Dynamic Analysis of Mono-Pile: Spectral Element Method

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Abstract : Mono-pile foundations are often used in soft soils in order to support heavy mega-structures, whereby often these deep footings may undergo dynamic excitation due to many causes like earthquake, wind or wave loads acting on the superstructure, blasting, and unbalanced machines, etc. A comprehensive analytical study is performed to study the dynamics of the mono-pile system embedded in cohesion-less soil. The soil is considered homogeneous and visco-elastic in nature and is analytically modeled using complex springs. Considering the N number of the elements of the pile, the final global stiffness matrix is obtained by using the theories of the spectral element matrix method. Further, statically condensing the intermediate internal nodes of the global stiffness matrix results to a smaller sub matrix containing the nodes experiencing the external translation and rotation, and the stiffness and damping functions (impedance functions) of the embedded piles are determined. Proper plots showing the variation of the real and imaginary parts of these impedance functions with the dimensionless frequency parameter are obtained. The plots obtained from this study are validated by that provided by Novak,1974. Further, the dynamic analysis of the resonator impregnated pile is proposed within this study. Moreover, with the aid of Wood's 1g laboratory scaling law, a proper scaled-down resonator-pile model is 3D printed using PLA material. Dynamic analysis of the scaled model is carried out in the time domain, whereby the lateral loads are imposed on the pile head. The response obtained from the sensors through the LabView software is compared with the proposed theoretical data.

Keywords : mono-pile, visco-elastic, impedance, LabView