Numerical Simulation of Underground RC Structures During Earthquakes

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1．Introduction

Many underground structures during the Hyogoken-Nanbu earthquake were destroyed. In order to insure the safety of underground structures and develop a rational seismic design guideline, seismic performance of underground RC structures of nuclear power plant subjected to strong motions requires further attention. Analytical method based on the effective stress analysis, FLIP is widely used to study seismic response of structures and to verify results from centrifuge modeling.

2. Centrifuge test and numerical modeling

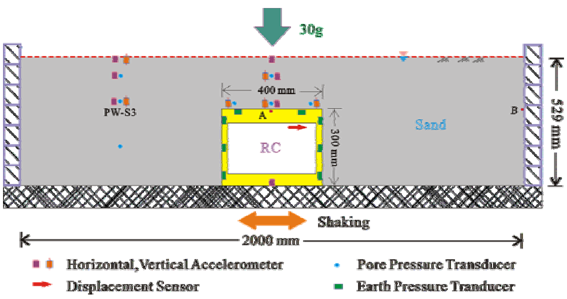

Fig. 1 Centrifuge test model

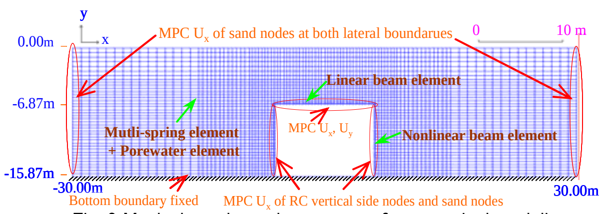

Fig. 2 Mesh, boundary, element type for numerical modeling

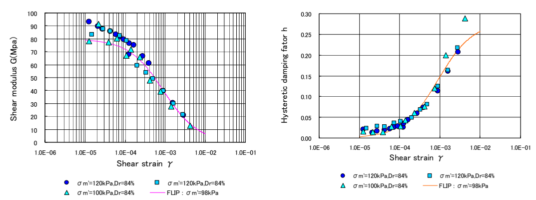

Fig. 3 Sand deformation parameters from test and used in FLIP

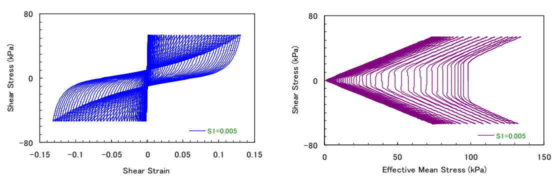

Fig. 4 Cyclic curves of undrained simulation using Flipsim

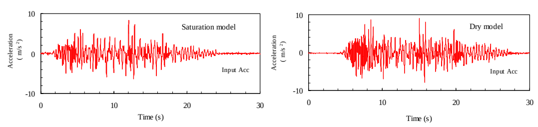

Fig. 5 Input-waves of numerical simulation

3. Results and comparisons

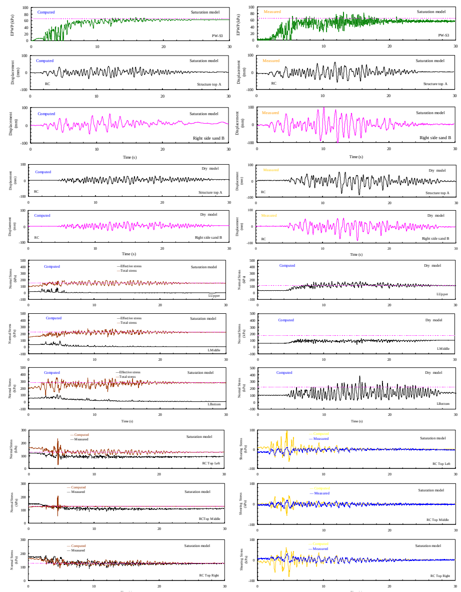

Fig. 6 Seismic responses of saturation model and dry model

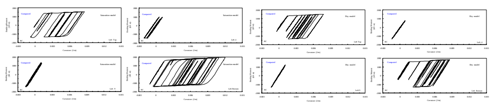

Fig. 7 Bending moment-curvature relationship

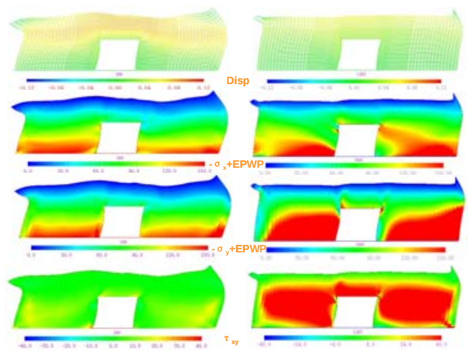

Fig. 8 Normal stress, shear stress with Max x-displacement of RC structure

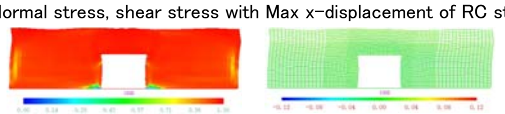

Fig. 9 EPWP ratio, deformation of saturation model after shaking

4. Conclusions

Results of numerical simulation are consistent with the one obtained from centrifuge tests. Displacements and plastic yielding area of RC structures and earth pressures of saturation model are larger than those of dry model. Compared with results of dry model, values of normal stress acting on the upper side of the RC structure in saturation model is smaller. This may be due to the arching effects induced by shaking.