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Large-scale movable-bed experiment on hydrodynamics and morphological evolution of the dune-beach system during a single storm event

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For the last few decades, coastal erosion has arisen as a global issue. Coastal erosion is accelerated mainly due to climate change (e.g., global sea-level rise and extreme waves) and artificial coastal structures. It results in a net recession of the shoreline and losses of coastal properties such as coastal infrastructure and beach material. As a result, the coastal communities become more vulnerable to coastal hazards and extreme waves. To protect coastal communities from extreme waves, coastal sand dunes were introduced as a natural and nature-based feature (USACE, 2013). For instance, the South Korean government placed an artificial sand dune on a beach on the west coast of South Korea where severe coastal erosion had occurred in an attempt to restore it. To achieve an adequate design of a coastal sand dune, it is essential to predict precise wave-induced sediment transport. However, the accuracy in wave-induced sediment transport prediction has not been sufficiently improved. Therefore, a laboratory experiment should be conducted to investigate the mechanism of wave-induced sediment mobilization and improve the accuracy of its prediction.

This study carried out a large-scale two-dimensional movable-bed experiment to analyze the erosion and accretion mechanisms of the dune-beach system during a storm and a post-storm. An entire storm event was reproduced in the flume, which was 100 m long, 2 m wide, and 3 m deep. The dune and beach profile was simplified by considering a representative natural dune on the west coast of South Korea on a 1:4 scale. An Acoustic Doppler Velocimeter (hereinafter ADV), ADV profiler, wave gage, and echo-logger were mounted on a movable cart to obtain wave and morphological characteristics over a wide range of flume. Also, CCTV and stereo cameras were installed to observe the erosion process of the dune and the entire wave transformation even in the very shallow water region (swash zone). So, through stereo imagery, wave transformation and runup were successfully measured. In addition, the Echo-logger measured the acoustic backscattering strength of the water column at a specific location near the sandbar crest to invert the backscattering strength measurements into suspended sediment concentration.

The tested wave conditions, representing a typical storm in South Korea for the past two decades, were divided into seven sea states consisting of one normal case, five erosive cases, and one accretive case sequentially. The dune face collapsed during the erosive case, and two sand bars

were generated underwater. After the erosive cases, the accretive case caused the onshore sandbar to move landward and decay. This study shows the relationship between nearshore hydrodynamics and morphological evolution through data obtained by the experiment. Moreover, with the sedimentation aspect, the sediment core data on the sand bar, sampled after the experiment, successfully captured the storm history.