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Seismic Effect of Foundation Flexibility on Concrete Dam Considering the Interaction of the Fluid and Body of the Dam

Behnam Mehdipour[1+], Masoud MirMohamadSadeghi[2] and Hamidreza Saba[3]

[1]Department of Civil Engineering, Young Researchers and Elite Club, Najafabad Branch, Islamic Azad University, Najafabad, Isfahan, Iran

[2]Department of Civil Engineering, Power and Water University of Technology (PWUT), Isfahan, Iran

[3]Department of Civil Engineering, the University of Tafresh, I.R. Iran

Abstract. Dynamic behavior of concrete dams is very complete due to the various phenomenons which are effective in dynamic response of the dams against earthquakes.Some examples of the phenomenons could be mentioned such as: interaction of the lake water and dam structure, interaction of rock foundation and structure in dynamic behavior of the whole structure**.**Various parameters influence the behavior of the Dam during an earthquake. During an earthquake, due to the low shear force between the bottom of the reservoir and the fluid is not directly affected by ground movement due to the dam at the reservoir hydrodynamic pressure waves are created. In this paper the dynamic analysis of Dam foundations and taking into account the effects interaction Dam and reservoir are provided. All analysis are done by means of ANSYS software and as a case study Pine flat dam is chosen.Results of analyses showed an interaction of Dam and reservoir due to decrease frequency.

Keywords: Dynamic analysis, Interaction of Dam and Fluid, Pine Flat Dam, ANSYS software, Finite Element Method.

1. Introduction

Structure and properties of materials the dam and reservoir was more specific. But what concrete dams to earthquake response analysis of complex problems in structural dynamics makes regular interaction with the environment around the dam structure during earthquakes.In the late sixties, the majority of studies on the interaction of the dam and reservoir were performed by the analytical method. In the seventies, and with the development of numerical tools and the advent of computers,numerical methods also have their place in an open investigation.Finn and Vagner using finite element method and assuming the reservoir fluid compressibility methods for solving the dam and reservoir interaction explained .Interaction effects of dam and reservoir dam was by modifying the mass and matrix tree.Balachandaran assuming heterogeneous reservoir containing fluid and assuming harmonic vibrations of the earth and rigid platform, the hydrodynamic pressure distribution on the dam analyzed. The parameter values were variable density surface water from the bottom of the Reservoir. And sediment and impurities in the fluid, in terms of formulation and solution presented in the frequency domain[1], [2].

They Modeling of Westergaard and investigation into the upstream slope in their calculations, the hydrodynamic pressure distribution on the upstream side of the dam was calculated And compared their results with Zenger's work and show satisfactory results have been compared.

Careful studies by different researchers over time and the impact of various factors on the hydrodynamic forces exerted on the structure during an earthquake, such as pressure reservoir. Assumptions, possible estimates in terms of the equations of hydrodynamics.

+ Corresponding author.
E-mail address: zipaton@yahoo.com.

The method in 1990 was declared by Department of Earthquake Engineering dams obsolete methods that use large errors in the design of the dam creates

The seismic safety of concrete dams has always been considered as a major factor in the design of new dams and dam safety assessment after earthquakes in the area are discussed. Generally two reasons for growing concern about dams in earthquake resistance can be cited.

1 - The risks of injury due to the increasing population in the area downstream the dam.

2 - Several earthquakes occur in different areas of the world previously thought was inadequate safety measures and the need for continuing research in this area is felt [3]-[5].

2. Dynamic Analysis

Dynamic response of structures with low vibration periods, such as concrete gravity dams to earthquake loads, mainly due to their primary vibration mode. Therefore, the main mode of vibration modes that must be considered.Earth dam response to vibration in the vertical direction than the horizontal direction is less important than being ignored. Strong ground motions is appropriate for calculating the response of the dam that blocks vertical dam to separate the two-dimensional case considered in the analysis. It is assumed that each block on a vertical semi-infinite viscoelastic plate is located behind the water, probably associated with sediment deposits are located. Also ignored Modulus of elasticity of the dam body.is the effect of water downstream. The water level is so low because usually it does not affect the dynamic behavior of the dam [6]-[8]. Block geometry highest vertical dam height (Hs) 92/121 m, is shown in Fig. 1. (Dimensions in meters) and the material properties of the dam (Table 1) are listed. Earthquakes used in the analysis, Kern County, California, which is the horizontal component of earthquake on July 21, 1952, Lincoln station Taft (Taft Lincoln School) has been recorded. Fig. 2 is shown.

Table 1: Profile of Pine Flat Dam

27.85 Gpa	Modulus of elasticity of the dam body
22.4Gpa	Elastic modulus bedrock
0.2	Poisson’s ratio of body
0.33	Poisson’s ratio of bedrock
24.8kN/m3	Density Concrete

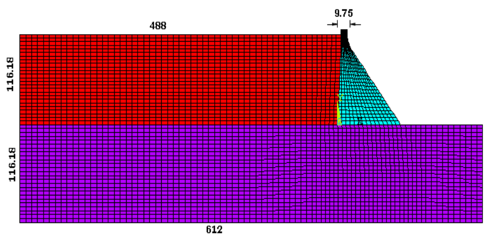

Fig. 1: Dimensions of the dam and reservoir modeling

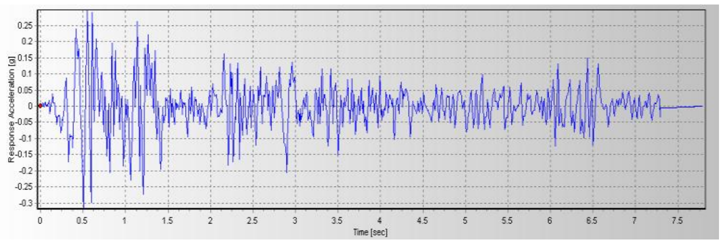

Fig. 2: Horizontal component of earthquake Taft Lincoln

With different aspect ratios for the dam and foundation stiffness in Flexible seismic behavior of concrete dam will be reviewed. (Equation (1)) In order to be flexible in assuming the proportions of (n) for the modulus of elasticity of the dam and dam foundation (0.25 and 0.5) dynamic analysis is performed.

$$Ef/Es=n \quad (1)$$

Elements of the dam in 2594 and 2384 the number is the number of nodes. Propagation phenomena and structures Immersion in water. Analysis of selected time step equal to 0.005 seconds and 7.5 seconds for the analysis of the Taft earthquake record are given.

2.1. Dynamic analysis in rigid state and reservoir full

Natural frequencies and modes of such structures are important parameters in the analysis. The determination of these parameters can be very useful in interpreting the behavior of the dam. Assuming a rigid dam with the foundation and fill the reservoir to seismic effects will be discussed.

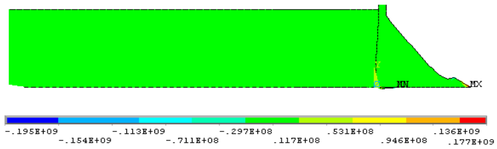

Fig. 3: Maximum stress in Sec .005 of the start of the seismic record.

As shown in Fig. 3, the maximum amount of tension 53.1 MPa.

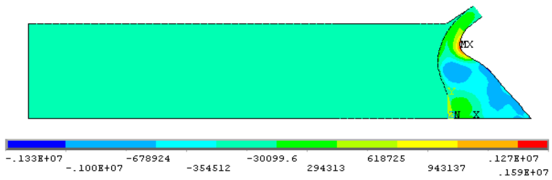

Fig. 4: Maximum stress in Sec 7.5

As shown in Fig. 4 shows the highest stress was observed in 1.59 MPa. In fact, the beginning and end of the analysis results for Maxim stress, decreased approximately 97% has been achieved.

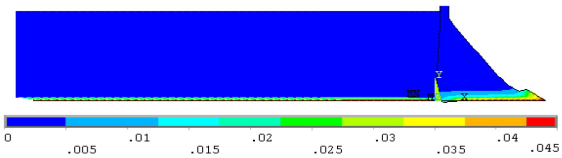

Fig. 5: Change the shape of the S .005 in the earthquake record

The maximum displacement into the sample average modeled, 4.5 cm at the toe of the dam will be the largest quantities.(Fig.5)

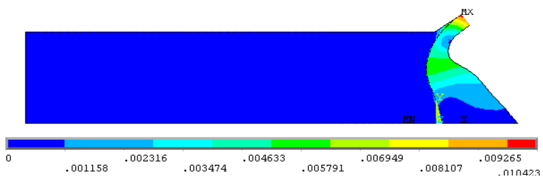

Fig. 6: Change the shape of the S 7.5 in the earthquake record

Actual concrete gravity dam with a vertical upstream or are very close to vertical. Hydrodynamic pressure slope Fig. 6, the maximum deformation occurs at the crest of the dam, but the highest value of the average displacement is less than the initial value s 0/005 would be (1.04 cm).

2.2. The Dynamic Analysis of a Flexible Foundation and reservoir Full

To study the effect of foundation flexibility on seismic behavior of concrete dam, by including a numerical comparison to the modulus of elasticity of the dam foundation, the analysis is done tests (n = 0.25).

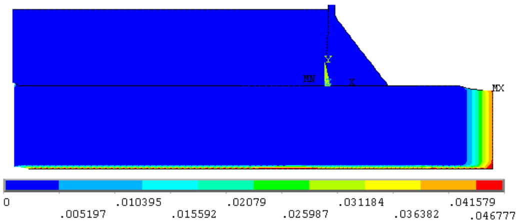

Fig. 7: Average maximum displacement in Sec .005 in earthquake

Fig. 7 shows the average maximum displacement of the second .005 earthquakes of 4.68 cm. Compared with the rigid foundation increases of about 5 percent.

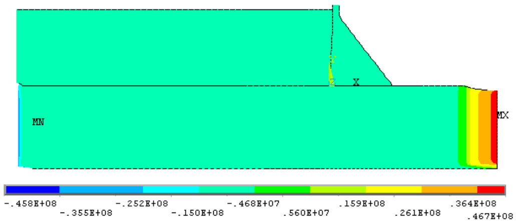

Fig. 8: Stress Maxim s 0.005 from the start of seismic records

Fig. 8 shows the stress on the second Maxim .005 is the start of a seismic record, with maximum tension 46.7 MPa during the dynamic analysis .Analysis was performed Compared with the rigid foundation and the reservoir is full, it shows a trend increase of about 17 percent.

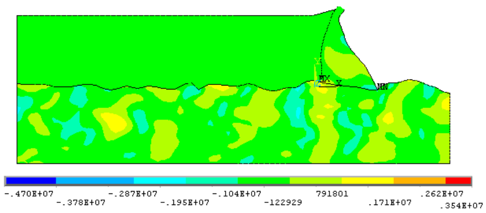

Fig. 9: Stress Maxim s 7.5 from the start of seismic records

Maximum stress values were observed in 3.54 MPa (Fig. 9). In fact, the beginning and the end results for Maxim stress analysis, the increase is about 86% were attained. For a closer look at the seismic response of concrete dam, the number (0. 5) for the modulus of elasticity of the dam foundation, are considered.

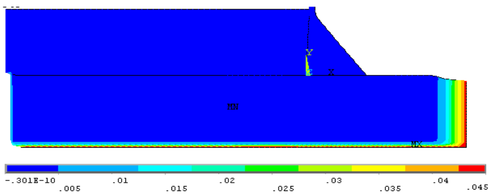

Fig. 10: Average Maximum displacement in Sec 0.005 in the earthquake.

Fig. 10 shows Average maximum amount of displacement s 0.005 earthquakes of 4.5 cm. Compared to the rigid fondation increases by about 5% compared to the state (n = 0.25) did not show noticeably changes.

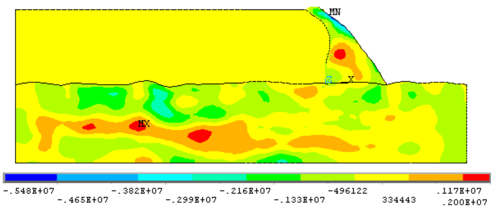

Fig. 11: Maximum stress in Sec 7.5 earthquakes.

Maximum stress values of 0.005 seconds earthquake48.4 Mega Pascal. Maximum stress was observed in 2 MPa. (Fig. 11).In fact, the results for Maxim stress of rigid state, the increase of about 60% has been achieved.

3. Conclusion

Interaction between the fluid and the dam body Cause Increases the effective mass and vibrational frequencies of the system is reduced. The percentage increase or decrease substantially depending on how the tension modulus of elasticity is the foundation and dam body.

- Increase the effective mass of the fluid near the body, reduce the frequency of vibration of the system.

- The percentage increase or decrease stress, modulus of elasticity of foundation and dam body is dependent, But how the reduction and increase does not follow a particular style.

-Interaction with the fluid reservoir, the seismic response of the system to change. Accordingly, the fluid pressure in the reservoir was impressed with the flexibility to increase flexibility, it will decrease., Which is declining in all proportions.

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