Peridynamics Modeling of Cement Fracture During Degradation

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Peridigm

Peridynamics (Peridigm)

- State-of-the-art fracture mechanics theory
- Nonlocal extension of classical solid mechanics
- Excels at modeling intersecting fractures

Degradation Reactions

Reactive-Diffusive Transport Model

- Focus on portlandite ($Ca(OH)_2$) dissolution (1-5 years)
- Diffusion driven hydration
- Linear degradation of material properties

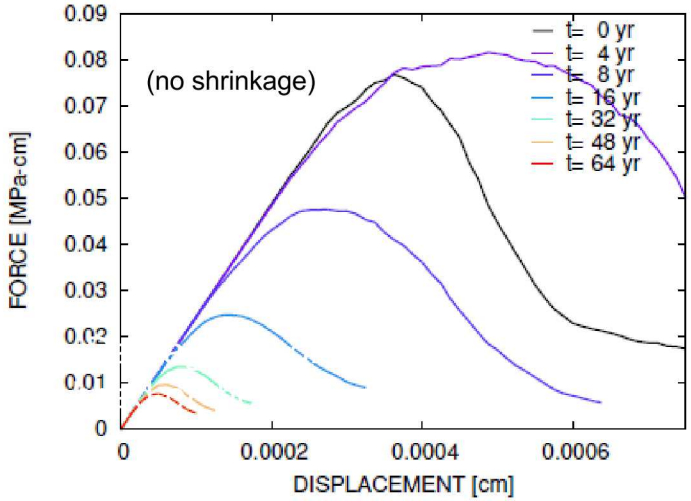
- Predictions of environmentally assisted fracture of cement that evolve with time and environmental/stress conditions
- Features of cement degradation are added to fracture simulations including changing: mechanical properties, diffusivity, reaction rate, shrinkage, porosity
- Calibration through flexural and compressive test specimens

$$\underline{\mathrm{Ca(OH^{-1})_2}} \leftrightarrow \mathrm{Ca^{+2}} + 2\mathrm{OH^{-1}}$$

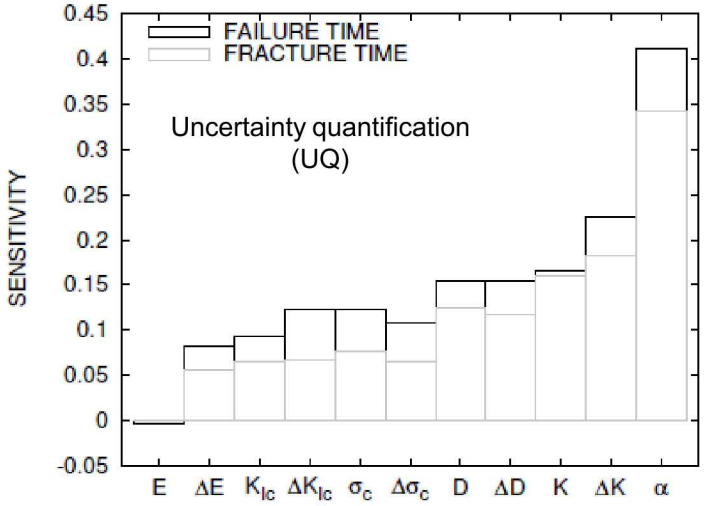
$$r = K_{\mathrm{fwd}}\, c_{\underline{\mathrm{Ca(OH^{-1})_2}}} - K_{\mathrm{rev}}\, c_{\mathrm{Ca^{+2}}}\, c^2_{\mathrm{OH^{-1}}}$$

$$\dot{c}_{\mathrm{Ca^{+2}}} = \nabla \cdot (D_{\mathrm{Ca^{+2}}} \nabla c_{\mathrm{Ca^{+2}}}) + r$$

$$\dot{c}_{\mathrm{OH^{-1}}} = \nabla \cdot (D_{\mathrm{OH^{-1}}} \nabla c_{\mathrm{OH^{-1}}}) + 2r$$



Change in force with loading duration to reach 0.001 cm applied displacement in the center of the specimen



Global (first order) sensitivities of time to fracture and failure to the selected material properties. Local sensitivities are given in years.