Modal Response of Dam-Reservoir-Foundation Interaction

Hashem Shariatmadar[1], Adel Mirhaj[2]

1- Assistant Professor, Civil Engineering Dept., Eng. Faculty, Ferdowsi University of Mashhad
2- Structural Eng., Civil Engineering Dept., Eng. Faculty

shariatmadar@ferdowsi.um.ac.ir

Abstract

Vital and special structure such as dams, must have sufficient safety margin under conditions like when earthquake occurred as same as normal servicing time. Hydrodynamic pressures induced due to seismic forces and Fluid-Structure Interaction (FSI) are evaluated. The interaction of reservoir water-dam structure and foundation bed rock are modeled using the ANSYS computer program. The analytical results obtained from over twenty 2D finite element modal analysis of concrete gravity dam show that the accurate modeling of dam-reservoir-foundation and their interaction considerably affects the modal periods, mode shapes and modal hydrodynamic pressure distribution.

Keywords: Concrete Gravity Dam, Modal Analyze, Dam-Reservoir-Foundation Interaction, Hydrodynamic Pressure

1. INTRODUCTION

Today, use of water resources plays an important role to promote economical, agricultural developments in each country. Aquifer saving, directing of ground water flow in order to percolation and especially "Dam construction" are of the new methods for this purpose. Iran on the base of technical potential of his experts has also been one of the famous pioneers in dam design and construction. Concrete hydraulic structures such as : dams, intake towers, piers and etc have been accounted of " Special structures", which not only in normal servicing conditions should have a proper margin of safety, But also in critical conditions like as major earthquake, local and global failures must be prevented.

The catastrophic consequences on life and property resulting from failure of large dams have led engineers to design and built these structures to resist strong ground motion with no or only minor damages. This has provided a strong impetus for wide researches, particularly in developing new methods of dynamic analysis for concrete gravity dams in seismic region.

2. Literatures Review

The evaluation of the important hydrodynamic forces that develop on the upstream face of a large dam during severe transient excitations has been the subject of numerous studies, starting with Westergaard's classical work [1] in 1933. Westergaard explained the physical behavior of dam-reservoir interaction for 2D coupled system [1]. Water compressibility and dam flexibility effects have been investigated by Chopra and Chakrabarti [2,3]. In the aforesaid study, forces exerted by impulsive water on walls was replaced by the same equal force due to a constrained lumped mass with spring at a specific height. Ghaemian and Ghobarah [4] have calculated nonlinear seismic response of concrete gravity dams including dam-reservoir interaction. It is found that proper modeling in dam-reservoir interaction is very important to predict exact crack pattern. Other numerical techniques using the displacement –based finite element method for dam-reservoir interaction problems in both time and frequency domains have been introduced by Chen and Taylor [5]. Fenves and Vargas [6] proposed a method for dam-reservoir interaction which is capable of developing symmetric matrices for the total equation of the system. Leger and Bhattacharjee [7] presented a methodology for the approximate representation of the dam-reservoir interaction. At the another study carried out by Lotfi [8], decoupled modal approach in time domain was proposed using the mode shapes obtained from symmetric part of sub matrices of eigen value equations of dam-reservoir system. In spite of the fact that a considerable amount of research has been directed towards the modeling of the dynamic response of