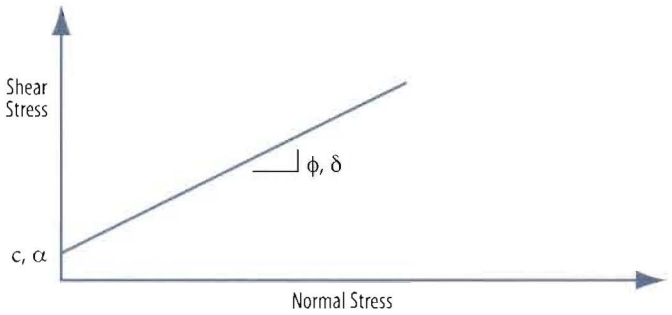
Design questions and answers for geomembranes

By Timothy D. Stark

Q **What is the difference between the strength parameters *c* and ø, and *a* and δ?**

A Good question because these parameters are frequently used interchangeably. *c* and ø, and *a* and δ are shear strength parameters used to represent the strength/failure envelope for a particular material. The strength envelope is obtained from laboratory shear testing (e.g., ASTM D5321) for



direct shear testing of geosynthetic interfaces. *c* and ø, and *a* and δ are typically used to represent the strength envelope for soils and geosynthetic materials/interfaces, respectively. The values of *c* and *a* represent the vertical intercept of the failure envelope and ø and δ represent the slope of the strength envelope. The strength envelope is plotted on a graph of normal stress applied to the material during the test on the horizontal axis and shear stress/strength on the vertical axis as shown below: The normal stress is calculated by dividing the weight or force applied to material being tested divided by the cross-sectional area of the specimen. If the strength envelope is stress-dependent (i.e., not a straight line), it is recommended that these strength parameters not be used and the entire stress dependent strength envelope be used in the stability analysis.

Q **Are GCLs hydraulically equivalent to a compacted low permeability soil liner?**

A A good, but difficult, question. GCLs are hydraulically equivalent to low permeability soil liner in terms of advective flow. However, GCLs are not hydraulically equivalent to low permeability soil liner in terms of diffusive flow unless a natural attenuation layer underlying the GCL is considered in the diffusion analysis.

Q **What effect does heat have on a Subtitle D composite liner system?**

A Heat can have many detrimental effects on a Subtitle D composite liner system. For example, heat can adversely affect the compacted low permeability soil liner by reducing its moisture content, leading to an increase in hydraulic conductivity and possibly cracking. Heat can also adversely impact a GCL by causing desiccation and cracking of the bentonite under certain conditions, such as low normal stress and high temperature gradient. Similarly, high heat can adversely impact the overlying geomembrane because heat can accelerate depletion of the anti-oxidants in the polyethylene geomembrane which reduces the time before polymer degradation begins. In general, high density polyethylene geomembrane manufacturers recommend a temperature less than 150°F in containment applications.

Q **Is there a maximum slope angle for geosynthetic lined slopes?**

A Yes there is, and the slope angle should not exceed the lowest geosynthetic interface friction angle, δ, of the system. The slope angle should not exceed δ because this condition can/will lead to tension developing in the geosynthetics and possibly progressive failure of the slope. Geosynthetics will stretch and possibly tear under tension because they are not designed to be under tension. The only geosynthetic that is designed to be under tension are geosynthetic reinforcement products, such as geogrids and high strength geotextiles.

Q **What design strength should be used for GCLs?**

A If the GCL is not encapsulated between two geomembranes, the slope design should/must assume that the GCL will be fully hydrated at a low normal stress (e.g., 5–10 psi for a liner system). If the GCL will be encapsulated between two geomembranes, the design strength can be assigned the average of the fully hydrated and as received moisture content strength envelopes. Another approach is to assume that some percentage of the GCL becomes hydrated and assign a hydrated strength to this percentage of the critical failure surface.

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