

Organic acid attack of hydrated cement

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Acid resistance is a required property for structural materials used in the aggressive environment of fermentation plants. Concrete resistance to sulphate or sea water is primarily discussed with regard to chemical durability whereas attack by organic acids has not attracted much attention.

This study was conducted on cement pastes made with three cements: 100% ordinary Portland cement (CEM I 42.5 R), 100% sulphate resistant Portland cement (CEM I 42.5 R-HS), and a mix of 85% ordinary Portland cement and 15% microsilica. The initial hardened cement paste specimens were cubes with an edge length of 30 mm. To compare the aggressiveness of different acids the cubes were immersed in solutions of four organic and three inorganic acids: formic, acetic, propionic, lactic as well as hydrochloric, sulphuric and nitric acid. The pHs were adjusted to 4.

The acid attack degradation process was analysed by X-Ray diffraction, 3D X-Ray computed tomography, and by colour values. Visual examination showed a significant colour change of the solutions: red orange by propionic acid, orange by acetic acid, and chartreuse by lactic acid. In the case of formic acid and the inorganic acids the solutions did remain unchanged and colourless. After 2 weeks, the samples immersed into organic acids were severely deteriorated whereas inorganic acids cause no significant change. 3D- μ XRCT images show that acetic acid is most aggressive by formation of two, well contrasted reaction layers (outer layer: 3 mm; inner layer: 2.3 mm). Using formic acid we observed layers of 0.8 mm and 0.7 mm, respectively. Propionic and lactic acids also generate layers in the mm-range. XRD analyses of the reaction layers provide mixtures of the three CaCO_3 modifications with amorphous phases: pure calcite by acetic acid attack, calcite plus aragonite by formic acid, and vaterite plus calcite by inorganic acid attack. The addition of microsilica reduces the thickness of the reaction zone. The application of sulphate resistant Portland cement improves the durability against formic acid and lactic acid only.