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Quasi-Static and Dynamic Analysis of Vertical and Horizontal Displacements in Earth Dams (Case Study: Azadi Earth Dam)

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ABSTRACT

Seismic analysis of earth and rockfill dams is generally done in two ways: quasi-static and dynamic. However, a quasi-static method with easy application and simple assumptions may lead to unsafe and uneconomical results. In the present study, two static and dynamic analyzes have been used nonlinearly using the Rayleigh Damping rule to calculate the settlement and horizontal displacement of Azadi Dam in the stages of the end of construction and steady-state seepage. Also, in numerical analysis, Abaqus software and a simple elastoplastic behavior model based on the Mohr-Coulomb criterion have been used. The seismic analysis results show that settlement is more sensitive to horizontal displacement, so that settlement at the upper, middle, and lower levels of the shell is 66%, 55%, and 52% more than horizontal displacement, respectively. The highest amount of settlement occurred in both quasi-static and dynamic states in the dam's upper levels, with the difference that in the dynamic state and the full reservoir, the upstream shell is more affected by settlement. Also, settlement in the dynamic analysis is 37% higher than the quasi-static analysis.

Keywords: **Abaqus, quasi-static analysis, dynamic analysis, settlement, horizontal displacement**

1. INTRODUCTION

Seismic design and analysis of earth and rockfill dams are done by two methods, quasi-static and dynamic. The method of dynamic analysis is mainly based on stress analysis and displacement, which is usually done with the help of finite element methods. This method is commonly used to analyze the stability of large dams in the study phase. Lack of accurate software for dynamic analysis of earth dams, the limited number of experts aware of dynamic analysis, the complexity of dynamic analysis method, expensive tests for determining soil dynamic properties, frequency, and ease of analysis with quasi-static software are the reasons for widespread use of the quasi-static method. Due to these cases, determining the accuracy of the quasi-static method and creating a relationship between the solutions of the two quasi-static and dynamic methods is of interest to earth and gravel dam design engineers. Today, the development of finite element and finite difference software has made it possible to use dynamic analysis as well as quasi-static analysis. Ambraseys and Sarma, 1967examined the response of earth dams to several earthquakes [1]. They calculated the time history and distribution of earthquake acceleration in the dam body. (Sarma, 1975) developed diagrams for calculating the critical horizontal acceleration in which the critical horizontal acceleration is the acceleration that can bring the soil mass limited to a landslide level into equilibrium [2]. (Tsai et al., 2006) by studying the dynamic response of the Pao-Shan dam, studied the effect of core dimensions on the potential of earth dam response as well as the effect of core width and height ratio and dam length and height ratio at the first natural frequency [3]. (Tsompanakis et al., 2009) Using a neural network, evaluated the dynamic response of the sample embankment (laboratory) using the finite element method. Considering the nonlinear behavior of soil materials, he concluded that the magnification module would shrink as the maximum earthquake acceleration increases and the materials enter the nonlinear section [4]. (Elia et al., 2011), investigated the seismic and aftershock