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Seismic Response of Concrete Gravity Dam- Reservoir Systems Including Foundation Flexibility

Leila Khanmohammadi
Assistant Professor of Civil Engineering- Payame Noor University- Tehran- Iran-
Postal Code: 19395-3697

L.khanmohammadi@pnu.ac.ir

Abstract

Because of the reservoir and foundation effects, seismic response of concrete gravity dams are more involved than other common structures. This problem is mostly sourced by the differences between reservoir water, dam body and foundation material behaviors. To account for the reservoir effect in dynamic analysis of concrete gravity dams, two methods are generally employed. Eulerian method in reservoir modeling gives rise to a set of coupled equations, whereas in Lagrangian method, the same equations for dam and foundation structure are used. In this paper, a general procedure for analysis of the response of concrete gravity dams, including the dynamic effects of reservoir with Lagrangian modeling and flexible foundation, to the horizontal and vertical components of different earthquake loads is presented. Analysis of dam-foundation-reservoir system performed to calculate reservoir hydrodynamic pressure on dam face and dam displacement under earthquake, for dam-foundation-reservoir systems with various dimensions, characteristics and earthquake. Then results of dam-foundation-reservoir system analysis is evaluated in different conditions such as rigid foundation and flexible foundation and in different cases such as loading frequency, boundary condition and foundation elasticity modulus effects.

Keywords: Seismic response, Concrete gravity dam, Lagrangian method, Foundation flexibility.

1. INTRODUCTION

The linear dynamic analysis of concrete gravity dams provides important information about the response of dams with consideration of reservoir and foundation interaction to earthquake. So, the research must be able to evaluate the response of dam with consideration of dam's interaction with reservoir and its foundation. This problem has been studied vastly with different researchers.

The first research on the analysis of concrete gravity dam has been done by Westergaard [1] in 1930 and its analysis response for hydrodynamic pressure on the dam face was clear.

But Kotsubo [2] showed that Westergaard's finding is valid just when the harmonic excitation period is smaller than the fundamental natural reservoir period. Hilborn [3] also studied the effect of the length of reservoir on hydrodynamic pressure.

The findings of Jacobson [4] support the above researches. Werner [5] showed that the responses are not sensitive to the length of the reservoir. And the Bustamante [6] studied the result of the reservoir's length for a range of periods of excitation greater than the fundamental natural period of reservoir. He also studied the effect of surface waves under harmonic excitation and its ignorant error. Zangar [7] determined hydrodynamic pressure for various shapes of the upstream face of dam. In a paper in 1961, Kotsubo [8] found and presented hydrodynamic response of a reservoir and arch dam under earth harmonic movement. In the way Chopra [9] presented the response of dam under the horizontal and vertical acceleration of the earth. Chopra [10] also studied on dam-reservoir interaction and its semi-infinite foundation. Ahmadi [14] evaluated seismic response of concrete gravity dams including hydrodynamic interaction using Eulerian method. Recent researches and methods of analysis of dams are also presented in references [16] to [18]. In this paper we present and investigate dam crest point displacement with consideration of its interaction with reservoir and foundation, by reservoir modeling using Lagrangian method.