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(Technical Note)

Comparison of Static and Dynamic Stress-Strain Analysis in Earth Dams (Case Study: Azadi Earth Dam)

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Abstract

Seismic analysis of earth and pebble dams is generally carried out in two quasi-static and dynamic methods. Although the quasi-static method with easy application and simple assumptions provides barrier safety, it can sometimes lead to unsafe and uneconomical results. In the present study, the Riley attenuation rule used in stress - strain calculations of the Azadi dam and both nonlinear static and dynamic analysis are used. Also, a simple elastoplastic behavior model based on the Mohr-Coulomb criterion in Abaqus software has been used. Comparison of the results showed that in both analysis, the maximum strain of Azadi dam core was above the core and the highest stress occurred during the earthquake in the bottom. Moreover, dynamic stress is higher than static in σ_{xx} direction 49%, σ_{xy} 30%direction and σ_{yy} 28% direction. At the floor level, the maximum crustal stress is 29% higher in the middle level, 68% higher and in the upper level 72% higher than the core.

Keywords: *Abaqus, static analysis, dynamic analysis, stress, strain*

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Extended Abstract:

1. Introduction

The analysis and design of earth Dam and rock fill dams against earthquakes are performed in two quasi-static and dynamic methods. The dynamic analysis method is mainly based on stress and displacement analysis, which is usually, performed using finite element methods. This method is commonly used to analyze the stability of large dams in the study phase. (Tsompanakis et al., 2009) using the neural network to evaluate the dynamic response of the sample embankment using the finite element method. Considering the nonlinear behavior for earth materials, they concluded that the magnitude modulus decreases as the earthquake accelerates and the material enters the nonlinear part. In this study, static and dynamic analysis of stress - strain in Azadi earth Dam after end of construction stage and in steady-state seepage using Abacus software and nonlinear analysis are investigated.

2. Materials and methods

2.1. Dynamic equation governing the structural environment

By disrupting the dynamic equation of the structure and taking into account the forces acting on the earthquake in the time domain, using the finite element approach, the dynamic equation governing the dam and the wake will be written in the form of a matrix (1):

$$[M]\{U^{\cdot\cdot}\} + [C]\{U^{\cdot}\} + [K]\{U\} = \{F_1\} - [M]\{U_g\} + [Q]\{P\} \qquad (1)$$

[M], [C] and [K] are the mass, damping, and stiffness matrices, respectively. The displacement vectors are, respectively, the velocity and acceleration of the structures, and the body forces and the earthquake acceleration vectors, respectively.

2.2. Modeling the Azadi Dam in Abaqus Software

In this study, computation of pore water pressure was used to assume flat strain behavior in the dam. For this purpose, the largest section of the dam has been analyzed using Abaqus modeling software with eight-node elements. To perform the dynamic analysis and to derive the input stimulus, we used the idea of accelerating the mapping of the Tabas earthquake with a maximum acceleration of 0.83 g and a time of 33 s (Figure 1).

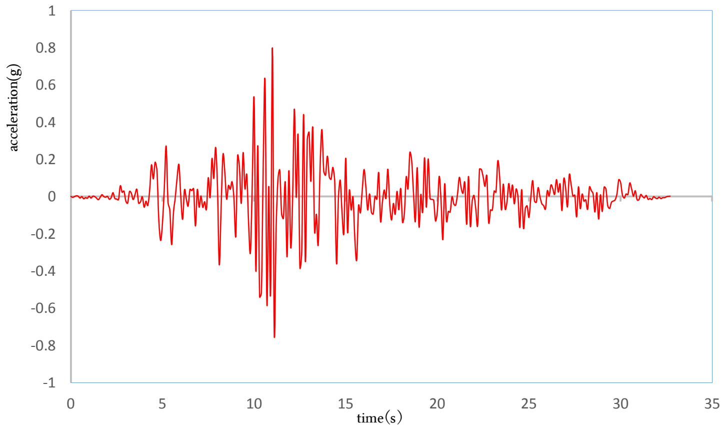

Fig1. Accelerogram used in Dynamic Analysis of Azadi Dam (Tabas Earthquake)

3. Tests results

3.1.Analysis of Stress - Strain Analysis of Azadi Dam by Static Method

The results show that the highest stress occurred in the σ_{xx} direction due to the high adhesion of the clay to the bottom of the core at 483 kPa in the opposite direction to the X-axis. The highest stress occurred in the σ_{xy} state in the upstream crust and this value decreased with a certain geometrical shape upwards and this decrease was 32%. The highest stress occurred in the σ_{yy} state in the upstream and downstream crust near the core, which is 964 kPa. The maximum strain occurs in the γ_{xx} direction within the core, this maximum being due to the fine-grained material in this section, its maximum value being 0.0034 which increased at a relatively high velocity to the shell and to 0.0002 at the side of the body. arrives. The strain irregularity is higher in the γ_{xy} direction than in the before and after mode, due to the multiple behavior of the heterogeneous Dam materials in this case, the highest value in this case being 0.009 next to the core, and the lowest being in the barrier value Is 0.0015. The maximum strain in the γ_{yy} direction is 0.00132 at the bottom of the kernel. The order of strain reduction in this case is higher than in the previous two cases, due to the resistance behavior of different parts of the heterogeneous Dam in this direction.

3.2.Analysis of Stress - Strain Analysis of Azadi Dam by Dynamic Method

The maximum stress in the σ_{xx} direction after the earthquake at the bottom of the core continues up to 30% of the shell width. Stress occurred in the σ_{xy} direction in the lower shell and 20% near the core below it. The greatest stress in the σ_{yy} direction after the earthquake occurs in the upstream shell at 15% distance from the core. In the strain state in the γ_{xx} direction, as expected, the highest strain occurred in the core. Strain in the γ_{xy} direction The maximum strain of 0.0124 occurred near the core. Most of the strain occurred in the γ_{yy} state after the earthquake at a distance of 0.125 m above the shell upstream of the core.

4. Conclusion

To control stresses during an earthquake, more coarse material must be added. The stress in dynamic state is higher than static in the direction of σ_{xx}% 49 in the direction of σ_{xy} 30% and in the direction of σ_{yy} 28%. At the floor level, the maximum crustal stress is 29% at the middle level 68% and at the upper level 72% higher than the core. The strain in the γ_{xx} direction as expected was the highest strain in the core due to the fine material in the area and its high post-earthquake density, with the highest strain being 0.0037 and the lowest value being 0.0007.

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