Development of Efficient Computation Method for Strong Ground Motion using Macro-Micro Analysis Method, the Voxel FEM and GIS

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Strong ground motion information with high resolution and high accuracy could have significant role for making counter measures against earthquake disaster. Recent development of seismology reveals that strong ground motion is strongly affected by fault mechanism, wave propagation in deep crust, and wave amplification near surface. Though full 3-D numerical simulation can provide strong ground motion information with such setting, there could be two major difficulties: 1) huge amount of computation; 2) uncertainty of soil-crust information.

For resolving these difficulties, new analysis method, macro-micro analysis method (MMAM), is proposed. This analysis method takes advantage of the multi-scale analysis and the bounding media theory. The multi-scale analysis can reduce computation amount required at one time, and the bounding media theory can resolve the uncertainty of soil-crust structure information. For more reduction of computation amount, the finite element method with voxel element (VFEM) is applied for wave propagation simulation. The borehole data is used for modeling soil-crust structure. Geographical Information System with soil-crust structure auto-modeling tool is developed to handle a huge amount of borehole data efficiently.

In order to verify the basic validity and effectiveness of this method, reproduction of earthquake observed in Yokohama City is attempted. The results of this numerical simulation indicate the strong ground motion is clearly affected by 3-D soil-crust structure. In addition, wave amplification near surface computed by the conventional method (based on 1-D wave theory) is compared with this result. This comparison shows that the result of conventional method might have large difference from this result near the complicated 3-D soil structure, and such full 3-D numerical simulation is needed for reproduction of strong ground motion with high resolution and high accuracy.