Effect of Salt Solution on Geotechnical Properties of Thonnakkal Clay and Lateritic Soil and Excess Salt and Water Removal by Electrokinetic Remediation

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Abstract— *clayey soils are commonly used as barriers in municipal and industrial waste sites to isolate ground water from contaminants. With migration of contaminated fluids and replacement of pore fluids of soil, the chemistry as well as physic-chemical properties of the pore fluid is changed, and soil is contaminated. Increased stresses in soil and the reduction of shear strength by contamination together make the clay liner more prone to failure, leading to underground water pollution. In order to improve the engineering behaviour of clayey soils, several improvement techniques are available in geotechnical engineering practice. The present study deals with the effect of salt solution on geotechnical properties of Thonnakkal clay and lateritic soil. The clay samples were mixed with varying percentage (0, 5, 10, 15 and 20%) of salt solution, to improve the strength of soil. After this excess salt removal and water by electrokinetic remediation will studied.*

Keywords— Thonnakkal Clay, Lateritic Soil, Contamination, Electrokinetic Remediation

I. Introduction

Clayey soils are commonly used as barriers in municipal and industrial waste sites to isolate ground water from contaminants. With migration of contaminated fluids and replacement of pore fluids of soil, the chemistry as well as physic-chemical properties of the pore fluid is changed, and soil is contaminated. Increased stresses in soil and the reduction of shear strength by contamination together make the clay liner more prone to failure, leading to underground water pollution. Under these conditions, the overall stability of the landfill structure and those around it may also be reduced. The effects of various chemicals on the permeability and other hydraulic properties of soils, while the influence of hazardous wastes and contaminated water on the shear strength has been practically neglected. The increasing use of clays in soil engineering practice necessitates a better understanding of their behaviour and their changes in various environments.

Here the study is concentrated on the effect of salt solution on geotechnical properties of Thonnakkal clay and lateritic soil. Then excess salts and water removal by electro kinetic remediation. In first study conducting compaction, CBR (Soaked and unsoaked), Triaxial tests, UCS test etc. Soil remediation can be conducted in two ways: in-situ and ex-situ. Electrokinetic remediation can be performed as an in-situ remediation where the soil is not excavated for the purpose of decontamination (De Battisti and Ferro, 2007). This method involves the application of direct current of low density to the contaminated site. An electric field is created by inserting electrodes in the contaminated site and passing low density DC making the contaminant particles mobile in the soil media. The contaminants get transported towards the electrodes and they are pumped out. This technique is usually used for removing organic and inorganic pollutants including heavy metals, radio nuclides and hydrocarbons from soils with low permeability.

A low current is used in the order of mA/cm^{2}per cross sectional area since it would be safer for the personnel working there and also to avoid the adverse effects of heating. The ground water in the boreholes generally suffices as a conductive medium for the passage of current but in a situation where the groundwater proves to be insufficient, external processing fluid is used as conductive medium (Acar and Alshawabkeh., 1993).

The electrodes with their casings are inserted in the soil which is contaminated. There should be a minimum of two electrodes to carry out the process and they are the anode and the cathode. The anode is positively charged and it attracts the negatively charged contaminants and the cathode is negatively charged and it attracts the positively charged contaminants when the current is passed (Sharma and Reddy. 2004). The contaminated water from the electrode casings are removed by pumps. The removal sometimes is improved by using surfactants or weak acids at the reservoirs. The electrode arrangement depends on the extent of contamination. In areas of extensive contamination of soils the electrodes may even be arranged in a grid with alternating cathode and anode layers.

II. Materials and Methodology

A. Materials Used

1) Thonnakkal Clay

Collected from English India Clay Ltd., Thonnakkal. The basic engineering properties of clay are presented in table 1. Figure 1 shows clay.

Properties	Values
Specific gravity	2.2
Liquid limit (%)	52.1
Plastic limit (%)	30.5
Plasticity index (%)	21.6
Shrinkage limit (%)	24
Maximum dry density (g/cc)	1.32
Optimum moisture content (%)	22
Unconfined compressive strength(kN/m^2)	65.4

Table 1: Properties

Fig. 1: Thonnakkal Clay

2) Lateritic Soil

Collected from locality near college. Rich in iron. Properties are given below in Table 2. Figure 2 shows the lateritic soil.

Properties	Values
Specific gravity	2.58
OMC (%)	19
MDD (g/cc)	1.43
Effective size, D10 (mm)	0.23
Uniformity coefficient, Cu	7.39
Coefficient of curvature, Cc	1.25
Liquid limit	45%
Plastic limit	42.4%
Plasticity index	2.6%
Shrinkage limit	37.25%

Table 2: Properties

Fig. 2: Lateritic soil

3) Electrokinetic Remediation Setup

Electrodes with their casings are inserted in the soil which is contaminated. There should be a minimum of two electrodes to carry out the process and they are the anode and the cathode. The anode is positively charged and it attracts the negatively charged contaminants and the cathode is negatively charged and it attracts the positively charged contaminants when the current is passed (Sharma and Reddy. 2004). The contaminated water from the electrode casings are removed by pumps. The removal sometimes is improved by using surfactants or weak acids at the reservoirs. The electrode arrangement depends on the extent of contamination. In areas of extensive contamination of soils the electrodes may even be arranged in a grid with alternating cathode and anode layers. Figure shows the example of a setup diagram.

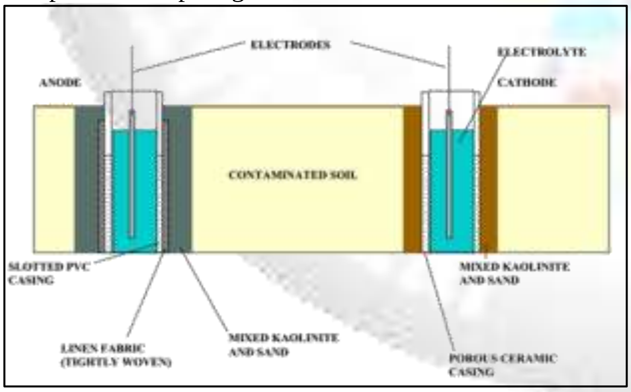

Fig. 3: Electrokinetic setup model

B. Test Conducted

The study consists of experimental laboratory work to evaluate the effect of salt solution on Thonnakkal clay and Lateritic soil based on compaction behavior, CBR values shear strength characteristics using triaxial tests. Clay and lateritic and salt were collected. Clay was tested to determine its engineering properties. The tests were performed in accordance with the procedures specified by IS 2720 and the results are explained in subsequent sections. Clay was blended with different proportions of salt solution. They were prepared by adding 0%, 5%, 10%, 20% of salt solution respectively with clay and locally available lateritic soil. From this the effect of salt solution on geotechnical properties on lateritic soil and locally available clay can be evaluated as follows.

1) Determine the initial properties of lateritic soil and clay
2) Salt solution (NaCl) – 0, 2, 5 and 10% in combination with soils.
3) Determining optimum content of salt solution by conducting standard proctor compaction test.
4) Conducting un-soaked CBR test on stabilized samples.
5) Conducting triaxial test on different % of salt solution on both soils.
6) Excess salt removal using soil remediation techniques by electrokinetic method.

III. Results and Discussions

Fig. 4 shows compaction curves of lateritic soil with different % of salt solution

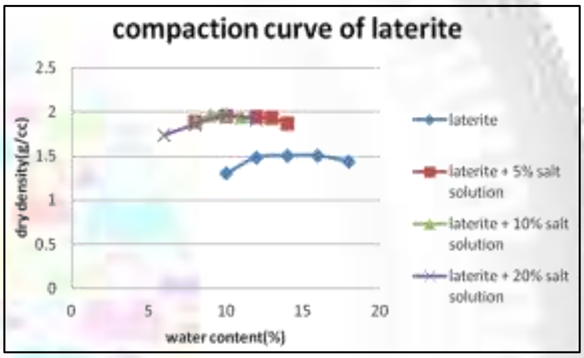

Fig. 4: Compaction curves in laterite soil

Figure 5 shows the compaction curves of Thonnakkal clay soil with different % of salt solution

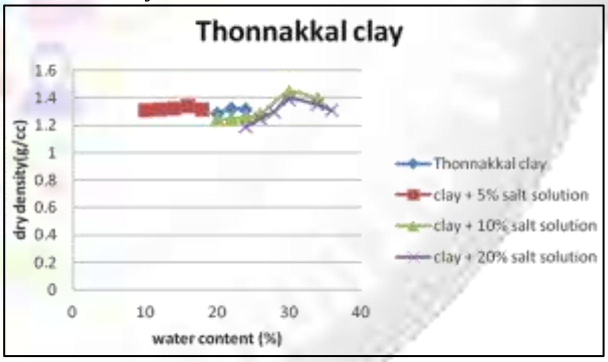

Fig. 5: Compaction curves of Thonnakkal clay soil with different % of salt solution

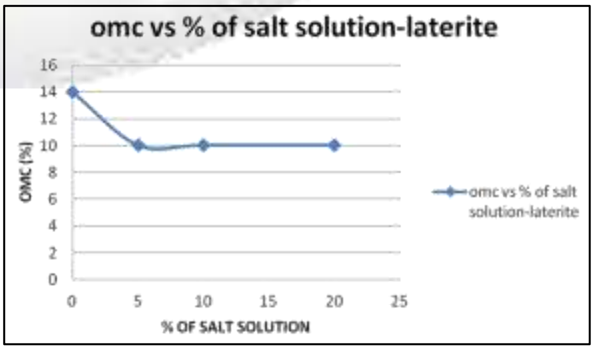

Fig. 6: OMC Vs % of salt solution on lateritic soil

Figure 6 shows the variation of OMC with different % of salt solution in laterite soil. OMC decreases with percentage of salt solution. This is due to the chemical changes in soil due to salt solution and water.

Figure 7 shows the variation of OMC with different % of salt solution in clay. OMC increases at 5% salt solution and then becomes constant throughout rest percentages of salt solution.

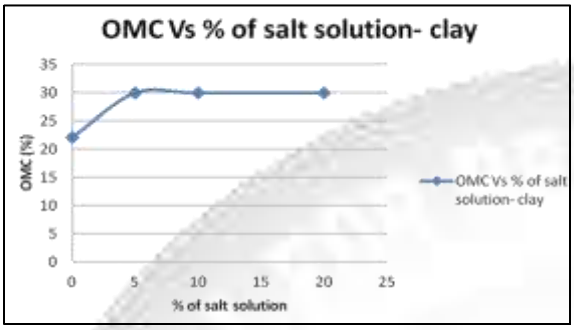

Fig. 7: OMC Vs % of salt solution on Thonnakkal clay soil

Figure 8 shows the variation of MDD with different % of salt solution in laterite. MDD increases up to 5% and then becomes constant throughout all % of salt solution due to chemical changes occurred in lateritic soil components and salt solution.

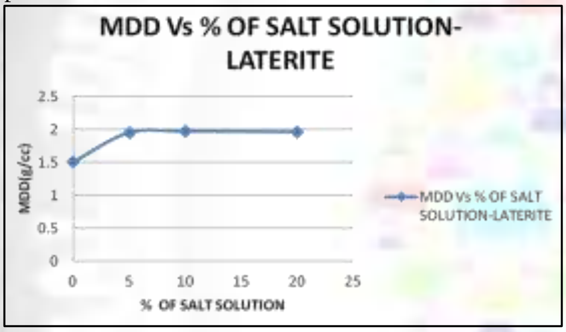

Fig. 8: MDD Vs % of salt solution on lateritic soil

Figure 9 shows the variation of MDD with different % of salt solution in clay. Upto 5% salt solutions maximum dry density increases and then decreases and becomes constant throughout all rest % of salt solution due to agglomeration of soil with chemicals ie., salt solution.

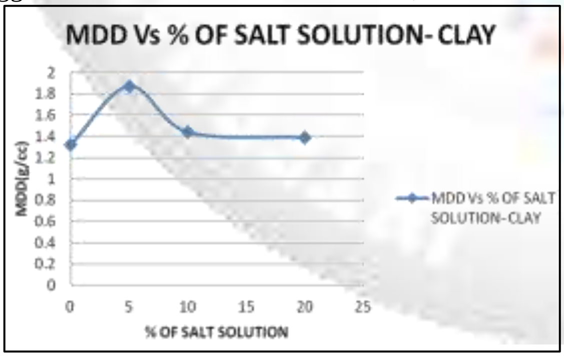

Fig. 9: MDD Vs % of salt solution on Thonnakkal clay soil

Other works done are as follows:

1) Un-soaked and soaked CBR test on stabilized samples.
2) Conducted other tests for finding the change in effect of soil performance when come in contact with salt solutions, ucc, direct shear etc.
3) Excess salt removal using electrokinetic remediation.

IV. Conclusions

– OMC decreases with percentage of salt solution in lateritic soill. OMC increases at 5% salt solution and then becomes constant throughout rest percentages of salt solution in Thonnakkal clay.
– MDD increases upto 5% and then becomes costant throughout all % of salt solution due to chemical changes occurred in lateritic soil components and salt solution
– Up to 5% salt solutions maximum dry density increases and then decreases and becomes constant throughout all rest % of salt solution due to agglomeration of soil with chemicals i.e., salt solution.

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