Doubling the Life of Concrete Structures

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ABSTRACT:

All commercial nuclear power plants in the United States have concrete structures. Nuclear power plants and dry storage systems will be more economical if their service life can be reliably designed for a life span of longer than 60 years. Transport properties are crucial to the durability of concrete. Improvement of transport properties will pave the way to the development of "superior concrete" identified in the Topic FC-4.1 Storage.

All properties of concrete depend on its microstructure. Durability of concrete in particular depends on transport properties of concrete. Thermal cracking results from high internal temperature gradient, which depends on the rate of heat conduction in concrete; drying shrinkage cracking is caused by high internal moisture gradient, which depends on moisture transport in concrete; and corrosion of reinforcement bars is due to high chloride concentration in pore solution of cement paste, which depends on chloride transport in concrete. For concrete structures in cold regions, freeze/thaw resistance of concrete is especially important—improperly air-entrained concrete can be damaged by the formation of ice in the internal pores of concrete.

This project will focus on the study of transport properties of concrete and their improvement, in order to prolong service life of dry storage systems. The other important effort is to improve the measurement techniques for transport properties of concrete. Several new and nondestructive methods will be developed for this purpose.

The main objective of the proposed research is to develop methods for doubling the service life of concrete structures. The nanoscale viscosity modifiers will be used to control transport phenomena in the conductive pathways. The selected representatives are glycerol and propylene glycol, among polyols, and triethanolamine and triisopropanolamine, among alkanolamines. While viscosity modifiers will be responsible for transport properties of pore solution, another mechanism to be explored will be the reduction of pore volume by addition of nano SiO2, a nano-filler/nano-pozzolanic promoter among particles of C-S-H gel.

The project will study the effect of temperature load and temperature cycling (freezing and thawing) on the conductive pathways, as well as the combined effect of temperature, moisture, and strong wind on durability of concrete.

It will exploit the DC, AC electrochemistry (EIS), and Scanning Probe Electrochemical Techniques in the methods for non-destructive evaluation of concrete performance, i.e., evaluation of concrete microstructure (conductive pathways), and hydration mechanisms. Although the power of scanning probe electrochemistry to study the transport properties of materials is starting to be recognized, it has not yet been used for characterization of concrete.