Alkali-activated materials for stabilisation of high-water-content very soft clays

Research scholar: Meghna V. S. Supervisor: Dr. Rakesh J. Pillai

Abstract

Soft clays exhibit low shear strength and high compressibility, and the presence of organic matter further increases their sensitivity and susceptibility to secondary consolidation. Chemical stabilisation of these soft clays with high organic content using conventional binders such as lime and ordinary Portland cement (OPC) is widely reported to be ineffective. On the other hand, alternative cementitious materials such as alkali-activated materials (AAMs) offer a promising and more sustainable approach for improving their engineering performance. In this study, the stabilisation of very soft organic (O) and inorganic (I) clays with high natural water content using AAMs was investigated. A novel sample preparation approach with AAMs was proposed for the stabilisation of these clays. The influence of clay mineralogy, organic content, water content and activator molarity on the effectiveness of stabilisation was investigated using mechanical and microstructural characterisation. Unconfined compressive strength (UCS) and plasticity characteristics of stabilised soft clays were determined at different curing periods. In addition, the long-term performance of the stabilised clays was evaluated through durability and leachability tests. The results showed that the UCS of AAM-stabilised soft clays increased with an increase in curing period and activator molarity, suggesting that AAMs are effective in stabilising soft clays with high natural water content. Microstructural characterisation using TGA, FTIR, QXRD and SEM was carried out to elucidate the mechanism of AAM stabilisation. TGA and QXRD studies confirmed the formation of hydration products, such as C-S-H, hydrotalcite, stratlingite and silicocarnotite in stabilised soft clay samples that contributed to the enhanced mechanical performance. QXRD studies further indicate the participation of clay minerals in alkali-activation, leading to microstructural densification and improved mechanical performance. Durability test results showed strength reduction and mass loss during cyclic exposure, indicating degradation of the stabilised matrix, which was further confirmed by FTIR and XRD studies. Leachability tests indicated the leaching of sodium, aluminium, and calcium from the stabilised clay, while heavy metal concentrations remained negligible. Overall, the study highlights the effectiveness of AAM stabilisation in enhancing the mechanical performance of very soft organic and inorganic clays with high water content and contributes to the development of sustainable ground improvement techniques for problematic soils.