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Titre:

Application of SFEM to describe concrete's cracking and ageing in Nuclear Containment Buildings

Abstract:

Being a heterogeneous and multiphasic material, concrete properties show intrinsically spatio-temporel variations (in addition to epistemic and ontological ones related to the mixing, casting and curing processes). For large reinforced and prestressed concrete structures such as Nuclear Containment Buildings (NCB), these variations directly affect the kinetic of their ageing process in terms of cracking, drying, creep and tightness. They also lead, within the structure's volume, to a non-negligible spatial heterogeneousness of the concrete's behaviour to the applied Thermo-Hydro-Mechanical (THM) loads during the operational lifespan. Consequently, and for strategic structures such as NCBs, the introduction of such variations in numerical models is a mandatory step to enhance the assessment of their present behaviour and the accuracy of predictive analyses of their future one. Eventually, accounting for such uncertainties whilst performing THM FE analysis should help operators of strategic civil engineering structures to better define their anticipative repair and maintenance schedules based on predictive analyses and history dependent risk assessment.

In this context, the aim of this contribution is to suggest a global coupling strategy of THM models and Stochastic approaches adapted for the strongly non-linear and time consuming simulations of NCBs and for the large number of inputs they require (more than 50 parameters). After giving a brief description of the used THM models, the general stochastic analysis strategy is detailed: (a) a 1st order variance-based analysis is performed to select the most important parameters per THM calculation step (b) for a reduced number of parameters, the probabilistic coupling is achieved using non-intrusive methods. Particularly, concrete cracking patterns are defined according to a stochastic size effect law and a regularized, local and damage-based model. The spatial heterogeneity of concrete's properties (Young's modulus, tensile strength, etc) is described at the Representative Structural Volume scale (to minimize the computational cost) using Random Fields and the ageing effects on concrete's long term behaviour (uncertainties propagation) is assessed using methods such as: perturbation/quadrature methods and projection methods namely the polynomial chaos expansion approaches. Finally, the CDFs of the considered variables of interest (peak temperature at early age, water content, number of cracks, strains/stresses, air leakage rate) are sought.