Research on the sustainable development and renewal of Macao inner harbour under the background of digitisation

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Abstract
With the passage of time, the Inner Harbour of Macao has experienced changes, prosperity and decline. For a long time, the twin problems of flood and transformation of the traditional business district have been the ones primarily responsible for affecting the development of the Inner Harbour. This paper analyses the Inner Harbour region through the form of five layers. Based on these factors, the cultural, economic and ecological characteristics of the Inner Harbour are summarised. The paper mainly studies solutions to the problems of flooding, and presents flood control initiatives that can prevent waterlogging in the Inner Harbour, so as to enhance and activate the old city waterfront.

Keywords: hydrophilic concept, inner harbour, urban renewal, cultural and creative industries

1 Introduction

Tracing back the history of life, we find that the ocean is the starting point of all living things; and water has bred thousands of life forms. The long history of human evolution has its origin in the figure of water, and the moistening characteristic of water has provided development space for humans. The primitive transit river on the urban border has gradually developed into today’s urban river. The urban river plays an important role in defending against foreign enemies, transporting goods and so on. The role of this water body in fulfilling the needs for various fortifications has given rise to today’s urban river. Due to the rapid development of modern...
industry, urban rivers have also encountered many problems, such as water pollution, floods and other disasters, which are more a ‘cure’ for urban rivers than a landscape design.

Macao’s Inner Harbour has a long history, mainly consisting of freight transport, inland river transport and fishery terminals, with a total of 34 terminals. The Inner Harbour of Macau is located in the west of Macau peninsula. It is a tributary of the western river. The waterway runs between the Macau peninsula and Wan Chai, Zhuhai. The Inner Harbour is 3500 m in length from lighthouse No. 12 to Fai Chi Kei. Since 1998, with the relocation of the casinos, the decline of fisheries and the commissioning of the deep-water port of Kowloon and Macao, the commercial activities in the Inner Harbour have been gradually reduced, leaving a lot of space empty.

With the passage of time, the Inner Harbour wharf has experienced various changes, from prosperity to decline, and is a witness to the shipping changes of the Inner Harbour. In recent years, the vacancy and idleness of the Inner Harbour wharf have given rise to various social, economic and ecological problems. If Macao is regarded as the skeleton of the city, the Inner Harbour waterfront space is one of the leading factors in the skeleton of the city, and its existence increases the vitality of the city. Owing to the high density of Inner Harbour, the ecological problems that need to be solved urgently and the relatively backward economic development, it is not only imperatively necessary but also inevitable that Macao take the road towards sustainable development.

To renovate the Inner Harbour wharf, we need to conduct an in-depth research on the Inner Harbour of Macao. Figure 1 is a hierarchical analysis process combining its historical stories, social activities, rituals (religious behaviour), land forms and commercial forms.

![Fig. 1 Sketch of the stratified analysis of Macao Inner Harbour. Source: Drawing by Urban Planning PhD Students of the City University of Macau](image)

1.1 Historical stories

The study of the historical events associated with the Inner Harbour focuses on its expansion process. In the early official documents of Macau, it is difficult to find a specific regional scope of the Inner Harbour; and especially in the map of Macau in 1622, the location of the Inner Harbour is generally limited to the west side of the Macau Peninsula, the development process of the Inner Harbour is a continuous outward migration process, and most of its land is reclaimed from the sea. In 1866, the land part of the Inner Harbour was expanded greatly; the block of Meiji in the Inner Harbour was published in the Macao Gazette in 1873; the Portuguese and Macao governments promulgated a decree to define the scope of the Inner Harbour in 1989, from the Ma Ge Fort to Sha Li Tou [1]. The Opium War is an important turning point for the urban development of Macao, when the Portuguese began to gradually establish a unique colonial management of Macao; and until their return, Macao still retained a large number of elements of the colonial period [2].
1.2 Social activities

The social activities of the Inner Harbour have always been dominated by the ethnic Chinese. The places where social activities take place mostly have certain social attributes, such as the riverside new street station (Rua do Almirante Sérgio), which gathers people for leisure activities, and the No. 16 terminal, which encompasses commercial, entertainment and catering functions for people to carry out commercial activities [3]. The Macao Inner Harbour is connected with Zhuhai Wan Chai port by water, which is one of its important social activity fields. The Wan Chai Port connects Zhuhai free trade zone, Crosmen business district and Hengqin area, serving as the life link between Zhuhai living area and Macau old town, and bridging the life bridge of Zhuhai-Macao residents. At present, the Hao Tong Wharf of Wan Chai Port is still active in the flower trade industry. They take a boat to and from Haojiang every day to send flowers and blessings to compatriots on the other side.

1.3 Rituals

For a long time, Macao has been colonised by Portugal, and its religious culture is the integration of the East and the West. The Portuguese take the Church as the core of their religion, while the Chinese people, who are deeply influenced by Chinese traditional culture, mainly build temples, such as the famous Ma Temple. However, the long-term cultural heritage does not make the two different religious cultures mutually exclusive, but rather makes them respect each other, such that they together constitute one of the unique religious characteristics of Macau [4].

1.4 Land form

Macao has had a clear division of land use since the middle of the 19th century. The commercial district, green space, residential area, entertainment area and industrial area form the pattern of the city. The commercial district is distributed in a straight line and is located between the Chinese residential area and the Portuguese residential area [5].

1.5 Economic

The commercial activities of the Inner Harbour are mostly concentrated in the areas surrounding the region from Sitakou Street (Praça de Ponte e Horta), Meiji Street and Bai Yantang Street to the new road; this region encompasses the catering, entertainment and residential functions of the Inner Harbour and is the main commercial area of the functional Inner Harbour [6].

The economic industry of the Inner Harbour is analysed by using the electronic map points of interest (POI) classification of urban areas. The data of the study came from the AutoNavi map. By combining the methods of data correction, de-duplication and field investigation, the Inner Harbour area was divided on the map, and a total of 5733 pieces of data were obtained. On the whole, the layout of this region presents a polycentric pattern with uneven spatial distribution of catering industry. The area around San Ma Road, near the Pai Fong area of Tai San Ba and the area near the north section of Ha Wan Street, are leading in the development of catering service facilities. Among them, the catering industry establishments on both sides of the new avenue are highly concentrated, with a large number of Chinese restaurants, Western restaurants, coffee shops and dessert shops, etc., to meet the diverse needs of consumers. The area near the Inner Harbour in the historic urban area of Macau is incentivised by the tourism industry and has a relatively high concentration level. There are many Chinese restaurants, cake and dessert shops and snacks-vending shops here. The two areas mentioned above are prosperous and flourish owing to patronage from tourism. In the vicinity of Shishipu Casino and to the south of Xiaohuan Street, there appeared a secondary centre of catering service facilities, serving primarily Chinese food and fast food, to meet the daily catering needs of residents. In contrast, the development of catering service facilities in Sidakou, Industrial Docklands and the vicinity of Caohei Street lags behind (Figure 2).
2 Extraction of elements in the Inner Harbour area

Through a scrutiny of the details associated with the Inner Harbour of Macao, we ascertain its history, events, social activities, commercial activities, etc., and the result is our investigation and research into the economic, cultural and ecological construction of the Inner Harbour of Macao.

From the economic point of view, the Inner Harbour of Macao has gathered the main industries of Macao since modern times through the way of reclamation, and it is an important commercial district and a Chinese–Portuguese commercial residential area dominated by the Chinese. The commercial district has a long history and possesses its own characteristics. In particular, the surrounding areas of the new road and the front of the Assembly Pavilion still retain the original traditional commercial characteristics dominated by retail trade. However, the relocation of economic activities in the port led to the region’s backward economic model, and the current commercial function of the port appeared to be characterised by a recession and transfer situation. In addition to these, the new road has relatively high-end catering, entertainment and shopping functions; other areas—for instance, the region from SitaKou block, Meiji Street and Baiyantang Street to the new road of these several locations—encompass some restaurants and hotels, but the grade is lower. The World Heritage route, the new road area and Basutar Old Street have become a new business core area of the Inner Harbour, which is the result of Macao’s vigorous development of tourism \[1\]. In recent years, the development of Macao’s gambling tourism industry is in full swing, but most of the visitors who arrive at Macao to participate in gambling games gather outside the Inner Harbour, and the commercial value of the Inner Harbour is greatly reduced.

From a cultural perspective, Macao is a Chinese-dominated society, and its cultural tradition is basically the cultural tradition of the mainland of China. Although the Portuguese have governed Macau for hundreds of years and infiltrated it with Portuguese culture, it is only a combination of China and the West for Macau’s society and culture. For most Macau residents, their values and habits are still far from those of the Portuguese. Although the main form of Chinese culture in Macau is Lingnan culture, it also contains the characteristics of diversification in other areas of Chinese culture. Chinese traditional Confucianism, Taoism and Buddhism, as well as numerous folk gods, still stand side by side with the sacred God in Macao. The Mazu Pavilion, which
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existed before the Portuguese entered Macau, has undergone many meals after the Portuguese stayed in Macau. The scale of the pavilion is getting larger and larger, and the incense is becoming more and more prosperous. While the influence of Mazu belief is expanding, the folk beliefs from the mainland of China include Sanpo God, Water Immortal Gu, Nazai, Nuwa, Baogong, Xuanwu and so on. Lingnan culture, as a form of extension and development of Chinese culture in the south of the Five Ridges, represents the Chinese society dominated by Chinese culture in Macao. Although Fujian people entered Macao very early in history, the Fujian people who lived in Macao for a long time have mostly become integrated into the culture of South Guangdong.

From the ecological point of view, the geographical location of the Inner Harbour is located in the west of the Macao Peninsula, adjacent to the Wan Chai area of Zhuhai; connecting the two places is a river; the coastline of the Inner Harbour is 3500 m long; and due to the artificial reclamation of a large quantity of hard ground, the Inner Harbour channel is getting narrower and narrower. In addition, due to the low terrain, astronomical tides, large amounts of rainfall and other weather effects, and backward municipal facilities, the Inner Harbour has long been encountering a flood problem, which has not been solved so far. Therefore, in the process of transformation of the Inner Harbour area, a major problem that cannot be ignored and urgently needs to be solved is the problem of flooding in the Inner Harbour area. The Inner Harbour should first solve the problem of flooding, in order to develop characteristic leisure tourism like other areas in Macao. As a result of long-term suffering from floods, diversified development will become empty talk. In recent years, a number of scholars have proposed solutions to the problem of the Inner Harbour. For example, Yang Liu and Yingqing Fei, in ‘Waterlogging countermeasures of waterfront cities – Taking the Inner Harbour of Macao as an example’, have used the concept of sponge city to put forward suggestions for its transformation. Jianghan Gao and other scholars, aiming at redevelopment of the Inner Harbour area, also put forward design suggestions for the open space of the Inner Harbour. Recently, the relevant planning departments of the Macao government have also proposed to build bridge gates to resist the reversal of seawater inflow caused by typhoons and other special weather phenomena. However, in the long run, it is suspected that simply building bridge gates might superficially address the symptoms but not cure the root cause, because bridge gates can only prevent the reversal of seawater from one side, when the terrain in other places is below sea level; or, because the blockade of bridge gates makes water impact on both sides of mountain slopes, it will also cause seawater to reverse from other areas. The construction of the bridge will cause more pollution, and the establishment of a height of 3.5 m may be problematic, said Au Ping-kwong, chairman of the Macao Civil Engineering Laboratory, at the 2nd Binhai Urban Planning and Design Forum. In the opinion of Chairman Au Ping-kuang, waterproofing along the Inner Harbour can be done at a height of more than 5 m, and it has little impact on the landscape. The dyke can prevent floods, replace clean water and allow people to walk. The reason it is built 50 m away is to avoid moving the wharf, but the wharf can lose its original function. In the past, goods from Hong Kong would have passed through the wharf in Macao, but at present, the opening of the Hong Kong–Zhuhai–Macao Bridge can completely take over the transportation function here.

Fig. 3 Integration of economy, culture and ecology
Based on the analysis of the economy, culture and ecology of the Inner Harbour, the aim of the renewal of the Inner Harbour is to find a balance between the three, that is, to consider not only the inheritance and protection of culture but also the improvement of ecological environment, and to develop the economy of the Inner Harbour and improve the living standard of the people (Figure 3). The integrated development of economy, culture and ecology has overlapping effects on multiple levels, comprehensively reflecting the development process of Macao’s Inner Harbour. In the actual analysis, we focus on the influence and mechanism study of the three factors on Macao Inner Harbour.

3 Results and discussion

After consulting various domestic and foreign cases and conducting local research into the Inner Harbour, the author fully considers the harbour’s own characteristics, and through a large number of field investigations and expert interviews, comprehensively puts forward the renewal strategy of the Inner Harbour of Macao.

3.1 Waterfront landscape design method of inner harbour

The landscape design in modern society pays more attention to people’s feelings because of the perceived need to add humanistic thought to the design. Further, the nature of hydrophilicity is discussed as an important index in the design of hydrophilicity landscape. Therefore, in the landscape design of modern society, those designs that incorporate waterscapes have a unique significance, which cannot be replaced by landscape design in the general sense [7].

The key to create a vibrant urban hydrophilic space lies in the participation of people in the space, including the activities of users, and in order that the hydrophilic space might be full of vitality, it is important, when planning the landscape, to bear in mind that the connection between people and water includes not only actual contact, but also psychological affinity. Such an understanding is not only essential to enable urban residents to better participate in hydrophilic activities and to make the space landscape ornamental but also contributes towards fulfilling the need to enrich the hydrophilic experience of space activities. The structural design of each part of the water body must fully demonstrate the human hydrophilic nature as the principle. Additionally, it is necessary to adjust the structure reasonably according to different hydrophilic activity scopes, and make people willing to integrate into the water environment again on the premise of ensuring safety [8].

3.2 Experience of hydrophilic design in Hafencity, Germany

Waterfront is an important node of the urban network structure, is a huge system having a complex structure and is also the ideal place for human living. Excellent waterfront landscape design results can not only enhance the charm of the city but also highlight the humanistic temperament. Hafencity was gradually abolished in 1960 because of the loss of its original freight function, and the single function became an obstacle to the development of Hafencity. At the same time, the dyke surrounded the centre of Hafencity and was isolated from the port area, although its ground level was 4–5.5 m horizontally, and the 4.5 m-high pedestrian area was flooded frequently during the flood season every year.

The renovation plan of Hafencity waterfront area first considers the relationship between Hafencity and the old urban area. Since the Hafencity waterfront is close to the old urban area, the first consideration is to integrate it with the old urban area in order to enhance the vitality of the city, and thus 25 bridges have been renovated or built as new roads to connect the old urban area with the port. New buildings and roads have been built on top of the site’s historic highest waterline (6.45 m in 1976) to meet new flood demand, and the basement of the building, normally used as a garage, can also be used as a dam to resist flooding. Roads, squares and piers along the waterfront remain roughly the same landmark height (4–5.5 m in water level) as they were when they were first used as walkways and squares to create hydrophilic and recreational areas (Figure 4).
3.3 Design scheme of Macao Inner Harbour

There are many similarities between the Inner Harbour of Macau and the port of Hafencity. The Inner Harbour has also undergone a long period of shelving from prosperity to decline, and is located close to the old city. Thus, it is advisable to use the convenience of the old city to activate the region; and problems of flooding, including the avoidable damage that arises from poor control measures over flooding, need to be remedied [9].

The solution is to divide the coastal area of the Inner Harbour into three areas (Figures 5 and 7): hydrophilic platform (buffer zone), viewing corridor and commercial area. The design of the hydrophilic platform has multiple advantages. First of all, it can make tourists experience a closer contact with the water. Second, the hydrophilic platform is actually a buffer zone; the use of elevated design can make the back commercial area and the front hydrophilic platform have a transitional process, so that the water poured into the Inner Harbour will
not directly enter into the built-in commercial area or even the residential area [10]. The commercial area will set up a restaurant area, a processing area, an outdoor sales area and some public facilities, aiming at making full use of the coastal area, not only taking into account the needs of tourists but also meeting the commercial needs of businesses. Commercial behaviour can activate the area, so that the originally abandoned Inner Harbour and its idle space can be activated and utilised. In the commercial area, Area A is set as an overhead parking area (Figure 5). The purpose is to improve the carrying capacity of tourists and solve the problem of public parking.

Fig. 6 Design of car park in Area A

Fig. 7 Draft overall design concept for the Inner Harbour coast (2)

The overall design concept of the Inner Harbour is shown in Figure 6. The Inner Harbour faces Zhuhai across the sea. The first layer of the coast is equipped with a buffer. The design concept of the hydrophilic platform is to build a place of activity at the water’s edge, which can be extended to the water’s surface. It is characterised by having railings and other equipment to protect human life and ensure safety. The hydrophilic platform plays an important role in landscape design, but landscape designers also need to carefully consider the design elements. Hydrophilic platform, based on the material, can be classified into stone and wood. After anti-corrosion treatment of wood, a platform can be built in the wetland park, and thus the application is very wide. Since the unique texture of wood can weaken the traces of artificial transformation of nature, and stone hydrophilic platform is relatively solemn and stable, it is the latter that is mostly used in urban water plazas and some formal occasions [11]. Buffer’s design method can learn from sponge city’s methods, and both have a good drainage system and good buffer filling (Figure 8). The main purpose is to ensure backward water recycling, and the use of a buffer-function pro-horizontal platform to resist floods caused by bad weather [12].
The flood control line is set at 2.5 m, and then, behind the buffer area, is the second layer – the wind and rain corridor, which is about 2.5 m high (Figure 9). After considering the water level, 1.5 m below the wind and rain corridor, a steel water gate is set up to block the invasion of water. Usually, the corridor inside can be used for people to rest, or on holidays and other special days, the same can be transformed into a creative or thematic market, and when the water level exceeds 2.5 m, people can move above the corridor.

The third floor is the commercial district. The first floor of the commercial district can be used for idle space design, usually for a parking lot, so that even if the water flooded the bottom floor, the second floor’s area can also be used normally, or even temporarily assume some of the uses or functions of the first floor, such that the arrangement will not cause great economic losses. The fourth floor is the adjacent old town. The door of the old town is made of steel or iron as the main material of the water gate, to block some of the water in this area, and such a blocking effect prevents water from reaching deeper areas of the old town, thereby preventing it from submerging the old city (Figure 8). In addition, we try to design a brand (Figure 5). Through the brand settings and the Inner Harbour functional zoning after the renewal of the Inner Harbour area, the areas hidden in the various factors are superimposed in the design-related activities node. This solves the problems of the Inner Harbour, so that its vitality regeneration is achieved [13]. As shown in Figure 5, a striking logo (Figure 10) is designed on the top floor of the commercial district. The billboards should be large and have visual impact. Neon lights can be used to make them have commercial characteristics, so that Zhuhai across the sea can clearly see the updated image of the Inner Harbour, which will ensure a good propaganda for the activated Inner Harbour.

In the process of the development of the Inner Harbour, due to the Portuguese colonisation, the Inner Harbour area has certain traces of Chinese–Portuguese cultural integration, among which the dock building is a typical representative. This important historical feature provides inspiration and direction for the renewal of the Inner Harbour. Preserving and inheriting the architecture and landscape under the background of Chinese and Portuguese culture makes the renewal of the Inner Harbour different from those of other cities and unique.
4 Conclusion

The urban orientation of Macao is becoming more and more diversified. As an important part of Macao, the Inner Harbour should be effectively renewed both from the perspective of urban development and that of people’s livelihood. In recent years, due to its special geographical environment, the Inner Harbour has caused corresponding ecological problems (flood is the biggest problem). In our opinion, first of all, we should solve this problem, since the problem of flooding has seriously affected the development of the Inner Harbour. However, tackling the problem of flooding needs significant professional expertise, and thus there arises the need to form a team of professionals, who, through accurate calculation or repeated experiments and the use of reasonable methods (such as Jianyi Zheng’s functional wetland reclamation model), can be expected to fundamentally solve the ecological problems of the Inner Harbour. Once plans to address the problem of flooding have been satisfactorily put into implementation mode, thereafter we may move on to the simultaneous development of characteristic leisure tourism and other industries. It bears reiteration that for the Inner Harbour, the most urgent need is flood control. Through proper flood control measures, we can ensure that the Inner Harbour has a good ability to resist floods. On this basis, economic development, foreign investment, social development and a series of sustainable measures can be implemented more effectively. A good ecological environment is the basis of the sustainable development of a waterfront, and it improves economic benefits and brings a comfortable and beautiful life and play experience for residents and tourists.

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