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SOIL-FOUNDATION-STRUCTURE INTERACTION BY AN EXPLICIT TIME INTEGRATION METHOD

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Since the mid 1990s, numerical analysis has been widely used in civil and infra structure design, particularly earthquake resistance design and research. However, in contrast to static analysis, dynamic analysis is less reliable because of a lack of reference data. For these reasons, verification of the dynamic numerical analysis has been performed based on either earthquake measurement data or dynamic centrifuge test results in geotechnical engineering fields. Several research groups have used shaking table or geotechnical dynamic centrifuge test results for the verification of dynamic numerical analysis[1][2][3][4]. However, need is to verify if the motion recorded at the base of the soil model container in the centrifuge facility is the true base rock input motion or not.

In this study, the soil-foundation-structure interaction response of a single-degree-of-freedom (SDOF) system supported by a shallow foundation was analyzed by dynamic geotechnical centrifuge test and using three-dimensional finite difference analysis results. The appropriate input motion measurement method for the verification of seismic response analysis is examined also. Dry silica sand was used to prepare the test soil layers. Seven types of SDOF structures, which contained different natural periods and centers of gravity, were used in the centrifuge test. The responses of the soil deposit and the structure were measured in terms of acceleration at the free field and structures. (Fig. 1)

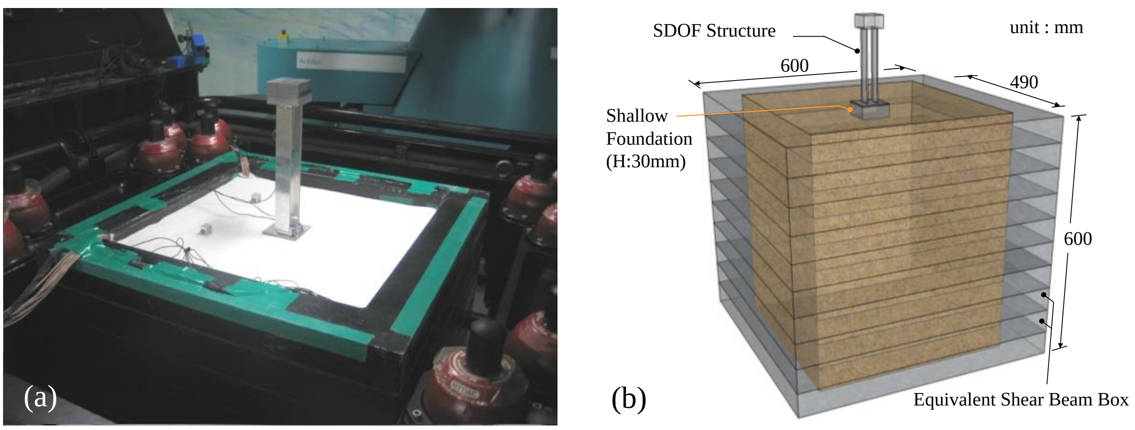

Fig. 1 Construction of the test specimen.

An equivalent shear beam (ESB) model container was used to minimize the reflection of horizontally propagating waves at the horizontal boundary.

The numerical analysis was conducted by using finite difference code FLAC 3D with the same prototype dimensions of centrifuge test. The program conducts dynamic analyses of time domain using an explicit method. The nonlinearity of the soil was analyzed using a hyperbolic model. Rayleigh damping was used to eliminate high frequency noise and represent the minimum damping of the soil. The SDOF structures were modeled with quadratic solid and shell elements. The hollow shallow foundation was modeled with a liner element of the discrete Kirchhoff triangle-constant strain triangle shell and coulomb-slider interface. The combined local damping was used in the structural damping to prevent drastic increments in analysis time when stiffness-proportional Rayleigh damping was employed. The numerical analysis results concur with the dynamic centrifuge test measurements. (Fig. 2)

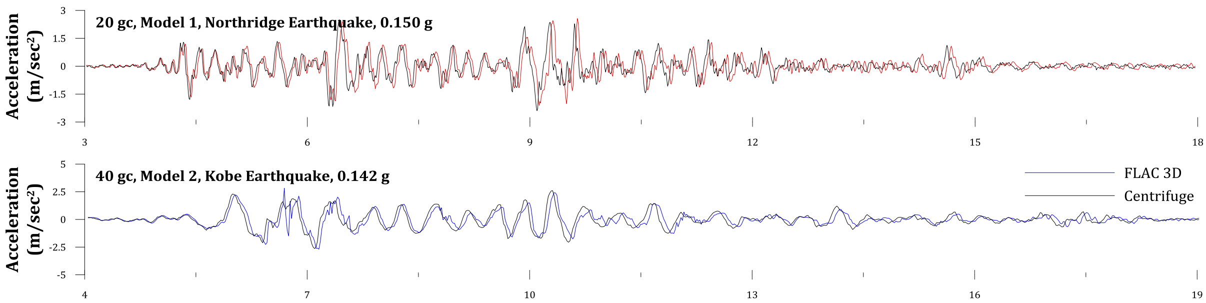

Fig. 2 Comparison of dynamic responses (Horizontal acc. at the top of SDOF str.)

Both rigid and compliant base conditions were adopted for the numerical analysis to identify the excitation boundary condition of the centrifuge test. From the results, it appears that the base rock outcrop motion generated by using deconvolution method is free from the distortion of downward the propagating wave through ESB.

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