

Extract From: "NOVEL COMPOSITE LANDFILL LINERS"

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Final Report for Phase 1a

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**This extract describes the mineralogy and chemical evolution
of a self-healing barrier in service**

5.4.4 Post-extraction examination of Cell 1

Fifteen months after construction, cell 1 was dismantled, as the site owners required the land for operational purposes. It had been intended that in the late stages of the project, the monitored cells would be cored by rotary drill, in order to provide samples for examination. As sufficient time was available, Cell No. 1 was emptied and dismantled using a mechanical digger, which allowed visual inspection of the component layers after service. A number of samples were recovered for microanalysis and particular attention was paid to collecting material from the interfaces between layers.

5.4.5.1 Top Layer Concrete, Cell 1

The borate slag binder seems has produced a perfectly adequate paste-aggregate bond with the ferrosilicate slag used as a fine aggregate. The slag (opaque in figure 53) shows no signs of reaction with the binder or of other deterioration at the interface.

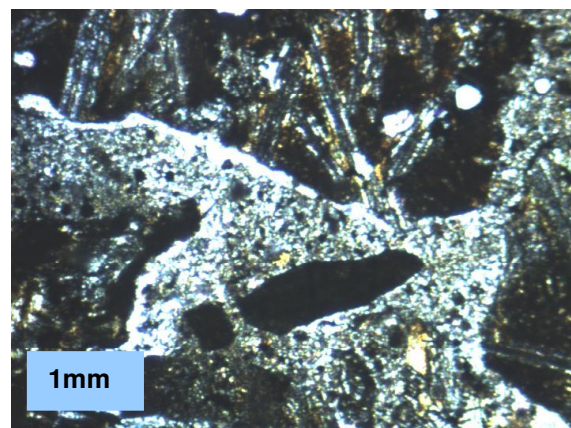
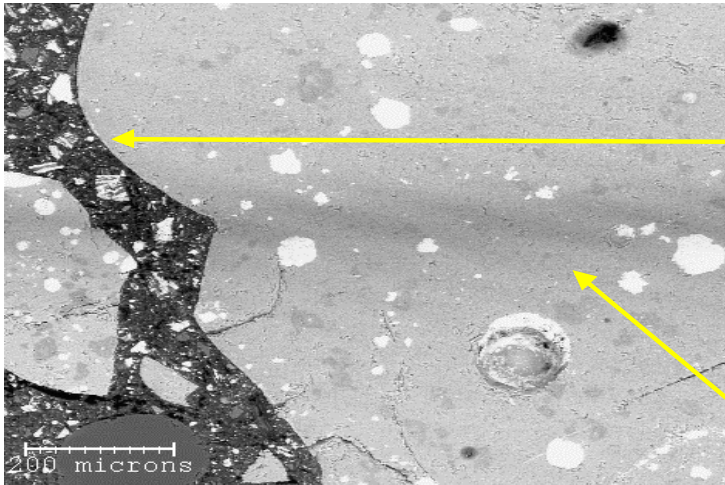


Figure 53 Optical thin section through top layer concrete after dismantling of Cell 1

By comparison, the interface between the borate slag and the limestone (coarse) aggregate shows some evidence of dissolution at the surface of the limestone. It would seem reasonable to expect this porosity to be filled by calcium diborate

dihydrate, owing to the very low solubility of this phase and indeed this is partly the case (figure 54). Surprisingly, however, the compound is seen lining pores within the hydrated borate binder matrix, suggesting that calcium ions were, at some stage, sufficiently mobile to migrate away from the paste-aggregate interface (figure 55).

The limestone aggregate shows only minor dissolution at its binder interface



The internal porosity of the limestone is fairly uniform at 13%

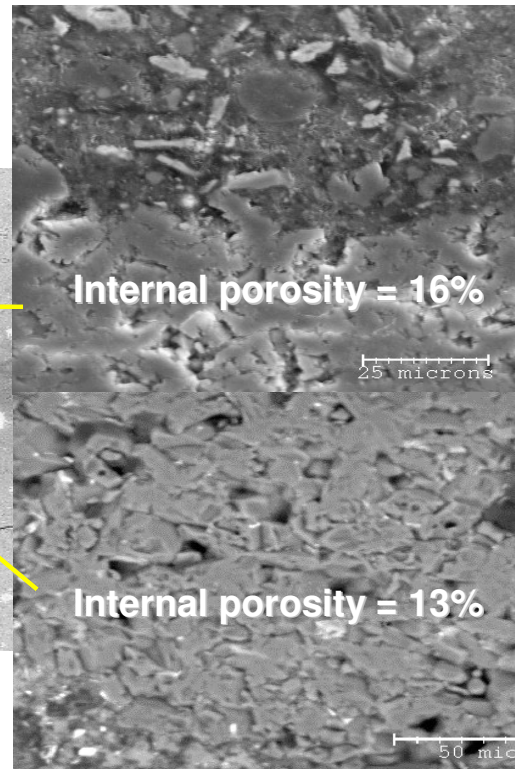
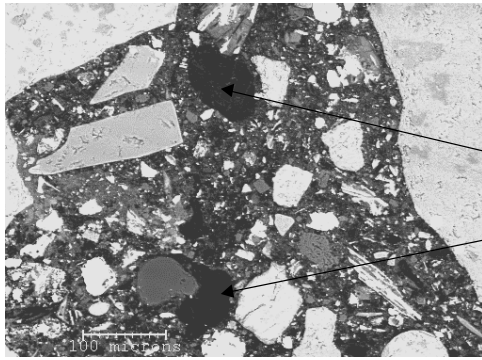


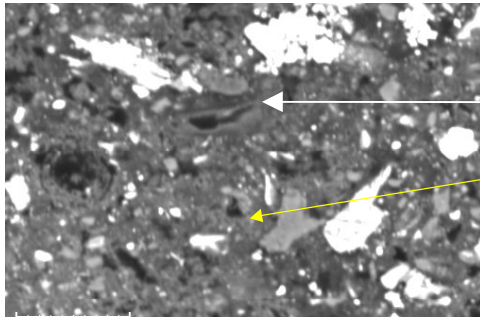
Figure 54 Interface between the borax slag binder and limestone aggregate in the upperconcrete of cell 1. SEM, polished section, backscattered image.

It is suggested that dissolution of the limestone by permeating leachate, released calcium ions to solution and that interaction of this limestone pore solution, with that typical of the borate binder, would result in rapid precipitation of calcium diborate. Where this occurred in the connective porosity of the binder, the pores were lined with precipitate which occluded the binder from the permeating solution. In this way, calcium ions were free to move away from the aggregate-binder interface, despite their high reactivity towards borate ions.

This model presumes two mutually reactive pore solutions co-exist at some stage in the evolution of the top layer concrete, forming a highly insoluble precipitate when they interact... This is supported by the presence of two types of porosity in the borate slag binder; one type with well developed pore linings of the precipitate, the other devoid of precipitate as shown in figure 55 below:



Formation of major dewatering channels in borate cement



Precipitation of calcium diborate dihydrate as a pore lining in the binder.

Calcium must be mobile

Figure 55 Porosity in top layer concrete. SEM, polished sections, Backscattered images

The upper most layer (approximately 35mm thick) of the borate slag concrete shows considerable reaction with the landfill leachate. The physical integrity of this reacted layer is similar to that lower in the concrete, where the leachate has presumably not permeated. This appears to be due to precipitation of a reaction product in the pore spaces and figures 56 to 58 show that there are two distinct reaction products. One compound forms encrusting, botryoidal masses on the surface of the borate slag, where it is remote from the limestone. This is a calcium-zinc salt of 1:1 stoichiometry, which suggests a hydroxy-carbonate, double carbonate or double hydroxide, such as a calcium zincate. The compound contains minor quantities of iron and aluminium and variable sodium content up to about 8 mol%. It is of course possible that the sodium is sorbed onto the phase, rather than structurally incorporated in it.

Our conclusion from this and other work is that by emplacing adjacent layers containing two sparingly soluble which are mutually reactive, it is possible to promote autogenous crack healing. The implications of this are far-reaching: Most cementitious media develop cracks at some scale during their service lives. Ensuring that, should solution-transfer occur through these cracks, it will carry a suitable reactive solute, passivation of the crack surface by mineral overgrowth is ensured.