POLYMER MODIFIED BENTONITES IN GEOSYNTHETIC CLAY LINERS (GCLS)

Introduction

Polymer modified (using chemical additives) bentonite are typically used on **marginal, suboptimal quality bentonites** to enhance some material properties. These additives are rarely disclosed and their composition unknown. Their long-term benefits are also not known at this time.

As a minimum requirement, the chemical makeup of a polymer (chemical) additive should be detailed, with a Material Safety Data Sheet (MSDS) provided. Furthermore, some polymer additives are water soluble and may disperse from the product partially or completely over time.

Technical Background on Bentonite Form (EPA Vic., 2014)

Bentonite in GCLs can be supplied as a natural sodium bentonite, a sodium-activated bentonite (also referred to as activated bentonite, sodium-activated calcium bentonite or activated sodium bentonite) or as calcium bentonite. Natural sodium bentonites are arguably preferred for critical applications, as they typically contain essentially exchangeable Na^{+}, have the **optimal** mineralogy and chemistry, and require minimal processing to achieve a low hydraulic conductivity GCL. The designation calcium bentonite traditionally has been used to describe bentonites containing less than 60 per cent exchangeable Na+, with the remainder being Ca^{2+}, Mg^{2+}, K^{+} or more typically, combinations of these. Bentonites sourced within Australia often have higher levels of exchangeable Mg^{2+} than Ca^{2+} but are still generally referred to as calcium bentonites.
Sodium activation, or beneficiation, must be done to increase the amount of exchangeable Na^{+}. This also serves to increase swelling, dispersion, hydration and gelling properties of the bentonite, which in its normal Ca^{2+} (or Mg^{2+}) form, would be suboptimal (Harvey and Lagaly, 2006). In some bentonites, a portion of the Ca^{2+} and Mg^{2+} may be associated with a carbonate phase that is either inherent in the mineralogy or may form during beneficiation. Upon hydration, a part of these carbonates dissolves and releases Ca^{2+} and/or Mg^{2+}, which can displace Na^{+} (Guyonnet et al., 2005). Thus swelling, dispersion and gelation of sodium-activated bentonites may be **suboptimal**, because significant levels of Ca^{2+} and Mg^{2+} will remain in the bentonite during hydration (Harvey and Lagaly, 2006). **In such cases, other additives, such as polymers or pH modifiers, may be added to improve the swelling and sealing capability of sodium-activated bentonites. However, the nature and suitability of these additives is difficult to check. If used, the manufacturer should provide their details and demonstrate their nature, suitability and long-term durability.**

Quality Control Index Tests (c.f. Fluid Loss & Swell Index Technical Notes)

Industry has accepted as a basis for manufacturing quality control (MQC) and construction quality control (CQC) a number of short-term index tests to assess the bentonite quality of a GCL product and as a predictor for long-term containment performance. These include; 1) fluid loss and 2) swell index.
However, these very same index tests do not provide any guidance on its long-term performance. Very limited laboratory and field testing relating to GCLs using polymer (chemically) modified bentonites is available not only in the short-term but also in the long-term (Gardam et al., 2014 and Scalia et al., 2014). In practice, the addition of polymer (chemical) additives is generally a very small percentage of the overall bentonite mass to be modified. MQC and CQC procedures such as testing and auditing of the type, quantity, distribution and consistency of the added polymer additive and the bentonite both

during manufacture and when subject to CQC acceptance audits upon site delivery are unknown and cannot be easily be determined.

Regulatory Guidelines

The following extracts clearly state the precautions of using polymer modified bentonites in GCLs for landfill containment applications. They are all from **current best practice guidelines**;

EPA VICTORIA
Best Practice Environmental Management (BPEM) *Publication 788.2*, 2014 – page 93: Appendix E2.1.1.2 – Bentonite Form;

"… other additives, such as polymers or pH modifiers, may be added to improve the swelling and sealing capability of sodium-activated bentonites. However, the nature and suitability of these additives is difficult to check. If used, the manufacturer should provide their details and demonstrate their nature, suitability and long-term durability"

THE GEOSYNTHETIC RESEARCH INSTITUTE (GRI), USA
GRI-GCL5, 2013 – page 23: Clause 11.7 - *Design Considerations for Geosynthetic Clay Liners (GCLs) in Various Applications;*

"It should be noted that there is presently (2011) several ongoing research efforts in modifying both sodium and calcium bentonites, primarily (but not exclusively) with polymer additives. The goals of these efforts are to reduce cation exchange. Of course, the long-term performance of these polymers needs to be addressed, as well as the environmental impact. If polymers are added they should be noted in the product data sheets."

ENVIRONMENT AGENCY (EA), UK
EA Publication: *Using Geosynthetic Clay Liners in Landfill Engineering*, ver.3 – page 5: Clause 2.4

"2.4 Additives

Some GCL manufacturers use additives to enhance certain characteristics such as initial swell and leachate resistance in reinforced GCLs, or in the form of glues in unreinforced liners. The nature and suitability of these additives is difficult to ascertain. As a result we would prefer they were not used unless the manufacturer is able to demonstrate their nature, suitability, and long term durability. Manufacturers must provide details of all additives used in the manufacture of their GCLs. Where the additive is a polymer, you must ascertain the manufacturer has not used excess polymer during the manufacture of the GCL. Excess polymer can cause excessive swelling of the clay/polymer filling in needle punched GCLs pushing the geotextiles apart, and allowing bentonite migration and subsequently loss of integrity."

Summary

The main issues with polymer (chemically) modified bentonites in GCLs are the long-term performance and durability of the GCL. The polymer additive may provide a benefit during the first swell cycles but after that and during future drying/hydration the performance is unknown and cannot be guaranteed.

The referenced paper regarding polymer modified bentonite by Gardam et al. (2014) clearly states that the achieved test results for modified bentonites is short-term only. It also notes in the conclusion that *"Further tests are required to validate these results over longer time periods and larger flow volumes and to influent-effluent chemical equilibrium".*

Other studies on polymer modified bentonite GCLs by Scalia et al. (2014) with cooperation of Colorado State University shows that after two years, the polymer has been lost from the polymer modified bentonite GCL during permeation.

Furthermore, as a minimum requirement, identification of the polymer/chemical additive should be detailed on the technical datasheet and MSDS for transparency and full disclosure. In addition, documented long-term performance results should be presented and not only short-term index bench tests. This will enable the design engineer to be able to make informed decisions and for stakeholders to be aware of potentially harmful chemical additives to people and to the surrounding natural environment.

REFERENCES & FURTHER READING

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