論文の内容の要旨

Development of Seismic Analysis Method for Large Structures Based on Fault-Structure System

（断層ー構造物系に基づく大型構造物の耐震解析手法の開発）

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This thesis aims to develop a seismic analysis method for large structures based on the fault-structure system. The main parts of this thesis are the following: (1) the development of a combined multiscale analysis and parallel computing for seismic analysis of large structures based on fault-structure system; and (2) a preliminary study for developing an inverse modeling method with high accuracy for estimation of underground structure. The main focus is to efficiently handle the computation cost of performing fault-structure system analysis using high-fidelity numerical model.

The fault-structure system is a system that includes a fault, the crust structure, local soil condition, and a target structure. The analysis of the fault-structure system includes different processes, such as the fault-rupture, wave propagation in the crust, wave amplification in the soft soil, and the dynamic response of the target structure. Solving all these processes in a single analysis is a computational problem because the resulting computation cost is still expensive for current available computers. Thus, efficient handling of the computation cost is crucial in order to develop a seismic analysis method based on a fault-structure system.

In Chapter 2, the main objective is to improve the macro-micro analysis (MMA) by combining this multiscale method with parallel computing. The MMA method by Ichimura and Hori (EESD,2006) is a two-step procedure that leads to a computationally-efficient scheme for solving the fault-structure system. However, in application to problem requiring high fidelity numerical models, large computation costs still exist. Thus, improvements to the macro analysis code of MMA were implemented. We proposed a prepartitioning approach to generate meshed model in parallel. Then, we extended the analysis to parallel computing on a distributed-memory computer. Numerical experiments were conducted to (1) verify the accuracy of the MMA based on the parallel code, (2) validate the applicability for wave propagation simulation, and (3) test the applicability of the fault-structure system for seismic analysis of NPP building structure. Satisfactory results were obtained in application to actual problem settings.

Chapter 3 is concerned with a preliminary study for developing an inversion method with high accuracy for estimation of underground structure. To investigate the advantage of using high resolution three-dimensional models, the surface topographic effect is considered. The topographic effect is investigated on a conventional inverse modeling method that is used to estimate the crust layer interface shape. A forward-inverse modeling method is developed, that uses high resolution three-dimensional model to obtain the sensitivity functions. To study the surface topography effect, a comparison of analysis results of models with and without topography is conducted. Results confirm the advantage of the extended method in modeling the surface topographic effects.

The seismic analysis method developed in this study utilizes computational techniques to generate high-fidelity numerical models for use in estimation of structure response based on fault-structure system. This method is demonstrated in both forward and inverse modeling (verification, validation, and application examples on simple and actual problem settings). This study is considered a preliminary step for realizing the practical application of fault-structure system analysis to not only large structures, but to a general class of structures as well.