TECHNICAL NOTE

Bentonite Resistance to Cation Exchange for Geomembrane Supported GCL Products

GSE GundSeal GCL

In general, hydration and permeation of sodium bentonite by clean rainwater should result in bentonite hydraulic conductivities in the range outlined in Table 1. If water percolates down to the GCL through a soil containing significant amounts of leachable calcium, magnesium, or other polyvalent cations, however, these cations will preferentially exchange with the sodium in the bentonite, reduce its swelling capacity, and potentially increase its hydraulic conductivity. The calcium concentration in the soil water need not be high - over a period of years, the slow leaching by the dilute calcium liquid will cause gradual replacement of sodium by calcium, and an increase in hydraulic conductivity. The mechanism of cation exchange in sodium bentonite and degrative effects on hydraulic performance is documented by Egloffstein (1997).

Table I

Compressive Stress (kPa, psf) on GCL	Approximate Hydraulic Conductivity (cm/s)
0	Do Not Use GSE GundSeal
5 kPa or 100 psf	5 x 10^{-9} cm/s
20 kPa or 400 psf	2 x 10^{-9} cm/s
20 kPa to 500 kPa (400 - 10,000 psf)	2 x 10^{-9} cm/s to 1 x 10^{-10} cm/s
> 500 kPa (10,000 psf)	1 x 10^{-10} cm/s

Table 1. Recommended Preliminary Estimate of Hydraulic Conductivity of the Bentonite Component of GSE GundSeal Permeated with Fresh Water (Daniel 2001, work in progress).

The problem of cation-exchange-induced changes in hydraulic conductivity has been documented for three full-scale case histories where fabric encased GCLs have been used (Dobras and Elzea, 1993; James et al., 1997; and Melchior, 1997). In all three cases, the GCL was a geotextile-encased GCL without a geomembrane component, which allowed the exchange process to occur throughout the entire area of the GCL. An advantage of GSE GundSeal related to resistance of bentonite cation exchange is that its protective geomembrane should not allow massive cation exchange to occur. With GSE GundSeal, cation exchange is limited to comparatively small areas where water has access to the bentonite through overlaps or imperfections in the geomembrane. In two of the three cases where problems were reported, the cover soils were calcium materials, which is the worst type of cover material in terms of potential for deleterious chemical alterations. The case described by Dobras and Elzea (1993) involved a GCL covered with crushed limestone, and the case reported by James et al. (1997) involved a GCL covered with a soil that was almost pure calcium (chalk). In the case reported by Melchior (1997), the soils contained a mix of ions, illustrating that bentonite will preferentially adsorb calcium even in situations with a mix of ions in the permeating water.

In all three cases, the hydraulic conductivity of the bentonite increased one to two orders of magnitude as a result of calcium replacing sodium in the bentonite. These changes are large and significant. However, there was no protective membrane component separating the bentonite from the overlying soils in any of these cases, and had there been a membrane component, the impact of the calcium replacement would have been orders of magnitude less because the area affected by the exchange would have been limited to overlaps or other zones where permeation by several pore volumes of water could occur. Also, the changes did not occur immediately but typically took several years of permeation before the calcium replacement was complete and the damage was done.

Recommendations to minimize the degrative effects of cation exchange on sodium bentonite include providing long term protection with an adjacent geomembrane (Egloffstein, 1997, Daniel, 2000). Given the geomembrane backing of GSE GundSeal GCL, the bentonite component will be protected against cation exchange in comparison bentonite alone, unprotected by an overlying or underlying geomembrane component.

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