Modeling Chloride Attack Degradation in Reinforced Concrete and Developing Artificial Neural Network Framework for Detection

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Concrete structures often interact with various chemical and physical degradation agents during their service life. One of the primary factors for concrete structural degradation relates to chloride attack. It alters the structural properties due to corrosion in reinforcement bars, loss of concrete-rebar bond, and cracks in concrete. Therefore, detection of concrete degradation at early stages can be quite valuable. In recent years, some frameworks that are developed based on simulation studies have shown that the chloride degradation can be modeled in three distinct phases over the life of a structure. However, most of these frameworks consider only uniform chloride concentration around the exterior surfaces of the structure. In this study, we develop a novel methodology to detect concrete degradation at early stages by utilizing the power of advanced chloride degradation simulations in conjunction with Deep Learning algorithms and sensor data.

The objective of this study is to first simulate the chloride attack and the corresponding degradation in concrete structures to understand the time-dependent behavior of degradation. It involves simulation of chloride ion diffusion followed by the expansion of corrosion products and finally modeling the crack damage in concrete. The concrete damage plasticity (CDP) model is used as a concrete constitutive model to simulate the time-dependent behavior of concrete degradation. Then, a simulation-based non-destructive testing analysis is carried out to generate sensor data. Lastly, the measured sensor data is used to develop a data-driven AI-based framework to detect degradation in concrete structures. This novel AI-based framework aims to detect both the location as well as the severity of concrete degradations caused by the long-term exposure to chloride ions.