Preface

Sodium hydroxide is a valuable alkali that has been used in various industries including paper and pulp, soap and detergent, petroleum, textile, and alumina industries etc extensively. According to World Bureau of Metal Statistics, the production of aluminium has been doubled to approximately 3.55 million metric tonnes in the last decade which consumes large volume of sodium hydroxide manufactured. The huge production and utilisation of sodium hydroxide make it a causative source of sub-surface soil pollution in many parts of the world, particularly in locations where it is thriving. The intense interaction of chemical contamination causes mineralogical and microstructural changes in soil, resulting in alteration in the geotechnical properties of soil. Apart from this, one major problem associated with the alkali interaction is unexpected heaving in the foundation soil that causes failure of the structure. Therefore, it is pertinent to take into account the heaving behaviour and alteration in geotechnical properties of such contaminated sites as well as to find out the remedial measures to control alkali-induced-heaving and to improve the geotechnical properties of alkali-interacted soils. With the aim of assessing these problems, an attempt has been made to evaluate the heaving and other geotechnical behaviour of soil by prolonged interaction of different concentrations of alkali contaminant and also to develop remedial measures to control the alkali-induced heaving and to suppress the detrimental effect of alkali on the soil. Despite that, a sustainable and dependable remediation strategy can be proposed to perform in-situ to counteract the deteriorating effect of alkali contamination on the strength of the soil.

A comprehensive experimental programme has been planned to achieve these objectives. The experimental investigations along with the detailed material methodology and the results obtained are discussed into seven chapters of this thesis. The first chapter provides a background of the effect and source of alkali contamination, along with some case histories of structural failure due to alkali contamination and the need for its consideration from a geotechnical point of view. The second chapter summarizes a detailed review of the documented literature on the effect of alkali contamination on heaving as well as deterioration of geotechnical properties of soil and the use of different additives to control the alkali-induced heaving and to improve the geotechnical properties of alkali-contaminated soil. The application of the electrokinetic (EK) technique for the stabilisation of problematic soil is also presented in detail in this chapter. The different materials used and various methodologies adopted in the study are presented in detail in chapter 3. The soil used in the study was collected within the campus of Banaras Hindu University, Varanasi, which was later artificially contaminated with NaOH at concentrations of 8, 12, and 16 M in the laboratory. Followed by the selection of industrial waste by-products and different chemicals to control the alkali-induced heaving as well as for stabilising of alkali-interacted soil. The chapter also gives a detailed design and fabrication of the large-scale rectangular, circular and bench scale EK equipped models used in this dissertation.

The fourth chapter presents a series of geotechnical tests conducted for an assessment of the effects of different concentrations of alkali solution on the heaving behaviour and alterations in the engineering properties of the soil. Later, the 16 M NaOH solution was used to assess the alkali-induced heaving in the large-scale rectangular and circular models through the electrokinetic technique. The fifth chapter presents a series of geotechnical tests to investigate the influence of different percentages of two different industrial waste by-products namely, Ground Granulated Blast Furnace Slag (GGBFS) and Alccofine, on the alkali-induced heaving and their efficiency to improve the engineering properties of uninteracted soil and alkali interacted soil. Further, the optimum percentage of waste by-products was used to stabilize the alkali interacted soil through a bench scale EK model to simulate the field condition. The sixth chapter aims to examine the effect of different three concentrations of three chemical stabilizers (Enzymatic Induced Calcite Precipitate (EICP), sodium silicate and sodium carbonate with calcium chloride salts) on the index and strength properties of alkali interacted soil through bench scale electrokinetic test. The test results show that the addition of industrial waste by- product and the ingression of chemicals not only enhanced the engineering properties of uninterated and alkali interacted soil but also controlled the alkali-induced heaving in soil effectively. The last chapter summarizes the major conclusions of the study along with its limitations and future recommendations. On one hand it was seen that alkali contamination significantly deteriorates the engineering properties of the soil, on the other hand, a remarkable recovery was observed in those properties when stabilized through various industrial and chemical stabilizers. Although the large scale and bench scale studies have been attempted in this work, still there has been vast scope to further conduct these studies on a field scale for better reliability of the results.