SEISMIC RESPONSE OF THREE-DIMENSIONAL STRUCTURES ON NONLINEAR FOUNDATION ANALYZED BY DIFFERENTIAL-INTEGRAL EQUATIONS

by

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SYNOPSIS

The nonlinear dynamic response problems have been solved by either direct integration or mode superposition. The latter may be achieved by obtaining the subsequent modal spectrum as deformation proceeds or, for localized nonlinearities, using the time-independent modal data with nonlinear correction terms. These modal approaches used system modes. In this paper, the soil-structure interaction problem involving nonlinear soil foundation is analyzed by solving a set of integro-differential equations using the fixed-base modes. The main advantages of this approach are the reduced number of equations to solve and improved physical understanding of the problem.

INTRODUCTION

Consider a lumped-parameter dynamic model simulating a linear elastic structure with rigid base on a nonlinear soil foundation subjected to seismic excitation. The superstructure equations are written in terms of the displacements relative to base. Using the modal transformation associated with the fixed-base modes of the superstructure, it can be shown that the governing equations of the system can be reduced, for general three-dimensional problems, to six integro-differential equations for the degrees of freedom of the base, $\{u\}$,

$$\left[M\right]\{\ddot{u}\} + \left[\tilde{C}\right]\{\dot{u}\} + \left[\tilde{K}\right]\{u\} = -\left[M\right]\{\ddot{u}_g(t)\}$$

$$-\left[P\right]^T\int_0^t \left[F_1(t-\tau)\right]\left(\{\ddot{u}(\tau)\} + \{\ddot{u}_g(\tau)\}\right)d\tau$$

$$-\left[P\right]^T\int_0^t \left[F_2(t-\tau)\right]\left(\{\ddot{u}(\tau)\} + \{\ddot{u}_g(\tau)\}\right)d\tau$$

The above equations are of the Volterra type. The soil nonlinearities appear in $[\tilde{K}]$ and $[\tilde{C}]$. For plane motion problems, only two equations need to be solved. The terms involving integrals correspond to the external forces exerted on the base by the superstructure. The matrix [P] contains the modal data of the fixed-base modes. These equations can be solved numerically by the established integrating-iterating process.

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