



Global Synthetics

TECHNICAL INFORMATION

Bentofix®

Geosynthetic Clay Liners for Landfills

From the inventors of needle punched thermally locked Geosynthetic Clay Liners and now polyethylene coated GCL with options for coating thickness and coating texture. The polyethylene is extrusion applied to form an intimate bond with the Bentofix® GCL substrate.

This innovative development reduces the risk of desiccation, cation exchange, gas emission and potential bentonite erosion loss issues of many competitor GCL that use glue applied, thin film sheet membranes that attempt to address these issues.

Bentofix® continues to develop technological advantages for your industry.

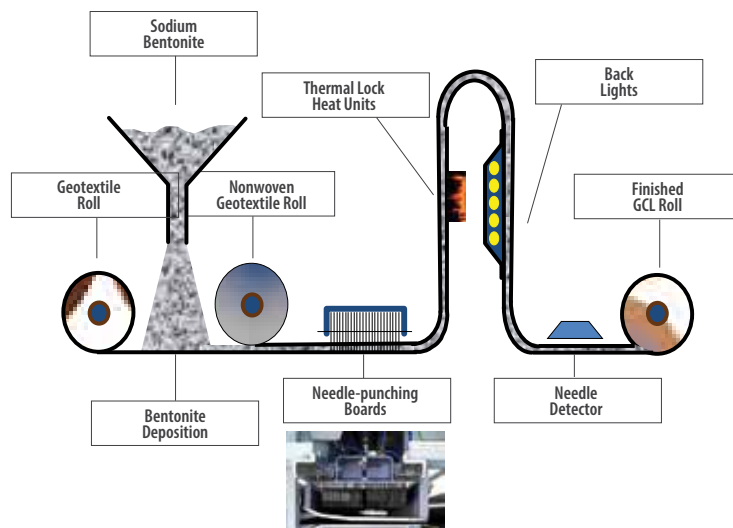
Historical Perspective of **Bentofix**® in Australia

Bentofix® GCL has been successfully installed throughout Australia for over a decade. Millions of square metres of **Bentofix**® product continues to effectively contain potentially hazardous wastes across Australia.

Bentofix® is a shear strength transmitting geosynthetic clay liner. The product consists of a high quality sodium bentonite powder encapsulated between an upper and lower layer of geotextile. The **Bentofix**® products are continuously needle punched through all components and then will be subject to some controlled heat treatment such that the fibres are effectively “thermally locked” in place to obtain high long term shear strength.

The Original Invention

Manufacturing Schematic – Needle-punched GCL



Innovation of the **Bentofix**® Product

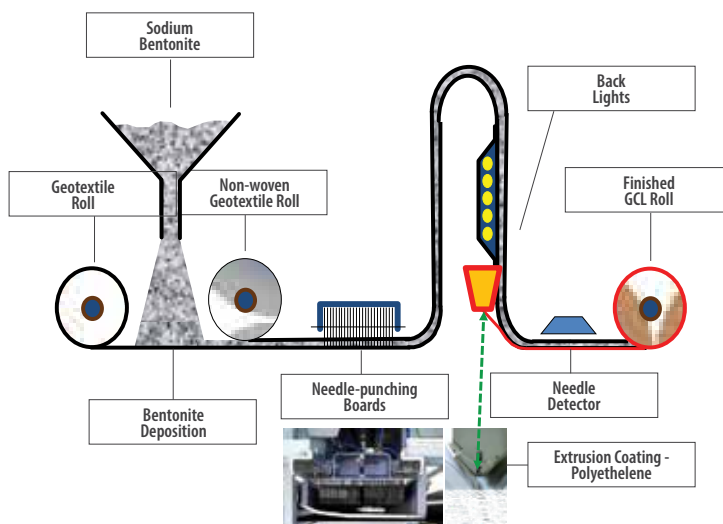
Recent product innovation has led to a unique coated product which combines all the proven benefits of the **Bentofix**® GCL with a speciality polyethylene extruded coating directly applied during the manufacturing process. These products are known as **Bentofix**® X2 NSP4900 and X5F NSP4900.

Polyethylene has a remarkable and proven history of high resistance to chemical attack from many leachates found in landfill applications. Additional product features include a range of applied coating thicknesses ensuring extremely low hydraulic conductivities. A unique optional texturing pattern ensures high interface friction values that assist in overcoming potential instability issues of the GCL on steep slopes.

Additional benefits include the ability to reduce cover to landfill caps by overcoming desiccation issues, provide a positive gas barrier layer and extend the range of sealing applications in a wide range of soil types. Additional supporting information is available from Global Synthetics.

The Latest Innovation

Manufacturing Schematic – Needle-punched GCL with Additional Polyethylene Coating



Bentofix® GCL Specification

Bentofix® Sodium Bentonite Properties

Bentofix® Geosynthetic Clay Liners contain a sodium bentonite powder that is processed to exceed all requirements of local Australian and International standards for bentonite quality. The use of a powdered sodium bentonite ensures positive hydration and hence compliant sealing properties.

PROPERTY	TEST METHOD	UNITS	VALUE
Bentonite Particle Size	Dry Screen ¹	% passing 75 microns	≥ 80
Swell Index	ASTM D5890 ²	mL/2g	≥ 24
Fluid Loss	ASTM D5891 ³	mL	≤ 18
Montmorillonite Content of Bulk Sample	XRD Quantitative Mineralogy Analysis ⁴	% Bulk Sample	≥ 70
Montmorillonite Content of Bulk Sample- Methylene Blue	VDP69 (Methylene Blue) ⁵	mg/g	≥ 300
Calcium Carbonate Content (CaCO ₃)	XRD Quantitative Mineralogy Analysis ⁶	% Bulk Sample	≤ 2
Polymer Additive	Manufacturers Statement Nil Polymer Additives ⁷	Nil Additive	Manufacturers Statement Nil Polymer Additives
Cation Exchange Capacity	Methylene Blue	c mol/kg or meq/100g	≥ 70

Test Method Explanation

Note 1- Bentonite Particle Size

Particle size provides an indication of the reactive surfaces. Smaller particle sizes generally react more efficiently and effectively with water to result in better swelling, lower fluid loss, higher swelling pressure, greater gel strength and lower permeability.

Note 2- Swell Index

This is an index test that evaluates the swelling potential of the bentonite component of a GCL. The index relates to bulk swelling under minimal confinement. The swell index is generally inversely proportional to GCL permeability. Generally the higher the swell index the lower the GCL permeability.

Note 3- Fluid Loss

This is an index test that evaluates the fluid loss properties of the bentonite component of the GCL under standard conditions of pressure over specified intervals of time. A low fluid loss value is indicative of the ability of the bentonite to restrict movement of liquid under load. A low fluid loss value is related to GCL permeability. The lower the fluid loss value the lower the GCL permeability.

Notes 4 & 5- Montmorillonite Content

Both methods of either X Ray Diffraction (XRD) or by Methylene Blue titration quantify the mineralogy of the bentonite. The montmorillonite content can be expressed as a percentage of the bulk sample or as a size fractionated percentage such as less than 0.5 microns. Good agreement is obtained between chemical analysis of bentonite using method VDP69 and XRD methods of deriving montmorillonite content. The higher the montmorillonite content the better the performance of the GCL.

Note 6- Calcium Carbonate Content

Generally the calcium content must be kept to minimal levels as calcium montmorillonite has a much lower swelling potential than sodium montmorillonite. The presence of calcium can be determined by XRD methods and performed on a size fractionated percentage of the bentonite (≤ 0.5 micron fraction).

Note 7- Polymer Modified Bentonite Powder

The addition of chemical modification of the bentonite powder, with polymers, will generally give higher swell index values and lower fluid loss numbers. Both these test methods are short term tests with little documentation on the long term performance of these altered powders. Both local and International Specification documents for the use of GCL either do not allow their use or warn strongly against use unless the manufacturer can fully substantiate long term performance of the candidate GCL.

In all instances, the use of polymer modification must be fully disclosed by the manufacturer.

Bentofix® GCL Specification

Bentofix® GCL Properties & available grades

Grade NSP4900

Bentofix® NSP4900 is a shear strength transmitting geosynthetic clay liner, continuously needle punched through all components. The upper layer is a polypropylene non-woven geotextile and the carrier layer (bottom) is a polypropylene woven geotextile. Unique to this product, the fibres are “thermally locked” to ensure high long term shear strength. The use of high quality sodium bentonite powder ensures a low permeability containment product ideally suited to applications of landfill containment. Additional edge impregnation of bentonite powder is placed 500mm wide along both longitudinal edges of the roll in the cover layer. A 300mm edge overlap line is placed on the carrier side of the GCL.

Grade X2 NSP4900

X= Coated

2= Polyethylene 200 gsm Coating (0.2mm nominal thickness)

Bentofix® X2 NSP4900 is a shear strength transmitting geosynthetic clay liner, continuously needle punched through all components. The upper layer is a polypropylene non-woven geotextile and the carrier layer (bottom) is a polypropylene woven geotextile. Following on from the needling process a liquid polyethylene coating of 0.2mm thickness is applied to the entire surface of the woven side of the GCL. Polyethylene has excellent resistance to many leachates found in landfills. This coating is in direct and intimate contact with the GCL with excellent bond characteristics.

The use of high quality sodium bentonite powder ensures a low permeability containment product ideally suited to applications of landfill containment. Additional edge impregnation of bentonite powder is placed 500mm wide along both longitudinal edges of the roll in the cover layer. A 300mm edge overlap line is placed on the coated side of the GCL.

The innovative use of a composite GCL/polyethylene coating ensures extremely low permeabilities less than 1×10^{-14} m/sec and meets the requirements of GRI specifications for coated GCLs.

Grade X5F NSP4900

X= Coated

5= Polyethylene 500gsm Coating (0.5mm nominal thickness)

F= textured frictional surface.

Bentofix® X5F NSP4900 is a shear strength transmitting geosynthetic clay liner, continuously needle punched through all components. The upper layer is a polypropylene non-woven geotextile and the carrier layer (bottom) is a polypropylene woven geotextile. Following on from the needling process a liquid polyethylene coating of 0.5mm thickness is applied to the entire surface of the woven side of the GCL. Polyethylene has excellent resistance to many leachates found in landfills. This coating is in direct and intimate contact with the GCL with excellent bond characteristics.

The use of high quality sodium bentonite powder ensures a low permeability containment product ideally suited to applications of landfill containment. Additional edge impregnation of bentonite powder is placed 500mm wide along both longitudinal edges of the roll in the cover layer. A 300mm edge overlap line is placed on the coated side of the GCL. The innovative use of a composite GCL/polymer coating ensures extremely low permeabilities less than 1×10^{-14} m/sec and meets the requirements of GRI specifications for coated GCLs.

Additionally a highly textured surface is provided to increase interface shear of this GCL.

Bentofix® GCL Typical Guide for Landfill Applications			
Bentofix® Application	Bentofix® Grade		
	Bentofix® NSP4900	Bentofix® X2 NSP4900	Bentofix® X5F NSP4900
Base lining			
Flat or shallow slope	✓	○	○
Side slopes > 1V:2H	○	—	✓
Capping			
Flat or shallow slope	○	✓	○
Slopes > 1V:2H	○	—	✓
Liquid/leachate Containment	—	✓	○

✓ Suggested product grade
 — Further analysis required
 ○ Optional product grade

Product Selection Notes and Limitations

- Where there is the risk of Ion exchange from the subgrade, high salinity in the ground water, a harsh leachate, or potential for desiccation beneath a wrinkled geomembrane, possible bentonite erosion on slopes, or when the GCL is used in contact with geonet; then a coated GCL (Bentofix® X2 or X5F) is suggested for use to minimise these risks.
- Bentofix® coated GCLs may be used alone as a single liner for a landfill cap. The coating protects the GCL against possible desiccation, internal erosion, Ion exchange and root penetration, and provides an instant gas barrier.
- The cover soil thickness can be reduced by up to 50% when a Bentofix® coated GCL (X2 or X5F) is used as a single liner for a landfill cap.
- The slope angles indicated are typical only and should be verified with appropriate testing using specific site soils. Other influences may be the use of other complimentary geosynthetics such as HDPE liner and Geonets in

Bentofix® GCL			Recommended GRI or NAUE	EPA GRI GCL3	Bentofix® NSP4900	Bentofix® X2 NSP4900	Bentofix® X5F NSP4900
Material Property	Test Method	Units	Manufacturer's Testing Frequency	MARV	MARV	MARV	MARV
Bentofix® GCL COMPONENTS							
Cover Nonwoven Geotextile Mass	ASTM D5261	g/m ²	1 sample per 20,000 m ²	≥ 200	≥ 200	≥ 200	≥ 200
Carrier Woven Geotextile Mass	ASTM D5261	g/m ²	1 sample per 20,000 m ²	≥ 100	≥ 100	≥ 100 (+ Coating)	≥ 100 (+ Coating)
Bentonite Mass @ 0%mc	ASTM D5993	g/m ²	1 sample per 4,000 m ²	≥ 3700	≥ 3700	≥ 3700	≥ 3700
GCL Mass @0% mc	ASTM D5993	g/m ²	1 sample per 4,000 m ²	≥ 4000	≥ 4000	≥ 4200	≥ 4500
Bentofix® COATING CHARACTERISTICS							
Polyethelene Coating	ASTM D5261 EN ISO 9864	g/m ²	1 sample per 4,000 m ²	≥ 100	n/a	≥ 200	≥ 500
Polyethelene Thickness	Microscope - Direct Measurement	mm	1 sample per 20,000 m ²	n/a	n/a	≥0.2 (typical)	≥0.5 (typical)
Bentofix® GCL STRENGTH PROPERTIES							
Tensile Strength (machine direction)	ASTM D6768	kN/m	1 sample per 20,000 m ²	≥ 4.0	≥ 10.8	≥ 10.8	≥ 10.8
Peel Strength	ASTM D6496	N/m	1 sample per 4,000 m ²	≥ 360	≥ 360	≥ 360	≥ 360
CBR Strength	EN ISO 12236 / ASTM 6241	N	1 sample per 20,000 m ²	n/a	≥ 1800	≥ 1800	≥ 1800
Bentofix® PERMEABILITY/ HYDRAULIC PROPERTIES (MaxARV Values ¹)							
Permeability / Hydraulic (GCL only)	ASTM D5887	m/s	1 sample per 25,000 m ²	≤ 5x10 ⁻¹¹	≤ 2.5x10 ⁻¹¹	≤ 2.5x10 ⁻¹¹	≤ 2.5x10 ⁻¹¹
Permeability @ 35 kPa	ASTM D6766	m/s	1 test per year	1 x 10 ⁻⁸	1 x 10 ⁻⁸	n/a	n/a
Permeability @ 500 kPa	ASTM D6766 (mod)	m/s		5 x 10 ⁻¹⁰	5 x 10 ⁻¹⁰		
Permeability / Hydraulic (Coated GCL)	ASTM D5887	m/s	1 sample per formulation	n/a	n/a	≤ 1 x 10 ⁻¹⁴	≤ 1 x 10 ⁻¹⁴
Index Flux (Q ¹⁰) GCL Only	ASTM D5887	(m ³ /m ²)/s	1 sample per 25,000 m ²	≤ 1 x 10 ⁻⁸	≤ 9 x 10 ⁻⁹	≤ 9 x 10 ⁻⁹	≤ 9 x 10 ⁻⁹
Bentofix® COMPONENT DURABILITY							
Geotextile and Reinforcing Yarns	See GRI GCL3 Sect 5.6.2	% Strength Retained	1 test per year	≥ 65	≥ 65	≥ 65	≥ 65
Polyethylene Coating	See GRI GCL3 Sect 5.6.4	% Strength Retained	1 test per year	≥ 85	n/a	≥ 85	≥ 85
Bentofix® GCL EDGE IMPREGNATION							
Edge Width Treatment	Direct Measurement	mm	Each Roll Treated	n/a	500	500	500
Bentofix® GCL EDGE OVERLAP MARKING							
Overlap Mark	Direct Measurement	mm	Each Roll Marked	300	300	300	300
Bentofix® ROLL DIMENSIONS (typical standard-other roll lengths available to suit specific projects)							
Roll Width	Direct Measurement	m	Each Roll Measured	-	5	4.85	4.85
Roll Length	Direct Measurement	m	Each Roll Measured	-	40	40	35
Roll Mass	Direct Measurement	kg	Each Roll Measured	-	980	1020	930
Bentofix® GCL SPREADER AND STINGER BAR AVAILABLE					YES	YES	YES

1 MaxARV = Maximum Average Roll Value - a MaxARV value is defined as the Mean or Typical values plus 2 standard deviations.

2 MARV = Minimum Average Roll Value - a MARV is defined as the Mean or Typical values less 2 standard deviations.

Our commitment to Quality

NAUE does not chemically modify the sodium bentonite that is used in any of our **Bentofix**® GCL's ensuring the owner, operator and landfill designer of secure containment for the life of the landfill.

Bentofix® GCLs are rigorously tested from raw material supply right through the production process to the finished product.

Bentofix® GCLs are produced under certified ISO9001 Quality processes. All in-house laboratories are fully accredited by National Testing Associations to ensure that test standards are maintained at the highest levels. State of the art test equipment is used to ensure repeatable quality product is produced and that our specification values are achieved. We use the highest quality bentonite and do not chemically alter our bentonites with polymers to achieve our stated specifications and those recognised by statutory regulators around the world.

The following extracts clearly state the precautions of using polymer modification of the bentonite powder in GCLs for landfill containment applications. All precautions are from current best practice guidelines;

EPA VICTORIA

Best Practice Environmental Management (BPEM) Publication 788.2, 2014 – page 93: Appendix E2.1.1.2 – Bentonite Form;

"... other additives, such as polymers or pH modifiers, may be added to improve the swelling and sealing capability of sodium-activated bentonites. However, the nature and suitability of these additives is difficult to check. If used, the manufacturer should provide their details and demonstrate their nature, suitability and long-term durability"

THE GEOSYNTHETIC RESEARCH INSTITUTE (GRI) - USA

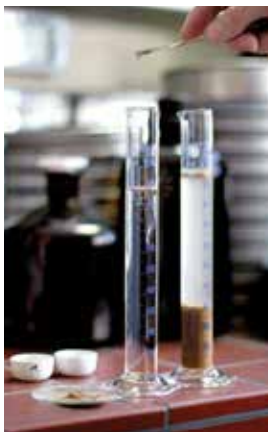
GRI-GCL5, 2013 – page 23: Clause 11.7 - Design Considerations for Geosynthetic Clay Liners (GCLs) in Various Applications;

"... It should be noted that there is presently (2011) several ongoing research efforts in modifying both sodium and calcium bentonites, primarily (but not exclusively) with polymer additives. The goals of these efforts are to reduce cation exchange. Of course, the long-term performance of these polymers needs to be addressed, as well as the environmental impact. If polymers are added they should be noted in the product data sheets."

ENVIRONMENT AGENCY (EA) - UK

EA Publication: Using Geosynthetic Clay Liners in Landfill Engineering, ver.3 – page 5: Clause 2.4

"... Some GCL manufacturers use additives to enhance certain characteristics such as initial swell and leachate resistance in reinforced GCLs, or in the form of glues in unreinforced liners. The nature and suitability of these additives is difficult to ascertain. As a result we would prefer they were not used unless the manufacturer is able to demonstrate their nature, suitability, and long term durability. Manufacturers must provide details of all additives used in the manufacture of their GCLs. Where the additive is a polymer, you must ascertain the manufacturer has not used excess polymer during the manufacture of the GCL. Excess polymer can cause excessive swelling of the clay/polymer filling in needle punched GCLs pushing the geotextiles apart, and allowing bentonite migration and subsequently loss of integrity."





Bentofix® a name to be trusted for quality



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