Analysis of Slope Stability and Soil Liquefaction of Zoned Earth Dams Using Numerical Modeling

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Abstract

The design of dams requires comprehensive studies to ensure the safety and feasibility of these important engineering projects, as any possible failure case may lead to considerable losses in human life and properties. Specifically, analyses should be performed to evaluate seepage, slope stability, and soil liquefaction of large earth dams. In this study, numerical modeling, based on finite element methods, was used to analyze seepage, slope stability, and liquefaction of Makhoul Dam which is a large zoned dam, currently under construction on Tigris River in the north of Iraq. Earthquake shakings impose additional hysteric and short-term loads that may lead to dam failure due to high pore water pressure, piping, and soil liquefaction. Therefore, the dynamic stability of the dam and soil liquefaction were also evaluated, as a result of applying an earthquake shaking to the dam. For the static condition, the dam was safe against internal erosion and slope failure, as the calculated value of the safety factor was greater than the allowable value. However, the results obtained from the dynamic analysis indicated that a possible earthquake, with an acceleration of 0.38g and 10 seconds period, led to upstream slope failure, a relative displacement as high as 2 meters at the dam crest, and soil liquefaction at the upstream slope. As discussed herein, dam redesign or geotextile reinforcement may be considered to reduce the effects of earthquakes on the dam.