7th National Congress on Civil Engineering, 7-8 May 2013
University of Sistan and Baluchestan, Zahedan, Iran

Dynamic Analysis of Dam-Soil Interaction in Time Domain

Saba Golchin[1], Reza Attarnejad[2]

1- Research Assistant, School of Technical Science, University of Tehran, Iran
2- Member of Academic Board, School of Technical Science, University of Tehran, Iran

Saba.golchin@yahoo.com

Abstract

In dynamic analysis of many lifeline structure, the soil-structure interaction plays a very important role. In this study, the effect of soil-structure interaction on the dynamic response of structure has been examined.

Time domain dynamic analysis of inclined dam−soil interaction was conducted using finite element method and scaled boundary finite element. The substructure method is used to analyze soil-structure system. Finite element method is used to analyze the structure and scaled boundary finite element is used to analyze the unbounded soil region. The scaled boundary finite element is a numerical finite element-based procedure in the circumferential direction and analytical procedure in the radial direction. Due to analytical solution in the radial direction, the radiation condition is satisfied exactly. The soil region is considered as a homogeneous half-space. The material behavior of dam and soil is assumed to be linear. A two dimensional plane strain dam model has been used for the time history analysis to compute the responses against earthquake loading considering the effect of soil-structure interaction.

Keywords:Concrete dam, soil-structure interaction, scaled boundary finite element, Newmark algorithm, seismic response.

1. INTRODUCTION

The response of a dam during an earthquake depends upon characteristics of the ground motion, the surrounding soil and the dam itself. Damage sustained in recent earthquakes highlighted that the seismic behavior of structure is highly influenced not only by the response of the superstructure, but also by the response of the foundation and the ground as well. Hence it becomes imperative to consider the effect of soil-structure interaction for heavy structures such as concrete gravity dams. For stiff and massive structure on relatively soft soil, the effect of Soil-Structure Interaction(SSI) are noticeable and lead to an increase in the natural period and a change in the damping ratio of the system[1][2][3].

In dynamic soil-structure problems, analysis methods can be classified into three groups[4]: (1) time domain and frequency domain analysis methods, (2) substructure method and direct method, (3) rigorous methods and approximate simple physical models.

An excellent amount of work on dam-reservoir-foundation interaction in the frequency domain has been carried out by Chopra and his colleagues[5][6]. However, frequency domain based methods are difficult to understand compared to the time domain based methods. Also, incorporation of nonlinear material behavior will be a prohibitive task for frequency domain based methods.

Time domain methods are capable of studying nonlinear behavior of dam and foundation domain. In frequency domain, the solving procedure is easier than time domain but it can deal only with linear aspects.

In substructure method the whole media is represented by an impedance matrix which could be attached to the dynamic stiffness of the structure. This hypothesis renders the soil-structure interaction problem simpler and reduces the analysis efforts.

To solve the soil-structure interaction problems, several analytical and numerical methods have been developed. Applying analytical methods is limited to simple structures and uniform soil media, while numerical methods such as finite element method (FEM), infinite element method, and boundary element method (BEM) are widely used.

In the finite element method the domain is spatially discretised into non-overlapping elements. A great flexibility exists in representing the geometry and the material. The finite element method is well suited for nonhomogeneous, anisotropic materials of arbitrary-shaped structure with non-linear behavior[7]. For an unbounded domain, the finite element method cannot satisfy the boundary condition at infinity exactly[8].