Approximating effective diffusivities of hazardous ions solidified in portland cement

Glen Taffinder, Aye Kyi and Bill Batchelor

Environmental and Water Resources Engineering Area, Department of Civil Engineering, Texas A & M University, College Station, TX 77843-3136 (USA)

Abstract

Solidification of hazardous waste using portland cement has attracted much attention in recent years as a hazardous waste disposal technology. However, leaching behavior of contaminants is not well understood. (Leaching of wastes from the portland cement matrix can be characterized with a numerical model.) Leaching is generally known to be resisted by both chemical and physical mechanisms. The physical mechanism is associated with reduced mobility caused by the structure of the solid matrix. Important characteristics of the solid are porosity and tortuosity.

Physical transport of contaminants through the solid matrix can be modeled by Fick's law of diffusion. Fick's law is based on the effective diffusivity, which depends only on physical factors such as molecular diffusion and pore structure. Effective diffusivity coefficients for hazardous ions in portland cement have not been determined, although observed diffusivities which combine physical and chemical mechanisms have been measured.

The MacMullin number relates effective diffusivity of an ion in free solution to the effective diffusivity of that ion in the pore structure of a solid. The MacMullin number is defined as follows:

$$Mn=\frac{C_P}{C_B}=\frac{D_M}{D_E} \quad (1)$$

where, C_P denotes the electrical conductivity of the porewater, C_B the electrical conductivity of the bulk solid, D_M the molecular or free solution diffusivity, and D_E the effective diffusivity.

The MacMullin number was determined for portland cement pastes at water-to-cement (w/c) ratios of 0.4 through 1.0 at 0.1 increments at curing times of 7, 28, and 90 days. The results indicate that the MacMullin number; (1) decreases as the w/c ratio increases, and (2) increases with time for a given w/c ratio.