

## **BENTOMAT® CL**

### **GEOSYNTHETIC CLAY LINER SPECIFICATION GUIDELINES**

This specification is intended for use as a **GENERAL GUIDELINE** for developing a specification for a specific project. It is **NOT** intended as a substitute for a detailed specification, which must be written to address site-specific conditions.

## **1.0 GENERAL**

### **1.1 Scope**

This specification covers the technical requirements for the furnishing and installation of the geosynthetic clay liner described herein. All materials used shall meet the requirements of this specification, and all work shall be performed in accordance with the procedures provided herein and the contract drawings.

### **1.2 Definitions**

For the purposes of this specification guideline, the following terms are defined below:

Geosynthetic Clay Liner (GCL) A manufactured hydraulic barrier consisting of clay bonded to a layer or layers of geosynthetics.

Geomembrane An essentially impermeable geosynthetic composed of one or more geosynthetic sheets.

Geotextile Any permeable geosynthetic comprised solely of textiles.

Minimum Average Roll Value For geosynthetics, the value calculated as the typical value minus two (2) standard deviations from documented quality control test results for a defined population from one specific test method associated with one specific property.

Overlap Where two adjacent GCL panels contact, the distance measuring perpendicular from the overlying edge of one panel to the underlying edge of the other.

### **1.3 Unit Prices**

Measurement will be made of the total surface area in square metres covered by the GCL as shown on the contract drawings. Final quantities will be based on as-built conditions. Allowance will be made for GCL in anchor and drainage trenches but no allowance will be made for waste, overlap, or materials used for the convenience of the Contractor. GCL installed and accepted will be paid for at the respective contract unit price in the bidding schedule.

### **1.4 Submittals**

A. With the bid, the Contractor shall furnish the following information:

1. Conceptual description of the proposed plan for placement of the GCL panels over the area of installation.
2. GCL manufacturer's MQC Plan for documenting compliance to Sections 2.1 and 2.2 of these specifications.
3. GCL manufacturer's historical data for multi-axial tension testing of the laminated GCL per Section 2.1E.
4. A copy of GCL manufacturer's ISO quality Certificate of Registration.

- B. At the Engineer's or Owner's request the Contractor shall furnish:
  - 1. A representative sample of the GCLs.
  - 2. A project reference list for the GCL(s) consisting of the principal details of at least ten projects totaling at least 100,000 square metres in size.
- C. Upon shipment, the Contractor shall furnish the GCL manufacturer's Quality Assurance/Quality Control (QA/QC) certifications to verify that the materials supplied for the project are in accordance with the requirements of this specification.
- D. As installation proceeds, the Contractor shall submit certificates of subgrade acceptance, signed by the Contractor and CQA Inspector (see Sections 1.6 and 3.3) for each area that is covered by the GCL.

### **1.5 Qualifications**

- A. GCL Manufacturer must have produced at least 30 million square metres of GCL within the past three years, including at least 3 million square metres with 65 N/10cm peel strength.
- B. The GCL Installer must either have installed at least 100,000 square metres of GCL, **or** must provide to the Engineer satisfactory evidence, through similar experience in the installation of other types of geosynthetics, that the GCL will be installed in a competent, professional manner.

### **1.6 Construction Quality Assurance (CQA)**

- A. The Owner and Engineer shall provide a third-party inspector for CQA of the GCL installation. The inspector shall be an individual or company who is independent from the manufacturer and installer, who shall be responsible for monitoring and documenting activities related to the CQA of the GCL, throughout installation. The inspector shall have provided CQA services for the installation of the proposed or similar GCL for at least 5 completed projects totaling not less than 100,000 square metres.
- B. Testing of the GCL, as necessary to support the CQA effort, shall be performed by a third party laboratory retained by the Contractor and independent from the GCL manufacturer and installer. The laboratory shall have provided GCL CQA testing of the proposed or similar GCL for at least 5 completed projects totaling not less than 100,000 square metres.
- C. CQA shall be provided in accordance with the *GCL CQA Manual* provided by the engineer.

## **2.0 PRODUCTS**

- A. The GCL shall consist of a layer of granular sodium bentonite clay needlepunched between two geotextiles and laminated to a thin flexible membrane liner (Bentomat CL). The GCL shall comply with all of the criteria listed in this Section.
- B. Bentonite shall be a high-swelling sodium bentonite, with a minimum swell index of 24 mL/2g and a maximum fluid loss of 18 mL.
- C. Bentonite shall have a granular consistency (15 percent max. passing a No. 200 sieve [75 µm]), to ensure uniform distribution throughout the GCL and minimal edge loss during handling and installation.
- D. Prior to using an alternate GCL, the Contractor must furnish independent test results demonstrating that the proposed alternate material meets all requirements of this specification. Contractor must also provide evidence of successful use of the proposed alternate material on past similar projects. This evidence can include past direct shear results against similar materials under similar site conditions, and/or past permeability/compatibility test results with a similar leachate or waste stream. The Contractor also must obtain prior approval of the alternative GCL by the Project Engineer.

### **2.1 Materials**

- A. Acceptable GCL product is Bentomat CL, as manufactured by CETCO Limited or an engineer-approved equal.
- B. The GCL and its components shall have the properties shown in the Bentomat CL Certified Properties table.
- C. The moisture content of the bentonite in the finished GCL shall be between 20 and 40 percent, to ensure uniform bentonite distribution, consistent needlepunch density, and adequate electrical conductivity to maximize leak location survey sensitivity.
- D. GCL shall be needlepunch-reinforced, with a minimum peel strength of 65 N/10cm. To maximize large-displacement shear strength, GCL reinforcement shall be achieved solely through needlepunching, without any supplemental heat treatment.

### **2.2 Product Quality Documentation**

The GCL manufacturer shall provide the Contractor or other designated party with manufacturing QA/QC certifications for each shipment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer and shall include:

- A. Certificates of analysis for the bentonite clay used in GCL production demonstrating compliance with the swell index and fluid loss values shown in the Bentomat CL Certified Properties table.

- B. Manufacturer's test data for finished GCL product(s) demonstrating compliance with the values shown in the Bentomat CL Certified Properties table.
- C. GCL lot and roll numbers supplied for the project (with corresponding shipping information).

### **2.3 Product Labeling**

- A. Prior to shipment, the GCL manufacturer shall label each roll, identifying:
  - 1. Product identification information (Manufacturer's name and address, brand product code).
  - 2. Lot number and roll number.
  - 3. Roll length, width and weight.

### **2.4 Packaging**

- A. The GCL shall be wound around a rigid core whose diameter is sufficient to facilitate handling. The core is not necessarily intended to support the roll for lifting but should be sufficiently strong to prevent collapse during transit.
- B. All rolls shall be labeled and bagged in packaging that is resistant to photo degradation by ultraviolet (UV) light.

## BENTOMAT® CL CERTIFIED PROPERTIES

MATERIAL PROPERTY	ANALYSIS CONDUCTED BASED ON TEST METHOD	TEST FREQUENCY	REQUIRED VALUES
Bentonite Swell Index <sup>2</sup>	ASTM D 5890	10,000 m <sup>2</sup>	24ml / 2g min.
Bentonite Mass per unit Area <sup>3</sup>	ASTM D 5993/EN 14196	5,000 m <sup>2</sup>	4.0 kg/m <sup>2</sup>
Bentonite Fluid Loss	ASTM D 5891	10,000 m <sup>2</sup>	18 ml max.
GCL Peel Strength	ASTM D 6496	5,000 m <sup>2</sup>	65 N
GCL Index Flux	ASTM D 5887	25,000 m <sup>2</sup>	No Observable Flow
GCL Permeability	ASTM D 5887	25,000m <sup>2</sup>	No Observable Flow
Tensile Strength <sup>1</sup>	EN ISO 10319	20,000 m <sup>2</sup>	8 kN/m
Elongation	EN ISO 10319	20,000 m <sup>2</sup>	15 percent typical
Mass per unit area of woven geotextile	ASTM D 5261	1 per 20,000 m <sup>2</sup>	100 g/m <sup>2</sup>
Mass per unit area of (non woven) needle-punched geotextiles	ASTM D 5261	1 per 20,000 m <sup>2</sup>	200 g/m <sup>2</sup>
Mass per unit area of flexible Membrane liner	ASTM D 5261	1 per 20,000 m <sup>2</sup>	160 g/m <sup>2</sup>

***Bentomat® CL is a reinforced GCL consisting of a layer of natural sodium Bentonite between a woven and a non-woven geotextile which are needle-punched together and laminated to a thin flexible membrane liner.***

Notes:

- <sup>1</sup> All tensile testing is performed in the machine direction.
- <sup>2</sup> Bentonite properties as removed from the finished GCL.
- <sup>3</sup> Bentonite mass/area reported at 12 percent moisture.

## **2.5 Accessory Bentonite**

- A. The granular bentonite sealing clay used for overlap seaming, penetration sealing and repairs shall be made from the same natural sodium bentonite as used in the GCL and shall be as recommended by the GCL manufacturer. Seaming of GCLs shall be conducted in accordance with the manufacturer's specifications for each particular GCL. Please refer to the installation guidelines for Bentomat GCLs.

## **3.0 EXECUTION**

### **3.1 Shipping and Handling**

- A. The manufacturer assumes responsibility for initial loading the GCL. Shipping will be the responsibility of the party paying the freight. Unloading, on-site handling and storage of the GCL are the responsibility of the Contractor, Installer or other designated party.
- B. A visual inspection of each roll should be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging should be marked and set aside for further inspection. The packaging should be repaired prior to being placed in storage.
- C. The party responsible for unloading the GCL should contact the Manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.

### **3.2 Storage**

- A. Storage of the GCL rolls shall be the responsibility of the installer. A dedicated storage area shall be selected at the job site that is away from high traffic areas and is level, dry and well drained.
- B. Rolls should be stored in a manner that prevents sliding or rolling from the stacks and may be accomplished by the use of chock blocks. Rolls should be stacked at a height no higher than that at which the lifting apparatus can be safely handled (typically no higher than four).
- C. All stored GCL materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation.
- D. The integrity and legibility of the labels shall be preserved during storage.

### **3.3 Earthwork**

- A. Any earthen surface upon which the GCL is installed shall be prepared and compacted in accordance with the project specifications and drawings.

- B. If the GCL is placed over an earthen subgrade, the surface must be compacted to at least 90 percent modified Proctor density or to the extent required by the project specifications. Engineer's approval of the subgrade must be obtained prior to installation. The finished surface must be firm and unyielding, without abrupt elevation changes, voids, cracks, ice or standing water.
- C. The subgrade surface must be free of vegetation, sharp-edged rocks, stones, sticks, construction debris and other foreign material that could contact the GCL. The subgrade should be rolled with a smooth-drum compactor to remove any wheel ruts, footprints or other abrupt grade changes. Furthermore, all protrusions extending more than 12mm from the subgrade surface shall either be removed, crushed or pushed into the surface with a smooth-drum compactor. The GCL may be installed on a frozen subgrade, but the subgrade soil in the unfrozen state should meet the above requirements.
- D. On a continuing basis, the project CQA inspector shall certify acceptance of the subgrade before GCL placement.
- E. It shall be the installer's responsibility thereafter to indicate to the Engineer any change in the condition of the subgrade that could cause the subgrade to be out of compliance with any of the requirements listed in this Section.
- F. At the top of sloped areas of the job site, an anchor trench for the GCL shall be excavated or an equivalent runout shall be utilized in accordance with the project plans and specifications and as approved by the CQA Inspector. When utilizing an anchor trench design, the trench shall be excavated and approved by the CQA Inspector prior to GCL placement. No loose soil shall be allowed at the bottom of the trench and no sharp corners or protrusions shall exist anywhere within the trench.

### **3.4 GCL Placement**

- A. The areas to be lined with GCL shall be agreed upon by the Installer and the Engineer prior to installation.
- B. GCL rolls should be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging should be carefully removed without damaging the GCL. The orientation of the GCL (i.e., which side faces up) should be in accordance with the Engineer's recommendations.
- C. Equipment, which could damage the GCL, shall not be allowed to travel directly on it. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues.
- D. Care must be taken to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL. A temporary geosynthetic subgrade covering commonly known as a slip sheet or rub sheet may be used to reduce friction damage during placement.
- E. The GCL panels shall be placed parallel to the direction of the slope.



- F. All GCL panels should lie flat on the underlying surface, with no wrinkles or fold, especially at the exposed edges of the panels.

### **3.5 Anchorage**

- A. As directed by the project drawings and specifications, the end of the GCL roll shall be placed in an anchor trench at the top of the slope or an equivalent runout design shall be utilized. When utilizing an anchor trench design, the front edge of the trench should be rounded so as to eliminate any sharp corners. Loose soil should be removed from the floor of the trench. The GCL should cover the entire trench floor but does not extend up the rear trench wall.

### **3.6 Seaming**

- A. The GCL seams are constructed by overlapping their adjacent edges. Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. Bentonite-enhanced seams are required for installation of membrane-laminated GCLs.
- B. The minimum dimension of the longitudinal overlap for Bentomat CL should be 150 mm. End-of-roll overlapped seams should be similarly constructed, but the minimum overlap should measure 300 mm.
- C. Seams at the ends of the panels should be constructed such that they are shingled in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone.
- D. Bentonite-enhanced seams are constructed between the overlapping adjacent panels described above. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied within the zone defined by the edge of the underlying panel and the 150 mm line. A similar bead of granular sodium bentonite is applied at the end-of-roll overlap. The granular bentonite shall be applied at a minimum application rate of 0.4 kg/m.

### **3.7 Detail Work**

- A. The GCL shall be sealed around penetrations and embedded structures embedded in accordance with the design drawings and the GCL Manufacturer.
- B. Cutting the GCL should be performed using a sharp utility knife. Frequent blade changes are recommended to avoid damage to the geotextile components of the GCL during the cutting process.

### **3.8 Damage Repair**

- A. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 300 mm is achieved around all of the damaged area. Granular bentonite or bentonite mastic should be applied around the damaged area prior to placement of the patch. It may be desirable to use an adhesive to affix the patch in place so that it is not displaced during cover placement.

### **3.9 Cover Placement**

- A. Cover soils shall be free of large stones or other foreign matter that could damage the GCL. Cover soils should be approved the project Engineer with respect to particle size, uniformity and chemical compatibility. Cover soils with high concentrations of calcium (e.g., limestone, dolomite) are not acceptable.
- B. Soil cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. A minimum thickness of 300 mm of cover should be maintained between the equipment tires/tracks and the GCL at all times during the covering process. This thickness recommendation does not apply to frequently trafficked areas or roadways, for which a minimum thickness of 600 mm is required.
- C. Soil cover should be placed in a manner that prevents the soil from entering the GCL overlap zones. Cover soil shall be pushed up slopes, not down slopes, to minimize tensile forces on the GCL.
- D. Although direct vehicular contact with the GCL is to be avoided, lightweight, low ground pressure vehicles (such as 4-wheel all-terrain vehicles) may be used to facilitate the installation of any geosynthetic material placed over the GCL. The GCL supplier or CQA engineer should be contacted with specific recommendations on the appropriate procedures in this situation.