PHYSICAL AND NUMERICAL MODELING OF TSUNAMI INUNDATION IN COASTAL URBAN AREA

Nobuki Fukui, Graduate School of Engineering, Kyoto University, fukui.nobuki.22s@st.kyoto-u.ac.jp
Nobuhito Mori, Che-Wei Chang, DPRI, Kyoto University, mori@oceanwave.jp, chang.chewei.5z@kyoto-u.ac.jp
Tomohiro Yasuda, Takashi Yamamoto, Kansai University, tomo@oceanwave.jp, k198781@kansai-u.ac.jp
Andrew Kennedy, Zhongduo Zhang, Andrew Copp, University of Notre Dame, andrew.kennedy@nd.edu, zzhang24@nd.edu, acopp@nd.edu
Yu Chida, Port and Airport Research Institute, chida-y@p.mpat.go.jp

INTRODUCTION

The 2011 off the Pacific coast of Tohoku Earthquake Tsunami caused the catastrophic disaster to coastal areas. This coastal hazards emphasize the need for engineers to understand the fundamental processes causing damage and the potential of maximum damage in order to design coastal communities with increased resilience to tsunami events. Common methods used to evaluate local conditions caused by tsunamis include post-disaster reconnaissance field surveys, numerical modelling, and laboratory experiments.

Behavior of land side tsunami inundation is not well known as well as the fluid forcing, fragility characteristics and accuracy of tsunami hazard mapping. This study targets to understand local tsunami behavior in a city scale including complex buildings and improve modelling of tsunami inundation in an urban area. Laboratory experiments are an essential starting point in the investigation of urban roughness effects on wave propagation and maximum pressures on buildings in coastal communities. Physical modelling usually uses solitary wave, bore wave, but this study also uses wave imitating Nankai Trough Earthquake as a tsunami wave.

EXPERIMENTAL SETUP

This study uses the Hybrid Tsunami Open Flume in Ujigawa lab, Kyoto University (HyTOFU), which can generate arbitrary tsunami waveforms or irregular storm waves. Experiments are conducted at HyTOFU with combination use of flow-pump and mechanical piston wave maker. The 3D urban coastal city models, Kainan city, with 1:250 scale are used for the experiment. Experimental conditions are changed as follows: two solitary waves (H=5 cm and 6 cm); three constant flows (q=0.015, 0.025, 0.085 m^3/s); two tsunamis imitating Nankai Trough Earthquake (H=estimated tsunami height and $\sqrt{2}$ x estimated tsunami height). Wave heights from offshore to onshore every 1 m are measured by 12 wave gauges. Flow velocities offshore are measured by 2 ADVs. Overhead 4K video is taken to measure inundation area and flow velocities simultaneously. Inundation area is analyzed by detecting edge water dyed in red fluorescent color (Fig 1 left). Fluid velocity is analyzed by the movement of yellow fluorescent colored particles using PIV (Fig 1 right and Fig 2) in urban area (especially between buildings). The estimated flow velocities by PIV is compared with the velocities by ADVs. The physical model is 3D scanned and DEM data is arranged for numerical simulations.

MAJOR RESULTS

Large differences of inundation process between each incident wave appear due to the difference of transported mass flux. Constant flows inundate from the middle of urban area overflown from water channel. On the other hand, solitary waves start to run-up the area with low elevation near the port and inundate the urban area. Locally increase of the flow velocities is observed at the edge of inundation. Also, the local direction changes of flow due to the structures are observed (Fig 2). It indicates that local flow around structures needs to be investigated rather than using roughness coefficients. Further results of experiment and numerical simulation by NSWE model will be introduced at the conference.

REFERENCES

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

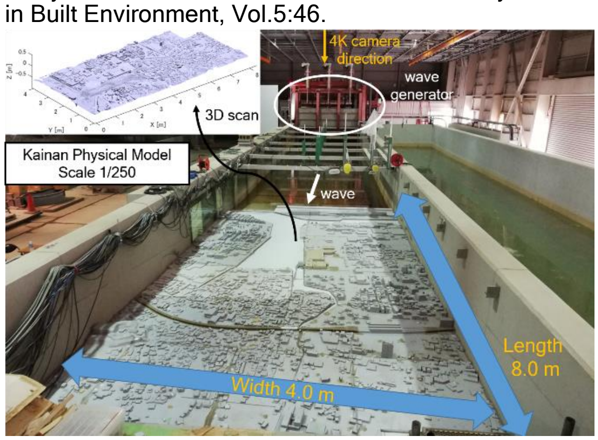

Figure 1. Overview of the experimental instruments

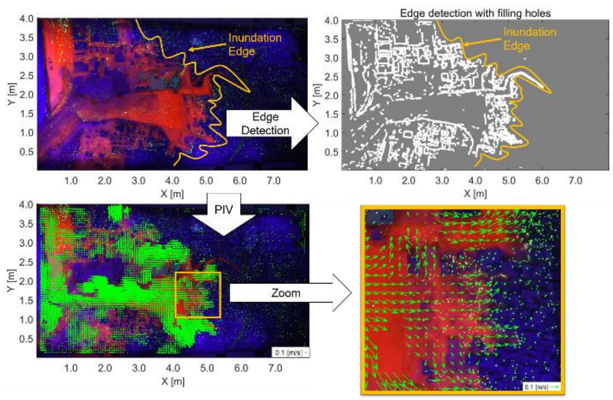

Figure 2. Outline of video image analyses (edge detection and PIV).