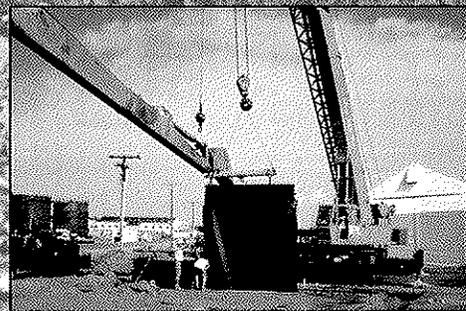
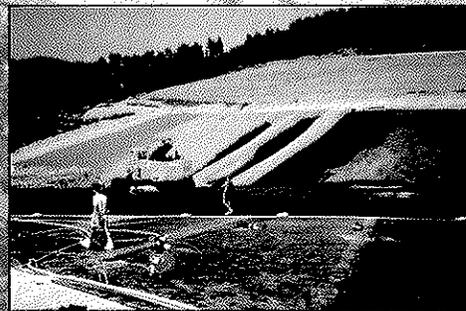
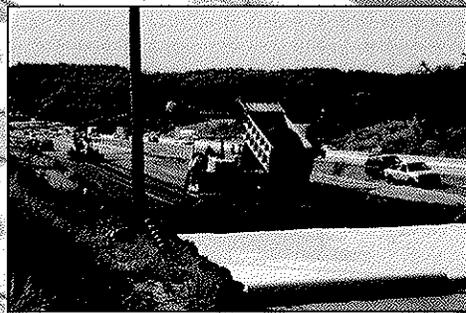




# DESIGNING WITH GEOSYNTHETICS

Fourth  
Edition



Robert M. Koerner

### 6.1.2 Hydraulic Properties

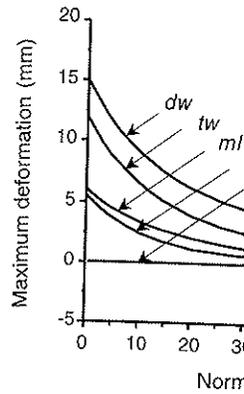
Since GCLs are used in their primary function as hydraulic barriers this section is critically important. The hydraulic properties considered here are: hydration liquid, free swell, moisture absorption, fluid loss, and permeability.

**Hydration Liquid.** Bentonite, the essential low permeability component of all GCLs currently available, is known to hydrate differently depending upon the nature of the hydrating liquid. It is also known to hydrate differently as a function of the applied normal stress. Figure 6.3 illustrates the hydration response of four GCLs to the following five different liquids: distilled water, Philadelphia tap water, mild landfill leachate, harsh landfill leachate, and automotive diesel fuel. In all cases, the distilled water hydrated the GCLs the greatest. In contrast, the diesel fuel resulted in no hydration. Obviously, with diesel fuel the adsorbed water layer on the bentonite particles never developed and no swelling occurred. This is an important and well-known finding, in that GCLs must be pre-hydrated with water if they are to be used to contain hydrocarbons and nonpolar fluids. The two types of landfill leachates and tap water fall intermediate between these two extremes. All three fluids have anions and cations within them, which diminish the hydration potential of the bentonite from the ideal case of distilled water. It is somewhat disconcerting to see that local Philadelphia tap water was found to be quite close in its response to leachate, but at least it was the mild leachate!

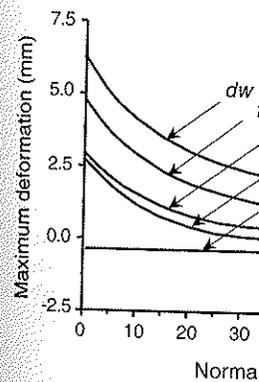
**Swell Index.** The amount of swelling of bentonite under zero normal stress has been formalized in a test known as swell index, and designated as ASTM D5890. In this test, a graduated cylinder is filled with 100 ml of water and 2.0 g of bentonite is added. The bentonite is milled to a powder and added to the water slowly so as to allow the clay to flocculate and settle to the bottom of the cylinder. After leaving the cylinder undisturbed for 24 hours, the volume occupied by the clay is measured and a recommendation is given. Heerten et al. [2] recommend a minimum swell index value of 25 ml.

A similar test, albeit under a very low seating load but one that can be readily performed in the field as a conformance test, is GRI test method GCL-1. In this procedure a CBR swelling test device is used wherein 100 g of the GCL clay component (along with its adhesive, if present) is removed from the product and placed in the mold. A light seating load of 0.68 kPa is placed on the test specimen with a dial gage attached. The test specimen is saturated and readings are taken for 24 hours. The hydration behavior is recorded (see Figure 6.4) and if the swelling meets or exceeds the manufacturer's value, the clay component is acceptable.

**Moisture Absorption.** The fact that the bentonite in GCLs can readily absorb water from the adjacent soil has been shown by Daniel et al. [4]. They placed samples of GCLs on sand soils of varying water contents from 1 to 17% and measured the uptake of water in the GCL. Figure 6.5 shows the resulting curves. Two important messages stem from this data: soils as dry as 1% can result in GCL hydration to 50% and the time for hydration is extremely rapid (e.g., within 5 to 15 days).



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