GROUND RESPONSE SPECTRA INDUCED BY A LIQUEFIABLE SOIL LAYER AS NATURAL SEISMIC ISOLATION

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Pore pressure build-up and occurrence of liquefaction phenomena during earthquakes can create two effects including amplification of incoming waves and thus soil subsidence (damage to structures) or attenuation of the seismic motion. It is well known that considering the presence of liquefiable soil layer and pore water pressure induced by it could change the stiffness of the layer and the frequency content of seismic motion (Bouckovalas & Tsiapas, 2015). Moreover, the shear waves of earthquakes are propagated into liquefied layer difficulty (Yang et al., 2001). It means that despite vertical component of seismic motion, the horizontal component is found to be amplified or de-amplified significantly at the surface, considering intensity and duration of shaking (Hakuni, 2004). In this regard, this paper deals with the effect of liquefiable soil layer on the seismic response spectra as natural seismic isolation with respect to its location and thickness in soil strata. Indeed, the liquefiable soil layer is taking into account as an isolator layer in order to dissipate the energy of seismic waves. The required natural seismic isolation is provided by changing the location and the thickness of the liquefiable soil layer. For this purpose, a series of one-dimensional numerical time-domain analysis is carried out by using DEEPSOIL software based on effective stress nonlinear soil behavior. The verification of the numerical model is accomplished using a real measured response spectrum from Wildlife liquefaction array during the 1987 Superstition Hills earthquake, which includes silty to clayey silt in uppermost layers, silty sand to sandy silt in the third layer and silty clay in beneath layers. Moreover, the parametric studies on the seismic response spectra are investigated by changing the location (X/H) and the thickness of the liquefiable layer (T/H) on soil profile (Figure 1), based on sequence or multiple earthquakes.

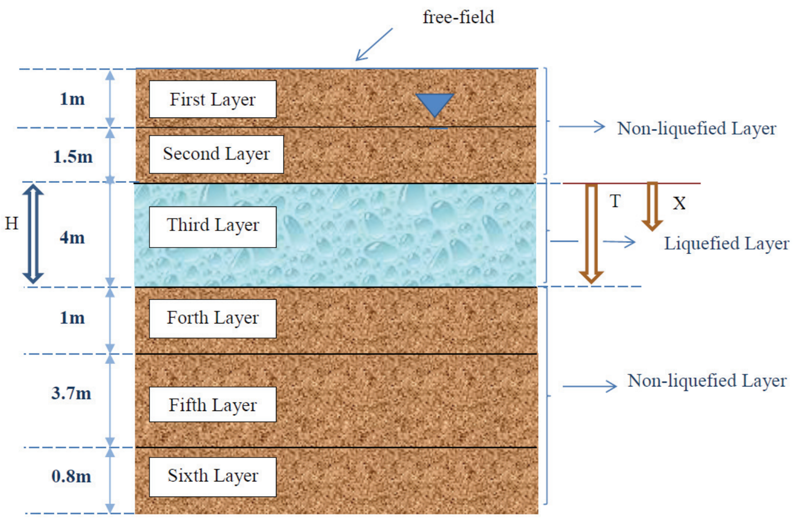

Figure 1. Soil profile in the parametric study.

It is worth mentioning that the sequential ruptures along the fault segments lead to multiple earthquakes which are often hard to distinguish them as fore-, main- and after-shocks, or a sequence of earthquakes from proximate fault segments (Abdelnaby, 2012). In this paper, the recent March 11, 2011, Tohoku earthquake with the magnitude 9.0 mainshock in Japan, which was followed by a significant magnitude 7.9 aftershock is taking into account.

The obtained results indicated that the deeper the position of the liquefied soil layer leads to increasing confining pressure and thus the liquefiable layer need to more excess pore pressure to fully-liquefied. Consequently, the increase of excess pore water pressure leads to reducing PGA and thus seismic response spectra is attenuated as shown in Figure 2. Besides, the characteristic period of the site is increased by deepening the location of liquefiable soil layer (Figure 3). It means that seismic response spectra are drastically attenuated for periods down to 1.

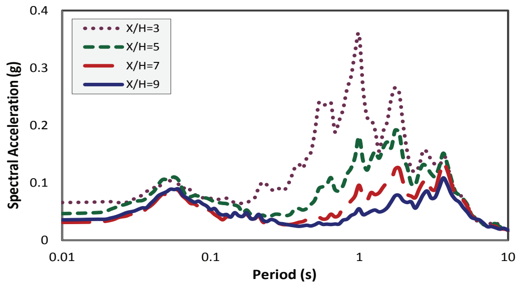

Figure 2. The variation of spectral acceleration of the site with respect to the variable location of liquefied layer.

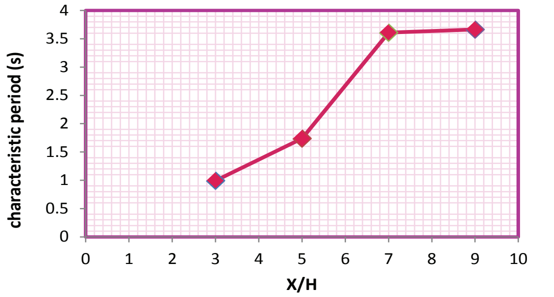

Figure 3. The characteristic period relation with variable location of liquefied layer (X/H).

Moreover, increasing the thickness of the liquefiable soil layer in constant location (X/H) on soil profile leads to de-amplification of the seismic response spectra of the site as well (Figure 4).

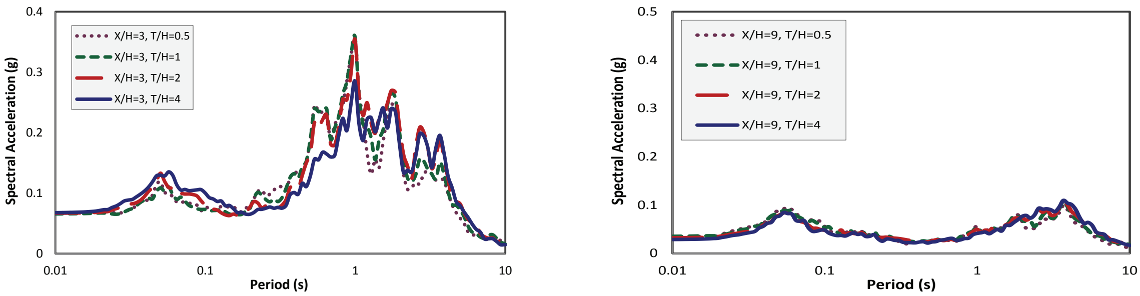

Figure 4. The variation of spectral acceleration of the site with respect to the variable thickness of liquefied layer in constant location.

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