Electrokinetic remediation of sewage contaminated soil and its impact on bearing capacity

M.V. Parikshith[1], C.S. Darshan[1], K. Rajath[1]

[1]*Civil Engineering Department, The National Institute of Engineering, Mysuru, India*

e-mail: parikshith.mv@gmail.com

Introduction

Soil is the foundation of ecosystem function, as well as for civil engineering structure. Understanding the soil system is the key to success and environmental harmony of any human use of land. One of the stark realities of 21st century is that the demands for soil usage are increasing by several billions, while the natural uncontaminated soil available to meet the demands is insufficient due to the contamination by industrialization and urbanization activities. There are many remediation techniques such as biological, thermal and physical treatments. Electrokinetic method is an effective method, which is rapid and less expensive. Many researchers have studied the remediation methods including the Electro Kinetic Remediation (EKR) by involving the construction of practical model. Al-Hamaiedh et al. studied the effect of oil contamination on soil properties and the feasibility of EKR to treat the oil contaminated soil by passing 1-4 mA of current using electro osmotic cell and obtained an oil removal efficiency of 30-50%. From the detailed literature review, the objectives of our study was to determine the change in the soil shear properties due to the intrusion of sewage water and to check the feasibility of Electrokinetic method by developing a practical lab scale model.

Electrokinetic remediation method is still in assessment in all research facilities since soil pollutant interaction cannot be known effectively. Soil polluted with sewage, if not treated will affect the ground water table, hence it should be removed immediately which is possible by this method. Electrokinetic Remediation is a process in which a low-voltage direct current electric field is applied across section of contaminated soil by introducing electrodes into the soil to move the contaminants. The principle of Electro kinetic remediation is similar to a battery, after electrodes are introduced and connected to a source of electric current, molecules dissociate into ions and moves towards oppositely charged electrodes. This dissociated ion attracts the opposite charged end of dipole free molecule and thus this method also acts as dewatering method. This technique requires external processing fluid as medium for conduction of current through the soil, but the pollutant itself act as conducting medium.

Materials and Methods

The EKR model apparatus consists of tank made of non-conductive material which is of acrylic glass. The dimensions of the tank are 0.4m(l) x 0.2m(b) x 0.3m(h) and thin copper plates are used as electrodes. A 12V battery is used as source for applying low voltage direct current for treatment of contaminated soil. One of the tank faces is made detachable for easy removal of soil after each trail. Also, one half of the base plate is provided with holes near cathode for the drainage of sewage water.

These are the following steps involved in the study:

- Soil sample collection and analysing the geotechnical properties according to SP-36 part2 1988.
- Pollution of soil due to overflow of sewage water from manholes and percolation near landfills are taken as our study area. These pollutants should be removed quickly before it reaches the groundwater.
- Sewage water collection from sewage treatment plant after screening process to avoid large floating particles and its properties are analysed.

- Polluting soil by sewage water in different proportions and determining the changes in shear properties of the soil.
- Treating the contaminated soil by introducing electrodes into the soil surface and connecting it to the opposite terminals of two batteries connected in series using jump clips and current reading is taken using ammeter.
- The treatment is done for two different linear spacing between electrodes and determining the improvement of soil shear properties in both the cases.
- Determination of water content at the regions of anode and cathode are done to validate the movement of water.
- Safe bearing capacity is calculated for both uncontaminated and contaminated soil samples using IS 6403-1981 for comparison and determining the efficiency of the treatment.

Results and concluding Remarks

Contamination of soil with sewage water (25% by weight of soil) reduces the value of cohesion(c) and angle of friction (Ø) from 28.5 kPa and 38.65^0 to 0 kPa and 30.35^0 respectively. The Electrokinetic method applied to the soil sample by introducing direct current increases the value of shear parameters c and Ø to 14.3 kPa and 34.2^0 respectively for 15cm linear spacing between electrodes. For 20cm spacing, treatment increases the shear parameters c and Ø to 11.3 kPa and 32.6^0 respectively. Safe bearing capacity decreases on contamination by 82.41% and Electrokinetic treatment provided with a current range of 0.3A increases it by 59.78% for 15cm spacing and 49% for 20cm spacing. The difference in the efficiency of treatment between 15cm and 20cm electrode spacing is due to the length travelled by current across soil sample which increases the resistance and a consequent voltage drop. Thus, this treatment is effective in treating the soil by removing the sewage water which moves from anode to cathode due to application of electric field with the help of the drainage holes provided near cathode. The results obtained are for sandy soil, however the efficiency of the method changes with soil type, electrode material and configuration of electrode arrangement.

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