Bonding clay to geosynthetic materials has created an economical, long-term solution for many applications.

Geosynthetic clay liners (GCLs) are hydraulic barriers made of clay bonded to a single geosynthetic layer or to multiple geosynthetic layers. Because of its low permeability, swelling capacity, and relative abundance, natural sodium bentonite is the preferred clay component of GCLs. A wide range of materials, including geotextiles and geomembranes, are used to carry and encapsulate the clay. Also, they provide the product with structural support.

GCLs are used primarily as substitutes for compacted clay liners (CCLs), providing significant advantages in cost, ease of installation, and performance. Primary applications include surface impoundment, secondary containment, and landfills.

The products have been used commercially for more than 10 years. GCL use has grown steadily, and standards have been authored to address swell and fluid-loss index testing, determination of flux, manufacturing, sampling, installation, and more.

Manufacturing process
GCLs are prefabricated sheets of processed bentonite clay available in multiple sizes. They are manufactured by encapsulating the clay between two or more layers of geotextile, or by bonding the clay to one side of a geomembrane. The geotextile-supported products hold the clay in place by soluble adhesives, I-ties, barbed-needle punching that interlocks the geotextile fibers, or by periodic rows of heavy stitching through the clay and fabric.

The numbers
Companies that submitted product data chart lines were asked to provide data determined through industry-accepted testing methods. Companies signed a certificate of compliance verifying the accuracy of this data.
### GEOSYNTHETIC CLAY LINERS

**Product Name** | **Bonding Method** | **Needlepunched Peel Strength (lb/in)** | **Panel Size Roll Width/Length (ft/ft)** | **Average Roll Weight (lb)** | **Bentonite Mass/Unit Area (lb/ft²)** | **Flux (m³/m²-s)** | **Swell Index (ml/2g)** | **Fluid Loss (ml)** | **Type or Structure** | **Weight (oz/yd² or mil)** | **NP** | **Remarks**
---|---|---|---|---|---|---|---|---|---|---|---|---|---
Agru America<br>Agru Geo Clay NN66<br>Needlepunch | 6.1 (3.5) | 4.7/45.7 (15.1/150) | 1700 (3750) | 3600 (0.75) | 1x10-8 | 24 | 18 | nonwoven | 200 (6.0) | nonwoven | 200 (6.0)
Agru Geo Clay WW66<br>Needlepunch | 6.1 (3.5) | 4.7/45.7 (15.1/150) | 1590 (3500) | 3600 (0.75) | 1x10-8 | 24 | 18 | nonwoven | 200 (6.0) | nonwoven | 105 (3.1)
CETCO<br>Bentomat 600CL<br>Needlepunched laminated | 175 (1.0) | 4.6/45.7 (15/150) | 1250 (2750) | 3660 (0.75) | 1 x 10-9 | 24 | 18 | geofilm/geotextile composite | NP | woven | 105 (3.2) | LL, LC, SIC, CL, SIL
Bentomat CL<br>Needlepunched laminated | 610 (3.5) | 4.6/45.7 (15/150) | 1250 (2750) | 3660 (0.75) | 1 x 10-9 | 24 | 18 | smooth FML/ geotextile composite | NP | woven | 105 (3.2) | LL, LC, SIC, CL, SIL
Bentomat CLT<br>Needlepunched laminated | 610 (3.5) | 4.6/45.7 (15/150) | 1340 (2950) | 3660 (0.75) | 1 x 10-9 | 24 | 18 | textured FML/ geotextile composite | NP | woven | 105 (3.2) | LL, LC, SIC, CL, SIL
Bentomat DN<br>Needlepunched | 610 (3.5) | 4.4/45.7 (14.5/150) | 1220 (2700) | 3660 (0.75) | 1 x 10-8 | 24 | 18 | nonwoven | 200 (6.0) | nonwoven | 200 (6.0) | LL, LC, SIC
Bentomat SDN<br>Needlepunched | 520 (3.0) | 4.4/45.7 (14.5/150) | 1200 (2650) | 3660 (0.75) | 1 x 10-8 | 24 | 18 | nonwoven | 200 (6.0) | nonwoven | 90 (2.7) | LL, LC, SIC
Bentomat ST<br>Needlepunched | 610 (3.5) | 4.6/45.7 (15/150) | 1200 (2650) | 3660 (0.75) | 1 x 10-8 | 24 | 18 | nonwoven | 200 (6.0) | nonwoven | 105 (3.2) | LL, LC, SIC
Bentomat 200R<br>Needlepunched | 175 (1.0) | 4.6/45.7 (15/150) | 1200 (2650) | 3660 (0.75) | 1 x 10-8 | 24 | 18 | nonwoven | 105 (3.2) | woven | 105 (3.2) | LL, LC, SIC
Resistex<br>Needlepunched per design | 4.4/45.7 (14.5/150) | 1300 (2870) | 4400 (1.0) | 4 x 10-9 | NP | NP | per design | per design | per design | per design | NP | NP

**Flux** is defined as “Flow rate/unit area” which can be converted to permeability using the equation:

\[ \text{Permeability} = \frac{\text{Flux}}{\text{hydraulic gradient}} \]

**Report result at a maximum confining stress of 35 kPa (5 psi) and 14 kPa (2 psi) head pressure.**

[1] CETCO® Resistex®, geosynthetic clay liners are engineered to provide the highest level of chemical compatibility in extremely aggressive leachate environments such as coal combustion product storage facilities, mining operations, and industrial waste storage facilities.

**Resistex** geosynthetic clay liners were tested against various leachates including but not limited to samples from EPRI (Electric Power Research Institute) and other industrial leachates, and should be considered as guide only. CETCO offers site-specific compatibility testing to verify the suitability of CETCO products. Site-specific geotechnical properties will be per design and appropriate testing will be conducted to confirm expected performance criteria.

**Companies were requested to provide minimum roll values (MARV). All claims are the responsibility of the manufacturer.**

« Geosynthetics recommends you contact the manufacturers before making any specifying/purchasing decisions »
**GEOSYNTHETIC CLAY LINERS**

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Bonding Method</th>
<th>Needlepunched Peel Strength ASTMD6496/N (lb/in)</th>
<th>Panel Size Roll Width/Length m/m (ft/ft)</th>
<th>Average Roll Weight kg (lb)</th>
<th>Bentonite Mass/Unit Area g/m² (lb/ft²)</th>
<th>Flux (1) ASTM D5847 [2] (m³/m²-s)</th>
<th>Swell Index ASTM D5890 (min) ml/2g</th>
<th>Fluid Loss ASTM D5891 ml</th>
<th>Type of structure</th>
<th>Weight ASTM D5861 (gm/mm)</th>
<th>Type of structure</th>
<th>Weight ASTM D5861 (gm/mm)</th>
<th>Manufacturer’s Suggested Applications [3]</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSE BentoLiner CNSL</td>
<td>needlepunched, polymer-coated</td>
<td>610 (3.5)</td>
<td>4.7/46 (15.5/150)</td>
<td>1180 (2600)</td>
<td>3660 (0.75)</td>
<td>1 x 10⁻⁹</td>
<td>24</td>
<td>18</td>
<td>nonwoven</td>
<td>200 (6.0)</td>
<td>PP geofilm/woven composite</td>
<td>105 (3.1)</td>
<td>High load applications with low hydraulic conductivity</td>
</tr>
<tr>
<td>GSE BentoLiner EC</td>
<td>needlepunched</td>
<td>175 (1.0)</td>
<td>4.7/46 (15.5/150)</td>
<td>1180 (2600)</td>
<td>3660 (0.75)</td>
<td>1 x 10⁻⁸</td>
<td>24</td>
<td>18</td>
<td>nonwoven</td>
<td>100 (3.0)</td>
<td>woven</td>
<td>105 (3.1)</td>
<td>low loads and flat slopes</td>
</tr>
<tr>
<td>GSE BentoLiner NSL</td>
<td>needlepunched</td>
<td>610 (3.5)</td>
<td>4.7/46 (15.5/150)</td>
<td>1180 (2600)</td>
<td>3660 (0.75)</td>
<td>1 x 10⁻⁸</td>
<td>24</td>
<td>18</td>
<td>nonwoven</td>
<td>200 (6.0)</td>
<td>woven</td>
<td>105 (3.1)</td>
<td>medium loads and slopes</td>
</tr>
<tr>
<td>GSE BentoLiner NWL</td>
<td>needlepunched</td>
<td>610 (3.5)</td>
<td>4.7/46 (15.5/150)</td>
<td>1180 (2600)</td>
<td>3660 (0.75)</td>
<td>1 x 10⁻⁸</td>
<td>24</td>
<td>18</td>
<td>nonwoven</td>
<td>200 (6.0)</td>
<td>nonwoven/woven composite</td>
<td>200 (6.0)</td>
<td>High load and steep slopes</td>
</tr>
<tr>
<td>GSE BentoLiner NWL-35</td>
<td>needlepunched</td>
<td>928 (5.3)</td>
<td>4.7/46 (15.5/150)</td>
<td>1180 (2600)</td>
<td>3660 (0.75)</td>
<td>1 x 10⁻⁸</td>
<td>24</td>
<td>18</td>
<td>nonwoven</td>
<td>200 (6.0)</td>
<td>nonwoven/woven composite</td>
<td>200 (6.0)</td>
<td>Very high load and steep slopes</td>
</tr>
<tr>
<td>GSE BentoLiner NWL-40</td>
<td>needlepunched</td>
<td>2.100 (12.0)</td>
<td>4.7/46 (15.5/150)</td>
<td>1180 (2600)</td>
<td>3660 (0.75)</td>
<td>1 x 10⁻⁸</td>
<td>24</td>
<td>18</td>
<td>nonwoven</td>
<td>200 (6.0)</td>
<td>nonwoven/woven composite</td>
<td>200 (6.0)</td>
<td>Very high load and steep slopes</td>
</tr>
<tr>
<td>GSE GundSeal Smooth HDPE</td>
<td>adhesive</td>
<td>NA</td>
<td>5.3/1 (17.5/200)</td>
<td>900 (2000)</td>
<td>3660 (0.75)</td>
<td>&lt;&lt;4 x 10⁻¹⁴</td>
<td>24</td>
<td>18</td>
<td>smooth HDPE geomembrane</td>
<td>0.4-2.0mm (15-80mil)</td>
<td>spunbond geotextile</td>
<td>25 (0.75)</td>
<td>all</td>
</tr>
<tr>
<td>GSE GundSeal Textured HDPE</td>
<td>adhesive</td>
<td>NA</td>
<td>5.3/1 (17.5/170)</td>
<td>900 (2000)</td>
<td>3660 (0.75)</td>
<td>&lt;&lt;4 x 10⁻¹⁴</td>
<td>24</td>
<td>18</td>
<td>textured HDPE geomembrane</td>
<td>0.5-2.0mm (20-80mil)</td>
<td>spunbond geotextile</td>
<td>25 (0.75)</td>
<td>all</td>
</tr>
</tbody>
</table>

Note: Also available in coal ash and brine resistant formulas.

**Terrafix Geosynthetics Inc./Terrafix Environmental Technology Inc.**

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Bonding Method</th>
<th>Peel Strength ASTM D6496 N (lb/in)</th>
<th>Panel Size Roll Width/Length m/m (ft/ft)</th>
<th>Average Roll Weight kg (lb)</th>
<th>Bentonite Mass/Unit Area g/m² (lb/ft²)</th>
<th>Flux (1) ASTM D5847 (m³/m²-s)</th>
<th>Swell Index ASTM D5890 (min) ml/2g</th>
<th>Fluid Loss ASTM D5891 ml</th>
<th>Type of structure</th>
<th>Weight ASTM D5861 (gm/mm)</th>
<th>Type of structure</th>
<th>Weight ASTM D5861 (gm/mm)</th>
<th>Manufacturer’s Suggested Applications [3]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bentofix NSE</td>
<td>needlepunched/enhanced polymer bentonite</td>
<td>610 (3.5)</td>
<td>4.7/22 (15.5/76.8)</td>
<td>1450 (3200)</td>
<td>4330 (0.893)</td>
<td>5 x 10⁻⁹</td>
<td>26</td>
<td>16</td>
<td>nonwoven</td>
<td>200 (6.0)</td>
<td>woven</td>
<td>105 (3.2)</td>
<td>LL, LC, SL, coal ash resistant</td>
</tr>
<tr>
<td>Bentofix SRL WE</td>
<td>needlepunched/enhanced polymer bentonite</td>
<td>610 (3.5)</td>
<td>4.7/22 (15.5/76.8)</td>
<td>1585 (3500)</td>
<td>4330 (0.893)</td>
<td>5 x 10⁻⁹</td>
<td>26</td>
<td>16</td>
<td>nonwoven</td>
<td>200 (6.0)</td>
<td>scrim/woven nonwoven</td>
<td>105 (3.2)</td>
<td>LL, LC, SL, slopes, coal ash resistant</td>
</tr>
<tr>
<td>Bentofix CNL</td>
<td>needlepunched/polymer-coated/ enhanced polymer bentonite</td>
<td>610 (3.5)</td>
<td>4.7/22 (15.5/76.8)</td>
<td>1630 (3600)</td>
<td>4330 (0.893)</td>
<td>1 x 10⁻⁹</td>
<td>26</td>
<td>16</td>
<td>nonwoven</td>
<td>200 (6.0)</td>
<td>PP geofilm/ scrim/ woven nonwoven</td>
<td>105 (3.2)</td>
<td>LL, LC, SL, slopes, coal ash resistant</td>
</tr>
</tbody>
</table>

**Notes:**

1. Flux is defined as “Flow rate/unit area” which can be converted to permeability using the equation: Permeability = flux/hydraulic gradient

2. Report result at a maximum confining stress of 35 kPa (5 psi) and 14 kPa (2 psi) head pressure.

3. CL = Canal liner, LL = Landfill liner, SC = Surface impoundment cover, LC = Landfill cover, SIL = Surface impoundment liner

NP = Not provided by manufacturer
NA = Not applicable, per manufacturer

Companies were requested to provide minimum roll values (MARV). All claims are the responsibility of the manufacturer.

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