Constructing and Practising the Protection System of Low-level Cultural Relics Buildings Based on Preventive Protection in the Context of Urban Renewal--Taking Shengzuo Longchang Temple as an Example[J/OL]. Journal of Beijing Architecture University, 2023, 39(6): 89-98. DOI:10.19740/j.2096-9872.2023.06.11.
- [22] Fu, Yuzhu. Research on quantitative analysis of wood structure deterioration and restoration technology of 20th century heritage buildings [D/OL]. Beijing University of Technology, 2016. <https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CMFD&dbname=CMFD201701&filename=1016785961.nh&v=>.
- [23] Liu Jiaxin. Disease Research on Brick Heritage Buildings in Southeast Coastal Areas [D/OL]. Harbin Institute of Technology, 2019. <https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CMFD&dbname=CMFD202101&filename=1020397609.nh&v=>.
- [24] Mi Zhendong, Sun Qing, Zhang Meng. Research on reinforcement and repair of modern brick and wood architectural heritage [J]. Building Technology, 2023, 54(13): 1646-1650.
- [25] CHEN Yan, CHEN Lin, DAI Shibing. Research on anti-corrosion measures for wooden columns of historical buildings [J/OL]. Heritage Conservation and Archaeological Science, 2018, 30(1): 63-71. DOI:10.16334/j.cnki.cn31-1652/k.2018.01.009.