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Investigation of the effects and degree of calcium exchange on the Atterberg limits and swelling of geosynthetic clay liners when subjected to wet-dry cycles

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Abstract: In the field, particularly in landfill cover system applications, a geosynthetic clay liner may be exposed to inorganic cations such as calcium, magnesium and aluminium which can alter the performance of the GCL bentonite component especially if accompanied by drying and re-wetting as a result of seasonal changes in temperature and rainfall. To investigate the impacts of wetting and drying, the Atterberg limits of the GCL bentonite component and swelling of the GCL were determined under wet-dry cycling with calcium chloride solution used for the wetting cycles. From the quantities of calcium chloride added at each wetting stage, estimates were made of the degree of ion exchange of calcium for sodium on the clay. The authors recognise that there is a substantial literature on the effects of inorganic salts such as calcium chloride on the behaviour of bentonite. However, so far as they are aware, the results of such tests involving cation exchange have not been investigated in terms of the degree of exchange achieved.

In the tests two calcium chloride solutions were used: 0.0 125 and 0. 125 M. This allowed a detailed investigation of the effects of the degree of sodium-calcium exchange on the bentonite and some, though more limited, consideration of the effects of ionic strength of the pore fluid. It is shown that for Atterberg limit tests, even using 0. 125 M calcium chloride solution, full calcium exchange could not be achieved as the amount of liquid added to bring the bentonite to the liquid or plastic limit did not contain sufficient calcium ion for full exchange. For the swell tests, much higher liquid-to-solid ratios were used so that near full exchange could be achieved though only after several wet-dry cycles. Using these data the paper develops a methodology for estimating the position of the cation exchange equilibrium and shows how complex this analysis can become. It also shows that on occasion only limited cation exchange may be achieved in laboratory tests whereas near full exchange may occur in the field. If the effects of full/near full exchange are to be investigated,

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laboratory procedures must be specially designed to achieve high degrees of exchange, for example, by using multiple exchange cycles, large liquid-to-solid clay ratios or by permeating the clay with the cation exchange liquid though such permeation procedures may take a very substantial time. (C) 2006 Elsevier Ltd. All rights reserved.

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