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Pile-soil Interaction under Vertical Harmonic vibration in layered soil

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Abstract

Simplified analytical models are represented for vertical harmonic vibration response of pile-soil interaction in layered soil. The pile is assumed to be vertical and elastic, the soil is considered as a linear visco-elastic layer with hysteretic type damping. The layer alone is solved first and the harmonic loading of the layers are used in the analysis of the pile response. The pile response to a harmonic load is obtained in a closed form and used to define stiffness and damping for the pile head. Parametric studies have been performed to investigate the effect of soil layer thickness and properties. A new technique initially developed by the first author has been used for analyses carried out in the current research. This segment by segment method (SSM) is used to determine the response of pile to deal with the soil heterogeneity along the pile shaft. It will be shown that the new technique is able to characterize the pile efficiently.

Keywords: Layered soil, vertical harmonic vibration, pile-soil interaction, linear visco-elastic layer, stiffness and damping

1. INTRODUCTION

Pile foundations are used to transfer forces of structures to lower hard layers. Therefore, study of piles in multilayered soils is of great importance. Different methods are used for studying the dynamic loads and pile-soil interactions. Dynamic findings of piles are often used for pile driving, machinery foundations and structures which are subjected to dynamic loads such as wind or earthquake loads. Various methods have been used to assess and study piles with dynamic loads. Some methods can be referred to like boundary element method by Keynia and kausel (1982) proposed an approximate method to calculate axial vibration of pile in half space based on the Beam-on-Winkler-Foundation (BWF) model. In this paper, the calculation of dynamic response of soil-pile interaction in multilayered soil, namely SSM (Ghazavi et. Al., 1997a, b); Ghazavi (2002), Ghazavi (2007), is given. The soil-pile interaction caused by vertical harmonic vibration in heterogeneous soils is studied herein using SSM approach. Results obtained from this method will be evaluated along with those of Nogami and Novak (1976).

2. ASSUMPTIONS

For analysis of soil-pile system subjected to axial harmonic vibration, the assumptions made are: a) the pile is vertical, elastic, end bearing, cylindrical with a circular cross-section; b)the soil is linear visco-elastic with hysteretic type damping, homogeneous, semi-infinite and isotropic; c)the pile is completely connected to the soil; d) only vertical harmonic vibration is considered and all the horizontal displacements are negligibly small.

The following equation is used to calculate displacements of soil under vertical harmonic vibration with the length H, which are fixed at one end (Nogami and Novak, 1976):

$$u(r,z)=\sum_{n=1}^{\infty} A_n K_0(q_n r)[C_n \sin(h_n z)+D_n \cos(h_n z)] \quad (1)$$

where: