GEOFABRICS TECHNICAL NOTE BGM-1

BGMS IN AUSTRALIAN CONDITIONS

INTRODUCTION

Geofabrics has partnered with BMI | Siplast in offering the Teranap Bituminous Geomembrane (BGM) in Australia and New Zealand as part of our lining product options for world-class environmental protection.

Teranap is an SBS modified bitumen geomembrane reinforced with a non-woven polyester geotextile. Teranap is **durable, easy to repair** and experiences **zero stress cracking** due to its excellent dimensional stability. Teranap is the only bituminous geomembrane with **integrated seam control technology.** This guarantees **long term mechanical, hydraulic** and **chemical containment** performance at overlaps, and enables thorough **CQA** evaluation from site**.**

Ideal for water storages, tailings dams, the containment of solid and liquid waste and management of biogas, Teranap is a great environmental protection solution for many projects.

When Geofabrics take on a product partner, our GRID Laboratory serves important function to evaluate the product to Australian project conditions. This document highlights an initial review with our partner BMI / Siplast of Bituminous Geomembrane projects, testing and published technical papers. Our future partnership will ensure that the Teranap BGM is tested by Geofabrics to Australian conditions, while using the Siplast R&D Laboratory to ensure that product innovation meets changing industry needs.

GEOFABRICS GRID LABORATORY

The Geofabrics GRID Laboratory is a dedicated team of geosynthetic and geotechnical professionals responsible for providing technical solutions to current and future environmental and engineering challenges.

We do this by undertaking targeted geosynthetic research using project design inputs and site-specific materials to develop innovative solutions with specialties in mining and landfill. During the last 10 years, the GRID has undertaken over 700 research and innovation projects, across a broad range of geosynthetic products used in a wide variety of infrastructure projects.

BGM HISTORY

There is a large volume of data where Teranap BGMs have been used as roofing membranes and as waterproofing liners in dams since the mid-1970s. These have demonstrated performance in exposed applications where the BGM offers waterproofing capability in high temperatures, UV and water depths acting on the liner over time.

As we move away from water applications toward contaminant containment, it is critical that the chemical limitations are well understood.

In the current landscape, BGMs are particularly being installed on aggressive subgrades with soil covers that preclude other Geomembranes. The available projects and data for the designer is far less here, and most testing carried out has occurred using site trials or traditional HDPE tests at controlled laboratory temperatures of 21ºC. The testing program for the Geofabrics GRID Laboratory is aimed to understand how Bituminous Geomembranes function in direct contact with Australian site soils and temperatures, evaluate the suitability of traditional HDPE Geomembrane tests and/or establish specific tests for this type of design analysis.

DESIGN CONDITIONS THAT NEED EVALUATION

TEMPERATURE IS CRITICAL

The idea that BGMs are unaffected by site temperatures is only demonstrated for waterproofing applications where there is no soil (stress) applied. Initial findings in the GRID laboratory already indicate that when laying on angular subgrades and applying certain cover soils, a BGM at elevated temperature may be susceptible to surface damage and certainly a reduction in shear performance will occur depending on the nature of the soil. An ambient temperature of 28ºC will cause a BGM temperature in excess of 60ºC, highlighting the vast gap between laboratory controlled testing and site temperatures. Each site soil presents different risk, the challenge is how testing can be carried out at elevated temperatures to analyse for design?

IS HDPE GEOMEMBRANE PIZZA TESTING APPLICABLE TO BGMs?

The GRID Laboratory has over 80 rock profiles from landfills and mines around the country. These are used to conduct what is termed the "stone pizza test" that is designed to understand aggregate strain imparted to a HDPE Geomembrane. This test is only used when a Geomembrane is installed as a base liner, it is not applicable on slopes where the potential aggregate stress is in the direction of fall. This method may be applicable to use for BGMs used on the floor of tailings dams or containments but has obvious limitations:

- Test results yield different results at higher temperatures – how is temp maintained?
- What is a suitable measure of BGM performance? By definition, thinning of any liner changes it's hydraulic conductivity/permeability (velocity in metres per second means a thinner liner increases flow volumes). It is clear that a correlation must be established between thinning of the BGM and hydraulic performance long term (6 months+).
- And the test duration is critical, for HDPE Geomembranes, the GRID and others have analysed testing from 24hr/1000hrs/10,000hrs testing. As a far more pliable membrane, BGM performance will be more susceptible to long term creep as aggregate pushes into the liner and can only be modelled by conducting the test and applying stress long term.
- Single stones also present far more potential in direct contact with a pliable BGM. HDPE uses the cushion geotextile to limit this effect, but evidence is clear that a pliable BGM with stones in direct contact, raises high doubt whether a fixed "Stone Pizza" should be used in preference over loose aggregate which should be considered preferable?

ANALYSING AGGREGATE DAMAGE ON SLOPES VS FLOORS

Aggregate damage to Geomembranes on the slope vs floor must be analysed differently. Direct shear testing provides a better method to analyse BGM damage on slopes, the shearing conditions must be considered closely, but simple analysis of visible damage or thinning of the BGM is insufficient, and must be followed by long term hydraulic testing (6 months+).
The GRID is developing methods to carry out shear testing at elevated temperatures, and model directly the damage impacts of soils. A fundamental aim with current knowledge must be to avoid stone embedment in the liner. Short term testing (Clinton and Rowe 2017) has identified a possibility that the BGM seals around a stone penetration but identified a need for further research. The Geofabrics GRID concur, with clear need to consider long term stress and temperature that can cause a stone to penetrate further or displace, as well as potential chemical dissolution and fracturing identified in the Rowe study. Stone embedment especially on slopes that observe increasing cover stress, will exacerbate and increase risk over time.

For site trials, it is critical that potential BGM damage analysis be carried out with the BGM installed on the slope, not tested on the flat, and at the highest install temperatures to ensure the worst case scenario. Angular stones present high risk, and need to analysed closely as per the photos below at even low confining stress;

DIRECT SHEAR TESTING

Slope stability analysis often begins with a 2-D analysis that considers the angle of slope compared it to a generated “friction angle” (from a MC Envelope) value for the BGM against both the slope and cover soil. To establish these values the BGM is subjected to direct shear testing at a range of project specific loads against the site soils or boundaries.
The success of this test on a small scale is directly proportionate to the consistency of the interface. A smooth HDPE Geomembrane demonstrates consistent friction against boundary Geosynthetics and soils because the interface is homogenous throughout. Textured HDPE is less consistent, and Geosynthetics that introduce interface variability will produce results that are inconsistent and must be tested specifically against site soils over multiple tests.

BGMs are generally designed with a root barrier side on the bottom, that exhibits shear results more like an HDPE Geomembrane, and a sandy layer on top, which presents more variability. It is absolutely critical that each BGM interface be considered in terms of the mechanisms that cause increased friction, damage factor risk and the impacts of site installation process.

The GRID has tested BGMs that aim to derive increased friction by removing the root barrier film. A sticky BGM interface presents inconsistency that is already observing variability in shear testing. Soils that contain loose stones that stick, change this design interface entirely. When installing a sticky interface BGM, the liner cannot be dragged down the slope allowing the interface to pick up dust and soil from the subgrade as it slides. This immediately moves the design interface friction closer to residual rather than peak friction values. The BGM must be rolled and placed intact without any soil adhered to the base layer to ensure laboratory tests reflect site conditions.
The conclusion for Direct Shear Testing is clear. The pliable BGM interfaces present a risk of increased Damage Factors. If a soil contains any outlying stones, testing must be carried out in conjunction with a full damage factor analysis to establish whether increased friction simply compromises the liner. If damage is observed, as per other Geomembrane types, simple observation of thinning and puncture is insufficient, methods must ensure that long term hydraulic testing is confirmed or protection methods such as using a Geotextile should be implemented onsite.

VEGETATION AND BITUMINOUS GEOMEMBRANES
It is well known that BGMs are susceptible to allowing the right vegetation to establish on the BGM surface and cause root penetrations. It is a critical reason for the implementation of a root barrier film and has been observed on projects that include water storages, tailings dams and other containments historically. The GRID has tested “lupins” grown on a BGM over a 6 week period (as per European Technical Standard PD CEN-TS 14416:2014). which is designed to understand resistance of polymeric/bituminous or GCL barriers to root penetrations. A designer must understand vegetation potential and the benefits of the root barrier film can serve critical function to protect the BGM as required. The GRID can assist with suitable vegetation analysis which is a critical consideration for any project with exposure conditions beyond a few weeks.

BGM with root barrier removed;

CONCLUSION
Bituminous Geomembranes present unique opportunity for specific containment projects where conditions demand a specific product for site conditions and there is a long history for use in

exposed water applications around the world. The GRID laboratory has reviewed extensive data for the use of Bituminous Geomembranes and identified growing use in alternative applications in Australia. As a result there is a critical need to ensure that product performance in Australian site conditions and current applications can be demonstrated. The pliable nature of a BGM brings a need for greater site specific understanding, considering how the product interacts with soil at elevated temperatures and long term stresses.

For BGMs more than other Geomembranes, the shear properties and damage factors will change depending on the subgrade type, angular material in cover soils and installation temperatures It is even more critical for these Geomembranes to correlate lab conditions to the installation risk, by considering the impacts of dragging the BGM across the surface, impacts of human traffic which certainly causes surface damage in 30ºC+ and placement of cover soil.

The Geofabrics GRID will establish testing programs with the Siplast R&D Facility to better understand the damage factor risk of using soils with aggregate or stones, and ensure site specific shear testing is carried out at elevated temperatures and linked to hydraulic performance.
The Geofabrics GRID is available to engage with clients and designers in this aspect and our local staff are more than willing to support site exposed and insitu trials to establish installation

The Geofabrics GRID has extensive reading available and references for further reading according to copyright laws; Specific Paper referenced is;

M. Clinton M, R. Kerry Rowe, 2017. Physical Performance of a Bituminous Geomembrane for use as a Basal Liner in Heap Leach Pads. Geo Ottawa 2017

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