Experimental Observation on Wave and Profile Changes in a Sandbar-lagoon System with Emergent Aquatic Plants on the Sandbar Crest

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ABSTRACT

Four scenarios with or without emergent aquatic plants on the sandbar crest at two water depths were conducted by wave flume experiments to study wave attenuation and profile changes in a sandbar-lagoon system. The rise of average water surface elevation decreases by plants when the incident wave propagates towards the sandbar, which is more obvious at low water depth than that at high water depth. Plants play an important role in wave attenuation and dune protection, which is more significant at low water depth than that at high water depth.

KEY WORDS: Emergent aquatic plants; sandbar-lagoon; wave attenuation; wave energy dissipation; profile changes; dune erosion

INTRODUCTION

An important means of wetland ecological restoration is to plant tamarix, mangrove, reed or other plants. These vegetation can effectively restore the coastal wetland ecosystem, and play an important role in maintaining coastal biodiversity, purifying water quality, reducing soil salinity and other aspects. Meanwhile, they also have strong functions of wind resistance and wave damping. Therefore, it is significant to understand the change process of wave, current and sediment transport in vegetation area. Physical experiment is a common method to study this field.

The variation of wave height (Zhang et al., 2017) and frequency spectrum can obviously reflect the wave attenuation. Gong et al. (2020) found that when wave period is large under the action of regular waves, water level rises in front and inside of the mangrove zone. The vegetation region generates a wave with double dominant frequency, and the harmonic energy is transferred to the dominant frequency wave as the wave passes through the vegetation region. Sediment transport characteristics are also required for ecological restoration in addition to wave attenuation characteristics. Ma et al. (2018, 2020) studied the wave attenuation mechanism and profile evolution process affected by artificial reef (AR), and found that wave breaking leads to the increase of energy in the high-frequency domain. Compared with natural beach without AR, the beach with AR is characterized by a breaker bar at a higher position and a scarp at a lower position on the profile. Kuang et al. (2020) further considered the combination effect of artificial submerged sandbar and AR on beach protection. In addition, Jiang et al. (2017) and Chen et al. (2016) studied the influence of mangroves on the variation of bank profile under the action of regular wave and isolated wave respectively.

Vegetated buffers can protect coastal dune environment under wave attack, help to filter pollution and provide habitat for wildlife. Interest in studying the influence of vegetation cover on dune erosion and overwash in many coastal areas has increased (Ayat and Kobayashi, 2015; Figlus, et al. 2011). The wave attenuation and erosion are directly related with the energy dissipation. Localized dissipation creates low wave energy, which may be significant for the response of neighboring shore lines (Dalrymple, et al. 1984). Based on the rate of energy change per unit area for dislocating sediment particles from their original location given by Türker and Kabdasli (2004). Türker et al. (2019) proposed a linear correlation of the wave energy coming out of the vegetation zone with the energy necessary to erode the coastal dune profile.

In this paper, Qilihai lagoon in the southwest of Beidaihe, China was taken as the research prototype. According to surface sediment particle size and wave data from field measurement, the wave flume experiment was designed and implemented to study wave attenuation and profile variation of the lagoon system with emergent aquatic plants on sandbar crest. Research results could provide guidance for implementing ecological bank revetment and restoration projects in the future.

METHODS

Experimental Design

The experiments were carried out in the wave flume (50 m long × 0.8 m wide × 1.2 m deep with the minimum and maximum working water depth of 0.2 m and 0.9 m respectively) of Laboratory of Hydraulic and Harbor Engineering, Tongji University. Based on the measured data and flume conditions, the experimental length scale is 10:1 (prototype: model), that is to say, wave height scale is 10 and wave period scale is 3.16. The actual wave characteristic values in the Qilihai region were selected as the significant wave height (SWH) of 1.0 m and the wave period of 5.1s.