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Procedia IUTAM 25 (2017) 10–17

Procedia IUTAM

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IUTAM Symposium on Storm Surge Modelling and Forecasting

Wave set-up height in river entrances due to extreme waves

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Abstract

Information of maximum water level, including wave set-up height, at a river entrance is very important in terms of river mouth morphology change, navigation transportation, and saline water intrusion into a river or lagoon. The wave set-up at a river entrance is the height of Mean Water Level above Still Water Level and usually occurs during an extreme event such as storm or hurricane. In this study, full field data sets from six river mouths located in Japan are compiled and analyzed. The results show that the wave set-up height is not only depending on wave breaking at the entrance but also affected by the river discharge and river mouth morphology. The wave set-up height attains from 2 to 13 percent of offshore wave height for the cases of average water depth at entrance ranging from 1.1 m to 6.5 m. The final result is obtained as a technical diagram for predicting the wave set-up height at the river entrance.

Selection and peer-review under responsibility of IUTAM Symposium on Storm Surge Modelling and Forecasting.

Keywords: wave set-up heigh; extreme waves; wave breaking; river entrance geomorphology

1. Introduction

Prototype scale study on wave set-up due to an extreme event at river mouths is of practical importance in terms of river mouth morphology change, navigation transportation, salinity intrusion into river and water environment especially for a river which has a lagoon or lake at the entrance. Wave set-up height is mainly caused by high wave breaking at the entrance. There are several researchers who studied an empirical relationship for wave set-up at river entrance such as Hanslow et al.[1,2] and Tanaka et al.[3,4]. Among them, Hanslow et al.[1] have conducted a very detailed

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2210-9838
Selection and peer-review under responsibility of IUTAM Symposium on Storm Surge Modelling and Forecasting.
10.1016/j.piutam.2017.09.003

measurement of wave set-up at the entrance of Brunswick Heads on the north coast of New South Wales in Australia. The obtained wave set-up was less than 3 percent of deep water wave height, while the maximum of wave height is up to 3 m, and average water depth at entrance is smaller than 4 m. Tanaka et al.[3] have found that the wave set-up in Nanakita and Natsui rivers are attained in a range from 10 to 20 percent of offshore wave height, respectively. The difference between these studies indicates that the occurrence of wave set-up has distinct dependence on river entrance morphology and the magnitude of the storm.

This paper investigates the wave set-up at river entrances based on a comprehensive field data set from Japan. Data from in total six different river mouths are employed where the wave set-up is extracted from the measured water level. The studied river mouths reflect varying conditions in terms of offshore waves, river morphology, and the presence of structures. Attempts are made to estimate the influence of various factors on the wave set-up and empirically based relationships are developed from which the wave set-up can be predicted once the offshore wave conditions are known together with the depth at the river entrance. This study is helpful for river authority and river engineers to find out the best solution in controlling the river mouth morphology change and environment management as well as salinity intrusion into the river.

2. Data compilation

In order to achieve the above objectives, the required data sets are the wave height in deep water, water level at some distance upstream of river, and tidal level, as well as the river discharge during the events. The transection water at river mouth is also necessary. In this study, two groups of river mouths will be concentrated. First group of river is facing the Pacific Ocean including the Old Kitakami, Nanakita, Natsui Rivers and Nagatsura Tidal Inlet (Fig. 1, Photo 1). These Rivers were impacted by a severe low pressure system as called typhoon number 18 at the beginning of October 2006. A maximum wave height and wave period of 7.5 meters and 11.5 seconds, respectively, was recorded. The significant superelevation of water level at the rivers entrance was obtained during the typhoon. The other group of the Iwaki and Yoneshiro Rivers is facing the Sea of Japan (Fig. 1, Photo 1). This area was frequently influenced by the continuous strong wind every year in the winter time. The maximum offshore wave height is often higher than 6.5 meters.

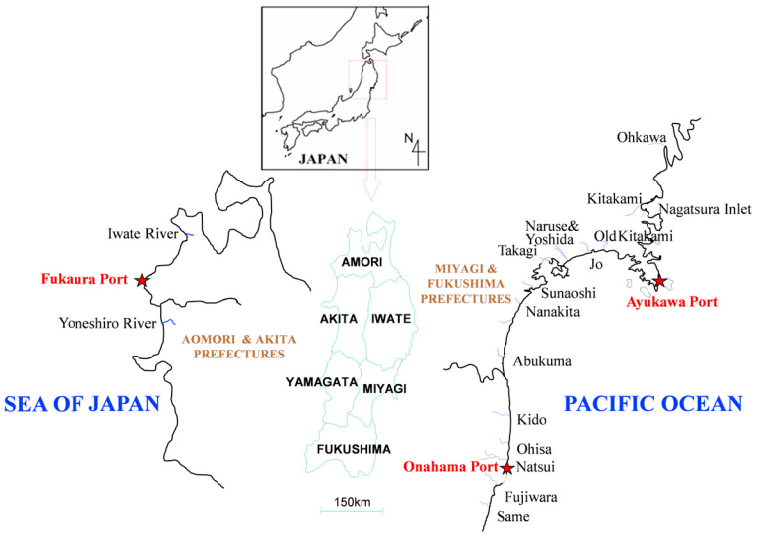

Fig. 1. Location of studied rivers facing the Pacific Ocean and Sea of Japan.