International Doctorate in Civil and Environmental Engineering

A hierarchy of models for the seismic assessment of concrete gravity dams

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Abstract

Concrete gravity dams represent a relevant part of the more than 540 large dams existing in Italy. Many of them are affected by material ageing, often were not designed to withstand seismic actions or were built in regions classified as seismic in a later time. Large dams are strategic structures and their damage, or even worse, collapse could result in a huge cost to the community, also in terms of loss of life. Seismic safety evaluation of a gravity dam is a matter of high complexity, because it involves interacting and nonlinear phenomena that are extremely burdensome to be accounted for in a model. International standard codes and guidelines do not provide neither clear analysis methods nor consistent assessment procedures.

This project is focused on the definition of a hierarchy of models with decreasing complexity degree, that can capture the essential aspects of the seismic behaviour of a concrete gravity dam. The relationship between model classes can be calibrated by means of information provided by the monitoring system within a Bayesian framework. The goal is that to minimize the computational burden in assessing structural fragility, without losing fundamental information.

In this context, the project has three main objectives. In the first part, different geometric models of concrete gravity dams (3D model, 2D model, "single slice" model, beam model) are studied with the aim of quantifying how much geometric simplification affects the results, in order to define a balanced hierarchy between derivable information and computational burden. Special attention is addressed to the evaluation of dam concrete damage during seismic shaking to assess both its effects within the interacting system, and

the post-seismic behaviour of the dam. In this regard, the accurate selection of the constitutive law among those proposed in literature was done and sensitivity analysis are conducted in order to define which constitutive parameters influence more the output of models. Finally, considering complex three-dimensional models, simplifications of the geometry of the dam and the basin, and interaction phenomena are proposed and evaluated through sensitivity analysis.