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Development of Non-destructive Methods for Detection of Alkali Silica Reaction in Concrete Structures

Alexander Heifetz, Sasan Bakhtiari, Igor Aronson, Valerii Vinokour, and Juan Lu, Argonne, National Laboratory, 9700 S. Cass Avenue, Argonne, IL 60439-4825; Anthony Bentivegna, CTL Group, 5400 Old Orchard Road, Skokie, IL 60077-1030

Concrete deterioration due to damage from alkali silica reaction (ASR) is one of the most common causes of concern for aging of thick concrete structures. Damage caused by ASR gel formation and expansion typically takes 25 to 50 years to develop into visible cracks in concrete, which could undermine structural integrity. Non-destructive detection of ASR damage at early stages requires the ability to sense the presence of ASR gel, and possibly small cracks, well inside the thick concrete structure. Currently, there are no standard non-destructive testing methods for in-situ detection and monitoring of ASR. Existing assessments of ASR in concrete mixes are based on length expansion measurements in accelerated testing of small concrete specimens, and petrographic imaging of concrete sections. In this paper, we report preliminary results of evaluating a microwave non-destructive testing method for in-situ detection of ASR. Using vector network analyzer (VNA), we have performed preliminary laboratory measurements of microwave transmission through concrete cylinders up to K-band (18GHz to 26.5GHz). Higher frequency microwaves can have wavelengths comparable to the size of aggregates inside concrete, thus enabling high resolution sensing of internal material structures. However, the smaller depth of penetration at higher frequencies limits the ability of the technique to probe through thick concrete media. Spectrum of microwave transmission through concrete cylinders (up to one foot-long) containing coarse aggregate (up to 1.5” in size) has been recorded with signal level 10dB to 15dB above the VNA noise level. A measurement campaign has been developed for validation tests to be performed on concrete prism specimens with and without ASR. Such specimens are currently under preparation using reactive and reaction-inhibited concrete mixes. Experimental efforts are supported by developing models and performing computer simulations. Microwave propagation in concrete is modelled using finite-difference time-domain (FDTD) computational solution of Maxwell’s equations. In parallel, we are developing the models of ASR gel formation and concrete damage using phase field method.