EFFECTS OF ADDING A SURFACE SOIL LAYER ON THE SEISMIC RESPONSE OF THE SITE

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Previous earthquakes, such as Manjil-Iran (1990), Kobe-Japan (1995) and Loma Prieta-California (1989) shows that surface soil layers have a great influence on devastation of the earthquakes. These damages are often due to the effect of soil layers to PGA and frequency content of the records. Most of researches' strategies to reduce earthquake damages involve changing structural parameters, including applying base isolation or dampers. A few new researches are trying to reduce PGA or change frequency content of wave record. They suggest to apply synthetic liner (Yegian and Catan, 2004) or use of mixture of rubber and soil under the foundation (Yaghmaee and Rahmani, 2012).

In this study, the effect of a single layer, added to the surface of a specific profile (Bam soil profile (Rayhani et al., 2007), on PGA and frequency content (response spectrum) of arriving records is investigated. Five records (PGA between 0.14g and 0.79g) have been considered and the added layer is assumed 1, 3 and 6 meters thick with shear wave velocity of 80, 200 and 400 m/s. DEEPSOIL software has been applied for the analyses. To investigate the accuracy of the software, seismic response of Treasure Island profile in 1989 Loma Prieta earthquake was computed and compared with the recorded response. Results of the software are satisfactory.

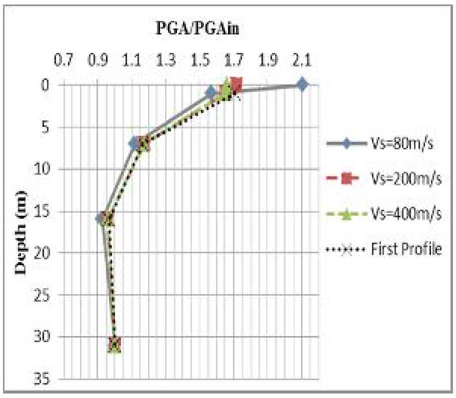

Figure 1. PGA ratio at depth for 1 m added layer

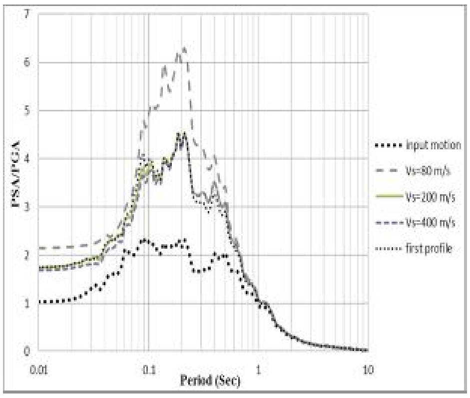

Figure 2. Normalized response spectra for 1 m added layer

Based on the obtained results, shown in Figures 1 and 2, adding a 1 m thick layer with shear wave velocity of 200 and 400 m/s don't change the PGA and response spectrum. However, the layer with 80 m/s shear wave velocity, raises the PGA and the response spectrum considerably.

For 6 m thick layer and the shear wave velocity of 200 m/s, the response of the earthquakes on the surface is amplified, however for the velocity of 80 and 400 m/s, the PGA on the surface is reduced by 54% and 20%, respectively (shown in Figure 3). Regarding the response spectrum, the layer with shear wave velocity of 80 m/s (and also 400 m/s) is beneficial as shown in Figure 4, but the response is amplified by using a layer having shear velocity of 200 m/s. It is clear that applying a thick weak layer beneath structures is out of practice, but it is studied in this paper to investigate the influence of the layer thickness on the response reduction.

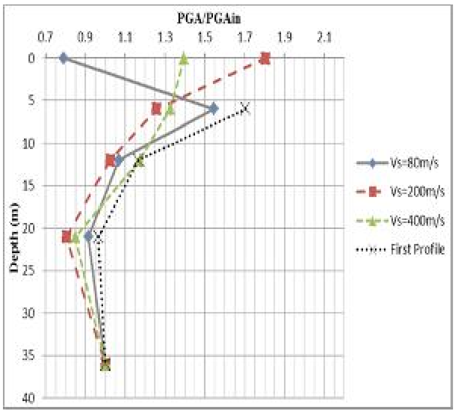

Figure 3. PGA ratio at depth for 6 m added layer

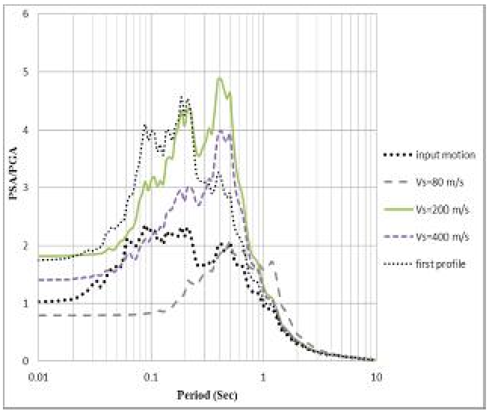

Figure 4. Normalized response spectra for 6 m added layer

Also, the effect of adding 2 layers consisting one 1 m weak layer with 80 m/s shear wave velocity beneath a 2 m hard layer with 400 m/s shear wave velocity was investigated. This case is similar to a weak layer that its surface had been improved by compaction; jet grouting, etc. furthermore, some natural profiles such as San Francisco airport profile is similar to this case. The results of this case are similar to the previous case having a 6 m thick added layer with shear velocity of 80 m/s. This shows that a 6 m weak layer, which may cause inconsistent settlement in foundation, can be substituted by a 2 m thick hard layer above a 1 m weak layer. In this case, results showed that this 1 m weak soil layer can reduces PGA more than 40% and shifts the frequency content to long periods. It is because of sliding behavior of weak soil layer (similar to synthetic liner behavior in soil isolation) and high damping of weak soil layer due to large strains.

In summary, it can be concluded that using a weak layer with sufficient thickness is a suitable method to decrease the response of structures having periods less than 1 second in strong earthquakes. Regarding that, using a weak layer with high thickness is out of practice, for its low bearing capacity and high settlement, it's better to apply a thin weak layer beneath a hard layer to reduce the response of low period structures.

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