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Influence of near-shore marine structures in a beach nourishment project on tidal currents in Haitan Bay, facing the Taiwan Strait*

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Abstract: The Longfengtou Beach in the Haitan Bay, located in Fujian Province of China and facing the Haitan Strait, has been suffering severe erosion due to the construction of seawalls. A simple beach nourishment project implemented has not achieved the anticipated beach restoration. Thus a practical solution has to rely on a combination with near-shore marine structures. In this study, a 2-D calibrated flow model is set up to investigate the effects of three different layouts of near-shore marine structures on the tidal current. It is shown that the breakwaters situated in both the north and south ends play a vital part in the protection against erosion. The offshore breakwaters can serve as a barrier to obstruct the current circulation then reduce the current velocity. The groyne linking the Guimo islet and the coast significantly reduces the south-to-north water exchange through the channel and redirects the current direction nearly perpendicular to the north breakwater, which cuts off the longshore transport that may have a negative influence on the beach, especially, the northern part. It is also noted that the monsoon at the site with different directions increases the current velocity. In general, proper layouts of marine structures can reduce the current velocity thus lead to less intense sand transport near the beach.

Key words: Longfengtou Beach, breakwater, groyne, tidal current, beach erosion, monsoon

Introduction

The coastal erosion is a worldwide issue leading to a severe ecological damage and a significant economic loss. Xie et al.[1] indicated that from the 1970s to the 1990s, about 60% of beaches along the west coast of the Taiwan Strait suffered erosion with an average annual recession rate of about 1 m/year and the maximum recession rate of 3 m/year-5 m/year. Many coastal erosion studies in this area were conducted in the past two decades. Wang et al.[2] investigated the causes and measures for the coastal erosion prevention in the Xiamen Island. Cai et al.[3] pointed out that the coastal erosion in the Meizhou Bay was caused mainly by the sand mining. Lin[4] claimed that soft cliffs on the northeast coast of the Pingtan Island appeared as the fastest recession area, with a retreat rate up to 5 m/year.

At present, the beach nourishments are often combined with the construction of traditional protection structures such as groynes (also named groins) and breakwaters, which are regarded as more efficient and economic than simple sand-filling or structures. Groynes are used to limit the coastal erosion due to waves and long-shore currents, and they are classified according to their shapes and arrangements as well as whether they are submerged or not. The detached breakwaters and groynes were built for the beach erosion control throughout the Taiwan coast, which main-

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tained the beaches over the last fifty years[5]. Here structures are designed to trap the littoral drift and the cross-shore sediment for creating a protective beach and they usually appear as a single structure or as a series structures along the shore. Biria et al.[6] investigated the effect of the submerged groyne on the sediment transport compared to the non-submerged one. Birben et al.[7] carried out physical and numerical studies of the offshore breakwaters, and suggested that the breakwater length and the distance between the breakwater and shoreline are the two most important factors that affect the sediment accumulation rate. In recent years, different kinds of breakwaters are widely applied in the beach protection in Qinhuangdao, China[8,9].

The Taiwan Strait is a long and wide shelf-channel with extremely complex hydrodynamics behavior characterized by strong tides. Storm surges frequently occur and significant oscillations due to tide-surge interactions during the typhoon season are observed by tide gauges along the northern Fujian coast, the west bank of the Taiwan Strait[10]. The seasonal circulation in the Taiwan Strait was analyzed using *in-situ* data, remote sensing and numerical models[11], and it is primarily dominated by the monsoons and the bottom topography[12]. In summer, a generally northward flow prevails in the strait[13]. However, the characteristics of the currents of the strait in winter are complicated with controversial interpretations. Guan and Fang[14] argued that further systematic field observations, especially in winter, were needed to verify the proposed Winter Counter-wind Currents. Qiu et al.[15] suggested that a southward current prevails in the Taiwan Strait during the northeast monsoon season based on the analyses of the trajectories of 110 satellite-tracked surface drifters from 1989 to 2007.

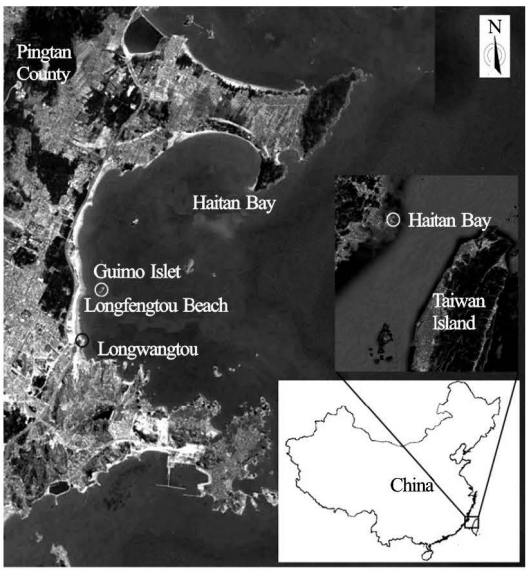
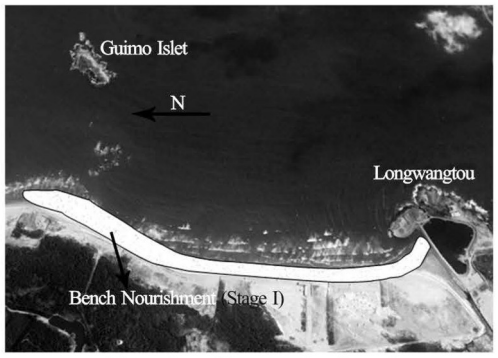
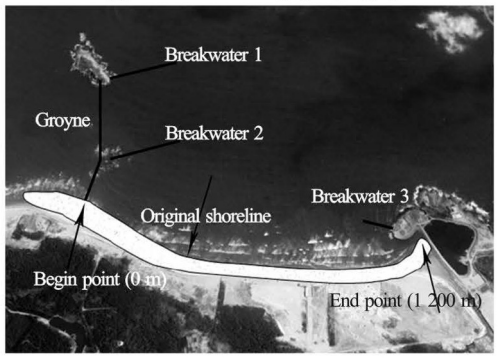


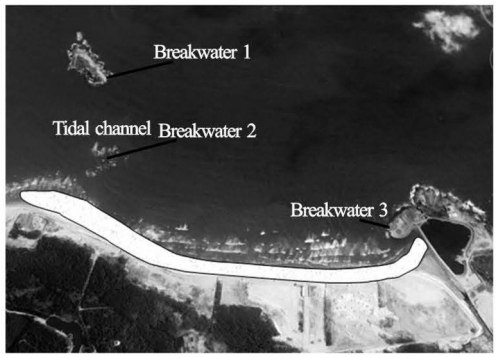
Fig.1 Study area: Longfengtou Beach and the Haitan Bay



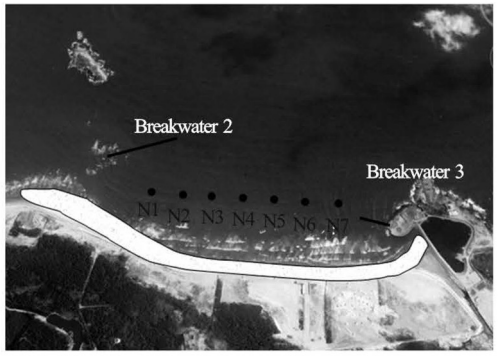
(a) Beach nourishment project (Stage I)



(b) Stange II: Scheme 1 (groyne and breakwater 1-3)



(c) Stange II: Scheme 2 (breakwater 1-3)



(d) Stange II: Scheme 3 (breakwater 2-3)and the points in Table 1

Fig.2 Schemes of the nourishment project (Stage Ⅰand Ⅱ) of Longfengtou Beach

The Haitan Bay (Fig.1), located in the east of Pingtan County, Fujian Province, China, facing the Taiwan Strait on the east, has several well-known and scenic bathing sites. The Haitan Bay waters feature a