A coupled chemical-mechanical approach to model biogenic sulfide corrosion in concrete sewer pipes

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ABSTRACT

This contribution focuses on the biochemical degradation of concrete sewer pipes, particularly on the influence of the chemical attack by sulfates on the load bearing capacity and durability of the system. The process under consideration is generally known as biogenic sulfide corrosion; this process is caused by bacteria of the genus *"Thio-oxidans"*, which can grow on the concrete surface above the wastewater level in relative acidic environments (Parker, 1945). These bacteria are able to oxidize sulfur compounds into sulfuric acid, which happens primarily at the tidal zones (Mori et al., 1991) and at the crown of the sewer pipe (Davis et al., 1998). Sulfuric acid may diffuse into the concrete pipe, whereby it typically reacts with the cement paste. The reaction products (gypsum and ettringite) only have limited structural properties, and eventually may lead to a loss of integrity of the cement paste itself. In addition, the reaction products introduce an expansive strain that may cause micro-cracking. This in turn influences the diffusive properties of the cement paste and further degrades the concrete section, until the system is no longer able to support the surrounding soil and collapses.

Some recent work focuses on the numerical simulation of the biochemical degradation process by mainly considering ettringite formation (Idiart et al., 2010; Cefis & Comi, 2017). In the present work the chemical description is enriched by coupling several (diffusion-)reaction equations via their reaction terms, whereby the main focus lies on the process of gypsum formation. The expansive nature of gypsum has been modeled by defining a chemical strain as a function of the gypsum concentration. In addition, the effects of chemical and mechanical degradation are accounted for in the model by introducing corresponding damage parameters in the governing constitutive equations. The numerical implementation of the model is carried within a finite element framework. The numerical simulations provide the concentration evolutions of the relevant chemical species across a sewer pipe cross-section, and demonstrate the capability of the model to adequately estimate the development of damage. This information is very useful for assessing the residual strength of the sewer pipe over time.

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