Effects of groundwater level on amplification of ground motion and liquefaction potential in urban area

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As a measure for prevention of ground subsidence, pumping-up of groundwater has been regulating at many cities on the alluvial plains in Japan. As excess pore-water pressure allows subsoil materials to reduce their strength and stiffness, such many cities under condition of shallow groundwater level are susceptible to suffer severe damages accompanying with the ground motion amplification and liquefaction.

In this study, we evaluated the effects of groundwater level on ground motion amplification and liquefaction potential of subsoils during strong ground motion in Osaka plain, southwest Japan. The scenario strong ground motion generated by the Next Tokai-Nankai Earthquake at Nankai-Trough, estimated by Central Disaster Prevention Council, was used as input motion. We adopted the underground models including the effect of groundwater-drop that results in stiffness increase caused by pore pressure decrease and the negative pore pressure generated by suction in unsaturated subsoil above the groundwater level.

As a result, the decreases of maximum acceleration and acceleration spectral intensity (0.1 to 10Hz) due to the groundwater-drop (0 to 5m) average to 5%. These reductions are nearly proportional to groundwater-drop.

The PL-value, which was defined by Iwasaki et al. (1980) indicating the liquefaction potential, decrease with groundwater-drop of 5m over the whole area. Accordingly, non-liquefying area, where PL-value is less than 10, increased from 33% to 73%. The non-liquefying area is also nearly proportional to the groundwater-drop in this analysis.

Thus, the amplifications of ground motions are, in general, suppressed by the groundwater-drop. The groundwater-drop also shifts the resonant frequency of the sublayer to higher. Therefore, in rare cases, the ground motion may be amplified if dominant frequency of the input motion are same or near to the resonant frequency of sublayer, resulted from the groundwater-drop. In the case, the groundwater level needs to be controlled appropriately, based on the frequency characteristics of input motion and the sublayer own near the surface.