UNIVERSITY of HOUSTON

CULLEN COLLEGE of ENGINEERING
Department of Civil & Environmental Engineering

CIVE 6111 Graduate Seminar Series

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Hysteresis from Multiscale Porosity: Water Sorption and Shrinkage in Cement Paste

Monday, November 3, 2014
10:30 am - 11:30 am
Room: D3 W205

Abstract

Cement paste has a complex distribution of water-filled pores and molecular-scale water-filled spaces. This distribution controls the hysteresis of water sorption isotherms and associated bulk dimensional changes (shrinkage). We focus on two locations of evaporable water within the fine structure of pastes, each having unique properties, and we present applied physics models that capture the hysteresis by dividing drying and rewetting into two related regimes based on relative humidity (RH). We show that a continuum model, incorporating a pore-blocking mechanism for desorption and equilibrium thermodynamics for adsorption, explains well the sorption hysteresis for a paste that remains above 25% RH. In addition, we show with molecular models that water in spaces of < 1 nm width evaporates below 15% RH, but re-enters throughout the entire RH range. This water is responsible for a drying shrinkage hysteresis similar to that of clays but opposite in direction to typical mesoporous glass. Combining the models of these two regimes allows the entire drying and rewetting hysteresis to be reproduced accurately, and provides parameters that can be used to predict drying shrinkage and hysteretic swelling. New strategies for quantitative analyses of the microstructure of cement paste, based on this mesoscale physical model of water dynamics, are discussed.

About the speaker:

Dr. Hamlin Jennings is adjunct professor in the Department of Civil and Environmental Engineering at MIT. From 1987 to 2010, he was professor in the Departments of Civil and Environmental Engineering (a term as chair), and Materials Science and Engineering at Northwestern University. He received a BSc in physics from Tufts University and a PhD in Materials Science from Brown University, after which he spent a decade first at University of Cape Town and then at Imperial College London, followed by five years at NIST in the USA. Current research is focused on quantitative evaluation of the small-scale structure of cement based materials in a form that connects processing to properties. In particular a model referred to as the “colloid model” or CM has been developed that starts with 5 nm particles that tend to pack together in configurations with identifiable density and pore structure. These concepts have been expanded at MIT and are poised to enable new strategies for the evaluation and design of cement based materials.