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SEISMIC ANALYSIS OF FAULT-URBAN AREA SYSTEM USING K COMPUTER

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In urban environments situated in seismically-active regions, scenario information on nearby faults are becoming widely available. For the purpose of estimating building response and possible damages, numerical methods are increasingly being employed. In this study, we aim to develop a computationally-efficient combined analysis of processes related to fault rupture, wave propagation, amplification and building response, by utilizing available scenario information. The Finite Element Method (FEM) which can tailor the element resolution to local wavelengths at the same time model irregular topography is used to generate the synthetic input ground motion to the building structure models.

In the wave propagation analysis, implementation of high performance computing is necessary to handle the expected huge computation cost. In our code, computational workload in model generation is delegated to available computer nodes by a parallel subdomain meshing approach. Here, using regular background grid and octree boundaries [1], the code selects candidate active faces (an active face is a shared boundary of two adjacent subdomains) for domain decomposition [2]. In transient analysis, implicit time integration and hybrid MPI-OpenMP parallelization are implemented. Each subdomain delegated to a single node is assigned one MPI process, and the task of computations within a subdomain is shared by spawned OpenMP threads. Figure 1 shows a result of performance test conducted on K computer for element-wise matrix-vector product operation. As shown, good performance was achieved for both tetrahedral and hexahedral elements. The problem IDs, P1, P2, P3, P4 and P5 correspond to 80-million (M), 440-M, 4.7-billion (B),

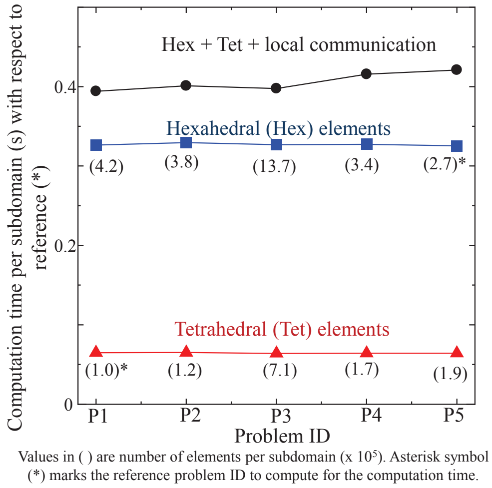

Figure 1: Performance test results

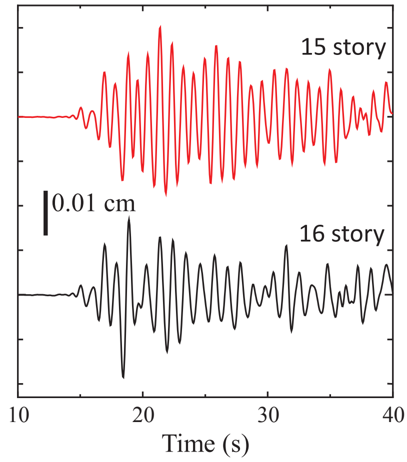

Figure 2: Response at top of two building models (transverse component)

4.8-B and 8.0-B degree-of-freedom models, respectively.

For the combined analysis, we simulated a scenario of a M_w 6.8 earthquake with an epicenter 46 km from Niigata City in Japan. The result of wave propagation analysis was then used as a three-dimensional boundary condition to an FEM model of a target region (including local soil) with dimensions, 900 $\times$ 900 $\times$ 42 m. The region includes 191 buildings with floor levels ranging from 8 to a maximum of 31. The results of this analysis were then used as input boundary condition to the Structure Response Analysis (SRA) module of the Integrated Earthquake Simulator (IES). Using IES-SRA, all the included buildings were simultaneously analyzed. Figure 2 shows a comparison of a displacement component at the top of 15- and 16-story building models that are 115 m apart. This result demonstrates that nearly identical buildings may respond differently to a nearby earthquake. While such computations are still expensive for engineering practice (the combined memory usage for this simulation is about 4.0 TB in K computer), results suggest that scenario simulation by FEM is an advantage for quantitative damage prediction.
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