Extract From: "NOVEL COMPOSITE LANDFILL LINERS"

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Final Report for Phase 1a

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INTRODUCTION

Project Background

This project concerns the transfer of technology developed for the underground storage of nuclear waste to the area of non-nuclear waste management. It focuses on the ability of a cementitious barrier to chemically condition liquid leachates, neutralising organic acids and reducing the mobility of priority pollutants such as transition metal ions and arsenic. This is similar to the way in which cement suppresses actinide leaching in the disposal of nuclear wastes.

Current Landfill Practice

Current landfill liner practice relies largely on the use of polymer membranes protected by sand or a sand-bentonite overpack. These protect the geosphere from release of leachates. Typically, such membranes are used below a geotextile layer which acts as a drainage blanket, allowing leachate to collect at a sump, prior to pumping and treatment. This construction is both expensive and vulnerable to puncture during its emplacement and susceptible to rupture during the operational phase of the landfill.

To protect the liner systems during waste emplacement, waste must be sorted to allow a layer of graded waste to protect the liner from sharp objects which may be present in the bulk of the waste. Waste sorting and emplacement of this so called 'fluff' layer of graded waste, adds to the operators' costs and leaves waste vulnerable to wind dispersal.

The new multi-layer barrier concept

This project is based on the theory that the pollution of soils and watercourses by the release of leachate may be prevented by adoption of a composite-barrier liner, which not only chemically conditions the waste, but is designed to be self-sealing through secondary mineralisation and will retain heavy metal ions through ion exchange, surface sorption, filtration and precipitation.

The properties of an ideal barrier system are:

- Low permeability. This must be less than 10^{-8} ms^{-1}.
- High cation exchange capacity
- The ability to chemically condition leachate through sacrificial action
- Construction from inexpensive materials
- Tolerance of deformation during service without barrier failure through brittle cracking
- The ability to promote self-sealing of cracks
- Ease of construction
- Sufficient strength to support a refuse vehicle during operation.

The design concept of the new composite landfill liners is to emplace a number of different layers, each of which compliments and enhances the behaviour of the others. Each of the layers has different properties, so that any defects such as cracks, are likely to form at different locations in different layers, thus limiting the creation of connected pathways through the barrier. In the design considered in this work, three layers are envisaged as illustrated in figure 2. The clay-based hydraulic barrier is sandwiched between two layers of concrete.

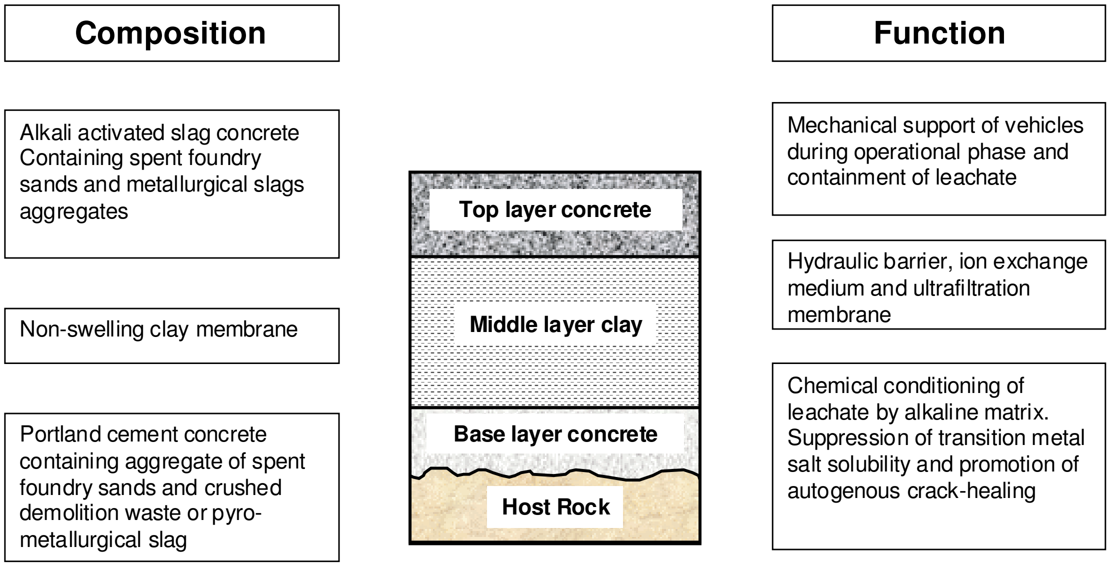

Figure 2: The new composite landfill liner.

1.3.1 The top concrete layer

The function of the top layer is:

- To provide a hard wearing surface to protect the lower layers from the effects of vehicular access, waste compaction and damage from sharp objects in the waste.
- To provide tensile strength in the barrier in order to resist damage from settlement during waste emplacement.
- To provide an initial barrier to leachate migration (enhanced by the crack sealing properties of the layer below).

The first two requirements are only necessary during the operational phase of the landfill. As this phase is relatively short, this layer will only be required to maintain its structural integrity for a short time. This offers the possibility of using waste materials such as metallurgical slags and spent foundry sands as concrete aggregates in this layer. Although neither material is suitable for use as an aggregate in structural concrete, owing either to slow reactivity with cement or poor bond strength with cement paste, both are suitable for this low-grade application. Co-disposal of demolition and metallurgical waste will suppress transition metal ion solubility by release of alkalinity from the cementitious binder, whilst offering an opportunity to re-cycle both waste streams with a genuine economic benefit. Currently, both these waste materials are disposed to landfill in Europe and the USA. In this project a novel, low-cost binder was used for the upper layer of the first site trial, containing Spent Borax which offers good bond strength with a range of poor quality aggregates.

1.3.2 The clay layer

The action of the middle layer is:

1) To greatly reduce the rate of mass transfer through the barrier by inherently low permeability and high cation exchange capacity.
2) To flow into fissures in the cementitious layers above and below, thus obviating the need for high quality, structural concrete.

Bentonite is not used for this layer because of its high cost and its loss of swelling properties in an alkaline environment. Unlike the swelling clays, kandites and illites are plentiful, relatively inexpensive and were used in this project in combination with concrete.

1.3.3 The lower concrete layer

The function of the lower layer is as follows:

- To provide a blinding layer giving a firm smooth base for the emplacement of the softer material in the middle layer.
- To provide a final chemical barrier to leachate migration by chemically condition solutions permeating through the liner.
- To provide a final physical barrier to leachate migration and promote crack healing through secondary mineralisation

In the first cell a low cost binder containing alkali activate slag (AAS) cement was used for the lower layer. The AAS concrete is known to hydrate relatively quickly in adverse chemical conditions (*e.g.* in the presence of clays and organics) and has a high ratio of strength to binder content. It may be activated by a range of alkali solutions and hence offers a suitable utilisation of alkaline industrial waste streams.

A mortar of zero cost was used for second site trial, containing Ferrosilicate slag sand, Cement Kiln Dust and Lagoon Ash. In addition a low cost binder containing no Portland cement binder and alkali activate slag was used for the lower concrete layer of the third cell.

OBJECTIVES OF OVERALL PROJECT (of which this phase -1a- is the first part)

The project seeks to minimise wastes from the metals and processing industries by applying them as alternative materials for use as landfill liners. To this end, a consortium of waste producers contributes to this project, under the management of the Mineral Industry Research Organisation, MIRO. In this phase the wastes arising from each partner's operation were analysed to assess their suitability for use as landfill liner materials. These wastes were then combined to produce novel composite landfill liners, which were investigated in the three field trial cells in a landfill site in Cheshire. The subsequent objectives of the project (phase 1b) are to refine its design where necessary and in collaboration with the regulatory authorities, encourage adoption of this new technology by the waste industry and landfill operators (see appendix 2). Phase two comprises a large scale trial and phase three is the full commercial application of the system.