Equivalent-Linear Site Response Analysis in the Kanto Plain

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The Kanto plain, the largest and most populated plain in Japan, is covered with thick marine sediments that can cause large amplifications of seismic waves during a big earthquake. The sediments thickness over the engineering base reaches to several hundred meters under the central part of Tokyo Metropolitan area. In this study, we evaluated the nonlinear site responses of layers between engineering base and free surface in the Kanto plain. We adopted an equivalent linear approach using DYNEQ program developed by Yoshida and Suetomi (1996) for the site response analyses. We use stochastic Green's function method to generate synthetic waveforms from 16 hypothetical earthquake source models located in the crust, and on the interface or within the of subducting Philippine Sea Plate. The simulations were done between the seismic sources and the engineering base where shear-wave velocity is equal to 500 m/s. Synthetic waveforms on the engineering base were used as input motion in DYNEQ program. Shear modulus versus strain (G/G_0-γ) and damping versus strain (h-γ) relationships of Central Disaster Management Council of Japan (CAO) are recognized to express the dynamic shear deformation of soil (clay, sand, and gravel). Shallow shear-wave velocity structural models above the engineering base were also provided by CAO. Resultant waveforms on the free surface show a systematic dependence on the thickness of soft structures above the engineering base. Large amplifications are dominant at short periods above shallow soft sediments, whereas peak amplitudes shifted to longer periods for sites located above deep soft sediments. Nonlinear site effects, inferred by de-amplification of the site responses, were typically obvious at short periods of approximately 0.2 s and shorter. Predominant periods of the soil was calculated based on empirical relations and compared to those obtained from the spectral ratio. Both predominate periods show disagreement at sites where nonlinear site responses are expected. The large deformations are mostly concentrated in shallow 30 m of soil inferred from shear strain analysis. Our analyses showed considerable effects of nonlinear response of surface layers to large seismic inputs on the engineering base. Our results reconfirm the importance of nonlinear soil effect consideration in risk assessment of structures.

Keywords: Equivalent linear approach, Site effects, Tokyo Meteropolitan Area

