



South Sea Pearl Eco Island Sustainable Development Mode

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Abstract. The South Sea Pearl Eco Island is an artificial island located in Haikou Bay on the west coast of Haikou, Hainan Province, which is a large-scale tourism infrastructure project of Hainan Province and Haikou City. The past decade has witnessed it grow from scratch but also showed its impact on the environment. Based on the current condition of South Sea Pearl Eco Island, this project aims at replanning and utilizing the existing wasteland and transforming it into an island comprehensive park with both ecological and economic values. A qualitative design was employed using observations, field research and literature searches. The following issues were eventually identified, waste issues, marine conservation, beach erosion and sedimentation, which provided a basis of assurance for future design planning.

Keywords: Artificial island · Sustainable development · Environmentally friendly design

1 Introduction

The South Sea Pearl Eco Island is an artificial island located in Haikou Bay on the west coast of Haikou, Hainan Province. It is a large-scale tourism infrastructure project of Hainan Province and Haikou City with a planned investment of over 100 billion yuan. Initially funded by Chinese developer HNA Group in 2010, the crescent-shaped island covers a sea area of 459.3 hectares, about 265.4 hectares have been reclaimed from the sea and was envisioned as a tropical tourism hub that will include housing, hotels, a theme park and some other economic facilities. HNA Group planned to develop the South Sea Pearl Eco Island into an important node on the Maritime Silk Road, the external gateway of the international tourism island and an international first-class leisure tourism destination. However, in 2018, the Central Environmental Protection Inspection Team conducted an inspection report to Hainan Province, and due to severe environmental damages, the island was required to suspend construction and rectification. In 2020, Hainan Province also issued the “Hainan Province Implementing the Rectification Plan of the Third Central Ecological Environmental Protection Inspectorate Inspection Report”, which involved the policy requirements for the South Sea Pearl Eco Island to remain suspended. Some of the is-

land's existing problems, especially environmental ones, must be urgently addressed if it is to develop further.

Based on the current condition of South Sea Pearl Eco island, this project aims at replanning and utilizing the existing wasteland and transforming it into an island comprehensive park with both ecological and economic values. Qualitative method was mainly employed in the research, like observations, interviews, field trip research and literature searches. Apart from these, for some specific environmental problems (waste issue; marine conservation; beach erosion and deposition), which were found from field trip research, some design ecology approaches were also applied in the final planning process. The project not only showed people's demands about artificial island planning and countermeasures to deal with environmental impacts but also applied the results into the planning process, which are beneficial to providing a high-quality waterfront living environment for the surrounding residents and also creating new tourism, recreational and universal education destinations for the city.

2 Literature Review and Problems Analysis

2.1 Literature review

Artificial islands are mainly built at urban harbors. Japan is the country that owns the largest number of modern artificial islands. Since the 1960s, due to the rapid economic growth in Japan, cities attracted many industries and populations, which resulted in the excessive concentration of the urban population. So, it is necessary to create some new space to meet the economic, cultural, and commercial functional requirements of the city, promote urban development, and improve the urban environment. Kobe artificial, located in the sea off the port of Kobe city, was built under this situation.

Although the construction of artificial islands has extensive international participation, it is still a controversial topic that faces much skepticism. Most studies pointed the finger at Dubai's first Palm Island since that island catalyzed all the other projects. After the field investigation in Dubai, the negative effects of artificial island construction on turbidity increasing, and alongshore deposit transport changes. In addition, the destruction of coral and fish resources is also widely regarded as the negative effects brought by Dubai's artificial island projects [1].

The international communities have already put forward some countermeasures to standardize artificial island construction, thus prompting its development in a more environmentally friendly direction. Equator Principles, a risk management framework, has been widely adopted by governmental and regional organizations to identify, appraise and manage projects' social and environmental (S&E) risks. The implementation of this principle has greatly promoted the sustainable transformation of artificial island construction, which also provides referential significance for the ecological development of the artificial island.

In recent years, many artificial islands have been built in China, which can be divided into two categories: one is for public entertainment, and the other is for military use. At present, China's civilian artificial islands include Sanya Phoenix Island, Dan-

zhou Ocean Flower Island, Artificial Island at Zhuhai Macao port and so on. There are also some islands, such as Hulu Island in Haikou, which were abandoned or waiting to be demolished for various reasons. So many new theories and technologies have been put forward and applied, such as a design method for the outer ring aquitard of the island to increase underground freshwater reserves [2], an ecological dual-purpose coral reef floating breakwater and power generation system suitable for the artificial island [3].

2.2 Current problems

4 sites were selected as the research subjects to conduct field trips respectively. After investigating the current situation of South Sea Pearl Eco Island, Ocean Flower Island and Phoenix Island were investigated subsequently considering their similarities with the front one in terms of ocean current, climate, environmental situation and geographical location. Additionally, Chengdu Live-water Park was also considered as an investigation site due to its referential values of pollutant purification from the biological perspective. The investigation and evaluation of all 4 research subjects are based on the items in the Field Investigation Status Analysis Table. Finally, relevant investigating results were summarized as 3 aspects: infrastructure, ecological situation and other aspects.

Waste Issue.

Based on field investigation, this study designated that the waste produced on South Sea Pearl Eco Island was not well treated. Some research also pointed out the challenges and importance of waste management to small islands [4]. Considering these, this study designated that waste treatment and management are highly essential to both ecological stability and island operation of South Sea Pearl Eco Island.

Marine Ecological Environment.

Marine conservation can be divided into various aspects. Apart from the monitoring of water quality, fish and sessile benthic invertebrates (stony coral, sponge and gorgonian) are also important conservation subjects.

Island-building activities in Hainan represented widespread damage to coral ecosystems and fishes through physical burial as well as indirect turbidity effects. Marine plants and creatures have always been regarded as significant influential factors in an island's sustainable development. Marine macroalgae are very beneficial in improving the physical and chemical properties of soil. However, marine ecosystems are less resistant to natural and anthropogenic catastrophes, which are more likely to be affected by human commercial activities compared with the ecosystem on the land [5]. Some previous research based on Hainan can also verify this point. For example, coral abundance in Hainan has declined by at least 80% over the past 30 years as the rapid development of artificial island-building and nearshore tourism [6]. In light of these, this study selected fish and coral as the research subjects to conduct subsequent planning due to their severe situation under current Hainan ecological conditions.

Beach Erosion and Deposition.

Research has already pointed out the negative effects of South Sea Pearl Eco Island on the stability of the beach on the west coast of Haikou Bay, which dramatically changed the prominent tongue-shaped shoreline. The construction of artificial islands will change the surrounding marine hydrodynamic environment, which will lead to the change of surrounding landforms and scouring and silting environment. The offshore distance of South Sea Pearl Eco Island is about 1.9km. Due to the relatively close offshore distance, the construction of the artificial island will also influence the stability of the west coast of Haikou Bay under the action of hydrodynamic forces such as wave coastal current.

The same results also can be observed on satellite maps. According to the top view of South Sea Pearl Eco Island and its coastline area in 2016 and 2021, 3 points at the same latitude and altitude along the shoreline were selected and named as A, B and C. After calculating, A and C are erosive zones, backed south for 35m and 24.8m respectively in the 5-year period. Point B, as a deposition zone, advanced northward 143m, which proved the actual existence of shoreline erosion situation.

3 Design Procedure and Specification

3.1 Waste Water Treatment

To resolve the waste water problem, apart from the setting of garbage collection points and garbage transport routes, some other countermeasures are also put forward in this project. The project combined the Sunken stormwater storage system and Integrated vertical-flow constructed wetland to collect, purify and store rainwater and sewage together. Rainwater flows into a network of rainwater pipes through collection ditches or small rainwater gardens on both sides of the road, through the Protective Soil Layer, Permeable Stratum and Water Collecting Layer of flowerpot, and eventually into the system for purification, storage and reuse. Besides, waste domestic water with less pollution will also be piped into the system, purified by the IVCW system and finally stored underground. The treated wastewater will be utilized for the park pond water supply and park vegetation watering, thus improving the island water utilization efficiency.

For wastewater that contains high COD, SS and BODs and cannot be directly purified, this planning project is planned to set up a preliminary sewage treatment station on the islands. After initial treatment, this kind of wastewater will be discharged into the urban sewage network for further treatment. The overall wastewater treatment plan is shown in Figure 1.

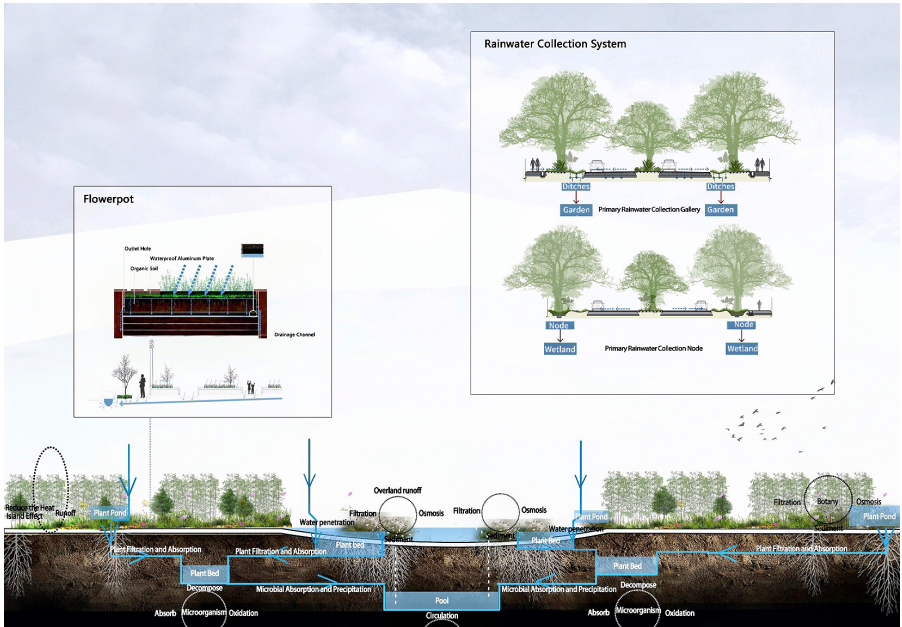


Fig. 1. Waste water collection and purification system

3.2 Marine Conservation

According to the topography of the surrounding sea and the living conditions of corals, this project divided two coral cultivation zones at shallow sea areas (depth within 5 meters) in the southwest of the island. The red line, in figure 2, is the nursery area, which commits the task of coral cultivation. By using tree-like structures made from PVC tubes, some coral nurseries will be established in this area. Besides, anti-fouling curtains will be placed along the red line area to reduce the spread of suspended matter in the ocean and avoid impacting the coral reef environment. The black line is the protected area, after six to nine months, the corals cultivated in the nursery area will be transported to this zone, which is shown in figure 2. To protect the coral living environment, boats and other recreational facilities will be banned from use in this area. In terms of fish protection, some artificial fish reefs will be placed in the surrounding ocean. In addition, a variety of fish fries are planned to be restocked during the non-breeding season. All selected fish are common species in Hainan, which is conducive to improving the survival rate.

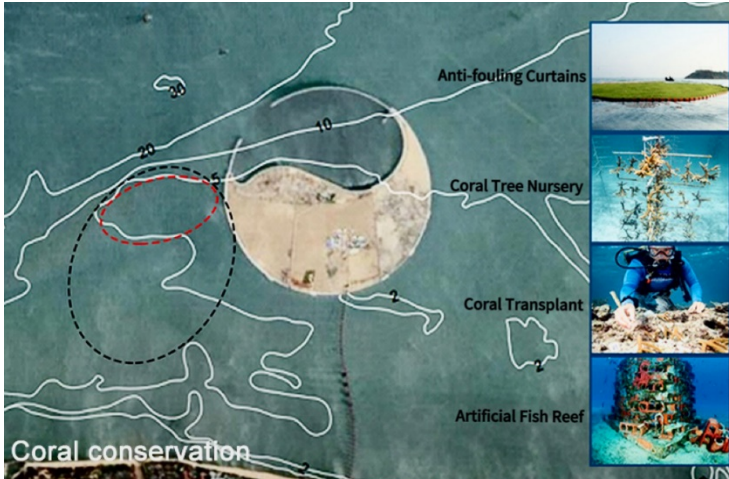


Fig. 2. Marine conservation strategy map

3.3 Beach Erosion and Deposition

After the completion of the South Sea Pearl Eco Island, the beach near the Wuyuan Estuary and Hainan Theater (bank A, C in figure 3) has been eroded sharply, and at the same time, the beach at bank B faces serious deposition problems. To maintain the stability of the beach on the west coast, Haikou Bay, the method of sand cyclic replenishment will be used to transport the silted sand from Bank B (deposition zone) to A and C (erosion hot spot) , in figure 3, thus forming a new dynamic balance.



Fig. 3. Road map of sand cyclic replenishment

4 Conclusion

Focused on 3 main problems in the construction process of South Sea Pearl Eco Island, a plan that stresses the balance of the ecological and economic values of this artificial island was put forward in this study. To achieve ecological benefits, the project adopted the concept of sponge city (which combined the sunken stormwater storage system and integrated vertical flow constructed wetland), coral distribution division, sand cyclic replenishment and some other methods.

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