

Development of hybrid HST-FE models for effects separation and deterioration assessment of concrete dams

Summary

This thesis presents novel developments in HST (Hydrostatic, Seasonal and Time effects) models for analysing concrete dam behaviour over time. The research introduces innovative hybrid HST-FE models (Hydrostatic, Seasonal, Viscoelastic and Time effects using Finite Element results) to better quantify time-related effects, particularly those associated with concrete swelling pathologies. The proposed methodology integrates traditional HST models with finite element analysis, enabling the separation of different time effects. This approach incorporates creep/relaxation functions to identify elastic and viscoelastic effects related to the hydrostatic pressure variations, the self-weight, seasonal temperature changes, and evolutionary pathological actions like concrete swelling.

In the analysis of displacement fields, both vertical and radial components are considered through the proposed models. The methodology distinctly accounts for creep effects associated with self-weight and hydrostatic pressure, where finite element models are specifically employed to estimate the elastic response due to self-weight. This allows for a more accurate separation of the various time-dependent effects, particularly in identifying the contribution of each loading condition to the overall structural response.

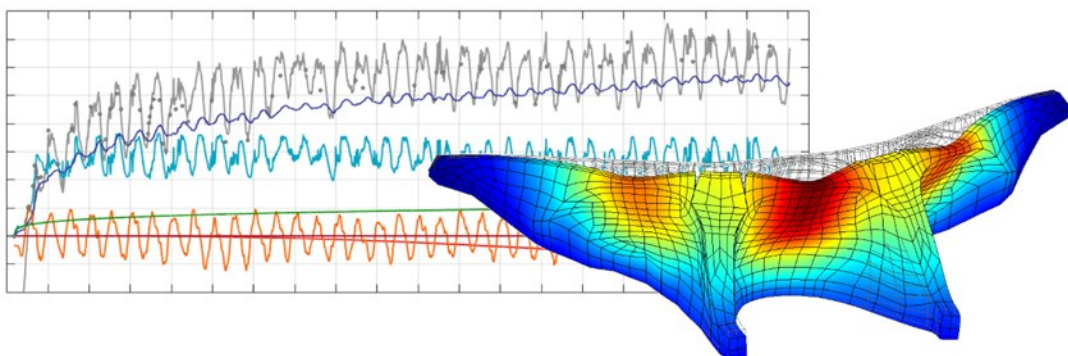
The research extends to analysing deformations measured in strainmeter groups, with new HST-FE models capable of determining stress histories while considering the tensorial nature of deformations and stresses. These models can separately track the time evolution of stress components associated with swelling action and stresses due to hydrostatic pressure and temperature variations.

The application of classical HST models has been extended to analyse natural frequency histories obtained through continuous dynamic monitoring. These frequencies are determined through spectral analysis of the acceleration records collected by the installed monitoring systems, providing valuable information about the global structural behaviour. This approach enables the identification of potential variations in the dam's dynamic properties, which can be indicators of structural changes or deterioration processes.

The methodology's effectiveness is demonstrated through three case studies: the Aguieira dam (89m high, three double-curved arches with low swelling), the Cabril dam (132m high, double-curved arch with significant horizontal cracking and moderate/low swelling), and the Cahora Bassa dam (170m high, thin double-curvature arch with moderate/high swelling). These cases present complex challenges, including integrated analyses of displacements, strains/stresses and natural frequencies.

Keywords

Large concrete dams, HST-FE hybrid models, Separation of effects models, Swelling effects, Viscoelastic effects.



HST separation of effects results and finite elements model results.



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Period

2016-2025

Funding

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