Applying tsunami numerical simulation for building damage assessment using load-resistance analysis and sediment transport modeling

A. Suppasri[1] , K. Pakoksung[2], R. Masaya[3], K. Yamashita[4], F. Imamura[5]

We wish that both building damage assessment and sediment transport modeling topics can be applied to the US west coast. Please find below for examples of our research activities in both topics.

1. Building damage assessment

Macro scale assessment of building damage by tsunami can be performed using two classical methods namely, fragility functions and weight factors based on their vulnerability. However, these methods do not consider the actual performance nor strength of the buildings and damage might occur before either of flow depth and flow velocity reach maximum values. This study aims to investigate if instead analytical force estimation of tsunami forces and building strength is able to predict building damage. About 20,000 damaged wooden buildings data in Ishinomaki City from the 2011 Great East Japan tsunami were used for this analytical experiment. The impact of floating debris was also added based on weight. Building strength from bearing wall is estimated from building design standard which is mainly based on floor area and building height. Resistance reduction coefficient was also added for aged buildings. Two damage (collapse) patterns (washed away and destroyed) were analytically assessed using sliding and overturning mechanisms. As results, it was found the proposed method could reproduce the actual dam-age condition with very high accuracy for both collapse patterns. Almost destroyed and washed away buildings occurred when the flow velocity is higher than 2 m/s regardless of flow depth. Besides, it was found using the maximum flow depth and flow velocity could underestimate the damage by up to 2-4 times. This new method will be useful for building damage assessment in areas that have no actual tsunami damage experience.

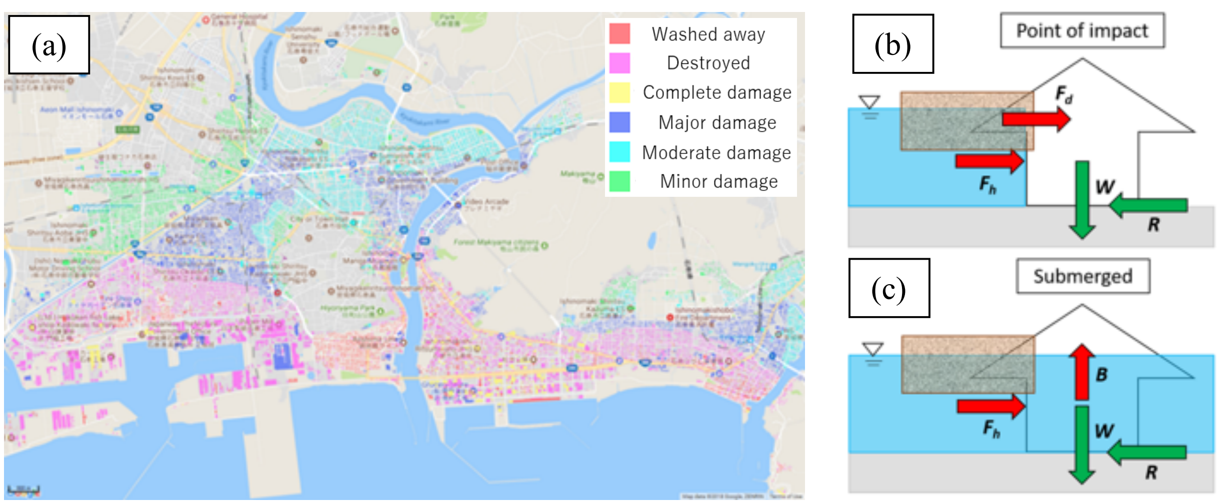

Fig. 1 (a) Distribution of building damage data from higher damage (pink) to lower damage (green): Destroyed and washed away was considered as collapsed (Non-repairable), (b) Building collapse condition: At the moment of impact, (c) Building collapse condition: When being submerged

[1] Assoc. Prof., International Research Institute of Disaster Science, Tohoku University, Japan (suppasri@irides.tohoku.ac.jp)
[2] Researcher, International Research Institute of Disaster Science, Tohoku University, Japan (pakoksung@irides.tohoku.ac.jp)
[3] Bachelor student, School of Engineering, Tohoku University, Japan (ryota.masaya.r6@dc.tohoku.ac.jp)
[4] Assoc. Prof., International Research Institute of Disaster Science, Tohoku University, Japan (kyamashita@irides.tohoku.ac.jp)
[5] Prof., International Research Institute of Disaster Science, Tohoku University, Japan (imamura@irides.tohoku.ac.jp)

2. Sediment transport modeling

Prathong Island is the location where geologists paid attention in surveying tsunami deposits after the 2004 Indian Ocean tsunami because of its good natural condition. In addition, not only the 2004 tsunami deposits but also deposits of earlier tsunamis was also found and the shoreline was recovered to its original position very soon. However, there is still no such numerical simulation approach applied to this study area to understand the sedimentation and recovery process during and after the 2004 tsunami. Therefore, numerical simulation of tsunami and sediment transport was applied to reproduced the 2004 tsunami. The simulation results provided good reproduction as the eroded areas and thickness of deposits against distance from coastline could be confirmed. It is found that the eroded sand occurred at shallow region where less amount of sediments was transported inland during the incoming wave. During the drawback, large erosion occurred near the coastline and deposited again in shallow area. Deposited sediments in shallow is probably the reason of the fast recovery rate of the coastline.

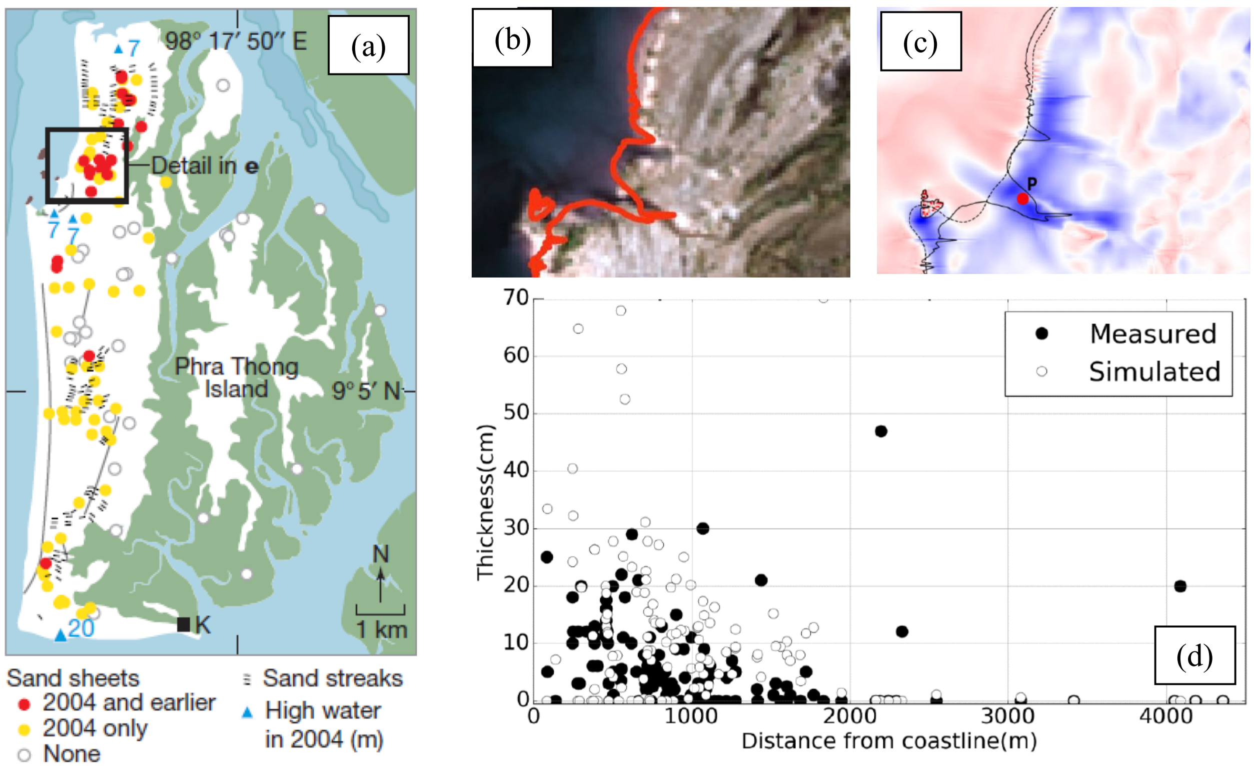

Fig. 2 (a) Distributions of tsunami deposits (Jankaew et al., 2008), (b) Shoreline after the 2004 tsunami and simulation result (red line), (c) Simulated eroded and deposited areas and shoreline before and after the 2004 tsunami, (d) Comparison between measured and simulated thickness of deposits against distance from coastline

References

1) Suppasri, A., K. Pakoksung, I. Charvet, N. Takahashi, T. Ornthammarath, and F. Imamura, New building damage assessment method based on numerical tsunami simulation and analytical force estimation: Case study of the 2011 Tohoku tsunami, JSCE proceedings (Coastal Engineering), 74 (2), I_451-I_456, 2018, https://doi.org/10.2208/kaigan.74.I_451
2) Masaya, R., Sediment transport process in Prahong Island, Thailand based on numerical simulation of the 2004 Indian Ocean tsunami, Graduation Thesis, School of Engineering, Department of Civil and Environmental Engineering, Tohoku University, 2019.