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Modeling of Foundation-Soil Interaction Problem by Using Reduced Soil Shear Modulus

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Abstract : In order to simulate the infinite soil medium for soil-foundation interaction problem, the essential geotechnical parameter on which the foundation stiffness depends, is the value of soil shear modulus. This parameter directly affects the site and structural response of the considered model under earthquake ground motions. Strain-dependent shear modulus under cycling loads makes difficult to estimate the accurate value in computation of foundation stiffness for the successful dynamic soil-structure interaction analysis. The aim of this study is to discuss in detail how to use the appropriate value of soil shear modulus in the computational analyses and to evaluate the effect of the variation in shear modulus with strain on the impedance functions used in the sub-structure method for idealizing the soil-foundation interaction problem. Herein, the impedance functions compose of springs and dashpots to represent the frequency-dependent stiffness and damping characteristics at the soil-foundation interface. Earthquake-induced vibration energy is dissipated into soil by both radiation and hysteretic damping. Therefore, flexible-base system damping, as well as the variability in shear strengths, should be considered in the calculation of impedance functions for achievement a more realistic dynamic soil-foundation interaction model. In this study, it has been written a Matlab code for addressing these purposes. The case-study example chosen for the analysis is considered as a 4-story reinforced concrete building structure located in Istanbul consisting of shear walls and moment resisting frames with a total height of 12m from the basement level. The foundation system composes of two different sized strip footings on clayey soil with different plasticity (Herein, PI=13 and 16). In the first stage of this study, the shear modulus reduction factor was not considered in the MATLAB algorithm. The static stiffness, dynamic stiffness modifiers and embedment correction factors of two rigid rectangular foundations measuring 2m wide by 17m long below the moment frames and 7m wide by 17m long below the shear walls are obtained for translation and rocking vibrational modes. Afterwards, the dynamic impedance functions of those have been calculated for reduced shear modulus through the developed Matlab code. The embedment effect of the foundation is also considered in these analyses. It can easy to see from the analysis results that the strain induced in soil will depend on the extent of the earthquake demand. It is clearly observed that when the strain range increases, the dynamic stiffness of the foundation medium decreases dramatically. The overall response of the structure can be affected considerably because of the degradation in soil stiffness even for a moderate earthquake. Therefore, it is very important to arrive at the corrected dynamic shear modulus for earthquake analysis including soil-structure interaction.

Keywords : clay soil, impedance functions, soil-foundation interaction, sub-structure approach, reduced shear modulus
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