The Inspection of Site Characteristics on Far Field Dynamic Stiffness of Soil-structure Systems in Coupled SSI Analyses Using the Cone Model

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Abstract

To anticipate the response of a foundation to seismic excitations including earthquakes, machinery loadings and explosions, it is essential to have at hand the dynamic stiffness of each two media which are attached to one. In coupled analysis methods, substructure and rigorous methods are made use at the same time each involving its own advantages and the whole putting aside individual disadvantages. In this paper, assuming the Cone Model as the method going to be used for the far field impedance calculation, different site characteristics have been inspected and their effects on dynamic stiffness of the far field are observed. Having categorized the problem into three major classes including uniform infinite, continuously non-uniform infinite sand and continuously non-uniform sand resting on bedrock, amplitudes of dynamic stiffness are calculated and it is observed that for infinite sand the more the depth gets the more the impedance amplitude results; and this is the case for all different site considerations. Convergence is observed for non-uniform infinite sand around a frequency of about 10 rad/sec with discrepancies observed for bigger frequencies. This is while for the half space consisting of uniform sand results converge for frequencies between 20 and 30 rad/sec and no discrepancy is observed afterwards. For the half space restricted to bedrock, the impedance amplitude period against frequency decreases with depth and no convergence is observed except for greater depths.

Keywords: seismic excitation, impedance, far field, Cone Model, half space

1. INTRODUCTION

The importance of soil-structure interaction (SSI) effects has been growing since the effects of incident motion frequency versus the natural frequency of the structure has come into consideration and resonance possibilities have been inspected. However, in order to account well for the interactional effects and interaction forces, one of the most important factors with which calculations and modeling procedures are followed will be the dynamic stiffness coefficient of the free field and of the far field of the site, which is strictly bound to some or all factors including the form of the foundation, geotechnical properties of the site, assumed plastic depth of the half space, geometry of the foundation, physical and geometrical specifications of the strata, etc. considering the method and hypotheses taken to calculate the stiffness coefficients. Cone Model is an approximate method which models the medium and wave propagation with simple hypotheses; yet the results obtained from this method are of very good accuracy which reveals the method meets engineering requirements for average projects and verifications with rigorous methods all confirm this acceptable accuracy.

The method assumes a one-dimensional model of propagation for the seismic wave whose traveling path is cone-like; as a conical bar conveying a wave through its cross section [2]. Three basic assumptions are considered to use this model to solve problems of interest: First, the Hook's law using the famous elastic-constitutive model with Young's modulus of elasticity; second, dynamic equilibrium; and third, basic equation of motion. Further derivations and expansions of the model have been carried out based on these three assumptions [2, 3]. It should be noted that the Cone Model must be made use of for axisymmetric problems, hence for other types of foundations an equivalent radius must be calculated with an acceptable method to which the results should comply and this is what has been done in this study converting the square cross section of the interface to an equivalent circular one setting the areas equal and carrying out the calculations for the unit of area.