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The Effect of Wave Reflection Coefficient of Reservoir in Concrete Gravity Dams

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ABSTRACT

One of the most important problems in evaluation of seismic behavior of concrete gravity dams is dam-reservoir-foundation interaction. In this paper to study the effect of dam-reservoir-foundation interaction on nonlinear behavior of concrete gravity dams, sensitivity analyses were done for determining the effect of wave reflection coefficient for mass less and massed foundation with different boundary conditions. With considering crack profiles, dam crest displacement and number of cracked elements, it's observed that increasing wave reflection coefficient causes instability of the structure.
Keywords: Concrete gravity dams, dam-reservoir-foundation interaction, boundary condition, wave reflection coefficient.

INTRODUCTION

In the safety evaluation of concrete gravity dams, one of the most important problems is dam-reservoir interaction. Some methods have been introduced by several researchers. The simplest way to solve the dam-reservoir problem was represented by Westergaard [1]. In this system, the dam was subjected to the horizontal ground acceleration and he considered the hydrodynamic pressure as a certain body of water moves. He found that it is possible because the hydrodynamic pressure has same phase in comparing with ground acceleration. This way is called the added mass method. Sharan [2] considered the radiation condition for the structure that submerged and surrounded by compressible fluid. In this approach, he used different geometry of the dam-reservoir interface to check the radiation damping boundary condition. One of the famous researchers in this branch is Chopra. He presented a solution for hydrodynamic pressure in the case of rigid dam [3], [4]. Chopra investigated seismic behavior of concrete gravity dams under horizontal earthquake and found out that dynamic response of dam-reservoir interaction problems depends on water compressibility.

Nonlinear analysis of concrete gravity dams including dam-reservoir-foundation interaction was carried out by Chopra & Fenves [5, 6]. They studied the effect of reservoir bottom absorption on dynamic response of dam.

In this paper to study the effect of dam-reservoir-foundation interaction on nonlinear behavior of concrete gravity dams, sensitivity analyses were done for determining the effect of wave reflection coefficient for foundation with different boundary conditions.

NUMERICAL METHODS

In this research to evaluate the seismic behavior of concrete gravity dams with dam-reservoir-foundation interaction the smeared crack model was represented by Bhattacharjee and Leger [8], was used applying the staggered method of solution that was used by Ghaemian and Ghobarah [9]. The computer code, NSAG-DRI [10], was used to investigate nonlinear analysis of the Pine Flat Dam as a case study.

The dam material and rock foundation parameters which used in analysis are represented by the following tables:

Unit weight	**24357** $\frac{N}{m^3}$
Modulus of elasticity	**27580** MPa
Poisson's ratio	**0/2**

Table 1: basic parameters of dam concrete

Unit weight	**25928** $\frac{N}{m^3}$
Modulus of elasticity	**22400** MPa
Poisson's ratio	**0/33**

Table 2: basic parameters of rock foundation

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In this paper a flexible mass-less foundation with fixed support at the base and roller support for sides [11],[12] (Fig.1)was compared another model, flexible massed foundation that is shown in Fig 2, such as Lysmer boundary condition, there are horizontal and vertical dampers in both sides of foundation but at the base only there are rollers.

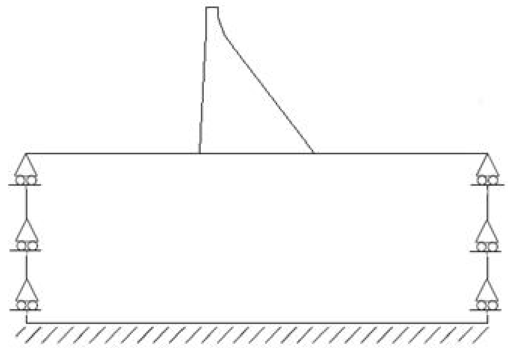

Fig. 1 :mass less foundation model

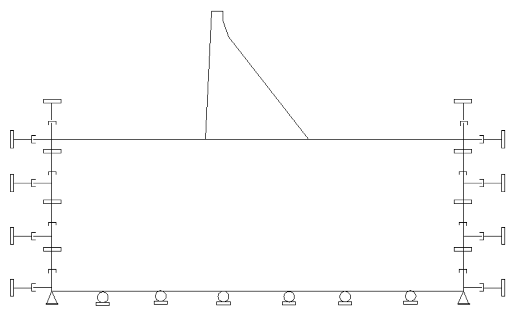

Fig.2 : massed foundation model

At the first step, self weight and hydrostatic load were applied on the models. In the second step dynamic analysis was carried out and Manjil earthquake record was included.(PGA= 0.5g).

In order to define the hydrodynamic pressure on the concrete dam, Sharan boundary condition was applied for truncated far end of reservoir [7] at a distance L=10h from the dam.

THE EFFECT OF WAVE REFLECTION COEFFICIENT

In this paper, sensitivity analyses were done for determining the effect of wave reflection coefficient (α) for mass-less and massed foundation with different boundary conditions.

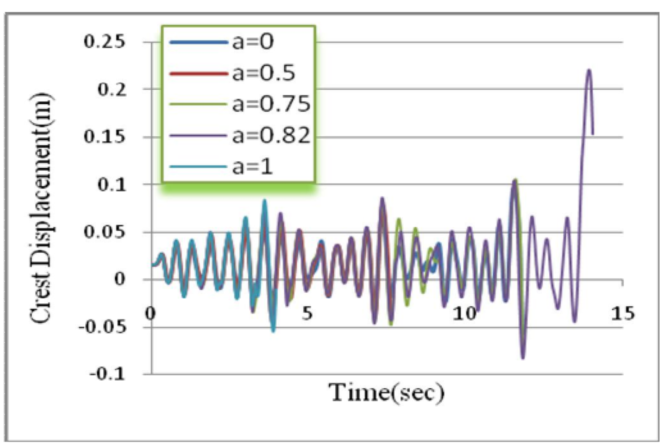

Fig.3 Time history of dam crest displacement for different wave reflection coefficient- mass less foundation

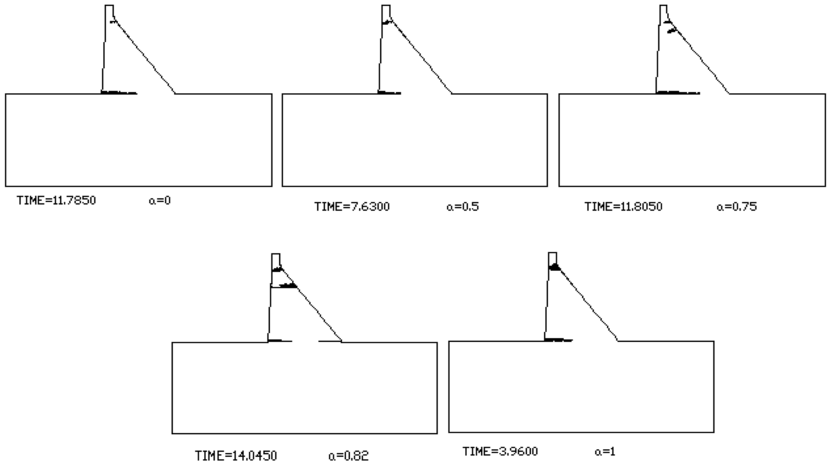

Fig.4 Crack profiles of dam for different wave reflection coefficient- mass less foundation

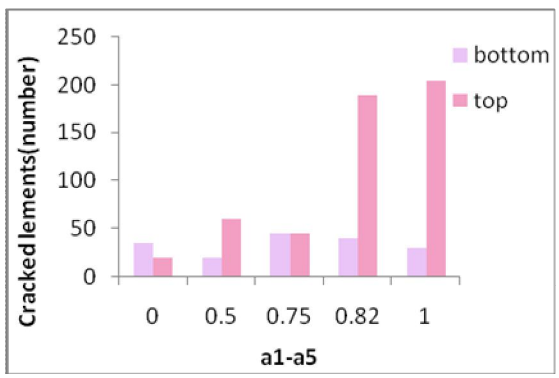

Fig.5 Number of cracked elements of dam for different wave reflection coefficient- mass less foundation

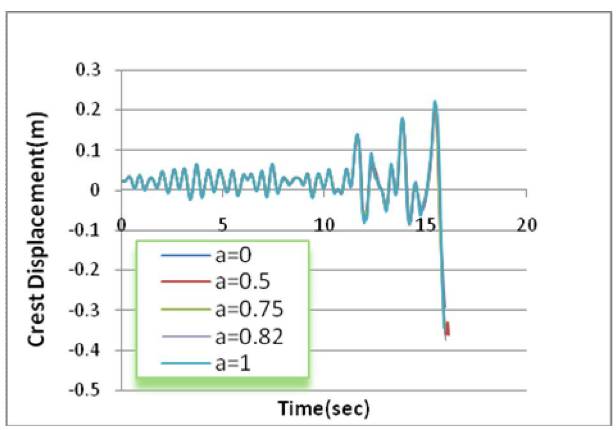

Fig.6 Time history of dam crest displacement for different wave reflection coefficient- massed foundation

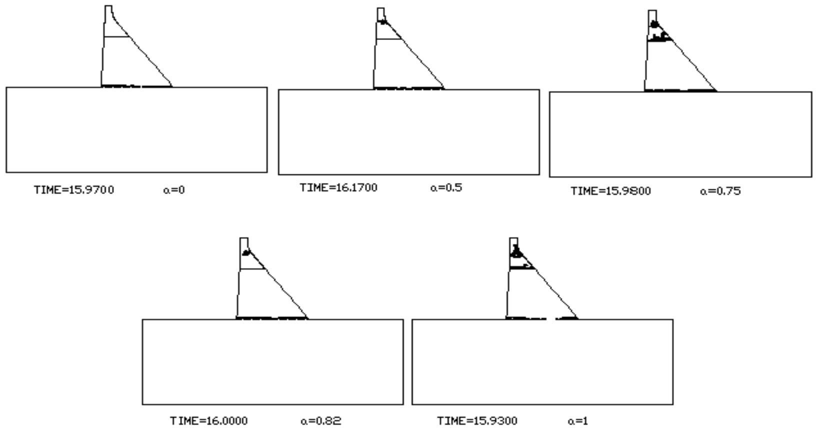

Fig.7 Crack profiles of dam for different wave reflection coefficient- massed foundation

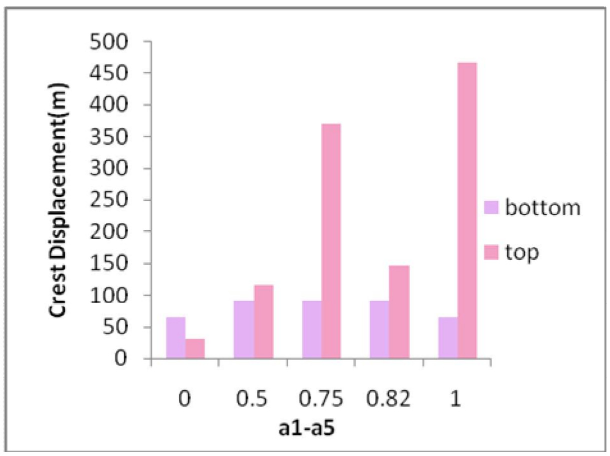

Fig.8 Number of cracked elements of dam for different wave reflection coefficient- massed foundation

The results of sensitivity analyses are represented by varying wave reflection coefficient (α) for mass-less and massed boundary conditions. With considering crack profiles, dam crest displacement and number of cracked elements, it's observed that increasing this ratio (0 to 1) ,causes instability of the structure.

It's concluded that increasing of α causes increasing number of cracked elements and maximum displacement of dam crest in mass less and massed foundation system that it 's because of reflection of wave from reservoir's bottom to the system.

Then increasing α, from 0 to 1, should cause the system more instable.

In comparison of mass-less and massed foundation, considering flexibility and structural damping, neglecting inertia and geometric damping in first and considering the geometric damping in second, it's concluded that it's better to select a value for wave reflection coefficient (α) near to 1 such as 0.82.

CONCLUSIONS

In this paper, sensitivity analyses were done for determining the effect of wave reflection coefficient (α) for mass-less and massed foundation with different boundary conditions.

With considering crack profiles, dam crest displacement and number of cracked elements, it's observed that increasing α (0 to 1), causes instability of the structure.

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