PHYSICAL AND NUMERICAL MODELING FOR DRIFT OBJECTS DUE TO TSUNAMI INUNDATION IN COASTAL URBAN AREA

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INTRODUCTION

In the 2011 off the Pacific coast of Tohoku Earthquake and Tsunami, many ships, containers, cars, and wooden debris of collapsed houses were drifted by a huge tsunami. Their drift objects prevented the rapid elimination of obstacles and debris on land and sea. In addition, in areas where tsunami-fire occurred, accumulated wooden debris caused the large-scale fire spread. Generally, when assuming tsunami damages in urban areas, the inundation depth and arrival time of tsunami are mostly used. In order to enhance the tsunami damage assumptions in urban areas, to understand the characteristic of tsunami flow and the behavior of drift objects in urban areas is also important. However, it is very difficult to measure the state of actual tsunami flow and the behavior of drift objects by tsunami flow. This study aims to understand the characteristics of drift objects behavior in an urban area through a series of experiments in a laboratory flume. This study also validates numerical simulation model by comparing with the experimental results.

EXPERIMENTAL SETUP

This study used the Hybrid Tsunami Open Flume in Ujigawa lab, Kyoto University (HyTOFU), which can generate arbitrary tsunami waveforms. The 3D urban city models (Kainan City, Japan) with 1:250 were used for the experiment. Experimental conditions were changed as follows: two tsunami conditions simulating Nankai Trough Earthquake (case 1: Level 2 tsunami height, case 2: $\sqrt{2}$ times larger (+0.1 Mw) than case 1); two kinds of installing wooden drift objects (installed 480 objects uniformly distributed and installed each 80 objects in 6 particular locations). Wave heights from offshore to onshore (every 1 m) were measured by 12 wave gauges. Flow velocities in offshore were measured by 2 ADVs. We used wooden model painted yellow fluorescent dye as drift objects. Video was taken by 4K camera from the top to measure the position of drift objects. These positions of each drift object were obtained by detecting the edge and the motion velocity of the objects was analyzed using PTV analysis (Figure 1).

MAJOR RESULTS

Figure 2 shows the example results of image analysis for case 1. 480 objects were gathered 6 locations (80 each) initially and drifted by the tsunami. The mean value and the coefficient of variation in all runs were estimated by using the final position of drift objects which obtained by the results of edge detection (Figure 2). The mean value is large in residential zone with high density and around large structures. On the other hand, coefficient of variation is small. This means that these areas are easy to accumulate drift objects because of the small flow velocity. It was found that the motion velocity of the individual drift object could be tracked, although further investigation is needed. The hydraulic experiments confirmed that drifting objects movement in the urban area was strongly affected by the macro and micro structure in urban area. The experimental results suggest the accumulation of drifting objects is related to the size and the density of structures. In the conference, we will present the results of investigating that the relationship between the building density and the density of drifting objects, and the reproducibility of the position of drifting objects by numerical simulation.

REFERENCES

Prasetyo at el. (2019) Physical modeling and numerical analysis of tsunami inundation in a coastal city, Frontiers in Built Environment, 5:46.

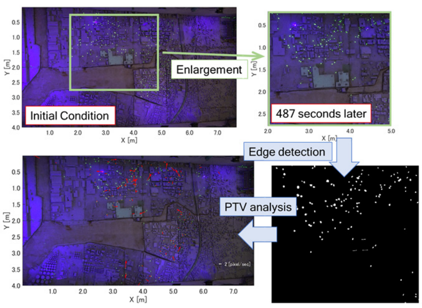

Figure 1. Outline of experimental setup and imaging for edge detection and PTV analysis

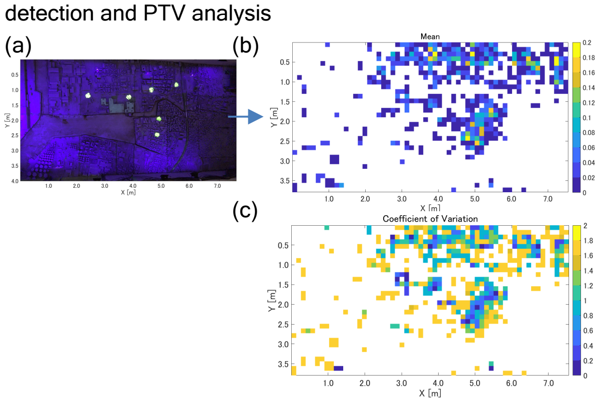

Figure 2. Density of drifted objects by image analysis: Case 1 (unit: no dimension) (a): Experiment setup, (b):Mean value, (c): Coefficient of variation