Damage-based simulation of AAR mechanical effects in concrete dams

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In this communication a damage model is proposed for simulation of the swelling phenomena and the deterioration of local stiffness and strength in concrete due to the alkali-aggregate reaction (AAR).

Concrete affected by AAR is conceived herein as a material heterogeneous at the meso-scale, constituted of two elastic-damageable phases acting in parallel, i.e. the gel produced by the chemical reaction (with vanishing shear stiffness, like a fluid) and the concrete matrix [1]. The gel phase exhibits a volumetric expansion in time, generating self-equilibrated stresses at the meso-scale also in the absence of external loading. Under the hypothesis of full saturation, the evolution of AAR processes depends locally only on the temperature history. The response of the concrete matrix phase to the mesoscopic stresses is described by a suitably adapted version of a previously developed isotropic "bi-dissipative" damage model [2] for concrete.

The model proposed herein has been first validated on the basis of the laboratory tests reported in [3]. Then, the model has been used for the 2D analysis of a concrete gravity dam affected by AAR. A preliminary transient heat-diffusion analysis, with imposed boundary temperatures, is required to compute within the dam the temperature field as a function of time, and, therefore, the local evolution of AAR swelling. The mechanical analysis with the proposed damage model is decoupled from the previous thermal diffusion problem, and is intended to simulate the structural effects of AAR within a dam along several years in service conditions.

In view of engineering applications, the evolution in time of the damage pattern within the dam, and the consequent possible reduction of the safety factor against collapse due to an "over-topping" wave, are analysed and critically discussed.

References

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