DEVELOPMENT OF MULTISCALE MULTIPHYSICS INTEGRATED SIMULATOR FOR TSUNAMI RUNUP CALCULATION COUPLED WITH STRUCTURE ANALYSIS

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INTRODUCTION

The 2011 Great East Japan Earthquake (GEJE) has shown that Tsunami disasters not only cause flooding damage but also can be a phenomenon accompanied by many damage of structures. In order to evaluate the damage of the building due to the tsunami, a three-dimensional numerical tank with structure analysis is required, but the calculation cost is very high to calculate from the tsunami source of the tsunami to the inundation zone. Therefore, the purpose of this research is to develop a system that can calculate the destruction of buildings from a wave source of the tsunami in a series and confirm its validity. Specifically, the stability of Tsunami breakwaters in Kamaishi Bay and the seawalls in Otsuchi Bay was investigated.

NUMERICAL SIMULATORS

For development of the coupling system, CADMAS-STR, the coupling simulators with structure analysis (Arikawa et al., 2009), is coupled with STOC-CADMAS system (Arikawa and Tomita, 2016), whose system consists of 3 different simulators, ML, IC and CS3D. The ML simulator approximates pressure by hydrostatic pressure and calculates the wave profiles based on an equation of continuity, primarily calculating from the source to the shallow region. The IC solves pressure based on a Poisson equation, but reduces computation cost slightly to calculate the area near a port by setting the water surface based on an equation of continuity. The CS3D also solves a Navier-Stokes equation and sets the water surface by VOF to deal with the inundation area, with its complex surfaces of overflows and bores. The STR solves the structure analysis including the geo analysis based on the Biot's formula. Overview of this system is shown in Figure-1.

VERIFICATION OF THE SIMULATOR

The numerical results compared with the physical experiments done by Arikawa et. al.,2012. It was good agreement with the experimental ones. Also, to investigate the falling and sliding of the parapet type seawalls, the numerical simulations were compared with experimental results and examined the stability of the parapet type seawalls. Finally, the system applied to the local situation at Kamaishi bay(Figure-2). About half of the breakwaters were washed away, whose situation was similar to the damage at Kamaishi bay after 2011(Figure-3). Also in Otsuchi Bay, the similar result was obtained.

CONCLUSION

Multiscale Multiphysics Integrated Simulator was developed to calculate tsunami phenomena from the wave source of the tsunami to the destruction of the structure. Results showed good agreement with both experimental and on-site results, and the validity of this method was confirmed.

ACKNOWLEDGMENTS

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REFERENCES

T. Arikawa and T. Tomita (2016): "Development of High Precision Tsunami Runup Calculation Method Based on a Hierarchical Simulation", Journal of Disaster ResearchVol.11 No.4
T. Arikawa, K. Hamaguchi, K. Kitagawa, T. Suzuki (2009): "Development of Numerical Wave Tank Coupled with Structure Analysis Based on FEM", Journal of J.S.C.E., Ser. B2 (Coastal Engineering) Vol. 65, No. 1
T. Arikawa et. al.(2012) "Failure Mechanism of Kamaishi Breakwaters due to the Great East Japan Earthquake Tsunami", 33rd International Conference on Coastal Engineering, No.1191

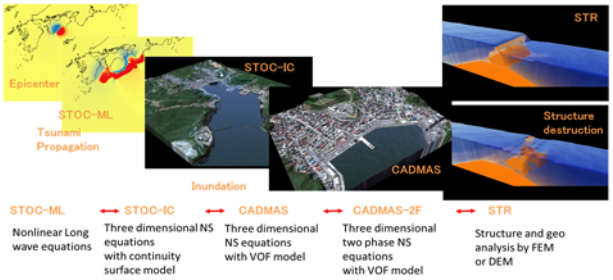

Figure-1 Overview of calculation system of Multiscale Multiphysics Integrated Simulator, STOC-CADMAS-STR

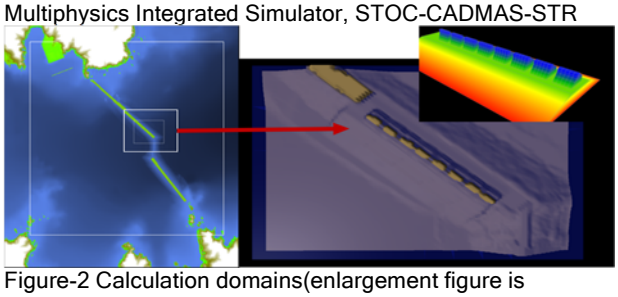

Figure-2 Calculation domains(enlargement figure is structural analysis domain)

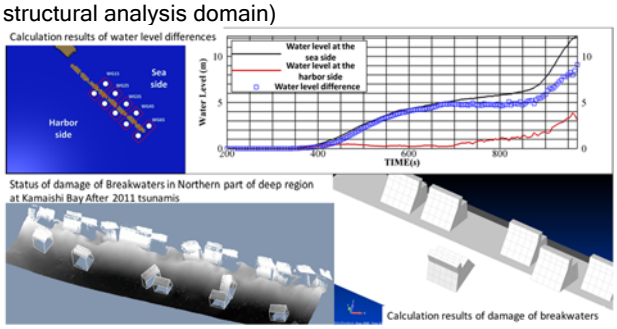

Figure-3 Calculation results of damage of breakwaters at Kamaishi Bay