Laboratory Study on the Effect of Artificial Sandbar on Beach Profile Evolution

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ABSTRACT

The artificial sandbar is well believed to be an efficient soft engineering alternative to prevent beach erosion. In this study, a physical experiment is conducted in a wave flume to investigate the evolution process of beach profile confronted by an artificial sandbar. The sandy beach has a slope of 1:50 and $D_50=0.16$ mm. The artificial sandbar, varying with the distance from shoreline, submerged depth and median grain size, is positioned offshore. The random waves with JONSWAP spectrum are chosen to represent storm wave conditions. The time series of free surface elevation along wave flume and equilibrium beach profile are acquired in the experiments. The overall characteristics of wave hydrodynamics over barred beach and the effect of different sandbar configurations on beach profile evolution are detailed discussed. Multiple linear regression analysis shows that the sandbar with smaller submerged depth or coarser sediment has the better protection effect for preventing beach erosion, while the location of sandbar does not has a significant effect.

KEY WORDS: Physical model; profile evolution; artificial sandbar; sediment transport

INTRODUCTION

Many sandy coastal systems dominated by waves in the world have one or more longshore sandbars (Ruggiero et al, 2016; Aleman et al, 2019; Eichentopf et al, 2018). Longshore sandbar is an important geomorphological unit in the coastal zone. The presence of sandbars protects the coast by causing waves to break further offshore. Therefore the study on beach profile evolution in response to the characteristic parameters of natural or artificial sandbar is important for the beach protection. Employing available theoretical solutions, established numerical models and high quality field and laboratory data, beach profile evolution with the presence of sandbars have been widely investigated over the past decade. For example, Marinho et al (2020) presented a numerical model to simulate subaqueous cross-shore profile behavior, including the evolution of longshore bars exposed to incident waves and the exchange of material between the bar and the berm. Spielmann et al (2011) used 2DV process-based model to analyze submerged bar nourishment strategies in a wave-dominated environment. The behavior of the various nourished profiles is analyzed in terms of wave dynamics and bars behavior. Aleman et al (2005) studied the movement patterns of sandbars under wave action and systematically considered the effects of different types of waves on the movement and equilibrium profile of sandbars using physical experiments. Larson et al (2013) presented a model to simulate the evolution of longshore sandbars influenced by incident wave conditions as well as the material exchange between the berm and sandbar, through physics-based formulations and simple schematizations of the governing processes. Later, Larson et al (2016) combined this model with modules to calculate dune erosion, overwash and wind-blown sand (forming a unique-coupled system), in order to simulate the evolution of a schematized profile at a decadal scale. Pan et al (2017) conducted beach profile surveys from 2011 to 2014 on West Beach in Qinhuangdao, China, and analyzed the post-nourishment beach profile evolution. Finally, a new equilibrium beach profile form was developed to represent low-energy sandy beaches with submerged berms. However, the effect of the artificial sandbar on preventing nourished beach profile from erosion is still not well understood yet. This paper mainly considers the beach profile evolution in response to the sandbar with different characteristic parameters, including the distance from shoreline, submerged depth and median grain size. The spatial variation of wave height along the barred beach profile and the change of wave spectrum under different sandbar configurations were investigated. The morphological characteristics of the beach profile is discussed as well.

EXPERIMENTAL OVERVIEW

Experimental Layout and Measurement Apparatus

The experiment was carried out in a wave flume (50 m long, 0.8 m wide and 1.0 m deep) located in the State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology. The lateral sides of wave flume are glass sidewalls that facilitate recording with a camera and visual observation of wave and beach profile evolution processes. Fig.1 shows the layout of experimental wave flume with a vertical two-dimensional coordinate system. Fifteen to eighteen capacity resistance wave gauges, depending on the case, were