17th Symposium on Earthquake Engineering
November 14-17, 2022
IIT Roorkee, India
Paper No. 107

Vibration Characteristics of Gravity Dams for Varying Reservoir and Tailwater Heights, and Interaction Effects

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Abstract

Vibration characteristics i.e., natural frequency and mode shape of structure or structural component are essential parameters in its earthquake resistant design. Modal analysis helps to calculate natural frequencies and mode shapes of the structure in free vibration. The present paper investigates the modal analysis of the gravity dams for varying reservoir and tailwater heights and interaction effects. For modal analysis, two gravity dams (e.g., Koyna and Outardes-3 gravity dams) are chosen. The Lanczos algorithm is used in Abaqus to find out dams un-damped natural frequencies and mode shapes. Various reservoir and tailwater heights are considered for the gravity dams. In addition, the effect of dam-foundation-reservoir and dam-reservoir interaction are considered for the modal analysis of the gravity dam. In finite element meshing, a 4 node plane strain elements are utilized for modeling purpose of both the dam and foundation domains; whereas, a 4 node acoustic elements are used to model the reservoir domain. The effect of reservoir surface waves is not considered in the numerical study. In modal analysis, lower reservoir water level causes more horizontal crest deformation; however, the consideration of higher reservoir and tail water levels of the dam makes it more flexible; and thus reduces the system's natural frequencies. As compared to dam-reservoir interaction, dam-foundation-reservoir interaction causes lower natural frequency for the system.

Keywords: Gravity dam, Reservoir and tailwater heights, Dam-foundation-reservoir interaction, Dam-reservoir interaction, Modal analysis