Unified Risk-Based Assessment Framework to Assess Sustainability and Resiliency of Civil Infrastructure

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Abstract
Sustainable development, which measures the impact on the environment, economy, and society has become a major focus in research. Civil infrastructure inherently has a direct connection with all three aspects of sustainability. As major climate events pose a threat to infrastructure, the potentiality of failure may increase with non-robust designs. In consideration of risk, as well as the need for sustainable development, a holistic assessment method is required to measure the quality of civil infrastructure. Proposed here is a unified assessment method that balances the resiliency and sustainability of civil infrastructure by the risk of occurrence of catastrophic events.
Sustainability Calculations - Performed static analysis on earthen dam • Measured volume of material based on geometry of dam • Computed environmental, social, and economic impacts All sustainability impacts related as annual worth over the design life of the dam, and summed together as one index value.

Environmental impacts: Used known power and resource requirements from models Developed, generated by manufacturer for total potential to water based on EPA emission standards which are harmonic (within ±5%).

Socioeconomic impacts: Impacts based on historical data. Constructor costs = $3.5 million in 1999. Average material costs = $4.5 million in 1999. Average inflation rate = 3.5%. Design life of all components is 100 years. Calculated using the conversion factor of $7.1. 

Economic impacts: Economic impacts are expressed in US dollars. 

Resiliency Calculations: Performed static analysis on earthen dam • Measured volume of material based on geometry of dam • Computed environmental, social, and economic impacts All resiliency impacts related as annual worth over the design life of the dam, and summed together as one index value.

Environmental impacts: Used known power and resource requirements from models Developed, generated by manufacturer for total potential to water based on EPA emission standards which are harmonic (within ±5%).

Socioeconomic impacts: Impacts based on historical data. Constructor costs = $3.5 million in 1999. Average material costs = $4.5 million in 1999. Average inflation rate = 3.5%. Design life of all components is 100 years. Calculated using the conversion factor of $7.1. 

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Model: Obtained material properties for Lucky Peak earthen dam from the U.S. Army Corps of Engineers. Probabilistic analysis was used to vary the material properties. Modeled earthquakes to simulate most probable seismic activity at Lucky Peak.

Model Availability: Consists of natural states - Static State - Squeeze - Slope Stability - Static Analysis - Dynamic Analysis - Physical Properties Analysis - Random Data Fitting

Model Outputs: Clay Layer Random Layer Shell Layer Porous Layer

Hazard Analysis: Potential hazards were determined based on location of the dam. Earthquakes were analyzed as a need to cause failure. Probability of occurrence of Peak Horizontal Acceleration (PHA) for various earthquakes were obtained from the U.S. Geological Survey. Relations between PHA and magnitude of earthquake were made by use of the Modified Mercalli Intensity scale to associate Peak Horizontal Acceleration (USGS 2002). 

Results: Results from all resiliency indexes were summed scaled to range from (-20,20), and results were plotted on a risk-type graph.

Future Work: • Framework exhibits a rigorous method that is more robust and can be used to assess the probability of the assessment framework. • Monte Carlo simulations will be performed on variability of sustainability impact values. • All index values will be imputed at single index value.