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EFFECT OF INCLUSION PILES ON SURFACE SEISMIC GROUND RESPONSE USING NUMERICAL APPROACH

Arian GHANBARI BIRGANI
M.Sc. Student, Department of Civil Engineering, Science and Culture University, Tehran, Iran
ghanbariarian72@gmail.com
Hamid ALIELAHI
Assistant Professor, Department of Civil Engineering, Zanjan Branch, Islamic Azad University, Zanjan, Iran
h.alielahi@gmail.com
Reza KEYHANI
Assistant Professor, Department of Civil Engineering, Science and Culture University, Tehran, Iran
r_keyhani@yahoo.com

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The experience obtained from recent earthquakes have indicated the influence of sites' stiffness on the surface seismic ground response. Stiffness of soil can be improving by different methods; the inclusion piles is one of them. In this regard the role of geometry parameter of the inclusion piles can be significant. This paper studies the effect of mentioned parameters on the Basin of North Tower of Izmit bay bridge stiffness. We calculated the effective depth of piles, considering the complex seismic characteristics by 1D (equivalent column) and 2D analysis, using FLAC2D software based on viscoelastic soil behavior. These effects are mostly evaluated using one-dimensional analysis. However, one-dimensional analysis is not able to predict the site responses and the effective depth of pile.

Huang et al. (2018) work shows that the installing reinforcement piles is an effective method to mitigate ground movement in liquefied soils. The effectiveness of pile reinforcement to reduce large flow deformation in the liquefied ground is significantly influenced by the pile embedment condition. It is recommended that the embedment length is at least 1 m or 2 m if the underlying soil is a dense or a medium sand (Huang et al., 2018). Subsurface conditions at the North Tower Izmir bay bridge location consist of 10 m of loose to medium dense sand layers with silt or silt seams, underlain by 127 m of dense sand and hard clay. Bedrock lies approximately 144 m below the mudline. All soils and the gravel bed are modelled with the elastic-plastic model with a Poisson's ratio $\upsilon = 0.3$ and the Hysteresis Sigmoidal (S3) model in *FLAC and DEEPSOIL* was calibrated to model the hysteretic behavior of soil (Zhang et al., 2013).

In order to verify the results of the numerical modeling, the 1D responses obtained from the FLAC 2D and DEEPSOIL 1D software have been compared using the viscoelastic soil behavior. In this study, the 2D modeling process includes introducing soil layers' characteristics and determining the lateral free-field boundaries and quiet boundary as the bottom boundary, are subjected to the 7 earthquake excitations. In the following, as shown in Figure 1, a two-dimensional model of the sedimentary basin is constructed using the FLAC 2D program, that Gravel bed net length of 82.50 m in the sea, with an overall length of 272.5 m and a depth of 144 m. Figure 2 shows the geometry of site with inclusion piles.

The obtained results indicated that the different surcharge has no effect on the effective depth of piles. Changing the geometric parameters of piles affect the effective depth of piles. Furthermore, the results represent the influence of mentioned parameters on the response spectra of site. Effective depth of pile estimated from the comparison of response spectra of the 2D simulation with FLAC2D with different depths of 1D simulation with DEEPSOIL.

The numerical analysis result in Figure 3 shows that the geometrical parameter of piles has effect on the effective depth of them but changing the surcharge has no effect on the effective depth (ED), as it is shown in Figure 3-a, with increase of L/D the ED decreases. In the L/D range of 5 to 25, variation of ED is significantly large but then it is less than

0.5. Part (b) shows that with increase of S/D effective depth decreases first in the range of 1 to 5.5 of S/D then it is fixed in the value of 4. Part (c) shows that with increasing the thickness we increasing the stiffness of pile therefor by increasing the stiffness of pile the ED of inclusion pile will increase.

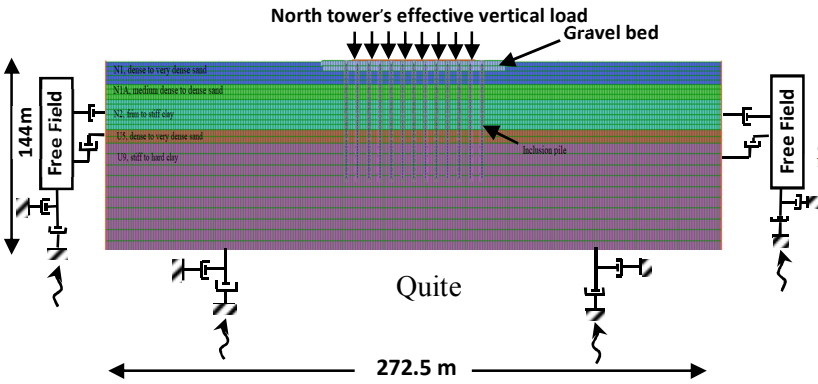

Figure 1. Finite difference mesh of FLAC 2D model.

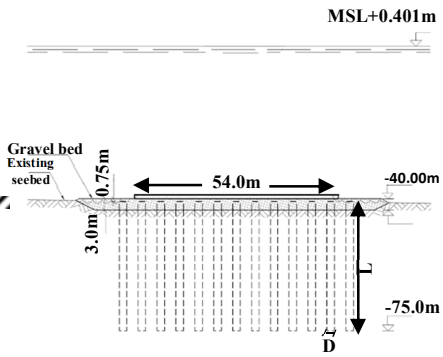

Figure 2. Geometry of site with inclusion pile.

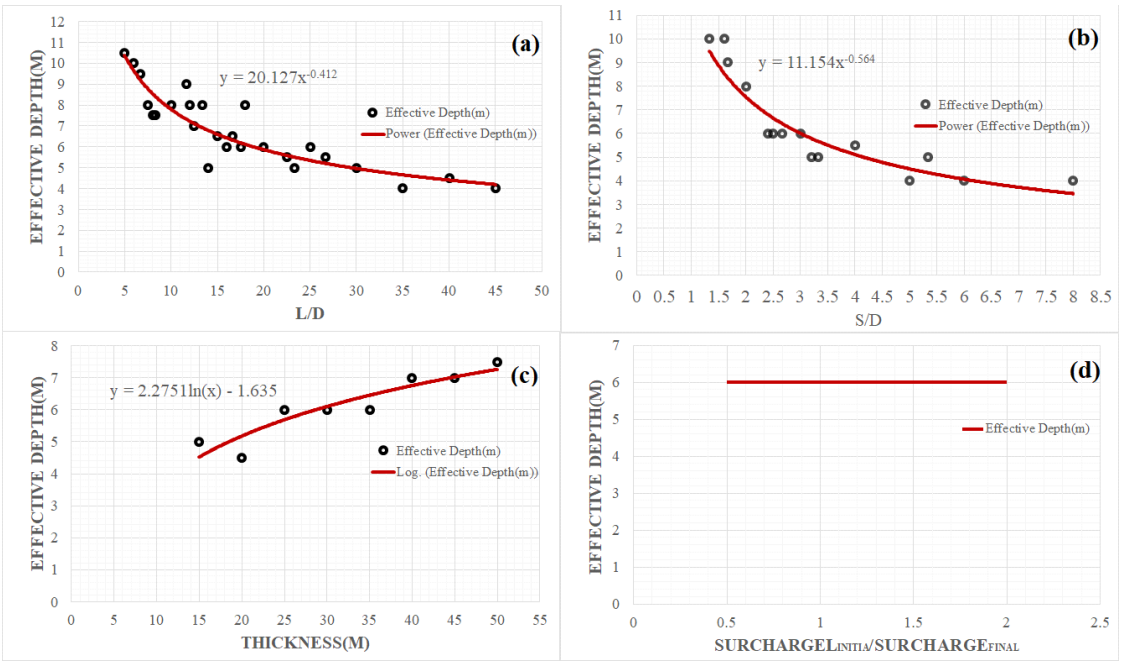

Figure 3. Effective depth of pile under the influence of: (a) L/D ratio, (b) S/D ratio, (c) Thickness of pile, (d) Surcharge.

The finding of this study prove the geometric parameter of pile has important role on the seismic ground motion responses. This issue is very important for the foundation of structures. The effective depth of piles by changing the geometric parameter of pile has change but one-dimensional analysis is not able to predict the site responses.

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