DESIGNING WITH GCLs FOR POND APPLICATIONS

Engineers designing ponds or canal liners must determine the expected change in water level resulting from two phenomena:

- the amount of water that passes through the liner; and
- the amount of water lost due to evaporation.

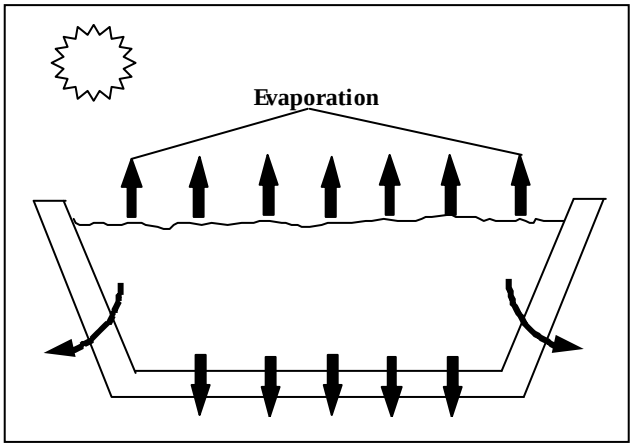

Figure 1

Each of the traditional methods of reducing the water flow through these structures, compacted clay liners (CCLs) and geomembranes, has serious drawbacks. CCLs are difficult, expensive and time consuming to build. Even when properly constructed, most CCLs will not perform as designed due to damage from environmental factors such as freeze-thaw and desiccation. While geomembranes can be installed faster than CCLs, they require specially trained personnel and seaming equipment. Additionally, geomembranes are susceptible to small punctures that can dramatically reduce their effectiveness.

Bentomat® CL and Bentomat CLT

Bentomat CL Geosynthetic Clay Liner (GCL) is reinforced and consists of a layer of sodium bentonite between two geotextiles, one of which is laminated with a thin membrane. Bentomat CLT is a reinforced GCL consisting of a standard needlepunched GCL laminated to a 20-mil HDPE geomembrane. These composite laminated (CL) GCLs combine the best features of a GCL and a geomembrane, making it an excellent choice for lining ponds and other water containment structures. CL series GCLs are very low permeability will significantly reduce the flow rate from a pond more economically than a thick compacted clay liner. CL series GCLs also has several advantages over pure plastic liners including:

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- Simpler installation;
- No special seaming equipment required; and
- Self-healing of small punctures.

* If the GCL is to be placed on a non-soil subbase such as gravel, the test should be conducted on that subbase.

Flow Rate through CL Series GCLs
The flow rate through CL series GCLs has been determined in the laboratory to be 95 gallons per acre per day (gpad) or 5 x 10^{-10} cm/sec. This value was determined by measuring the flux (flow) across the sample when a head differential equivalent to 4.6-ft (2 psi) of water was applied to the sample. The flow rate through the liner will be greater when the liner is used in ponds with depths exceeding 4.6 ft (2 psi). The CL series GCLs low flux makes them suitable for most wastewater treatment ponds.

Bentomat ST may be used in stormwater detention applications where relatively high flow rates are allowable.

Expected leakage rates for CL series GCLs and Bentomat ST for various pond depths are shown in Figure 2.

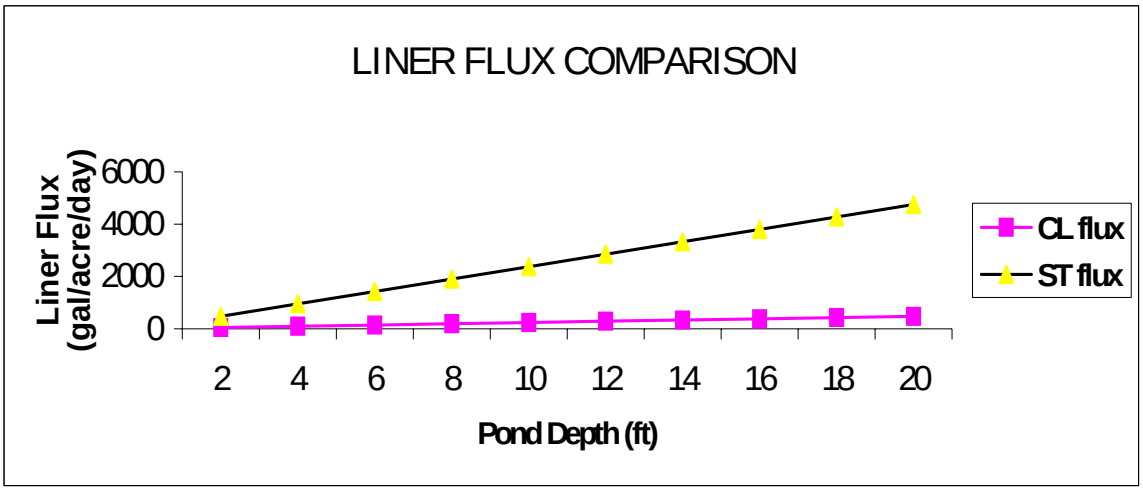

Figure 2

Flow Rate through the Seams
Flow through the seams of a GCL may be an important factor in determining the effectiveness of a GCL. Bentomat CL and CLT seam overlaps are augmented with 0.25 lbs./lineal foot of granular bentonite between the seams.

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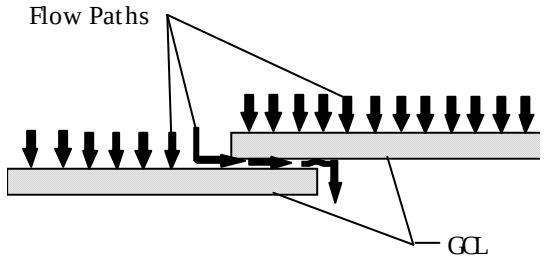

Figure 3

Recent testing has shown that these seams are highly effective. The graph below quantifies the expected flow through the GCL seams.

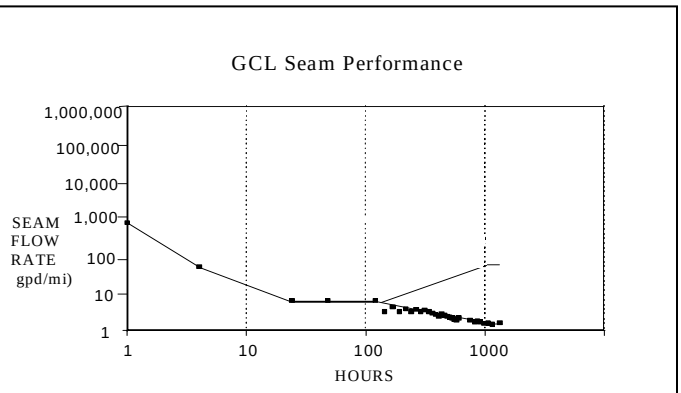

Figure 4

As this figure indicates, the long-term flow through the GCL seams was approximately 2 gallons per day per mile of seam (gpd/mi) or 4.7 l/km/day. This testing was performed with a 15-inch (45-cm) head of water and a 12-inch (30-cm) thick layer of sand cover soil. The seam flow rate can be estimated for other water depths by applying the following formula (assuming the same cover soil thickness): $q_{pond} = q_{test} * [h_{pond} / h_{test}]$

where

- q_{pond} = the flow rate through the actual pond;
- q_{test} = the flow rate measured in the GCL overlap seam flow rate test;
- h_{pond} = the height of water in the actual pond;
- h_{test} = the height of water in the GCL overlap seam flow rate test;

The extra flow rate through the overlapped GCL seams may impact the total flow rate through the liner. Designers should account for this additional flow rate when determining which type of liner will work best for their application.

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Evaporation
The evaporation at a given location can be estimated by referring to regional evaporation charts or by measuring the water loss in an evaporation pan and correcting for other additions and losses. Evaporation losses can range from 1/4 to 3/4 inches (6 to 18 mm) per day, depending on the specific site conditions.

Slope Stability
Another issue facing designers is slope stability. There are several main aspects of slope stability that should be analyzed: stability of the cover material, stability of the lining system and global stability of the embankment. All aspects of stability are important and should be checked for each project.

In any pond-lining project, there will be both sloping areas and flat areas. CETCO typically recommends that Bentomat CL be used on flat areas (less than 6 degrees steepness), and either Bentomat CL and CLT for sloping areas (greater than 6 degrees as described below). The stability of the cover material may necessitate placing the Bentomat CL membrane side down or the Bentomat CLT textured geomembrane side up on slopes.

With respect to the liner system, the stability of the GCL itself, the GCL/cover soil interface and the GCL/subgrade soil interface must be evaluated. The stability of each component of the liner system can be evaluated by the following equation:

$$FS = \frac{[(T/L) + S]}{[(z)\,(\gamma)\,(\sin\beta)]}$$

where

- FS = the factor of safety;
- T = the allowable long-term tensile strength in the layer above the critical surface being analyzed;
- T = 390 lb/ft (6 kN/m) for Bentomat CL;
- L = the slope length;
- S = the shear strength along the surface being analyzed (psf);
- $S = \gamma * z * \cos\beta * \tan\phi + c$

  γ = unit weight of the cover soil (pcf);

  z= thickness of the cover soil layer;

  β = slope angle (degrees);

  ϕ = internal or interface friction angle along the surface being analyzed (degrees); and

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c= the apparent cohesion along the surface being analyzed (psf);

The following table lists the typical allowable slope lengths for Bentomat CL (membrane side down) when used in a pond application. Please note that this table lists only typical values that are based on the following assumptions:

- subbase is smooth and well compacted (90% to 95% of Standard Proctor Density);
- liner cross-section is (top to bottom):
  1 ft. cover soil (Density = 95 pcf or 1500 kg/m^3);
  Bentomat CL (plastic down);
  silty sand (SM) subbase.
- the Bentomat CL is properly anchored at the top of the slope;
- the interface friction angle between the Bentomat CL (woven side) and the gravelly sand cover soil is 33^o;
- the interface friction angle between the Bentomat CL (membrane) and the subbase soil (SM) is 17^o;
- the pond will be filled shortly after placement of the cover material.

Any changes in the above conditions may reduce the allowable slope length for Bentomat CL indicated in the table below:

Side Slope	Cover Soil Depth,in (cm)	Factor of Safety	*Max. Allowable Length,ft (m)
4H:1V	12 (30)	1.2	>150 (45)
3H:1V	12 (30)	1.2	45 (14)
3H:1V	24 (60)	1.2	28 (8.5)
2H:1V	12 (30)	1.2	18 (5.5)

* Longer slopes may be possible using Bentomat CLT (membrane side up) or a wedged slope or reinforcement. To help analyze other cases, CETCO can provide a GRI cover slope stability program upon request. Please contact your CETCO representative for a copy.

CONSTRUCTION

Subbase Preparation

The construction requirements for CL series GCLs are simple. The subbase on which the liner is placed should be smooth and well compacted. An uncompacted subbase might settle out from underneath the liner. This would place the liner in tension and increase the flow rate through this section of the liner. Also, the subbase should be free of any protrusions larger than 1/2 in (12 mm) in diameter.

GCL Storage and Handling

When GCL arrives on site, it should be stored off the ground in a clean dry location on a flat surface such as pallets. Each roll comes in a plastic wrapper to keep the liner dry. An additional plastic tarp should be placed over all the rolls of GCL to ensure that they are not prematurely hydrated.

Construction Sequence

With the exception of a ramp to allow access to the base, the GCL should be installed on the side slopes first. GCL should be overlapped in corner areas and at all joints to ensure that area is completely covered. Once the slopes are completed, the liner can be placed on the base.

Always remember to install only as much GCL as can be covered the same day. DO NOT LEAVE ANY GCL EXPOSED OVER NIGHT. A minimum of 12 in (30 cm) of soil should be placed on the liner (see section on Cover Soil below). The leading edge of the GCL should be wrapped in plastic and covered with sandbags or soil to prevent accidental hydration.

Anchoring on Slopes

The GCL must be secured whenever it is placed on a slope. The most common method of securing the liner is an anchor trench. The anchor trench should be at least 1.5 ft (45 cm) wide, 2 ft (60 cm) deep and it should start at least 3 ft (60 cm) back from the edge of the slope. The GCL should be extended down into the trench and along the trench bottom.

Cover Soil

The performance of the GCL is affected by both the amount and type of cover soil placed on the liner. The cover soil should be a minimum 12 inches thick layer of aggregate or sand with a maximum particle size of 1 in (25 mm).

SOILS THAT CONTAIN HIGH LEVELS OF SOLUBLE CALCIUM AND MAGNESIUM OR OTHER DIVALENT CATIONS (e.g. limestone) SHOULD NOT BE USED AS COVER SOIL.

If the leachate generated from this type of cover soil contains a high total dissolved solid concentration of calcium and magnesium, these cations may chemically react with sodium bentonite, breaking down its structure. The result may be a substantially higher flow rate through the liner.

Similarly, the liquid stored in the pond should not contain a total dissolved concentration of calcium and magnesium.

Compatibility Test

ASTM D6141 has been developed as an initial compatibility test of soils and liquids with GCLs. The testing involves a swell index and fluid loss test. The designer or owner is responsible for determining the chemical compatibility of GCL with the proposed cover soil and the liquid to be contained within the pond. (Please contact your CETCO representative for information on laboratories that are experienced and qualified to perform GCL compatibility tests).

CETCO's GCLs have been tested and shown to be compatible with MSW leachate, livestock waste and dilute sodium cyanide solution.

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SUMMARY

CL series GCLs are excellent choices for a pond liner because of their low permeability, simple installation requirements and self-healing capabilities. Unlike geomembranes, CL series GCLs do not need any special equipment or skilled labor for installation. The panels can be simply unrolled into place and covered with backfill. Also, GCLs ability to seal punctures means that the small holes that are unavoidable during installation will not permanently affect the performance of a CL series GCL liner.

REFERENCES

Cooley, B.H. (1994), "Seam Performance of Overlapped Geosynthetic Clay Liners," M.S. Thesis, University of Texas, Austin, Texas.

IMPORTANT

As each application is project specific, this Technical Reference is provided solely as an aid in determining the compatibility of BENTOMAT® products for design consideration. This Technical Reference is not intended nor should it be used to establish product recommendations for any given installation. To the best of our knowledge, the technical data contained herein is true and accurate at the date of issuance, but subject to change without prior notice.

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