Effects of Weathering on the Water and Gas Permeabilities of Porous Building Substrates

Laura Townsend
Environmental Engineering, School of Engineering, University of Vermont
33 Colchester Ave. Burlington VT 05405

Understanding the permeability of building materials is an important factor in studies of contaminant transport. Examples include contamination from fire, acid rain, and chemical and biological weapons. This research investigates the deterioration of porous building materials due to freeze-thaw cycling. Due to weathering, the surface permeability and macroscopic permeability of porous building substrates will be significantly different than that of unweathered substrates.

The materials tested in this study were Portland cement, a 5 ksi, and two 4 ksi compressive strength concretes, Arkose sandstone, Indiana limestone, and brick. Each sample was cored to produce five cylindrical specimens 2.75" in diameter and 3-5" in height.

The surface gas permeability was measured on the top surface of these specimens using the AutoScan II device manufactured by New England Research, Inc. of White River Junction, VT. The measurements were taken along a 3 mm grid producing a map of surface gas permeability.

The macroscopic gas permeability and hydraulic conductivity were measured for all specimens in general accordance with ASTM standards D4525 and D5084, respectively. The cored samples were then exposed to freezing and thawing cycles in general accordance to ASTM C666 in a Model SD-505 mechanical refrigeration chamber from Associated Environmental Systems. The specimens were exposed to intervals of 30 freeze-thaw cycles with the permeability testing carried out after each interval. Subsequently the specimens continued to be exposed to freeze-thaw intervals for an additional 120 cycles, or until they were degraded beyond testability.

It was found that the freeze-thaw degradation could significantly affect both the surface and macroscopic permeability of the studied building materials. Building substrates with initial low permeability were the least susceptible to freeze-thaw degradation. Those with initially modest or high permeability were significantly affected and their permeability increased considerably throughout the freeze-thaw cycles. The surface permeability was found to have a strong influence on the rate of degradation. It is reasonable to anticipate that if building substrates exhibit increased levels of deterioration due to weathering, contaminating agents may transport further into the substrate at a faster rate, allowing greater amounts of the contaminant to accumulate.