

# **Designing with GCLs**

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## **Design Issues**

**1- Liquid barrier is the focal point of attention**

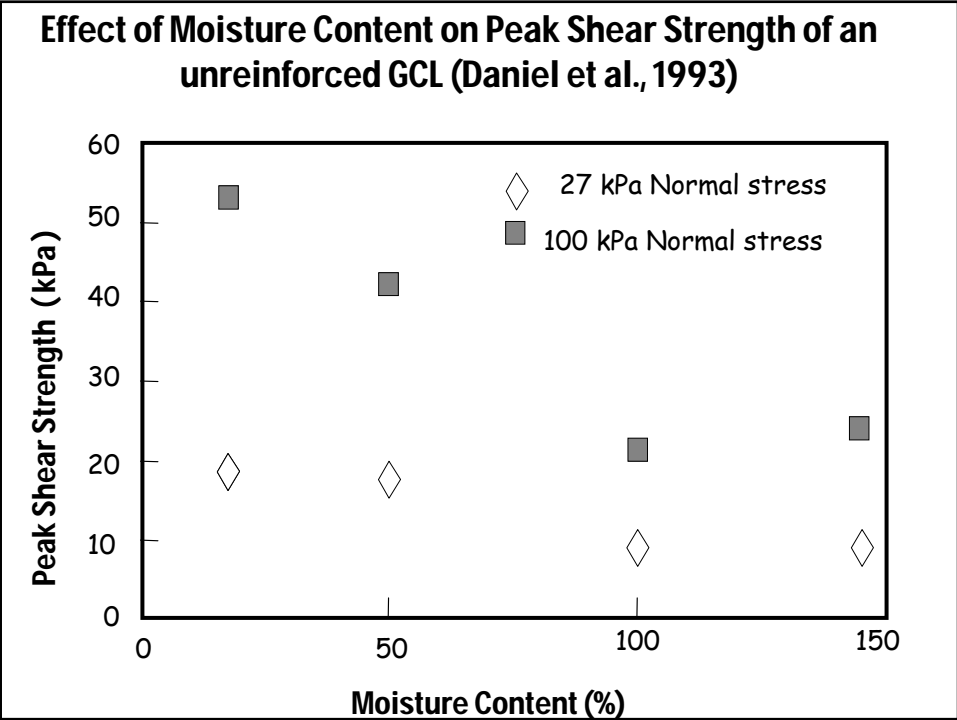
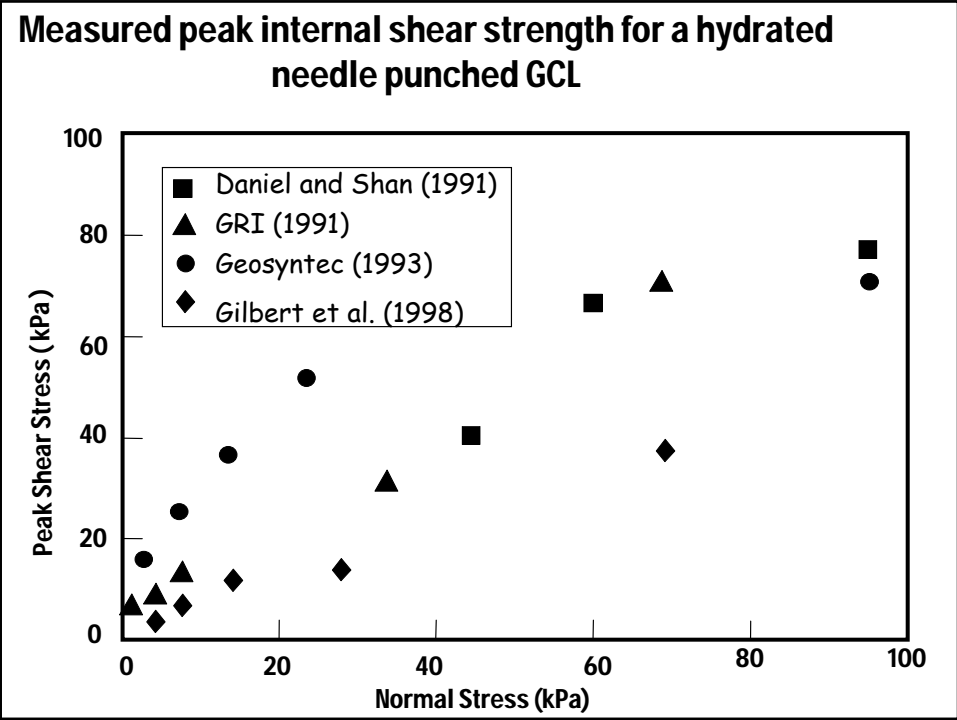
- Flow rate for water containment problems**
- Chemical compatibility, adsorption, and breakout time for solute problems**

**2- Shear strength consideration when GCLs are placed on side slopes**

- Direct shear testing is necessary and site specific conditions should be simulated in every way possible**



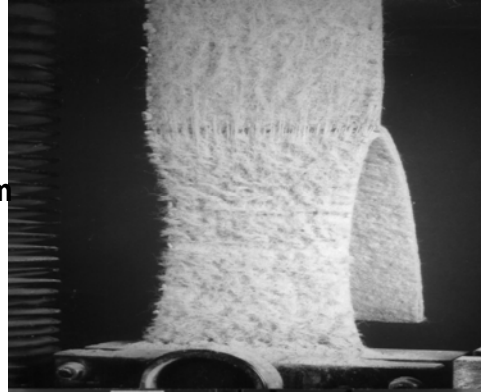
- **In most cases, shear strength of GCLs is being listed as site specific and product specific issue.**
  
- **In addressing the shear strength of GCL's there are three possible failure surfaces to consider:**
  - **The interface between the top of the GCL and the overlying material (soil or geosynthetics).**
  - **The internal structure of the GCL**
  - **The interface between the bottom of the GCL and the underlying material (soil or geosynthetics)**



## Effect of Needle Punching

● The peel strength of a GCL is an indicator of the amount of needle punching and thus, the internal shear strength of the GCL.

● The peel strength is the force necessary to separate or peel the two geotextiles of a 100 mm wide GCL specimen



● Typical material specifications for needle punched GCLs recommend a peel strength of 60 to 65 N/10 cm

Differences in peel strengths are caused by differences in the needling boards

The longer the service life of a needling board the more needles that are broken

In summary peel strength and, thus, internal shear strength varies with the magnitude of needling.

As a result the magnitude of needle punching can vary from roll to roll



## **Recommendations for evaluating GCL shear strength**

**Do not extrapolate failure envelopes over different normal stress ranges.**

### **For Hydrated GCLs:**

**Allow for a minimum of several weeks of hydration (monitor deformation with time)**

**Apply normal stress that will be applied during shear**

### **For Dry GCLs**

**Use a representative moisture content (as received versus field)**

**Evaluate sensitivity of strength to MC**

**Use a shear rate that is representative of field conditions (slower apparently more conservative)**

**Displace samples far enough (several cms) to obtain large displacement or residual behaviour**

**Consider ALL possible failure surfaces**

**BE WARY OF EXISTING DATA**

## **Interface Shear Strength**

- **GCL interface components**

  - Non Woven GTX, Woven GTX**

  - Smooth GM, Textured GM**

  - Bentonite**

- **Common interfaces with GCL**

  - Smooth GM, Textured GM,**

  - Non Woven GTX**

  - Geonet**

  - Soil**

- **Non-woven GTX/smooth GM:**

  - Not a common interface due to "intimate" contact concerns with non woven GTX (transmissivity)**

  - Polishing of GM leads to strain-softening**

- **Woven GTX/smooth GM:**

  - Bentonite extrusion through woven GTX reduces interface strength**

  - Variability between GCL products**

● **Non-woven GTX/Textured GM:**

**Texturing improves peak strength versus smooth**

**Variability between different GCL products**

**Post peak reduction in strength (up to 50%) due to pull out of GTX fibres and polishing of texturing**

● **Woven GTX/textured GM:**

**Post peak strength reduction caused by wear down of needle punch asperities**

**woven GTX provides lower peak strength than non woven**

### **Summary of Interface Shear Strength**

- ⌘ **Highly non-linear failure envelopes,  $c$  and  $\phi$  depend on normal stress range**
- ⌘ **Post peak strength reductions are possible**
- ⌘ **GCL bentonite can squeeze into interface and reduce shear strength**
- ⌘ **Internal shear strength may govern**

### **Recommendations for evaluating interface strength**

- **Perform site specific shear testing at representative normal stresses for interface of concern.**
- **Displace interfaces far enough to obtain large displacement or residual behaviour.**
- **If soil involved (i.e.CCL): Prepare soil samples to representative moisture contents and densities (and account for variability in field).**
- **Perform both undrained (rapid) and drained (slow) tests on interfaces with clay to identify critical condition**



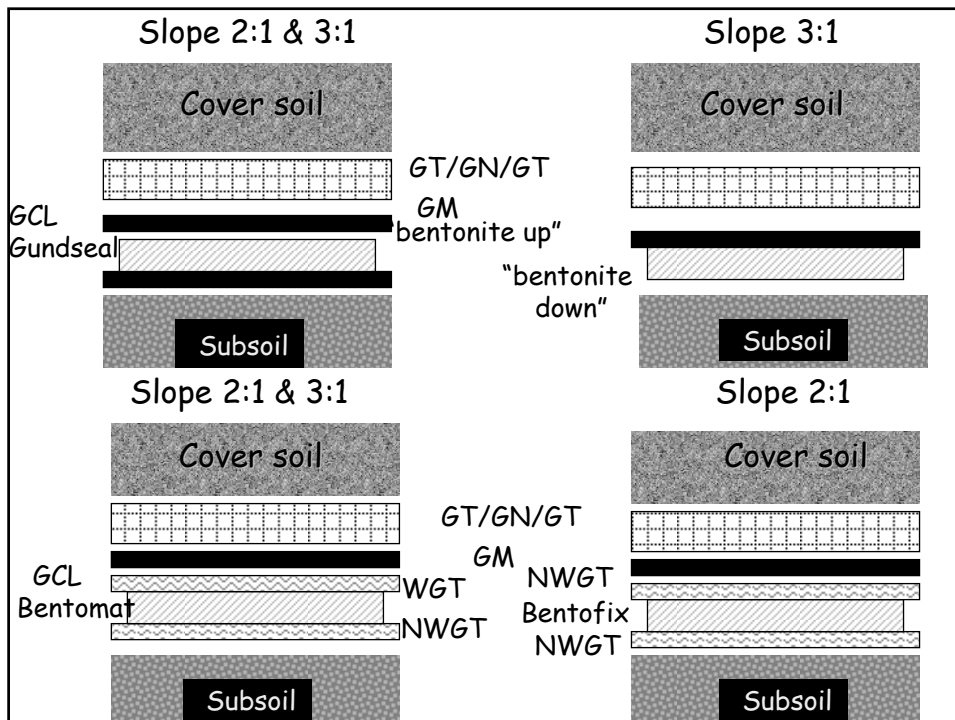
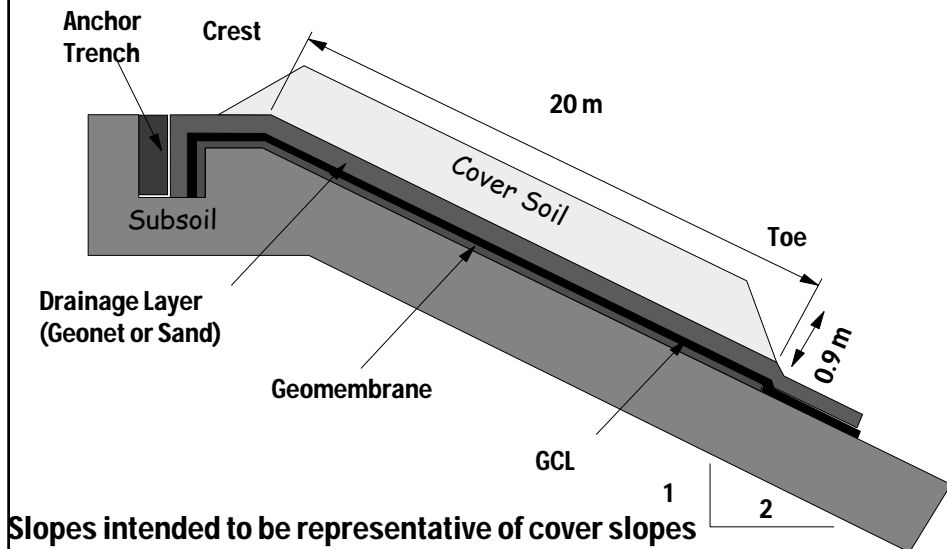
# Construction

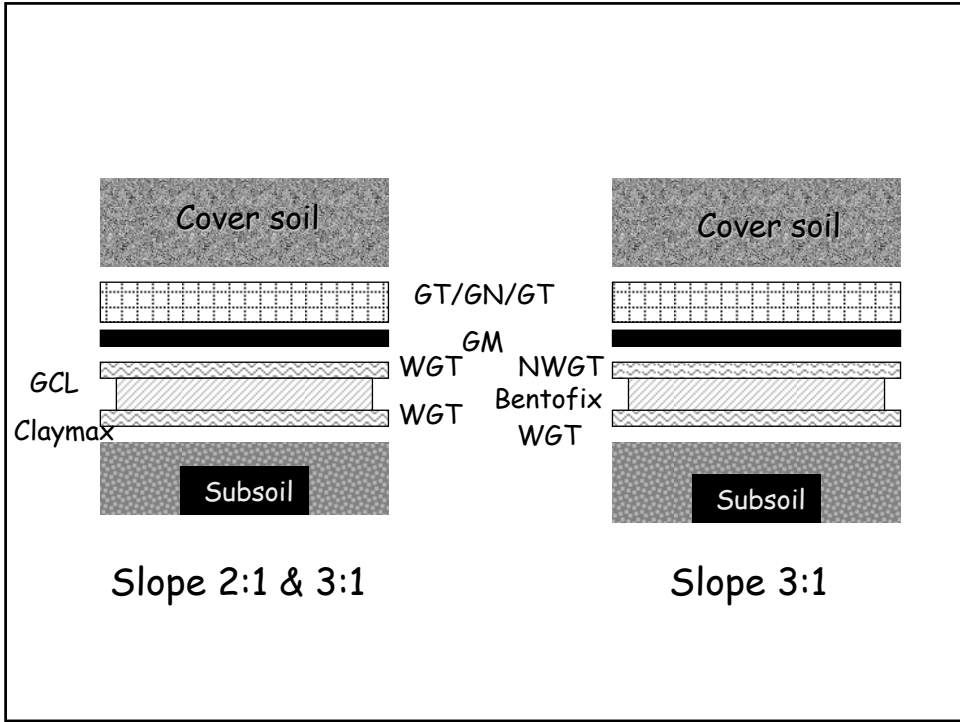


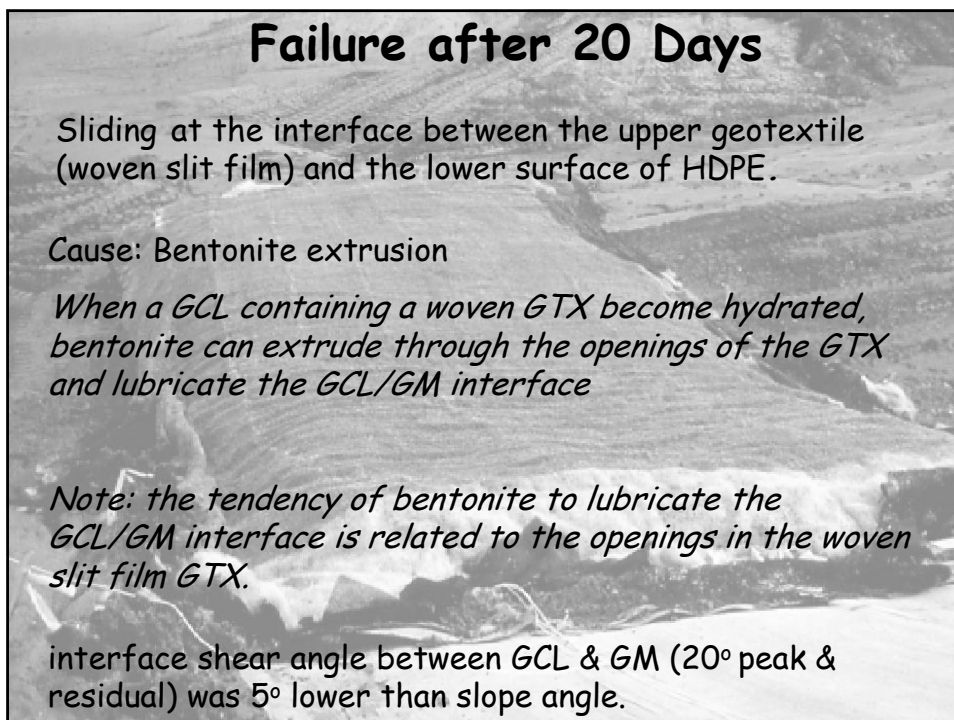
# Completed Test Plots

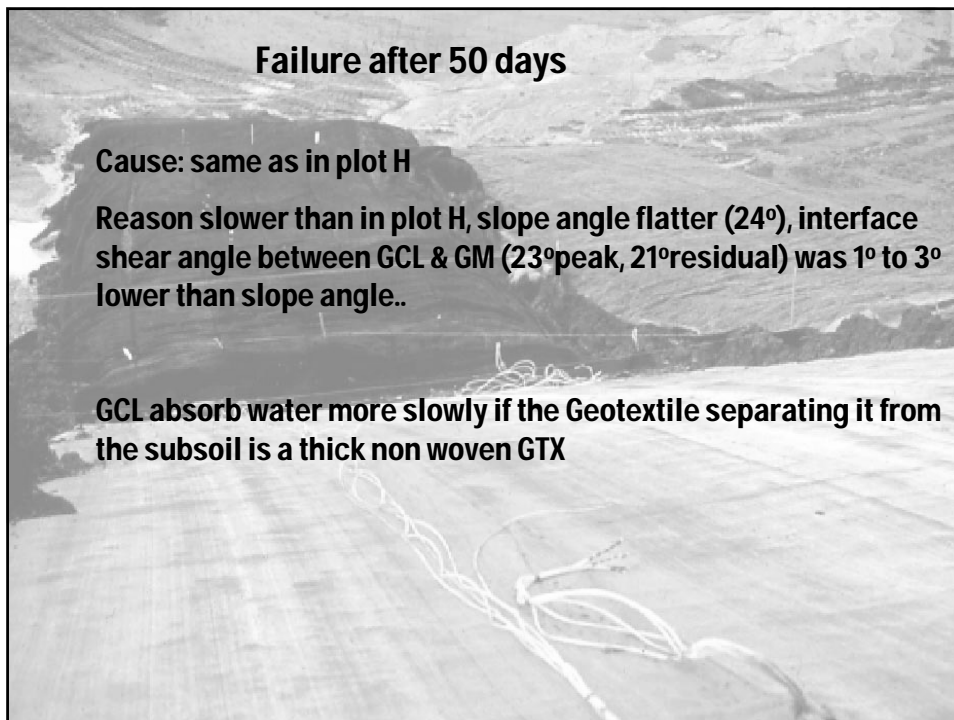
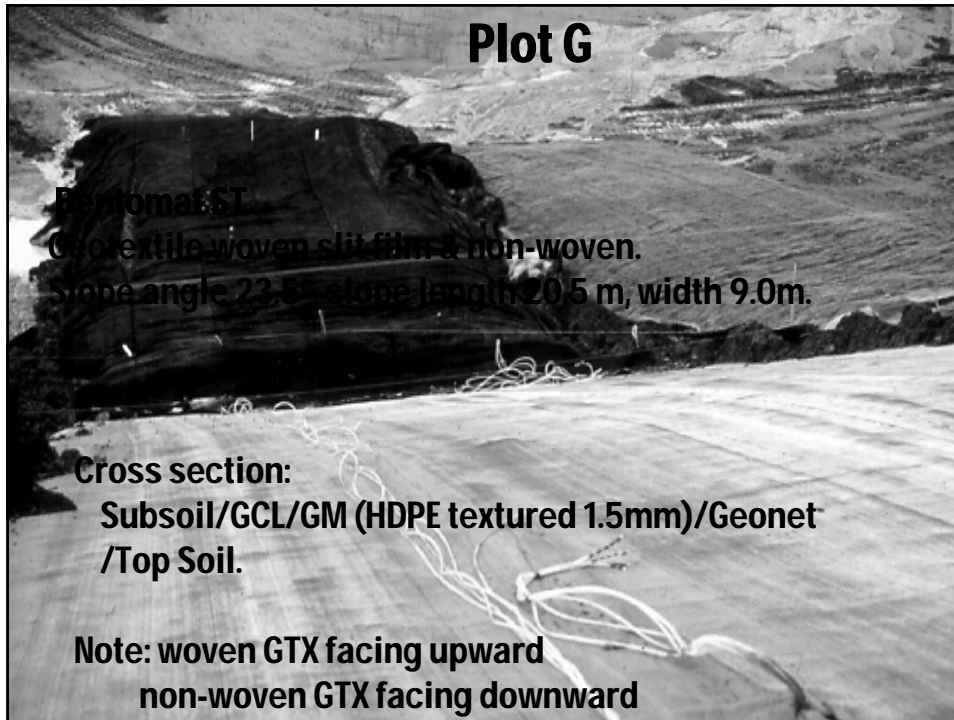


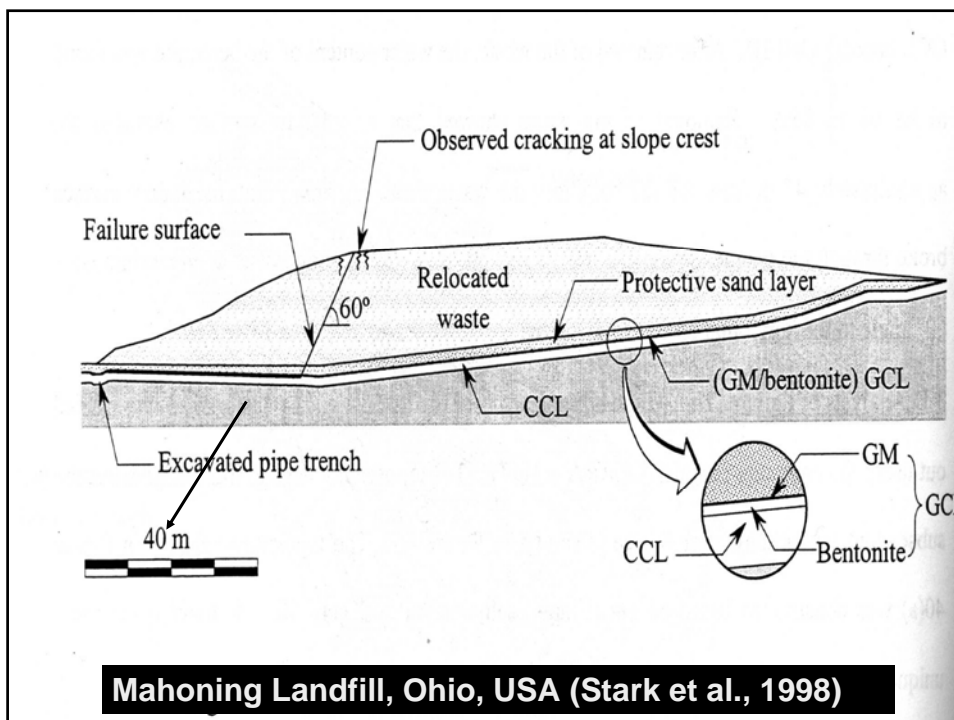
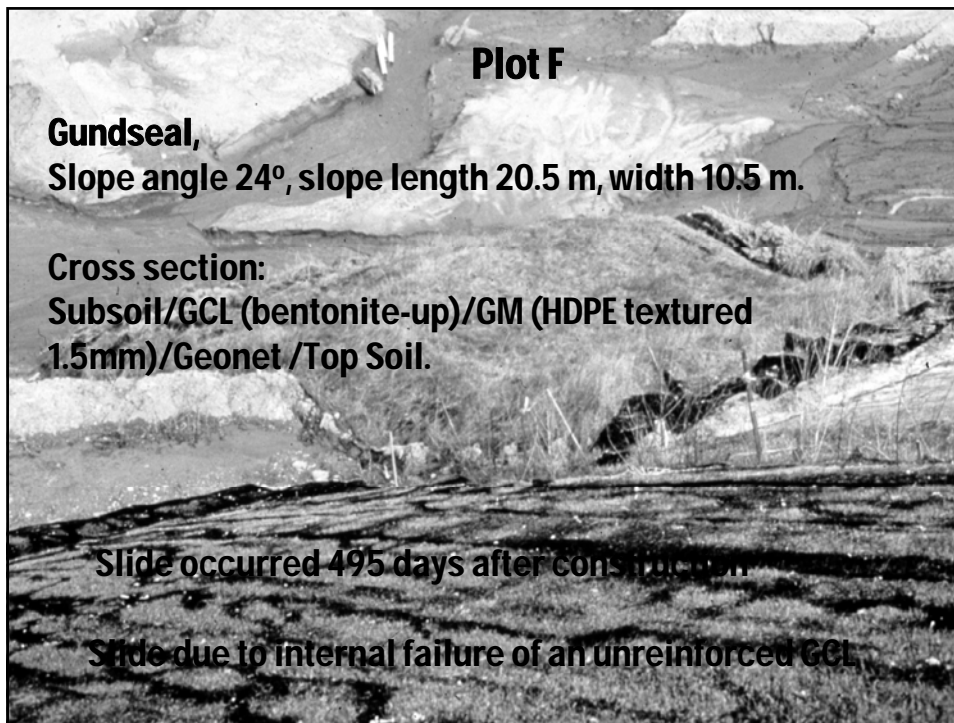
### Cincinnati field test, *Daniel et al. (1998)*

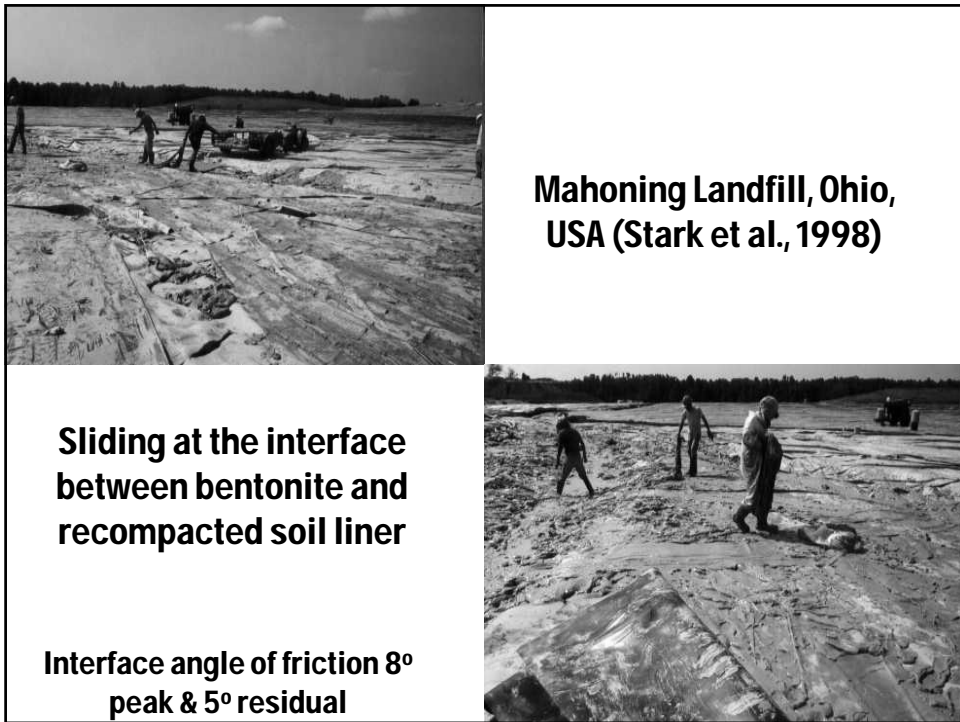












**General issues in the design for a GCL used as a single liner are as follows:**

- **Calculate the flow rate in the context of alternative materials, adsorption, and breakout time for both water and the solute in the containment.**
- **Calculate the shear strength for side slopes under all possible internal & interface conditions.**
- **Assess the possible implications of puncture, tear, and loss of bentonite, considering both the materials above and below the GCL.**
- **Carefully consider installation survivability of the GCL, considering both the subgrade and the backfill material**

**General issues in the design for a composite GM/GCL liner are as follows:**

- **Calculate the composite liner flow rate for water containment applications, and the flow rate adsorption and breakout time for solutes containment applications.**
- **Assess the internal and interface shear strength for the side slopes under short and long term loading conditions.**
- **Assess the GCL strength design and factor of safety. If the interface friction angle below the GCL is lower than those above it and also lower than the slope angle, the difference must be carried by the GCL in tension.**

- **Avoid lateral migration, or squeezing, and loss of thickness of the hydrated bentonite under heavy long term static loads. A suitable thick soil cover layer is necessary before trafficking**
- **Avoid the contamination of overlying GM seam areas from loss of bentonite. This has been a Pb with textured GM**
- **Carefully consider installation survivability of the GCL, considering both the subgrade and the backfill material**

## **Equivalency GCLs & CCLs**

### **Key Advantages of CCLs**

- ☺ **Many regulatory agencies require CCLs- Use of another type of liner may require time consuming demonstration of equivalency to a CCL, with an uncertain outcome.**
- ☺ **A CCL is a logical choice if large quantities of suitable clay are available locally.**
- ☺ **The large thickness of CCLs makes them virtually puncture proof**

- ☺ **The large thickness of CCLs and the fact that they are constructed of multiple layers makes them relatively insensitive to small imperfections in any one layer.**
- ☺ **There is a long history of use of CCLs**
- ☺ **Quality assurance procedures are reasonably well established for CCLs**

### **Key advantages of GCLs**

- ☺ **Small thickness of GCLs leads to low consumption of landfill space-has an economical advantage (more landfill space available for space) and an environmental advantage (less consumption of land for waste disposal).**
- ☺ **Construction of GCLs is rapid and simple**

- ☺ **GCLs can be shipped to any location-their use is not dependent upon local availability of materials**
- ☺ **Heavy equipment is not needed to install a GCL (helpful for final covers underlain by compressible waste)**
- ☺ **GCLs can accommodate large differential settlement.**
- ☺ **GCLs are more easily repaired than CCLs**

### **Criteria for performance assessment**

- ☺ **To replace a CCL with a GCL, one must:**
  - **Comply with all applicable regulations**
  - **Apply normal standards of care and professional practice for design**
- ☺ **There are no standard criteria to judge acceptability of replacing CCL with GCL**

**Criteria that might be considered are:**

  - **Hydraulic issues**
  - **Physical mechanical issues**
  - **Construction issues**