Non-Fickian sorption behavior of water vapor in cement based materials

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Abstract

The transport (diffusion) and sorption behavior of a material is normally quantified in terms of a transport coefficient and a sorption isotherm. Such a description is, however, simplified and may need to be complemented by more advanced models. For example is the transport coefficient a function of the concentration of the diffusing species, and there is often a significant hysteresis in the sorption isotherm, as well as complex scanning behavior under varying external vapor conditions. To add to the complexity of sorption processes, one of the more intriguing aspects of transport and sorption is non-Fickian behavior. This term refers to anomalous sorption behavior caused by local non-equilibrium in a material (it does not include odd behavior caused by external mass transfer resistance, hysteresis/scanning, or concentration dependent transport coefficients). For water vapor sorption into a porous material 'local non-equilibrium' means that it takes time for the moisture content of a small part of a material to reach the level that corresponds to the relative humidity in the pore system of that small part. Two possible models of non-Fickian behavior are multi-level transport coefficients and local mechanical relaxation.

Non-Fickan behavior has been extensively studied for natural and synthetic polymers. For polymers a classification of different extreme types of non-Fickan behavior has been developed; there is for example a Case II in which a linear mass uptake is seen (mass uptake is normally proportional to the square root of time). For wood, non-Fickian behavior is seen as a slow (or extremely slow) attainment of equilibrium in experiments with step-wise increasing relative humidity.

For cement based materials, non-Fickian behavior has sometimes been proposed as an explanation to unexpected experimental results, but it is often difficult to differ between the influence of non-Fickian behavior and the effects of for example external mass transfer coefficients and leaking sample containers. We have made long-term sorption experiments on different cement based materials in different humidity ranges under well controlled conditions and have studied the results from the point-of-view of possible non-Fickian behavior. The results of these studies will be presented.