Abstract

Investigation on nonlinear dynamic response of hollow steel piles subjected to vertical and coupled vibration with varying levels of exciting intensities is carried out numerically and experimentally in the present study. Single piles of three different lengths driven in layered soil medium are tested. The exciting force applied on the pile cap through the oscillator causes vertical motion under vertical exciting force and coupled horizontal and rocking motion under horizontal exciting force. Surface strain gauges at different points at different depth on the inner surface of the pile are attached to record variation of strain over the depth during each test. A Finite Element model has been developed using commercially available software Abaqus for the dynamic analysis of pile foundation in different modes. In the Finite Element Analysis, Mohr-Coulomb plasticity model is used to simulate the soil plasticity, whereas the pile-material is idealized as elastic. The effects of various influencing parameters such as exciting moment, length of pile, pile separation and slippage from surrounding soil on the nonlinear dynamic response of piles are investigated. Two different interaction conditions are considered in the analysis; one is allowing slippage and separation between soil and pile, and the other without allowing the slippage and separation. Slippage and separation between the pile and the surrounding soil considerably affects the dynamic response of a pile due to reduction of the stiffness of pile-soil system which results in reduction in resonant frequencies and increase in resonant amplitudes. Reasonable match between the measured and predicted response by Finite Element Model considering separation and slippage is found for both vertical and coupled motion. The numerical results are also used to establish empirical relationships between the extent of soil separation around the pile and the maximum vibration amplitudes under coupled vibration. The proposed FE model is applied for predicting the response of full-scale single piles under vertical vibration for which test results are available in the literature. The numerical results are compared with the experimental results of vertical dynamic responses and also static pile load test. It is observed that results obtained by FEM matched reasonably well with the experimental results. So, the proposed model is found to be capable of predicting dynamic response of full scale pile foundation with adequate accuracy as well.

Keywords: Coupled vibration, Horizontal excitation, Layered soil, Nonlinear analysis, Pile foundation, Resonant amplitude, Resonant frequency, Rocking, Separation, Slippage, Vertical vibration