Modelling Shore-parallel Breakwaters Effects on Coastal Morphology in Various Wave and Tidal Conditions at Sea Palling

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ABSTRACT

In the paper, the coast area at Sea Palling, Norfolk, UK has been studied, where 9 shore-parallel segmented breakwaters were constructed, including 4 surface-piercing and 5 low-crested breakwaters. The time-varying natural waves and tides combined with man-made a group of shore-parallel breakwaters makes the coastal morphology considerably complicated. In order to identify the main drivers on the morphological changes in nearshore region, a two dimensional depth-integrated and wave period-averaged coastal morphological model: COAST2D, is used to model 10 designed cases to analyze the beach and morphological response under 2 meso-tides and 4 wave conditions. The computed results shows wave height dominates the quantities of sediment transport volume, and wave directions as well as tides type such as neap and spring tides can change the morphological erosion and deposition patterns.

KEY WORDS: Shore-parallel breakwaters, Coastal morphology, Numerical modeling, Sediment transport, COAST2D model, Sea Palling

INTRODUCTION

Various coastal structures in nearshore area were widely built to protect the beach and reduce the coastal erosion which mainly caused by waves, tides and storm surge. Under the background of a predicted increase in storm frequency and the height of storm surge levels due to global climate change, they might play more vital functions to defend the storms and maintain the shoreline. To improve the existing design guidelines for such structures, many laboratorial physical models and numerical models are applied and lots of achievements are obtained. Generally, the physical models are mostly applicable to single breakwater. The numerical models are flexible and widely used to simulate the coastal morphological changes with breakwaters in many kinds of situations, see de Vriend et al. (1993), O’Connor et al. (1995), Nicholson et al. (1997), Zyserman and Johnson (2002), Cáceres et al. (2005), and Iskande (2007). They become the important tools to investigate the morphological processes at the coastal area with some kinds of breakwaters.

The study site is at Sea Palling, Norfolk, UK. Due to the coastal erosion throughout history (Halcrow, 1988), nine-segment, shore-parallel breakwater scheme was constructed in two phases, which consist of 4 high-crested and 5 low-crested reefs respectively during 1993-1997 (Hamer et al., 1998). The structures were designed to attenuate storm-generated waves, often enhanced by storm surge conditions, to protect the beach erosion. The asymmetric breakwater scheme ranks as one of the largest of its type, associated with meso-tidal and storm conditions, formed a profound impact on Sea Palling coastal morphology. Lots of field investigations and numerical modelling researches have been done. Thomalla and Vincent (2003) discussed the effects of four offshore breakwaters in Phase I built between 1993 and 1995 on beach responses. During the storm events, shoreline shape and coastal morphology are most volatile according to the measured 3-D beach topographic results (Dolphin, 2007). The long term regional impacts on sediment transport of meso-tidal at this area was studied, (Bacon, 2007), in which TELEMAC was used to simulate morphodynamics over the tidal tombolos behind the four, northern-most (updrift) breakwaters under tidal currents with a small wave-stirring (wave height, Hs=0.5m). The effects of shore parallel breakwaters on coastal morphology under natural tidal and storm condition are studied by COAST2D model, (Pan et al., 2007, 2008). There are both emerged and submerged breakwaters at Sea Palling, the wave overtopping effects cannot ignored in modeling. Its impacts on nearshore hydrodynamics and morphodynamics around shore-parallel breakwaters were studied by an integrated morphological COAST2D model, and the results were also compared against the field survey data (Du et al., 2008, 2010).

Although COAST2D has been calibrated and validated by the field survey data at Sea Palling, see Du et al. (2010), it is also validated by comparing the results calculated by a quasi three-dimensional (Q3D) of some cases in Zyserman et al. (2002) in this paper. The paper focuses on the impacts of coastal morphological drivers, which are selected as tidal types, wave height and wave direction. Some hypothetic cases for neap and spring tides and small and big wave conditions are designed and simulated by COAST2D, in which the wave overtopping is considered while the storm surge is ignored in the computation. The interaction of wave and tidal current at nearshore area shows different patterns in different wave height propagation direction condition. Finally, some conclusions are summarised.