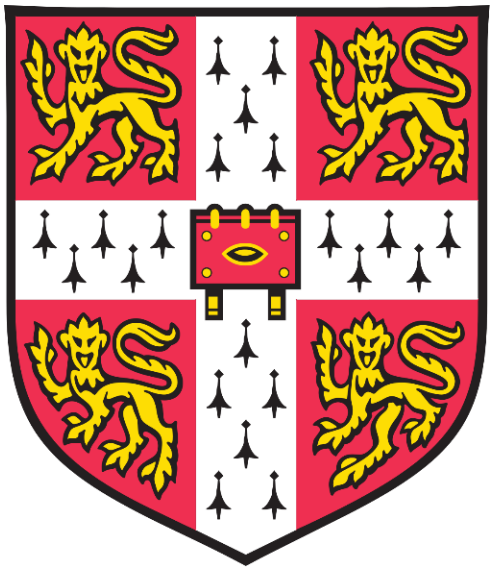
CRACK-RESISTANT AND SELF-HEALING CUT-OFF WALL MATERIALS INCORPORATING POLYMERS AND MINERALS



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Abstract

The contamination of soil and groundwater is a widespread issue that can adversely affect human health and ecosystems. The containment approach using cut-off walls is one of the most commonly-used land remediation technologies. However, the cut-off wall materials inevitably deteriorate under mechanical, chemical, and environmental stresses. The damage of cut-off walls can undermine their mechanical and transport properties, impacting their serviceability and reliability. This PhD research develops crack-resistant and self-healing cut-off wall materials incorporating polymers and minerals. The overall performance of four additives, including superabsorbent polymers (SAPs), oil sorbent polymers, reactive magnesia (MgO) pellets, and microencapsulated sodium silicate in two cut-off wall materials (cement-bentonite slurry and cement mixed soil) is the interest of this study.

In general, the addition of the SAPs and oil sorbents has negligible or only slightly adverse effects on the rheology, cement hydration, strength, and permeability of the cut-off wall materials. The crack resistance of cement-bentonite mixes is greatly improved by SAPs under wet-dry cycles, and the soil mix samples demonstrate enhanced self-healing performance thanks to the swelling of the SAPs. Similarly, the swelling of the oil sorbents managed to block 500μm-wide cracks completely, and the oil sorbent-containing samples show a marked recovery of permeability. The expansive hydration and carbonation of the MgO mineral also achieved effective healing by producing depositions and crystals on the crack surfaces of the cut-off wall materials. Microencapsulated sodium silicate, as another mineral healing agent, is released into cracks when the microcapsules rupture, and reacts with the cementitious matrix to fill and heal the cracks. The results demonstrate the improved average crack mouth healing and recovery of permeability provided by the microcapsules. X-ray microcomputed tomography and scanning electron microscopy were innovatively applied to investigate the self-healing process and mechanism. The microstructural analyses confirm the survivability, uniform dispersion, and crack-triggered rupture of the microcapsules, as well as the release of the healing agent and the generation of healing products within the cracks.

These results collectively demonstrate the great potential of these four polymer and mineral additives as crack-resistant and self-healing agents for cementitious cut-off wall materials, which could provide more resilient, sustainable, and reliable cut-off walls with significantly enhanced durability, reduced maintenance costs, enhanced safety, and protection against sudden or undetected failure.