Evolution of Seismic Analysis of an Embankment Dam

Khaled Chowdhury, PhD, PE, GE, SPD Dam Safety Production Center, USACE
Ethan Dawson, PhD, SPD Dam Safety Production Center, USACE
Erik Newman, PhD, PE, AECOM
Mark Dober, AECOM

Probabilistic seismic hazard analyses and nonlinear seismic deformation analyses to evaluate the expected seismic performance of embankment dams are routinely performed for high hazard dams. The State of Practice is rapidly evolving from simplified methods to use of fully-coupled seismic pore pressure generation and nonlinear seismic deformation analyses (NDA) using either finite difference or finite element analysis frameworks. An embankment dam constructed in the 1950s was recently evaluated using current State of Practice methods for seismic hazard characterization, site and embankment characterization, and seismic deformation analyses. Even though the dam shells and transition zones were constructed with lifts of 2 to 12 feet using potentially liquefiable materials, with only one dozer pass for leveling, a re-evaluation of the seismic performance of the dam performed in the late-1980s showed negligible seismic deformation potential. The approaches used with more recent ground motion, site characterization, and numerical modeling approaches indicate significantly different deformation estimates. The updated probabilistic seismic hazard analyses included development of seed motions using scenario-based target spectra; site characterization included selecting an appropriate Becker Penetration Testing (BPT) to Standard Penetration Testing (SPT) conversion method based on an evaluation of three common methods currently in use, and then comparing the results with in-situ relative density testing and construction history. Analysis cross sections included discretization of looser soil layers that were neglected in previous studies. The coupled liquefaction triggering and nonlinear seismic deformation analysis methods using FLAC were selected based on demonstrated predictive ability to estimate deformations in well-documented seismic performance case histories, and the final stability of the deformed core with reduced upstream shell support was estimated by limit equilibrium methods, a critical step in performing suitably comprehensive analyses. A set of pre- and post-deformed shape analyses was performed to assess the potential runout distance and remaining crest conditions. These updated analyses using the current State of Practice approaches and methods demonstrate that the evolution of procedures for seismic analyses of an embankment dam can be very important, in order to properly assess the expected seismic deformations and performance of a major embankment dam. Additional Co-Authors (5 and 6): Kevin Hazleton, PE, GE and Adam Gamblin, PE, Geotechnical Engineer, United States Army Corps of Engineers, Soil Design Section - Geotechnical Branch, 1325 J Street, 11th Floor, Sacramento, CA 95814-2922, kevin.hazleton@usace.army.mil and adam.gamblin@usace.army.mil