Impact Assessment on Seawall of Sediment Transport over a Dune during Huge Tsunami Attacks

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1. Introduction

During the 2011 Tohoku Earthquake and Tsunami, radioactive substances leaked from the Fukushima nuclear power plant, which caused tremendous loss of properties and serious environmental pollution. To prevent similar nuclear power plant accidents, it is necessary to consider tsunami impact under various conditions. The purpose of this study is to ascertain the influence of a dune in front of the seawall and the sediment transport on tsunami waves by conducting simulation analysis and comparing the results to hydraulic experiments, to provide data with a reference value to protect the nuclear power plant behind the seawall.

2. Overview of the analysis model

In this study, based on the 2DH-3D hybrid tsunami behavior analysis model, an analysis model which considers the suspended load and bedload of the sediment, the flow density changes, and dune deformation has been developed. The fluid analysis is based on the H-FRESH model developed by Pringle et al.[1)] The calculation of suspended load and bedload is adapted from 久保田 et al.[2)] The effect of tsunami wave force due to suspended load concentration employs the density current analysis of 永島 et al.[3)] For topographical changes, a combination of numerical schemes for debris analysis has been developed by Yoneyama et al.[4)]

3. Analysis area and conditions

Numerical analysis was performed for the previous hydraulic experiments of 奥谷 et al.[5)] The topography to be compared was the seabed terrain (gradient 1/10), the seawall (height 0.25 m), and dunes (height 0.075 m, grain size 0.1 mm and 0.2 mm) on land. Reproduction calculations were performed for multiple cases, but here, the seawall was installed 137.5 cm and 80.0 cm on the land side from the shoreline, and the input wave types are long-period wave (wave height: 10cm) and solitary wave (wave height: 12.5cm). Notably, the long-period input wave height was set to the maximum wave that did not overflow the seawall. The 1DH-2DV analysis was performed with the calculated mesh size in the longitudinal and vertical directions of the channel as 1 cm and the change in the transverse direction as 1 mesh. In the experiment, the waveform measured by WG1 (Figure-1) was input to the numerical model, and the wave force, flow velocity and water level were compared shown in Figure-3-(1-3).

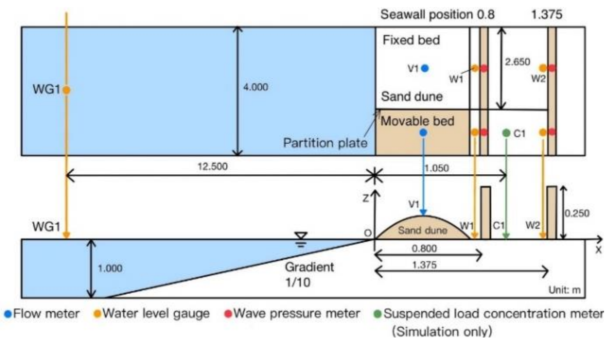
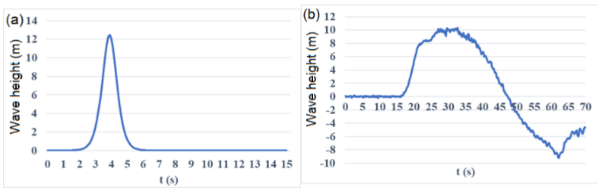


Figure-1 Experiment equipment



4. Conclusions

In this study, in order to evaluate the tsunami wave force acting on a seawall behind a dune, a numerical analysis model was developed that considering suspended load and bedload. After verifying this analysis model with hydraulic experiments, we examined how sediment transport affects the wave force of the tsunami acting on the seawall. The obtained results are as follows.

1) As a result of applying the numerical analysis model developed in this study to experiments, the wave force acting on the seawall of a long-period and solitary wave, the flow velocity at the top of the dune, and the characteristics of time-series changes in the water level immediately before the seawall can be reproduced appropriately. It is also confirmed that these values can be evaluated on the conservative side.

2) In the case of the incident long-period and solitary waves in this study, it was found that there was no significant difference between the wave force acting on the seawall, the flow velocity at the top of the sand dune, and the water level just before the seawall compared to the fixed bed, even if the grain size of the dune changes, are not affected by the fixed bed.

3) The reason why the wave force, etc. did not differ greatly from that of the fixed bed was thought to be that the deformation of the dune was small when the tsunami hit the seawall. In addition, it was confirmed by analysis that the wave force did not change greatly when the deformation of the dune was small.

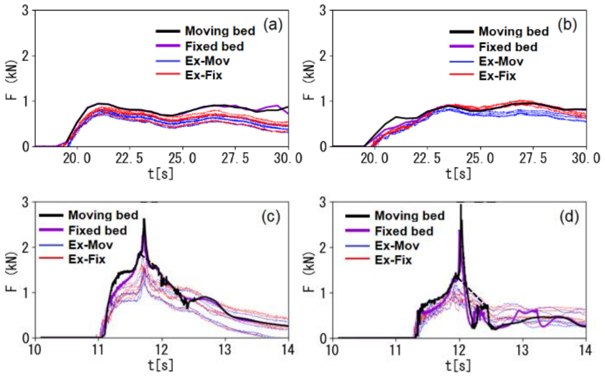
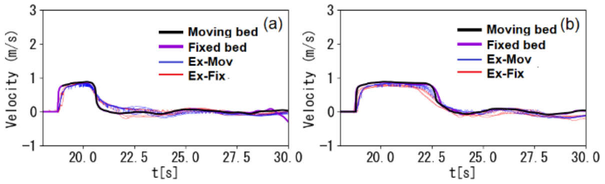


Figure-3-1 Simulated and measured wave force (kN) comparison



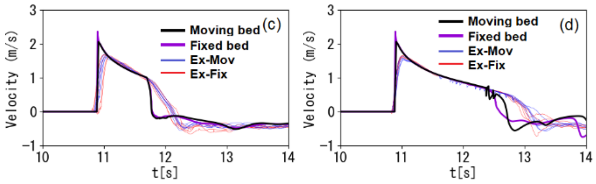


Figure-3-2 Simulated and measured flow velocity (m/s) comparison (on the dune top)

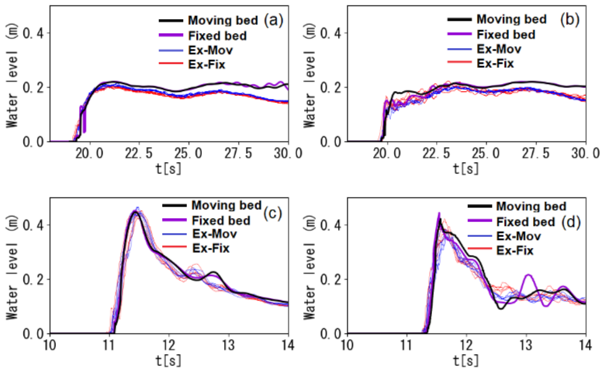


Figure-3-3 Simulated and measured water level (m) comparison (in front of seawall)

Figure-3 Simulated and measured results of long-period wave (a and b) and solitary wave (c and d) [Seawall Position: 80.0cm (a and c) and 137.5cm (b and d)]

References

1) Pringle, W. J., et al.: "Two-way coupled long wave-RANS model: Solitary wave transformation and breaking on a plane beach." Coastal Engineering 114: 99-118, 2016.

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