INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: An experimental investigation into the utilisation of organoclay-amended bentonite as a barrier material for waste containment applications

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SHORT ABSTRACT

The incorporation of a hydraulic barrier system is indispensable while designing an engineered waste containment facility to avert environmental pollution resulting from hazardous and toxic waste constituents. Bentonite is a widely adopted hydraulic barrier material owing to its distinct characteristics, such as high swelling capacity, extremely low hydraulic conductivity, and high sorption capacity. However, the long-term barrier performance of bentonite liners can be compromised by the permeation of chemicals from the waste. As a consequence, harmful contaminants from the leachate percolate through the failed liner and eventually contaminate the surrounding ecosystem. To enhance the barrier performance and reduce chemical sensitivity, alternative materials should be explored and utilised as amendments to conventional bentonite. Organoclays offer a promising solution due to their superior sorption capabilities and improved hydraulic performance in the presence of organic pollutants. This study investigates the efficacy of commercially available organoclays as an amendment to Indian bentonite in hydraulic barrier applications. Initially, an effort was made to understand the sorption performance of parent materials for the removal of heavy metals and phenol contaminants. Results demonstrated that organoclay exhibited superior sorption for both heavy metals and phenol, whereas bentonite was effective primarily in removing cationic heavy metals. Subsequently, the geotechnical properties of bentonite and organoclay-amended bentonite (BOC) were examined under various leachate conditions to assess their chemical sensitivity. Parameters such as plasticity, free swelling, swell potential, swell pressure, hydraulic conductivity, consolidation parameters and compressibility characteristics, were evaluated under different concentrations of inorganic salts (NaCl and $CaCl_2$), heavy metals (cationic: Pb^{2+} and Zn^{2+}, anionic: Cr(VI)) and organic pollutants (acetone and phenol). The research outcomes revealed that increasing concentration of inorganic salts and heavy metals reduced the liquid limit, free swelling, swell potential, swell pressure, coefficient of volume change, time for 90% consolidation, and compression index of both bentonite and BOC, while increaseing coefficient of consolidation and hydraulic conductivity. However, none of the samples surpassed the limiting hydraulic conductivity criteria of 10^{-9} m/s recommended for

hydraulic barriers by environmental protection agencies. When compared to bentonite samples, BOC exhibited less changes in geotechnical properties under the presence of these chemicals indicating the lower chemical sensitivity of BOC. Additionally, BOC displayed lower hydraulic conductivity than bentonite when permeated with high concentrations of organic contaminants, which was beneficial for barrier applications. The decreased permeability in the presence of organic contaminants and the reduced chemical sensitivity with inorganic pollutants indicate that BOC could function as a more efficient hydraulic barrier in waste containment systems that have significant levels of both organic and inorganic chemicals.