



**INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS**

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Programme of Study : Ph.D.

Thesis Title: GEOTECHNICAL INVESTIGATION ON THE BEHAVIOUR OF FIBRE-MIXED BLACK COTTON SOIL UNDER THE INFLUENCE OF VARIOUS PERMEANTS FOR BARRIER APPLICATION

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SHORT ABSTRACT

Engineered disposal systems are designed to isolate both domestic and industrial wastes from the natural environment by placing geotechnical barrier systems. Clay barriers function as low-permeability layers to effectively contain contaminants and prevent groundwater infiltration in landfills. This study investigates the use of naturally available black cotton (BC) soil as a barrier material due to its abundance and high montmorillonite content. However, its susceptibility to shrinkage limits its effectiveness. To address this, waste tire fibres—known to reduce shrinkage in clays—were added to BC soil at concentrations of 5%, 10%, and 15% (by dry weight). Considering engineering, economic, and environmental benefits, the fibre-mixed BC soil composite was evaluated for its suitability as a hydraulic barrier.

The long-term performance of fibre-mixed BC soil as a hydraulic barrier may decline due to exposure to hazardous landfill leachate, potentially risking groundwater contamination if its engineering behaviour is not properly assessed. Therefore, it is very crucial to test barrier material under the permeation of various salts and heavy metals, which are predominant in landfill leachate. For this reason, fibre-mixed BC soil was tested under two inorganic salts (NaCl and CaCl₂) at two concentrations of 0.1 and 1.0N, three heavy metals (two cationic: Pb(II) and Cd(II), one anionic: Cr(VI)) at three concentrations of 100, 500, and 1000 ppm, and two synthetic leachates (MSW leachate and fly ash leachate) to assess its suitability as a hydraulic barrier.

The study found that increasing tire fibre content up to 15% in BC soil significantly reduced swelling potential, swelling pressure, and time for 90% consolidation. The compression index decreased up to 10% fibre content but slightly increased at 15%. Hydraulic conductivity rose with fibre content but remained within the acceptable limit ($<10^{-7}$ cm/s), and UCS values exceeded the required threshold (>200 kPa) at 15% fibre inclusion. Chemical permeation with inorganic salts, heavy metals, and synthetic leachates further reduced Atterberg limits, free swell indices, and swelling parameters, regardless of fibre content. Swelling behaviour under various permeants was accurately predicted using a rectangular hyperbola model. Consolidation coefficients and hydraulic conductivity

increased significantly due to chemical exposure, while compression indices slightly decreased with higher concentrations of salts and metals. Divalent cations (Ca^{2+}) had a more pronounced effect than monovalent (Na^+), and Cr(VI) permeants showed the most adverse impact due to high K^+ concentrations. UCS values slightly declined with Cr(VI) but increased with Cd(II) and Pb(II). Synthetic fly ash leachate had a greater impact on geotechnical properties than MSW leachate due to higher heavy metal concentrations, though both caused UCS reduction. The hydraulic conductivity of 15% fibre-mixed soil exhibited a surpassing value at any given consolidation pressure under permeation of synthetic leachates and inorganic salt permeations at 1.0N concentration. Laboratory results clearly highlighted the importance of evaluating the influence of various permeants on the geotechnical properties of fibre-mixed soils.

