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Parametric Study of the Modal Behavior of Concrete Gravity Dam by Using the Finite Element Method

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Abstract

Considering the period of the first mode of dams is an essential part of its seismic behavior analysis. Therefore, it is crucial to calculate the natural frequencies. This paper aim is simulating and analysis of the finite element (FE) model of the Koyna concrete gravity as a case study. In order to investigate the suitable mesh size to achieve the grid independency, the element size is considered as a variable parameter and its optimized value is determined by using the Response Surface Optimization (RSO) method. In the independent grid, to controlling mesh quality, the Error Contour is utilized, which indicates fast variations of the energy in the adjacent elements and can recognize parts of the model that has a high error in calculating responses. The modal response of the dam with a rigid and flexible foundation with and without mass is appraised. The results indicated that modal frequencies in the condition of with and without Pre-stress are different in all cases. Moreover, the frequencies of the first four modes by increasing the mass and decreasing the stiffness of foundation, frequencies in the case without initial condition (without Pre-stress) have a slight increase and in the case with initial condition (Pre-stress) have considerable decrease.

Keywords: Modal Analysis; Concrete Gravity Dam; Grid Independence; Response Surface Optimization (RSO); Error Contour; Pre-stress.

1. Introduction

In the design of structures based on the response spectrum, the period of the first mode of the structure (structural period) is used to define spectrum acceleration (S_a). In regular structures, the behavior of the structure is largely dependent on the first mode period. Therefore, calculating the natural frequency of dams is an essential part of its seismic behavior analysis. Besides, the upshot of the frequency analysis can be used for damping calculation and the response spectrum analysis to evaluate the seismic behavior of the dam. Modal analysis is the process of determining the intrinsic dynamic specifications of the system in the form of natural frequencies, damping coefficients, and the shape of modes and applying them to create a mathematical model of the dynamic behavior of the system. Modal analysis is focused on the principle that the vibration response of the linear dynamic system is a collection of simple coordinate actions that are in vibration modes. This concept is similar to using a Fourier combination of sin and cos waves to show a complex wave. Vibration mode shape is related to system dynamic which is determined by physical specifications such as mass, stiffness, damping, and their distribution method. Each mode is described based on the modal parameters of the same modes, including the natural frequency, the modal damping coefficient, and the displacement pattern in that mode which is called mode shape. Mode shape may be real or imaginary and each mode corresponds to a natural frequency. The

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