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AN ALTERNATIVE FORMULATION FOR SORPTION ISOTHERMS FOR MODELLING CONCRETE AT ELEVATED TEMPERATURES

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An understanding of and an ability to analyse and assess the transport of moisture in cementitious materials exposed to elevated temperatures is very important in order to confidently predict the performance of these materials in safety critical applications including, for example, concrete structures exposed to fire, nuclear reactor vessels and well bore grouts. Specific behaviours associated with moisture movement and related to temperature include shrinkage, creep and ultimately the development of damage and fractures, all of which can lead to failures.

A key element in the behaviour of moisture within these porous materials is the equilibrium relationship between the water content and relative humidity, known as the water retention curve or sorption isotherm. These curves are dependent on several parameters including the pore structure of the material and the temperature.

To address these needs a novel formulation to describe the sorption isotherms as a function of temperature and based on the evolution of physical parameters is presented. The formulation considers both physical properties of the fluid (water) and of the concrete micro-structure. Although some of the considerations remain empirical they are based on experimental observations and are linked directly with the concrete material model and thus remain consistent with the overall representation of the concrete, no matter what material is represented.

The model formulation is successfully validated analytically against independent sets of experimental data up to temperatures of 80°C.

Implementation of the formulation into a fully coupled hygro-thermo-mechanical finite element model then allows further numerical validation through the reproduction of laboratory experiments. To verify the implementation and to act as a control experiment an isothermal drying problem is first considered. Then the seamless extension of the formulation to high temperature conditions is demonstrated through the analysis of laboratory tests representative of furnace temperatures (around 600°C).

The new formulation is found to work well under a variety of conditions in a variety of cementitious material types. Examination of the results further reveals the importance of understanding the thermal evolution of the micro-structure, and its effects on permeability and porosity in particular and the need to accurately represent these parameters in such models.