Landfill Reclamation: Making Waste Work

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Landfills in UK

- Modern (built after mid 1980’s) – Engineered containment landfills

- Older (built before mid 1980’s) – Dilute and disperse landfills
  - Former quarries
  - Former valleys
  - Often located on permeable geology
  - No engineered containment
  - Operated via ‘controlled tipping’ using daily cover of soils

*Tipping waste at Packington Landfill, Birmingham in 1987 (former quarry)*
Why Reclaim Old Landfills

- Vertase FLI seeing a growing interest from clients to reclaim, dilute and disperse landfills

- Driven by development (residential, commercial and infrastructure)

- Has inherent environmental benefits regarding a reduction in pollution potential
How to Reclaim Old Landfills?

A SIMPLE WAY....
- Remove all the waste for off-site disposal
- Import inert soils/aggregate for use as backfill
- Involves many vehicle movements and significant disruption

A SUSTAINABLE WAY....
- Remove unsuitable waste for recycling / energy generation
  - Wood, paper, textiles, plastic, rubber, metal
- Retain suitable waste for re-use as backfill
  - Soils, brick, concrete, rock
- Supplement any shortfall with imported inert soils/aggregate
- Involves less off-site disposal, fewer vehicle movements, less disruption
Designing the Strategy

SOME THINGS TO KNOW:

- Volume of capping soils
- Volume of waste
- Age and composition of waste
  - Estimate of unsuitable waste
  - Estimate of suitable waste
- Chemical quality of solids
- Chemical quality of water
- Ground gas regime
- Ease of waste separation – based on trials
- Disposal outlets for unsuitable waste
- Density of unsuitable waste

Geophysical investigation of Emerson’s Green landfill by BGS
Designing the Strategy

TYPICAL STEPS

- Cap removal
- Dewatering
- Waste excavation
- Waste separation
- Waste processing
- Backfilling (with suitable waste)
- Disposal (of unsuitable waste)
- Import to construct final levels
Cap Removal

- Variable thickness
- Typically cohesive (where present)
- Can be retained for re-use on site
- Generally leave the lower 100mm to avoid cross contamination with waste
Dewatering

Sumps excavated into landfill waste to enable dewatering prior to excavation

Lagoon being constructed to hold abstracted water during treatment prior to discharge
Waste Excavation
Waste Excavation – The Extent

- The full depth of waste may not require excavation
- Older layers of wastes (pre-1960s) may contain less unsuitable materials (plastic and biodegradable)

<table>
<thead>
<tr>
<th>Capping</th>
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<tbody>
<tr>
<td>Younger waste deposited 1970s/80s</td>
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<tr>
<td>Older waste deposited pre-1960s</td>
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<tr>
<td>Natural geology</td>
</tr>
</tbody>
</table>

More granular fines, rubble, ash
More consolidated? Less settlement potential?
Waste Separation

PROCESSES
- Pre-screening by excavator
- Mechanical screening
  - Trommel
  - Vibratory screeners
- Density separation by air flow
  - Air knife
  - Windshifter
- Magnetic separation
  - Magnet belts
  - Eddy currents
- Manual sorting
- Density separation by soil washing
Waste Separation

Waste → Pre-Screening → Mechanical Screening → Soil Fines → Blending → General Fill

- Coarse
  - Density Separation by Air
    - Light plastic
  - Magnetic Separation
    - Metal
  - Manual sorting
    - Wood, textiles, other
    - Brick, concrete, rock
  - Crushing → Aggregate
Waste Separation

MECHANICAL SCREENING
Waste Separation

DENSITY SEPARATION BY AIR FLOW
Waste Separation

MANUAL SORTING
Waste Separation

PRODUCTION EFFICIENCY

- Very dependent on PSD of soil
- Soil behaves as the ‘binder’ for the waste
  - Generally slow when clay content >20% and material is wet
    - Clogging
    - Balling
  - Generally not viable during wet weather
Waste Processing

- Shredding
- Crushing
- Blending
Characteristics of Waste Soils/Aggregate

PHYSICAL

- Not viable to remove all undesirable materials (typically <10% undesirable remain)

- Generally high moisture content (>20%)

- Complies with grading of General Fill classifications in SHW Series 600
Characteristics of Waste Soils/Aggregate

**TOC**

- CL:AIRE RB17 Forensic Description Method for 10-15kg samples
- TOC in range 1 – 4% by mass

![Image of waste soils/aggregate with labels for fine soil <10mm, plastic, wood, textiles, metal, coarse >10mm]
Characteristics of Waste Soils/Aggregate

**CHEMICAL**

- Frequently ‘Non-Hazardous’ as per WM3

- Potentially aggressive to concrete (Design Sulphate Class DS-2 or higher)

- No obvious inhibiting conditions for bacterial growth

**Example data for soil fines separated from waste at Emerson’s Green landfill in Bristol**

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Units</th>
<th>Range (mean)</th>
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<tbody>
<tr>
<td>pH</td>
<td>SU</td>
<td>7.6 – 8.5 (8.0)</td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
<td>mg/kg</td>
<td>0.1 – 23 (4.2)</td>
</tr>
<tr>
<td>Total PAHs</td>
<td>mg/kg</td>
<td>13 – 400 (69)</td>
</tr>
<tr>
<td>Arsenic</td>
<td>mg/kg</td>
<td>15 – 27 (21)</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/kg</td>
<td>140 – 770 (360)</td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/kg</td>
<td>29 – 54 (41)</td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/kg</td>
<td>0.28 – 1.1 (0.5)</td>
</tr>
<tr>
<td>WS Sulphate</td>
<td>mg/L</td>
<td>19 – 1500 (1000)</td>
</tr>
</tbody>
</table>
Characteristics of Waste Soils/Aggregate

BIOLOGICAL

- In-house gas generation potential tests confirm active bacterial population
- Potential to generate high concentrations of ground gases (carbon dioxide and methane) over short time-scales
- Monitoring shows concentrations (and gas generation rate) decline reasonably quickly after placement
Characteristics of Other Wastes

ADHERING SOIL

Wood

Tyres

Plastic & Textiles
Backfilling

- NOT to be confused with landfilling / disposal

- Can undergo compaction as General Fill using methods in SHW Series 600

- Can achieve end-product specifications
  - ≥95% relative compaction
  - ≤5% air voids

- Typically capable of CBRs in the range 2 – 5%

- Re-use outside of building/road footprints where there is a need

- Can be used beneath buildings with appropriate foundation designs
LIME ADDITION

- Often wet of optimum moisture content
- Quicklime addition trials have demonstrated moisture content reduction
- Organic content can increase the lime requirement / reduce the lime effectiveness
Backfilling – Strength Improvement

PLASTIC ADDITION

- Much published research concluding that addition of LDPE strips into soils improve shear strength at lab scale
- Conducted some field trials with landfill-derived shredded plastic for R&D
- Difficult in practice due to irregularities in type, shape, and distribution of plastic added to soils

*Trial pad with waste plastic mixed at approximately 5% by volume*
Pathway Intervention

PATHWAY INTERVENTION

- Cover systems in gardens and open spaces
  - Manage exposure to contaminants below

- Ground gas protection measures in buildings
  - Typically CIRIA Characteristics Situation 3 – highest level of passive protection

Trial house plot fitted with CS3 protection measures at Emerson’s Green to monitor gas accumulation in sub-floor void and within
The Future for Landfill Reclamation

- It is clearly technically possible to use site-won waste as general fill when reclaiming historic landfills without posing unacceptable risks to sensitive receptors.

- Retaining materials on site has obvious environmental benefits (relative to off-site disposal).

- How this fits with Waste Legislation is still being explored:
  - Is the soil and aggregate a waste?
  - Is the activity waste recovery?
  - Is the activity waste disposal?
  - Can the site-won soil and aggregate cease to be waste?

- A demand for landfill reclamation exists, so Regulatory/Private Sector collaboration is needed.
Further Reading


  - Published on-line: June 11th 2020
  - [https://doi.org/10.1680/jenes.19.00022](https://doi.org/10.1680/jenes.19.00022)
  - Contact: dscott@vertasefli.co.uk