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Investigations of geomembrane integrity within a 25-year old landfill capping

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ABSTRACT

Investigations have been undertaken at a 16 ha landfill capping to assess performance of the geomembrane component some 20–25 years after installation. The site has been the subject of quite extensive monitoring together with hydrological and other studies. Although environmental monitoring has shown no major concerns, there have been discrepancies in calculated water balance, leading to the recent investigations reported here. The capping, which is an interim solution, comprises about 1 m of cover soils over 0.375 mm LDPE geomembrane and surrounded by a perimeter drain. A robust final capping system will be constructed at a later date. Various remedial works were undertaken between 2010 and 2014 at the cap perimeter drains, also at a series of gas vent/probe holes through the geomembrane, to address the discrepancies in water balance, and the opportunity was taken to investigate the condition of the geomembrane which revealed a series of unanticipated gaps in the geomembrane. These investigations were subsequently extended over the whole cap to characterise the nature and extent of those defects and assess likely causes.

The series of investigations reported here represents a significant case history, one of relatively few, and which describes: the approaches adopted to pursue the series of investigations; the findings of that work; options considered to address the issues; lessons learnt and the intervention strategies which are under consideration in response. It also has implications for other landfill caps and highlights the importance of construction processes including construction quality assurance to ensure the integrity of geomembranes following placement is not adversely affected, also the need for good records management to assess system performance in service and plan future interventions.

1. Introduction

Investigations have been undertaken of a 16 ha interim cap at the UK's principal site for disposal of low level radioactive waste, known as Low Level Waste Repository, some 20–25 years after installation. These investigations, some of which were undertaken as precursors to phases of remedial works, were undertaken in stages over a number of years. The site has been the subject of quite extensive monitoring together with hydrological and other studies. Although environmental monitoring has shown no major concerns, there have been discrepancies in the calculated water balance. To better understand these discrepancies the investigation works described here have examined the integrity of the geomembrane of the capping system at particular locations: (i) near the perimeter drains as the adjacent geomembrane was exposed during remedial works to those drains, (ii) at gas vent probes through the capping to examine the gas vent-to-geomembrane connection and (iii) across the interim cap generally, with a focus on welds and tears. [This paper expands upon and updates Gallagher et al. (2015) which primarily reported on work in locations (ii) and (iii).]

1.1. Site setting

The site is situated on the coastal plain in north-west England, around 0.5 km from the Irish Sea coastline. A quite variable waste body was disposed on site from 1959 into a series of seven adjacent trenches (Trenches T1–7; Fig. 1 for cross section). Trenches T1–6 are typically about 5–8 m depth and trapezoidal in cross section; Trench

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7 is similar in depth but of variable width. The waste was tumble tipped into the trenches and covered, prior to installation of an interim cap system. The interim cap was constructed in two phases in 1988/89 (T1–6) and 1995 (T7). The purpose of the interim cap is to:

- minimise the percolation (or infiltration through the cap) of rainwater into the trenches;
- control the release of gases generated by waste decomposition; and
- provide a visually acceptable, protective cover for the trenches.

Design drawings show a multi-layer system, comprising bulk fill to profile, overlain by a low density polyethylene (LDPE) geomembrane, with a soil cover layer typically around 1.0 m over the geomembrane [The term 'LDPE' is used in this paper for the geomembrane, consistent with contemporaneous references (White Young, 1991); see also Section 2.1.1 for further discussion on the geomembrane classification]. The cap was profiled to a 1:25 batter with runoff to stone-filled perimeter drains, continuous around the whole of the trenches. A series of steel probes was driven through the cap into the trenches to provide passive gas venting, discussed further below. A significantly more robust final capping system will be constructed at a later date.

2. Investigation and remedial works

Investigations took place in 2010 to the geomembrane adjacent to the perimeter drain and in 2013–14 to the geomembrane on the remainder of the capping. These two stages of investigations are described below.

2.1. Investigations in 2010 of geomembrane adjacent to the perimeter drain

Surface water run-off from the interim trench cap is collected in trench cap perimeter drains and monitored at two gauges for the western and eastern parts, respectively. Detailed inspections associated with the annual monitoring had reported evidence of defects in these drains such that not all run-off was being collected and carried away, hence recharging the perimeter area groundwater. The entire trench cap perimeter drainage system was replaced in summer 2010. The original trapezoidal stone-filled channels were replaced with more efficient semi-circular open channel drains; this refurbishment led to at least a threefold increase in the volumes of waters being recorded during peak rainfall events due to a combination of more effective channelling of large flows and reduction in losses at the perimeter of the trenches.

During these remedial works the opportunity was taken to inspect the areas of the interim trench cap adjacent to the perimeter drains, exposed during the works. Fuller details are given below. In brief, the areas of the interim cap exposed were found to be in quite good condition considering the length of time for which it has been in place. The number of defects was moderate, consistent with a thin geomembrane without particular protection measures. Some more significant defects (tears) encountered were almost certainly the result of activity to expose the liner. The other main defects were a variable number of small holes, some of which may have been caused by exposing the liner, but most of which probably date back to construction. There was no particular evidence of deterioration with time.

Investigatory field work, comprising sampling of the LDPE geomembrane in the 5–10 m wide zone that was exposed during remedial works adjacent to and upslope of the perimeter drains, was conducted from late May to early July 2010, see Fig. 2. Samples of the LDPE geomembrane, typically 1 m × 1 m, were taken from adjacent to the cap perimeter drain at approximately 50 m intervals. The overlying soil material was removed using an excavator to expose the geomembrane as gently as practicable. Each sample was photographed and inspected for defects (holes, tears, dents and ripples) – these were counted and logged; refer Table 1. Geomembrane samples were tested to determine:

- Thickness (ASTM D5199);
- Density (ASTM D1505);
- Carbon black content (ASTM D1603);
- Tensile properties (ASTM D6693); and
- Notched constant tensile load (NCTL, ASTM D5397 – single point)

Three 1 m length samples of geomembrane welds were also obtained during the investigation and these samples were tested for shear and peel strength (5 coupons per sample length) to ASTM D6392.

Particle size distribution (PSD) tests to BS 1377: 1990: Part 2 (Methods 9.2 wet sieve and 9.4 pipette) were carried out on the soil materials directly above and below the liner from seven sample locations to determine the composition of the soil material and allow a comparison between the levels of damage (dents, holes etc.) of each geomembrane sample and the large particle content of the immediately adjacent soil. The PSD testing also allowed an assessment of any damage to the subgrade and overlying soils which may have occurred due to washout or similar.

2.1.1. Results of 2010 geomembrane testing

A total of 31 LDPE samples was taken for inspection of which 17 were sent for detailed laboratory testing. Results are summarised in Table 2 and discussed below.

The average thickness measurement (based on 31 field measurements with a micrometer and 17 laboratory tests) was 0.385 mm, with results ranging from 0.309 mm to 0.464 mm. The measured thickness generally exceeds the 0.375 mm thickness indicated in design drawings.

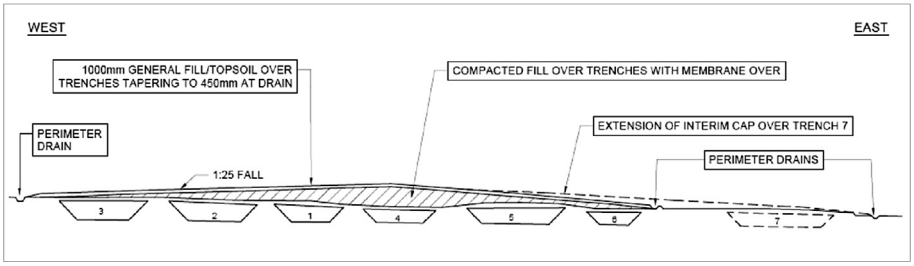

Fig. 1. Schematic cross section through Trenches 1 to 7 and interim capping. Not to scale.