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Probabilistic model for the representation of the reservoir water level of concrete dams during normal operation periods

Renato Pereira · António Lopes Batista · Luís Canhoto Neves

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Abstract The dam's reservoir water level varies over the year according to the water inflow and outflow, as a function of environmental events but also of dam exploitation management policy and human decisions.

In the Portuguese dam safety regulation, the normal water level (NWL) is considered as the optimum exploitation level. However, as proved by the continuous monitoring over the lifetime of a set of dams, the NWL is occasionally exceeded for non-negligible time periods.

The reservoir water level, to which the water pressure on the upstream face is related, is a fundamental parameter for the safety and reliability analysis of concrete dams. When water-induced actions are considering the leading loads, only the maximum reservoir water level, usually associated with a high-return-period flood, is relevant. However, for other combinations, in particular, earthquake scenarios, the consideration of the variability of the water level over time is crucial.

In reliability analysis of concrete dams, the reservoir water level has been considered either as a deterministic variable, once the loading scenario analysed assume water-induced actions as leading loads, or as a random variable defined using hydrological site information of a specific study case.

Renato Pereira
Departamento de Engenharia Civil, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Quinta da Torre, 2829-516, Caparica, Portugal
Tel.: +351-21-2948580
Fax: +351-21-2948398
E-mail: r.pereira@campus.fct.unl.pt

António Lopes Batista
Departamento de Barragens de Betão, Laboratório Nacional de Engenharia Civil, Av. Brasil 101, 1700-066, Lisboa, Portugal

Luís Canhoto Neves
Department of Civil Engineering, University of Nottingham, University Park, Nottingham NG7 2RD, United Kingdom

This work proposes a probabilistic model of the reservoir water level of any new dam based only on its geometrical properties, which provides a low-cost alternative to in-depth hydrological analysis. The proposed model can be useful in two stages of the lifecycle of dams: (i) initial design and feasibility stages, and (ii) routine safety assessment of existing structures, as in both stages the costs of a complete hydrological analysis is too high for the level of detail required.

For that, the recorded reservoir water level of 27 Portuguese large concrete dams is used. A normalized sinusoidal model, with annual period, is adjusted to the reservoir water level annual history of those dams by beta regression. Generally, a good agreement between observations and the proposed model, for most of the annual adjustments, was achieved.

The distribution parameters of the random variables were estimated through the maximum likelihood estimation (MLE) method. The physical, model and statistical uncertainties were quantified and can now be included in a reliability analysis procedure.

Keywords Concrete dams · Reservoir water level · Monitoring · Uncertainty modelling · Reliability analysis