TENCATE
Polyfelt

TECHNICAL DATA

Enviromat Geosynthetic Clay Liner

Enviromat is a New Generation Geosynthetic Clay Liner (GCL) made from quality polypropylene geotextiles and premium grade sodium bentonite powder mined in Australia. Enviromat GCL's are fibre-reinforced by needle-punching the composites across the entire surface area of the product. Unique to this product, the high tenacity fibres are then thermally-locked to ensure high long-term shear strength.

Property	Test Method	MQC [1] Frequency	Unit	Enviromat 80	Enviromat 100	Enviromat 200	Enviromat 300
GCL Mass - Components – MARV [2]							
Cover Non-woven Geotextile Mass per Unit Area	AS 3706.1	10,000m^2	g/m^2	220	270	270	300
Bentonite Mass (@ 0% moisture content)	ASTM D5993	2,500m^2	g/m^2	3600	4000	3700	4250
Carrier/ Composite Geotextile Mass per Unit Area	AS 3706.1	70,000m^2	g/m^2	110	110	380	380
GCL Mass - MARV [2]							
GCL Total Mass (@ 0% moisture content)	ASTM D5993	2,500m^2	g/m^2	3930	4380	4350	4930
GCL Strength Properties - MARV [2]							
Wide Width Tensile Strength (MD / CD) [3]	ASTM D4595	10,000m^2	kN/m	7 / 7	8 / 8	10 / 25	12 / 30
Wide Width Tensile Elongation (MD / CD) [3]	ASTM D4595	10,000m^2	%	11 / 11	11 / 11	100 / 70	100 / 70
CBR Strength	AS 3706.4	25,000m^2	N	1400	1600	2500	3000
CBR Elongation	AS 3706.4	25,000m^2	%	$\geq$ 15	$\geq$ 20	$\geq$ 50	$\geq$ 50
GCL Shear Strength Properties - Typical [4]							
Hydrated Peak Internal Shear Strength (@ 10kPa Normal Stress) [5]	ASTM D6243	Periodic	kPa	30	30	35	40
Hydrated Peak Internal Shear Strength (@ 30kPa Normal Stress) [5]	ASTM D6243	Periodic	kPa	50	50	60	70
GCL Hydraulic Properties							
Permeability, k – Typical [4] (t_{GCL} = 10mm)[6]	ASTM D5887	25,000m^2	m/s	3×10^{-11}	2×10^{-11}	2×10^{-11}	1.8×10^{-11}
Permeability, k – MaxARV [7] (t_{GCL} = 10mm)[6]	ASTM D5887	25,000m^2	m/s	$\leq 4 \times 10^{-11}$	$\leq 3 \times 10^{-11}$	$\leq 3 \times 10^{-11}$	$\leq 2 \times 10^{-11}$
GCL Longitudinal Edge Treatment							
Bentonite Impregnation (@ 0% moisture) Width $\geq$ 300mm - Typical [4]	Strew Test	Random	g/m^2	800	800	800	800
Edge Sealing			–	√	√	√	√
GCL Form of Supply (Roll)							
Dimensions (width x length)			m	4.7 x 45 or 4.7 x 35	4.7 x 35	4.7 x 30	4.7 x 30
Typical [4] Roll Mass		(Weighed every roll)	kg	975 or 800	875	730	825

NOTES

1. **MQC** = Manufacturing Quality Control – an ongoing system that monitors and tests materials during manufacture to ensure compliance with certification documents and contract specifications;
2. **MARV** = Minimum Average Roll Value – a MARV is defined as the Mean or Typical values less 2 standard deviations. Mathematically, it is implied that 97.5% of the results of the tested specimens will exceed the MARV. A MARV provides a confidence level of 97.5%;
3. **MD** = Roll Machine Direction, **CD** = Roll Cross-Machine Direction;
4. **Typical** = A typical value is the arithmetic mean of a set of results. This implies that 50% of the tested specimens will typically exceed this value and 50% will typically not meet this value;
5. **Peak value** reported at 10kPa and 30kPa normal stress. [The reported values are not intended to replace site specific internal shear or interface friction testing required for design];
6. $\mathbf{t_{GCL}}$ = thickness of GCL for calculation of permeability values (10mm provides conservative values);
7. **MaxARV** = Maximum Average Roll Value – a MaxARV is defined as the Mean or Typical values plus 2 standard deviations. Mathematically, it is implied that 97.5% of the results of the tested specimens will be less than the MaxARV. A MaxARV provides a confidence level of 97.5%. **NOTE** – in reference to GCL Permeability, **LOWER IS BETTER.**

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Enviromat Geosynthetic Clay Liner

Enviromat Geosynthetic Clay Liners contain a sodium bentonite processed to exceed the requirements of API Spec 13A, for which the bentonite supplier is a licensed manufacturer. The unique swelling properties and low permeability performance of Enviromat's sodium bentonite can be attributed to the following properties.

Property	Test Method	Unit	Value
Bentonite Particle Size	Dry Screen	% passing 75μm	80
	Wet Screen	% retained 75μm	2
	AS 1289-3.6.2[1]	% $\leq$ 0.5μm	$\geq$ 55
Swell Index	ASTM D5890[2]	mL/2g	$\geq$ 24
Fluid Loss	ASTM D5891[3]	mL	$\leq$ 15
Montmorillonite Content	XRD Quantitative Mineralogy Analysis[4]	% of Bulk Sample	$\geq$ 70
	ASTM C837 - Methylene Blue Index[4]	% of Bulk Sample	$\geq$ 70
Montmorillonite Content of Bentonite Particles $\leq$ 0.5μm	XRD Quantitative MineralogyAnalysis[4]	% $\leq$ 0.5μm	$\geq$ 95
Calcium Carbonate Content ($CaCO_3$)	XRD Quantitative Mineralogy Analysis[5]	% of Bulk Sample	< 1
Layer Charge and Layer Charge Distribution	Chemical analysis and structural	e^- per unit cell ($O_{20}(OH)_4$	0.8 – 0.85
	formula calculation[6]	% in tetrahedral sheet	< 35
Cation Exchange Capacity (CEC)	NH_4 displacement[7]	cmol/kg of Bulk Sample	75 – 85
	Barium Saturation Method – (e.g. Battaglia et al., 2006)[7]	cmol/kg ($\leq$ 0.5μm Particles)	95 – 100

EXPLANATION OF TEST METHODS

1. **BENTONITE PARTICLE SIZE – AS 1289-3.6.2 – 'Methods of testing soils for engineering purposes – Soil classification tests – Determination of the particle size distribution of a soil – Analysis by sieving in combination with hydrometer analysis (subsidiary method)'** – 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.

2. **SWELL INDEX – ASTM D5890 – 'Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners'–** 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 related to GCL permeability, ie. the higher the swell index, the lower the GCL permeability.

3. **FLUID LOSS – ASTM D5891 – 'Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners' –** This is an index test that evaluates the fluid loss properties of the bentonite component of a GCL, under 100psi (690 MPa) pressure, over a specified period of time. A low Fluid Loss value is indicative of the ability of the bentonite to restrict movement of liquid under load. Fluid Loss is directly related to GCL permeability, ie. the lower the fluid loss, the lower the GCL permeability.

4. **MONTMORILLONITE CONTENT –**
   XRD Quantitative Mineralogy Analysis – The method enables quantification of the mineralogy of a bentonite by powder X-ray diffraction and Reitveldt refinement. The XRD method can be performed on bulk bentonite, showing montmorillonite content as a % of bulk; or on size-fractionated materials, showing montmorillonite content as a % of size fraction (ie. $\leqslant$0.5μm).
   REFERENCE
   Taylor, J.C., Hinczak, (2004). Reitveldt Made Easy. Sietronics, Pty Ltd, Belconnen Australia, 201p.
   or ASTM C837 'Methylene Blue Index' – This traditional method is based on the assumption that the smectite clay has a CEC of 100 cmol/kg and was originally used to differentiate different smectite species.
   The XRD Quantitative Mineralogy Analysis is the preferred method.

5. **CALCIUM CARBONATE CONTENT – 'XRD Quantitative Mineralogy Analysis' –** As for Montmorillonite content, quantitative mineralogy analysis enables quantification of carbonate minerals present in bentonite.

6. **LAYER CHARGE AND LAYER CHARGE DISTRIBUTION – 'Chemical analysis and structural formula calculation'**- This method enables calculation, from chemical analysis, of layer charge characteristics of the smectite clay component of a GCL. Chemical analysis is quantified by XRF on **calcium** saturated purified smectite samples. Smectite layer charge is responsible for the cation exchange capacity of bentonite, but also influences swelling, sealing and gel formation. Layer charge values < 0.85e– per unit cell in combination with a tetrahedral layer charge < 30%, indicates a good swelling bentonite.
   REFERENCES
   1.Norrish, K., Hutton,J.T. (1969). "An accurate X-ray spectroscopic method for the analysis of a wide range of geologic samples", Geochemical Cosmochimical Acta, 33, 431–453.
   2.Bodine, M.W.Jr. (1987). "CLAYFORM: A FORTRAN 77 computer program apportioning the constituents in the chemical analysis of a clay or other silicate mineral in a structural formula", Computers and Geosciences, 13:77– 88.

7. **CATION EXCHANGE CAPACITY – 'NH_4 Displacement Method' –** 'This method has traditionally been used to determine CEC in SOILS. The NH_4 displacement method can be modified to enable direct determination of the cation exchange capacity of the smectite clay component of a GCL. The amount of NH_4 retained by the clay is quantified by X-ray Fluorescence (XRF). This method can be performed on the bulk bentonite, in which case "Bentonite CEC" is recorded. or on the monomineralic smectite isolated from the bentonite, in which case the "Smectite CEC" is recorded. The ranges in CEC values specified provide the best combination of good swelling and cation retention capabilities – see Note 6 **– LAYER CHARGE AND LAYER CHARGE DISTRIBUTION.**
   or **'Barium Saturation Method'** - 'The barium (Ba) displacement method enables direct determination of the cation exchange capacity of the smectite clay component of a GCL. The amount of Ba retained by the clay is quantified by X- ray Fluorescence (XRF). This method can be performed on the bulk bentonite, in which case "Bentonite CEC" is recorded. or on the monomineralic smectite isolated from the bentonite, in which case the "Smectite CEC" is recorded. The ranges in CEC values specified provide the best combination of good swelling and cation retention capabilities - see Note 6 – **LAYER CHARGE AND LAYER CHARGE DISTRIBUTION.**
   REFERENCE
   Battaglia, S.; Leoni, L.; Sartori, F. (2006). "A method for determining the CEC and chemical composition of clays via XRF", Clay Minerals, 41:717 – 725.

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