

## Time-space Variation and Spectral Evolution of Sandy Beach Profiles under Tsunami and Regular Waves

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### ABSTRACT

Beach recovery and non-recovery processes were examined by exposing beaches to solitary waves in combination with three kinds of regular waves. Under depositional regular waves, beach recovery processes under tsunami conditions were achieved within thirty minutes. Under erosional wave conditions, however, a beach recovery process was not observed. This is partly because a solitary wave does not break in the offshore bar crest, but does so near the shoreline.

**KEY WORDS:** tsunami; solitary wave; sediment transport; recovery.

### INTRODUCTION

The Great India Tsunami caused major damage to civil infrastructure. The Japanese Society of Civil Engineers (JSCE) sent teams of engineers to the disaster areas to examine the damage (JSCE, 2005). There was some damage to beaches and coastal structures due to the tsunami; i.e. beach erosion, scour and inundation. It is reported recently through the India Ocean Tsunami survey that a couple of beaches changed by the tsunami have recovered in only one month (Dalrymple and Kriebel 2005). However, not all the damaged beaches have recovered, and the actual recovery processes of beaches have not been clear.

Sugahara et al. (2003) have studied sheets of sediment deposited on the land due to the tsunami. Kobayashi et al. (2004) have also carried out experiments on onshore-offshore sediment transport under positive and negative solitary waves, and showed the importance of the initial wave profile for the swash sediment dynamics. The knowledge of sediment transport processes under tsunami conditions is less than that under wind waves. Therefore a method to simulate the beach profile changes due to a tsunami has not yet been proposed.

To examine the time-space variation of beach profiles, wave-number spectra of bottom profiles has often been used. Hino (1968) showed the “-3 power law” of the equilibrium spectrum of sand waves for high frequencies, based on a dimensional ground. Also the power spectra of linear transect of the Earth’s topography has a power law dependence on wave number with an exponent close to -2 over a wide range of

scales (Pelletier 1999). Briggs has carried out high-resolution (<1cm) roughness height measurements at seven locations on continental shelf sediments in water depths ranging from 18 to 50m, showing that slopes of the roughness power spectra were “-1.5” to “-3.0”. Yamada et al. (2007) showed the “-2.6 power low” of wave number spectrum at Okoshiki coast, Ariake Bay. Tsujimoto et al. (2007) showed through analytical results of the spatial spectrum that a filter layer would promote invertibility. From these facts, it can be ascertained that wave-number spectra of bottom profiles has the “-3 power low” for a stable beach and the “-2 power low” for an unstable beach. It will be possible to estimate the stability or the recovery process of beach profiles with the slope of power spectra.

In this study, laboratory experiments were performed to examine the beach profiles changes and the recovery process under solitary waves as a tsunami and a regular wave (such as wind wave) and the time-space variation of onshore-offshore beach profile were examined.

### EXPERIMENTS

Experiments were conducted in an 18m long, 0.8m deep and 0.6m wide water flume at the Kobe City College of Technology. At the end of the flume, movable beds with 1 to 10 slopes were made by sand which medium grain size was 0.48mm. A piston-type wave paddle was used to generate solitary waves. Free surface elevations were measured using wave gages and bottom profiles at 2cm intervals using a laser distance device.

#### **Experimental procedure 1(only solitary waves)**

Water depths were set to be 0.2m, 0.3m, and 0.4m, respectively. Effects on beach profile changes are mutually different in positive and negative solitary waves. As the former has more effect on beach profile changes than the latter, only single positive solitary waves were generated. A tsunami often attacks coastal areas after an earthquake as reported during the India Ocean Tsunami; the initial beach slope of 1/10 was exposed to a positive solitary wave six times. Bottom profiles were measured for every single wave at 2cm intervals from the top of the run-up to the critical depth for sediment movement. The experimental conditions are shown in Table 1, where K1 stands for Kobayashi’s conditions. The Cs parameter and type in Table-1 are explained in a later section.