

## BENTOMAT® CLT APPLICATION NOTES

CETCO has introduced Bentomat CLT to our line of laminated GCLs known as Bentomat CL and Claymax 600CL. Bentomat CLT is the only fully reinforced membrane-backed GCL available. Not only is the bentonite layer needlepunch-reinforced, but the laminated membrane layer is textured on both sides for secure interface friction in steep-slope applications. CETCO's Bentomat CLT gives engineers added design flexibility in an ultra-high performance package will increase factors of safety throughout all components of the lining system. Here are some application notes that may of use in working with this product:

### Description

Bentomat CLT is manufactured in a two-step process. First, Bentomat ST is manufactured in accordance with all industry MQC standards. Second, a 20-mil (0.5 mm) thick textured HDPE geomembrane is laminated to the non-woven geotextile side of the Bentomat ST. The geomembrane is supplied by a major producer in North America and is made from the same quality resin comprising today's state-of-the-art HDPE geomembranes. The lamination is accomplished using hot-melt adhesive, which has been applied to the geomembrane prior to its use by CETCO.

The dimensions of the product are 15' x 150'. Given its size and weight relative to the most likely type of application (ponds), in the future it may be decided to offer the product in shorter rolls, perhaps 100 feet, to facilitate installation in smaller projects with lighter-weight equipment. Additional project experience is required before any such decisions will be made.

### Applications

Bentomat CLT is ideally suited for the steep slopes in a liquid containment application such as a decorative pond, wastewater lagoon, or fresh water supply canal. The textured geomembrane will form a high-friction interface with either subgrade soil (applied geomembrane down) or cover soil (applied geomembrane up). The product may also be used in landfill cover applications where an added level of environmental protection is desired against root penetration, surface erosion, or desiccation. For liquid containment projects, Bentomat CLT would be used in combination with Bentomat CL or Claymax 600CL. It remains to be determined as to whether this product could be conceived of as a replacement for a traditional two-component composite GM and GCL lining system.

### Panel Orientation

It is expected that Bentomat CLT will be placed with the membrane facing up, analogous to a traditional GM/GCL composite liner system typically used in waste containment applications. The GCL portion of the product would then serve as a secondary liner as well as a cushioning layer for the geomembrane component. While the orientation could be reversed, it is not known whether this would provide any technical advantages. The end user may make the ultimate decision on the basis of the grain size of the subgrade soil and cover soil. In other words, the geomembrane component would be oriented against the soil layer offering the least potential for puncture.

## Seams

Bentomat CLT is manufactured with a 6-9 inch (150-250 mm) region at the *longitudinal* edge of each panel where the geomembrane is not laminated to the Bentomat. The purpose of this un-laminated zone is to allow and “interleaved” overlap where the geomembrane edges and GCL edges are each overlapped; **or** to allow maneuvering room for a dual-track wedge welder should heat-welding be desired.

The *lateral* edge of each panel is laminated continuously, with no un-laminated zone. This means that an overlapped seam will not be interleaved as is the case with the longitudinal edges. For a welded seam, the lateral edge must be cap-stripped; in other words, a narrow patch is placed over the standard lateral overlap and then extrusion-welded all the way around. Based on the level of detail work that would be required to implement continuously welded seams, it appears that overlaps are more feasible.

## Geomembrane Adhesion

The lamination process is highly effective and will result in a permanent bond. However, it is important to recognize that the technology has limits and that small areas of no lamination or lesser lamination may occur intermittently. This is perfectly normal and constitutes only approximately 5% of the total surface area of the product (edges not included). The product is designed to possess a geomembrane/GCL shear strength equal to or exceeding the shear strength of Bentomat ST. Production peel test results support this design objective, and laboratory attempts have failed to shear the product at the GM/GCL interface.

## Lamination Longevity/Compatibility

The long-term stability and chemical compatibility of the bond could be questioned. The best way to address this issue is to recognize that the laminated surfaces are a textured geomembrane and a non-woven needlepunched geotextile. Thus, even if there were a complete failure of the lamination due to long-term weakening or chemical attack, there will still be significant friction in the interface. In other words, a “worst-case scenario” brings little consequence to most applications unless the shear forces in the system exceed “normal” design parameters.

## Design Issues

Interface friction at the GM/GCL surface (excluding lamination adhesion) is quite high and is generally in the range of 25-30 degrees (peak) in most cases. This interface friction will yield a factor of safety of over 1.5 on a “typical” 3H:1V slope where a relatively thin veneer of cover is applied. Thus, slope stability is unlikely to be limiting design factor. With respect to the hydraulic performance of the product, it must be considered the “state of the art” and really does not allow a quantitative flux or permeability measurement. As with stand-alone geomembranes, the hydraulic performance of Bentomat CLT will be determined by the quality of installation and covering activities, not by the baseline flux or permeability. Central to this issue is the level of attention paid to installation details such as seams, penetrations, foundation seals, etc. These areas will require even more diligent inspection during the installation process.



### Other Installation Issues

Bentomat CLT will be marginally heavier and the roll diameter larger than the standard Bentomat products. This will require the installer to have adequately sized handling and installation equipment. Furthermore, the presence of the geomembrane will increase the overall stiffness of the product and will make it more difficult to conform to surface irregularities, bulging slopes, rounded corners, etc. This means that there is the possibility for a slightly increased waste factor. Detail work such as foundation seals and pipe penetrations will also be more difficult, although the procedures for these details remain unchanged. Finally, although not observed in field trials to date, there is the possibility that thermally induced waves and wrinkles could occur upon exposure to high temperatures. This could be problematic in applications where the seams are overlapped rather than heat-welded.