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主 論 文 の 要 旨

論文題目 Tsunami Impact on a Coastal Building and Effect of Spatial Configuration of the Building on Acting Tsunami Force（沿岸域の建物に作用する津波力と空間形状が及ぼす影響に関する研究）

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論 文 内 容 の 要 旨

Recent tsunami events of December 2004 Indian Ocean tsunami and March 2011 Tohoku earthquake tsunami have highlighted the magnitude of the destruction associated with the great waves. Vast damage to the coastal buildings in those events has raised the question of capability of coastline buildings to withstand against tsunami wave force. In most of the cases it was evident that the wreckage of the destroyed buildings has increased the damage to the surrounding buildings. On the other hand, well-constructed coastline buildings have the added advantage of using as a tsunami evacuation structures and as well as a frontline barrier for tsunami.

This study mainly focuses on simulating the interaction between tsunami and the coastline buildings. Even though numbers of past studies have been carried out on this area, there are still doubts on the understanding the tsunami interaction with structures because of its dynamic and complex behavior, and in design the infrastructure accordingly. Understanding the response of a coastline building and the variation in acting tsunami force with regards to the structural arrangement and configuration of the building, under tsunami event will provide a clear guidance to effective design, especially in the construction of structures like tsunami evacuation buildings. At the same time, the reliability of existing tsunami force estimation formula in estimating the tsunami force on three-dimensional building is discussed and suggested modifications are presented.

LS-DYNA, three dimensional nonlinear finite element modeling code is used and Arbitrary Lagrangian and Eulerian (ALE) algorithms are applied in the tsunami-structure modeling. Fluid-structure interaction is discussed. The failure mechanism of basic structural components of a reinforced concrete building is analyzed in order to develop a process to understand the tsunami interaction with comprehensive building in the future.

In the Chapter 1 of the dissertation, the study background and the motivation for the selected theme is discussed together with the study objectives.

Chapter 2 discusses the background of the numerical study. Three-dimensional numerical model developed by Lee et al. (2010) was used for the numerical analysis to estimate the behavior of acting tsunami force on three-dimensional rigid structure, which is discussed in detail under Chapter 4. Three-dimensional nonlinear finite element model LS-DYNA is used in the failure analysis of reinforced concrete structure under tsunami loading. The tsunami-structure interaction model is coupled with the three-dimensional numerical model developed by Nakamura & Yim (2011) in order to reduce the extensive computational cost of LS-DYNA simulation.

In Chapter 3, the 1:50 scaled laboratory experiments conducted in order to assess the tsunami interaction with multi-story building, is discussed. The effect variation of tsunami inflow condition and the configurations of the building, in the estimation of acting tsunami forced are assessed and presented in the chapter.

Chapter 4 discusses the numerical study conducted in the aim of evaluating the acting tsunami force on three-dimensional structure. The commonly used tsunami force estimation equation (Eq. 1.1) by Asakura et al. (2000), which is based on the two-dimensional laboratory experiments, is modified for a three-dimensional structure, considering the blockage ratio. Three-dimensional numerical model developed by Lee et al. (2010) is used for the numerical analysis and results are presented.

In Chapter 5, the failure of reinforced concrete structure under tsunami loading is discussed. Three-dimensional nonlinear finite element model LS-DYNA is used in the tsunami-structure interaction analysis and Arbitrary Lagrange Eulerian (ALE) method is used in solving the fluid-structure interaction (FSI). The three-dimensional numerical model developed by Nakamura & Yim (2011) is coupled with the FSI model in order to reduce the computational cost and the reproducibility of the combined model is verified comparing with the full-scale laboratory experiments conducted by Arikawa (2009). The developed model is applied to study the tsunami force acting on the lateral walls of enclosed structure and results are discussed.

Finally, in Chapter 6 the conclusions and discussion with the recommendations for the future research are presented.