Summary

The results of an experimental activity, which was carried out on a natural sodium bentonite by means of a novel laboratory apparatus, have been interpreted through a mechanistic model that allows the transport and mechanical parameters of semipermeable clays to be related to a limited number of physico-chemical properties. In such a way, both chemical osmosis and swelling pressure have been proven to be macroscopic manifestations of the same electrical interactions that occur between the solid phase and the ions in the pore solution. A second series of laboratory tests was conducted to investigate the existence of anomalies in the measured reflection coefficient, ω, which correspond to the occurrence of ω values outside the 0 to 1 range, when bentonites are permeated with aqueous mixed electrolyte solutions. Both negative ($\omega = -1.168$) and positive ($\omega = 1.064$) anomalous osmosis have been observed in contact with solutions of sodium chloride and potassium chloride, which denote a deviation from pure chemico-osmosis as a result of the build-up of a diffusion induced electro-osmotic effect. Given that bentonites modified with organic compounds and/or polymers are increasingly being used as part of pollutant containment systems, the available literature has been re-examined in light of the proposed theoretical model to advance the understanding of the mechanisms that underlie their superior containment performance. While intergranular pore clogging has been confirmed for bentonites amended with sodium polyacrylate, none of the commonly used chemical additives has been found to promote osmotic swelling based on the detrimental effect of an increase in the salt concentration on the reflection coefficient. Moreover, preservation of a dispersed micro-fabric has been attributed to modification with sodium carboxymethyl cellulose. Finally, an analytical solution for the calculation of the leakage rate through lining systems, which consist of a geomembrane overlying a geosynthetic clay liner, has been derived with the aim to include the effect of the bentonite semipermeable properties.