CASE STUDY:
TECHNICAL CHALLENGES AND AN INNOVATIVE RESPONSE TO LINING OVER EXISTING WASTEFILL (PIGGY-BACK)

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SUMMARY: Liner design on to an existing wastefill area.

The aim of this paper is to illustrate the practical and technical issues that BKS needed to address and the innovative thinking that was encompassed in the design of the lining system that was to piggy-back onto the existing wastefill area at the infamous Coastal Park landfill (G:L:B+) site.

The Coastal Park Landfill site falls within the South Peninsula Administration Area and is located approximately 8 km east of Muizenberg on the Cape Flats. It is situated south of Zeekoevlei and 400m from the False Bay coastline. The Cape Flats sewerage works is on the eastern side opposite the site and is separated from it by the Zeekoevlei canal that drains into False Bay. The Capricorn development borders the landfill site to the west. The site comprises an area of 75 ha of land in total.

The site is divided into two phases, namely Phase 1 and Phase 2. Wastefill took place in Phase 1 before the site was permitted. Since obtaining the permit, wastefill has been moved to the Phase 2 area. Phase 2 is the first lined area of the site in accordance with DWAF and DEAT requirements.

The existing wastefill is at least 10 years old with minimal treatment i.e. additional compaction, irrigation to aid settlement, etc., coupled with minimal historical data to use in the analysis. The depth of the wastefill is unknown. The depth of the wastefill lifts used to construct this old wastefill is unknown. The compaction efforts used in the past is unknown. Records of the material disposed into the old wastefill area are not available.

Design of the lining system onto the old wastefill pile involved aspects such as:

- Performance knowledge of the various liner types (geosynthetics) and options.
- Financial implications.
- Effects (movement) on the existing waste body upon placing a load onto the waste body.
- Liner requirements.
- Differential settlement.
- General settlement.
- Hydration of GCL’s using pure leachate.
- Slope design, slip slopes.
- Shear strength relationships.
- Interaction between the various synthetic liners, etc.

Initially the lining of the embankment was going to be an extension of the double lining system up a 1V:3H slope. Subsequent to a meeting with DWAF, the lining system was reduced to a single hydraulic barrier.

BKS then decided to reduce the grade to a 1V:6H slope to allow for earth moving machinery to travel on this embankment as the layer-works included sand drainage layers, natural mineral erosion protection layers, etc. By reducing the grade, many other required design investigations became redundant, due to a more-stable slope.

Two critical items needed to be addressed in this embankment design:

1. Settlement stability of the slope under load.
2. Guaranteed performance of the single hydraulic barrier.

Settlement of the wastefill embankment

Knowing the threat of large-scale settlement globally over the embankment and local differential settlement, the synthetic material types in the lining system were limited to flexible synthetic membranes. No clay is available nearby. Being the only hydraulic barrier, the choice was between HDPE, LLDPE, GCL and fPP. See comment below under, “Single hydraulic barrier.”

Due to the threat of differential settlement, and to achieve a functional hydraulic barrier, BKS incorporated three main items in the design, namely:

- **Initial compaction of the embankment.**

  It was a requirement of the contract to clear the embankment, ensure sufficient soil cover, send a 12 tonne vibratory roller up and down the embankment over 3 times and measure the settlement for information purposes.

  Table 1 : Settlement due to mechanical compaction

Strip #	SV	settlement	Average
1	10m 20m 30m	73mm 53mm 53mm	50mm
2	10m 20m 30m	65mm 53mm 67mm	
3	10m 20m 30m	47mm 38mm 50mm	
4	10m 20m 30m	22mm 27mm 53mm	

  The sand cover ranged from 220mm to 450mm over the waste body.

The aim was to compact the wastefill embankment as much as possible before installing the lining system.

- **Geosynthetic reinforcing grid.**

This is a product manufactured by Kaytech. It is a biaxial composite geosynthetic reinforcing grid, comprising high tenacity polyester yarn attached to a non-woven geotextile. The grid provides for high tensile strength at low strain, whilst the geotextile interacts with the sand-sized particles to mobilize the tensile strength of the grid. BKS decided to install a 100kN/m grid at 10% strain to reduce the effects of differential settlement. Apart from an anchor trench at the top of the embankment, the grid was placed simply (embedded) in the sandy subgrade layer.

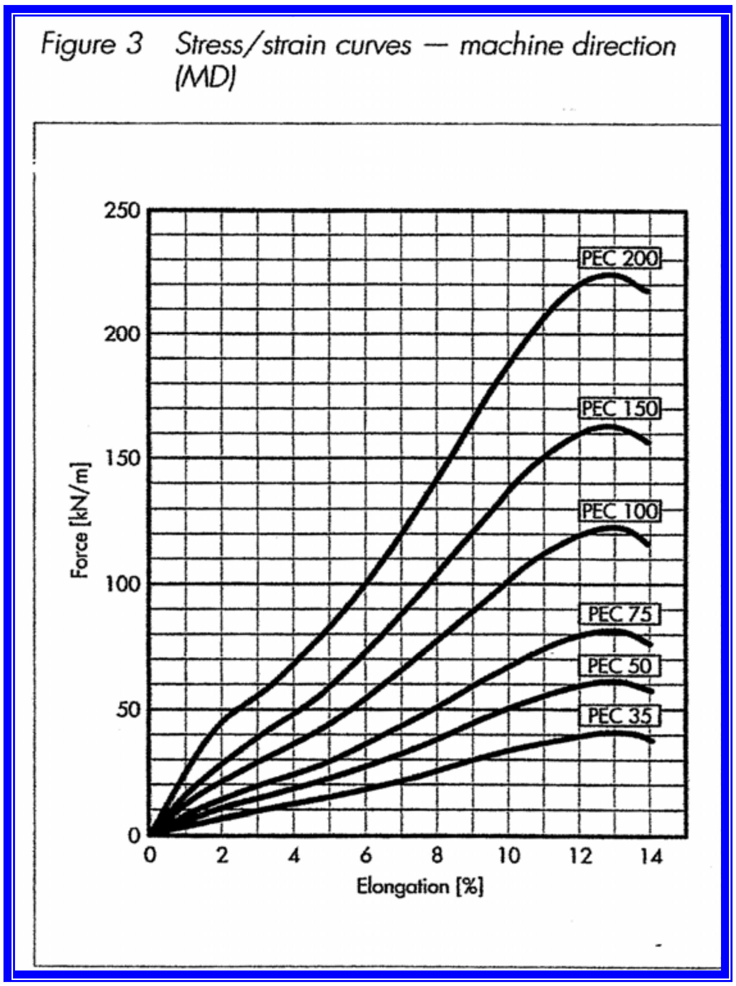


Figure 1 : Graph indicating the typical characteristics of the geosynthetic reinforcing grid

Photo 1 : Installing the grid.

- **Convex shape of the embankment.**

The design principal was to place the GCL to perform as a hydraulic barrier only and to not necessarily take up tensile stresses in the embankment. To help achieve this, over and above placing the grid (mentioned above) the following was also done:

Shaping of the embankment to a convex shape was done to take up general settlement whilst a geosynthetic reinforcing grid has been added to the subgrade to lessen any potential localised and general differential settlement. As settlement occurs, the geosynthetic reinforcing grid would start to strain and absorb the tensile stresses reducing settlement.
At the same time the convex shape of the fill slowly lost its shape whilst all this time the GCL remained under no real tensile stress.

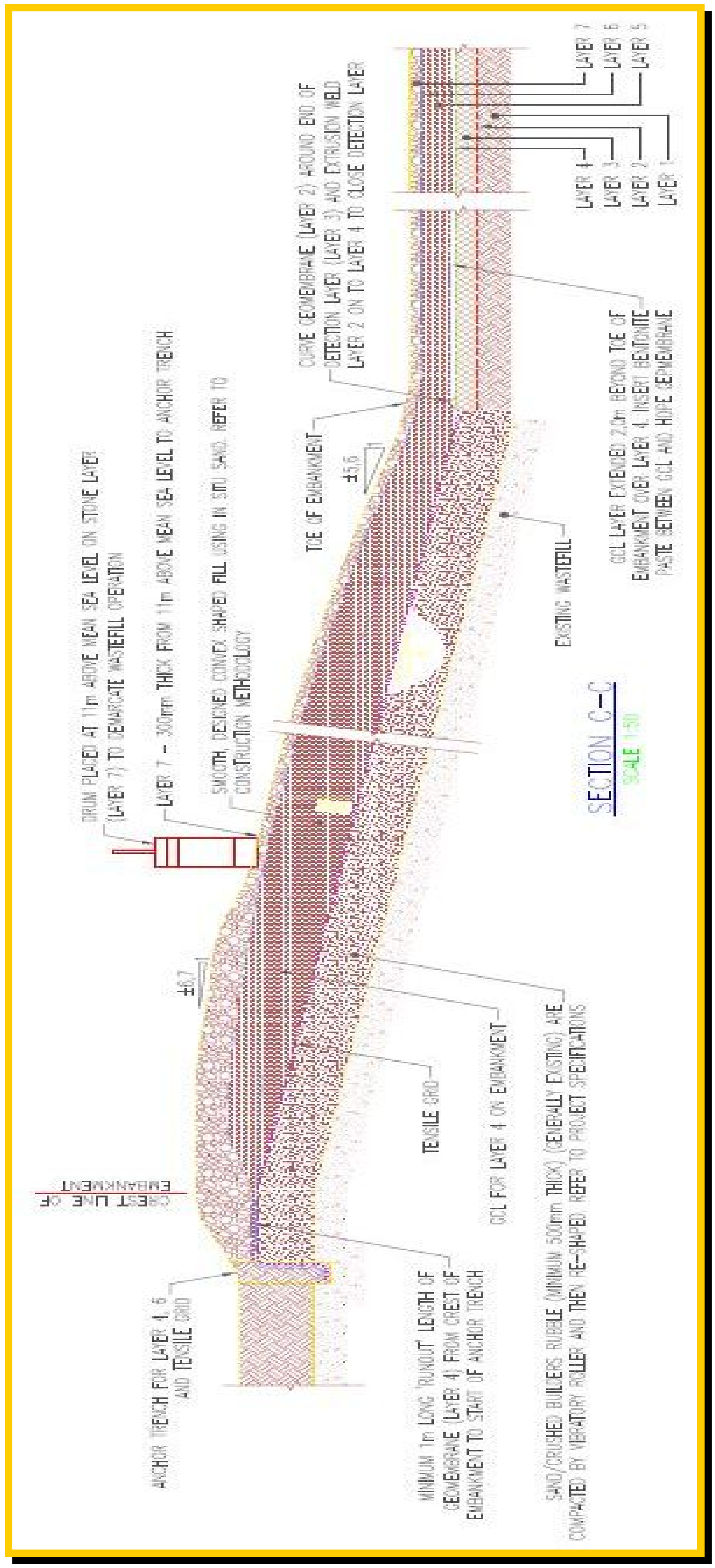


Figure 2 : Section of convex-shaped embankment (image has been stretched)

Single hydraulic barrier

Knowing the threat of differential settlement, as stated above, the material options for the single hydraulic barrier was limited to HDPE, LLDPE, GCL and fPP.

fPP was not chosen due to some recent research indicating that fPP may not be effective as a long-term barrier against leachate and is not an acceptable alternative due to known poor performance from stress-cracking. Even the GRI specification for this product has been removed from the Geosynthetics website.

LLDPE is not option to DWAF, the material is also generally more expensive than HDPE and GCL, plus there is a shortage of resin, so the price is increasing.

HDPE is an option, although HDPE has a poor coefficient of elongation (typically 30% multi-axial elongation) compared to the other alternatives (LLDPE typically has 65% multi-axial elongation,) but is nevertheless an option.

GCL was eventually chosen but the following issues needed to be attended to:

- **Extra overlap**

  The GCL panels would require extra overlap to cater for movement in the GCL due to possible differential settlement. The design allowed for a 1000mm overlap in the horizontal plane and a 600mm overlap in the vertical plane. Depending on supplier, generally a 150mm to 300mm overlap is recommended in “normal” applications. This obviously affects the cost of installation per square metre, nevertheless, this alternative proven a viable financial option. It was required that the overlap be staggered along the embankment i.e. not all along the same horizontal plane as the embankment length is longer than the typical roll length.

- **Hydration of the bentonite using raw leachate**

  BKS needed to be sure that the bentonite would form a “impermeable” paste when in contact with raw leachate from the site, being the only hydraulic barrier on the slope. In order for BKS to truly accept GCL as the suitable single hydraulic barrier on the embankment, a series of practical tests were done to ensure this:

- Letters of support from manufacturers for this application.

  BKS sent chemical test reports of the raw leachate (done over a period of time) to suppliers. In return letters of guarantee were obtained from suppliers to state that the use of GCL would be acceptable and the GCL would function when in contact with such leachate. (i.e. leachate and bentonite interaction.) Letters were received from suppliers stating their support for this application, vouching that the GCL would function as required.

- Crude on-site testing

Crude on site testing was done over a few days to visually inspect the hydration of the GCL using raw leachate. Basically the wheelbarrow has holes in the base. The GCL was the only barrier stopping the leachate from leaking out the wheelbarrow. Raw leachate was extracted directly from the landfill cell and poured into the wheelbarrow and left. The area beneath the wheelbarrow was prepared in such a way that any drops from the wheelbarrow would be detected. The test was run over 3 days.

The results were that little or no leachate managed to permeate through.

Photo 2 : Wheelbarrow with holes in the base, lined with GCL and filled with raw leachate

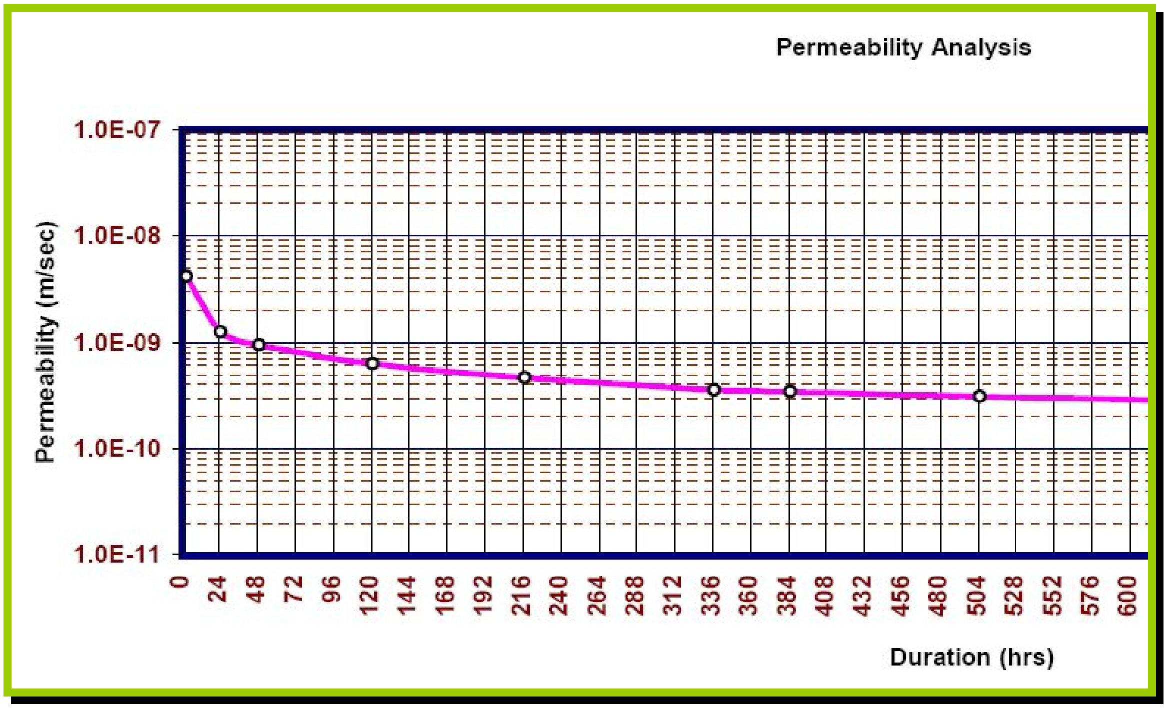
Photo 3 : holes in the base of the wheelbarrow
(the arrows show 3 of the many holes.)

- Laboratory testing

A sample of the GCL was sent to the testing laboratory in Durban together with a sample of the raw leachate for hydration and permeability testing. 20 litres of the raw leachate was put into new fuel cans and couriered to the laboratory in Durban.

A variety of tests were done, some pre-hydrating the GCL, some being tested from dry-to-direct contact with leachate. In all the tests, done over a length of time (.30 days,) the GCL did hydrate to acceptable levels.

Photo 4 : Sampling the raw leachate for the crude "wheelbarrow test" and for sending to laboratory in Durban.



Over and above all the tests, historically GCL has also been used at Bassasar Road Landfill in Durban with a slope of 1V:3,5H (albeit these slopes are relatively short in length.) No problems have arisen thus far on this portion of the site.

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