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Factors affecting GCL hydration under isothermal conditions

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ABSTRACT

The hydration of different GCLs from the pore water of the underlying foundation soil is investigated for isothermal conditions at room temperature. Results are reported for three different reinforced (needle punched) GCL products. Both a silty sand (SM) and sand (SP) foundation soil are examined. GCL hydration is shown to be highly dependant on the initial moisture content of the foundation soil. GCLs on a foundation soil with a moisture content close to field capacity hydrated to a moisture content essentially the same as if immersed in water while those on soil at an initial moisture content close to residual only hydrated to a gravimetric moisture content of 30–35%. The method of GCL manufacture is shown to have an effect on the rate of hydration and the final moisture content. The presence or absence of a small (2 kPa) seating pressure is shown to affect the rate of hydration but not the final moisture content. The GCL hydration did not change significantly irrespective of whether a nonwoven cover or woven carrier GCL rested on the foundation soil.

1. Introduction

Geosynthetic clay liners (GCLs) are often used as part of composite liners with a geomembrane liner placed over the GCL (e.g., Rowe et al., 2004; Guyonnet et al., 2009). GCLs have been found to be highly effective for preventing groundwater contamination provided that: (a) they are adequately hydrated (Petrov and Rowe, 1997), (b) the overlap between the panels is maintained (Rowe, 2005), (c) they are not subjected to excessive desiccation combined with cation exchange (Benson et al., 2010), or (d) internal erosion of the bentonite (Rowe and Orsini, 2003; Dickinson and Brachman, 2010). After placement, the GCL takes up water from the underlying soil and provided that it hydrates before contact with leachate, it is usually a very good barrier to advective transport of contaminants (Rowe, 2007). However while the performance of these GCLs as liners is known to depend, at least in part, on the degree of hydration that has occurred before it comes into contact with the contaminants to be contained (Petrov and Rowe, 1997), the rate of hydration of a GCL placed on an underlying subsoil has received very little attention and it is largely an article of faith that they will be adequately hydrated by the time they need to perform their containment function. Daniel et al. (1993) and Eberle and von Maubeuge (1997) have reported limited data for GCLs placed on sand. The former paper showed that, when placed on sand at 3% gravimetric moisture content, an initially air dry GCL reached 88% moisture content after 40–45 days. The latter paper showed that when placed over sand with a moisture content of 8–10%, an initially air dry GCL reached a moisture content of 100% in less than 24 h and 140% after 60 days. However these tests were on different foundation soils with water retention curves, different moisture contents and different GCLs and it is not clear to what extent the properties of the specific foundation soil and GCL affected the rate of hydration.

It is known that both the method of GCL manufacture (Rowe, 2007; Beddoe et al., 2011) and type of bentonite used (Bouazza et al., 2006) can both influence the performance of a GCL. For example, Beddoe et al. (2011) demonstrated that the water retention curve for a GCL was a function of how it was manufactured. Also, Bouazza et al. (2006) showed large differences in transport of liquids or gas between granular and powdered bentonite during the initial hydration of a GCL. Gates et al. (2009) reported that GCLs with fine grained (powdered) bentonite took up water faster and formed an effective seal sooner than coarse granular bentonite due to larger surface area of the bentonite particles.

The speed of hydration is important in terms of both assessing how fast the composite liner system must be covered with soil/waste if one aims to minimize damage due to shrinkage and wetting and drying cycles (e.g., Thiel et al., 2006; Gassner, 2009; Rowe et al., 2010, 2011; Bostwick et al., 2010), to minimize the

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