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EFFECT OF SALTS ON CONSOLIDATION CHARACTERISTICS OF SOIL

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Abstract—**Soil compressibility is one of the important characteristics of the soil. Volume changes in soils are important because of their consequences in terms of settlement due to compression. In addition, changes in volume lead to changes in strength and deformation properties, which in turn influence stability. In present paper effect of salt (NaCl) concentration on consolidation characteristics viz coefficient of volume compressibility, coefficient of consolidation, compression index and swelling index have been studied. The salt concentration was increased up to 7.5 % and effect of the same on various consolidation characteristics was studied. In addition change in Atterberg limits were also studied. Liquid limit and Plastic Limit both decrease with increase of salt percentage. Plasticity Index decreases with addition of salt at lower concentration and increases at higher concentration. Appreciable changes in compressibility characteristics were observed when soil was mixed with salts.**

Keywords—**Coefficient of volume compressibility, Coefficient of consolidation, Compression index, Swelling index, Atterberg limits**

I. INTRODUCTION

Generally, change in geotechnical behaviour of fine grained soils under the influence of inorganic salts depends on the chemistry of the soil constituents and the pore fluid. The source of chemical constituents may be indigenous or external such as contamination. For residual top soils, salts may be present in natural condition depending upon source rock. Ocean surge cause occasional flooding in coastal area with salt water lead to addition of salt minerals into soil. Metallic elements are present in greater amount in mining area [1]. Disposal of solid or liquid effluents, waste by products over the land causes alterations of the physical and mechanical properties of the soil. Alteration of soil properties sometimes causes degradation in soil properties. The wastes from chemical industries are found littering both urban and rural soils due to improper management system [2]. Modification of soil properties causing foundation failure, structural damage in light industrial buildings on soil contaminated by various industrial effluents have been reported. Soils are often subjected to uniform loading over large areas, such as from wide foundations, fills or embankments. Under such conditions, the soil which is remote from the edges of the loaded area undergoes vertical strain, but no horizontal strain. Thus, the settlement occurs only in one-dimension. The compressibility of soils under one-dimensional compression can be described from the decrease in the volume of voids with the increase of effective stress as compared to coarse soils. Soil compressibility is one of the important properties of the soil. Volume changes in soils are important because of their consequences in terms of settlement due to compression. In addition, changes in volume lead to changes in strength and deformation properties, which in turn influence stability. Knowledge about compressibility can be ascertained by results of Atterberg Limits and Laboratory Consolidation test. In present paper effect of NaCl on consolidation characteristics have been discussed. The NaCl was mixed in various percentage i.e., 0%, 2.5%, 5% and 7.5%. It has been observed there are appreciable changes in compressibility.

The rest of the paper is organized as follows. Proposed embedding and extraction algorithms are explained in section II. Experimental results are presented in section III. Concluding remarks are given in section IV.

II. PROPOSED ALGORITHM

1. Mechanisms behind the Modification in Physical and Engineering Properties of Soil

The modification of soil behaviour largely depends upon the clay particles which belongs to size 0.002 mm and less and it is unique in nature. Clay with a large quantity of water behaves like a viscous liquid, with less water it can be moulded and when dried it looks like a solid. On the other hand sand, silt or rock dust are very difficult to mould. The different nature of clay is due to net electrical charge on them. In general, clay particles surface are negatively charged and its edges are positively charged (Fig. 1). Due to the surface charge, it would adsorb or attract cations (+ve charged) and dipolar molecules like water towards it. As a result, a layer of adsorbed water exists adjacent to clay surface, usually a negative charge on their faces and a positive charge on their ends.[3]

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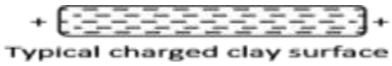

Fig. 1 typically charged clay particle

1.1 Diffuse double layer

To preserve electrical neutrality the negative charge of the clay particle is balanced by the attraction of cations which are held between the layers, and on the surface of the particles (Fig.2) while electrostatically attracted the concentration of these cations or counter–ions diminishes with increasing distance from the clay particle surface. The charged clay surface together with the counter–ions in the pore water, form the so-called diffuse double layer. [4], [5] Furthermore, the double layer is influenced by the valency of the counter–ions and the temperature.

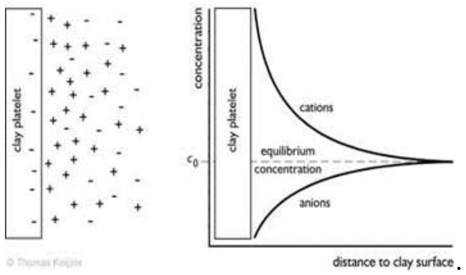

Fig. 2 Distribution of cations and anions adjacent to a clay platelet according to the diffuse double layer theory (Keijzer, 2000).

1.2 Change in thickness in diffuse double layer with the addition of salt in soil

The influence of pore fluid chemistry on the engineering behaviour of clay soil in many respects is still unclear a even controversial in some cases. However, modificatic engineering properties and behaviour have been reportec explained in most cases in the light of change in thickness in diffuse double layer with the addition of salt in soil. Changes in fine grained soil behaviour due to contaminants can be explained by changes in diffuse double layer theory and fabric changes. According to Gouy-Chapman theory by increasing the ion concentration, the thickness of diffuse double layer decreases which leads to flocculation of the clay particles [6].

III. Experiment and Result

2. Methodology

A soil with CI classification having LL 48.9, PL 25.1and PI 23.8 was selected for the study. For Atterberg Limits 425 μ passing air dried sample was mixed with 2.5%, 5% and 7.5% NaCl (% by weight), distilled water added and kept for processing for 24 hours. Atterberg Limits were done as per IS: 2720[7] (Part -5).

For determination of consolidation properties the same sample of 2mm passing was mixed with 2.5%, 5% and 7.5% NaCl (% by weight), distilled water added and kept for processing for 3 days. Consolidation test was done as per IS: 2720 (Part -15) [8]

3. Results and discussion

3.1 Atterberg Limits

It has been observed that both Liquid limit and Plastic Limit decrease marginally with increase of salt percentage. The decrease is more prominent in liquid limit as compared to plastic limit and plasticity index. The plasticity index value first decreases gradually and thereafter increases marginally as salt content is increased. All the blended and non-blended soil samples possess medium plasticity characteristics. The results are shown in Fig. 3

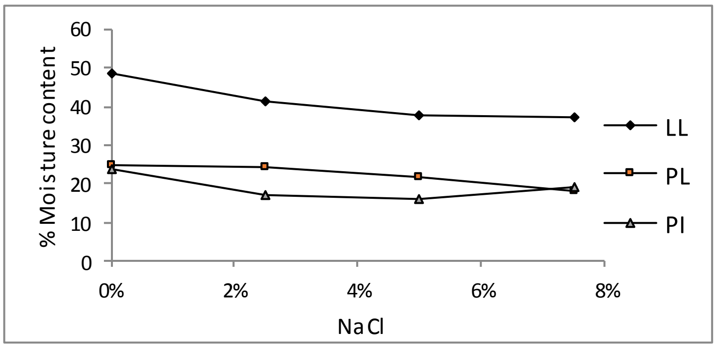

Fig.3 Variation of Atterberg Limits with NaCl

3.2 Consolidation parameters

3.2.1 Coefficient of consolidation (C_v)

The coefficient of consolidation (C_v) signifies the rate at which a saturated clay undergoes 1-dimensional consolidation when subjected to an increase in pressure.

The coefficient of consolidation (C_v) values are in the range 10.26-2.75 $\times 10^{-4}$ cm^2/sec for stress level 4.0-8.0 kg/cm^2, 13.66-3.1475 $\times 10^{-4}$ cm^2/sec for stress level 2.0-4.0 kg/cm^2, 21.65-3.97$\times 10^{-4}$ cm^2/sec for stress level 1.0-2.0 kg/cm^2, 36.84-4.41 $\times 10^{-4}$ cm^2/sec for stress level 0.5-1.0 kg/cm^2 for 0%, 2.5%, 5% and 7.5% blending respectively. It has been revealed from experimental values that C_v decreases with addition of salt. However the values of C_v fall more or less in the same range for all the blended cases i.e., for 2.5%, 5% and 7.5% blending of salt. The results are presented in Fig.4

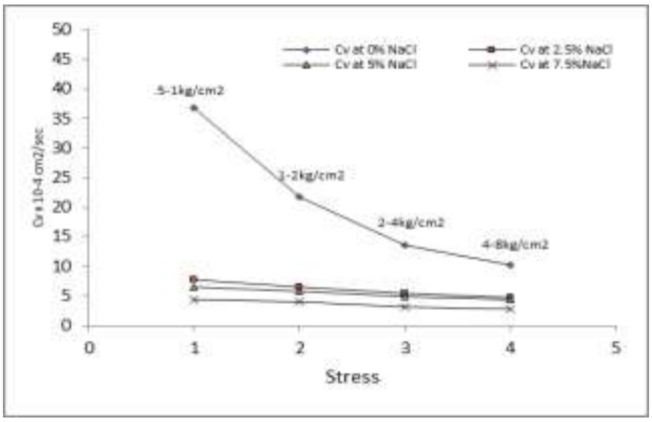

Fig. 4 Coefficient of consolidation (C_v) with NaCl and load increment

3.2.2 Coefficient of volume compressibility (m_v)

It has been observed that all the soil samples i.e., the unblended soil and blended soil samples i.e., 2.5%, 5% and 7.5% NaCl blended soil samples possess medium compressible characteristics having LL in the range of 48.9-37.2 and PI in the range of 23.8-19.1. The coefficient of volume compressibility (mv) fall in the range of 0.91-3.58 × 10^{-2} cm^2/kg. mv values are in the range 0.91-1.01 × 10^{-2} cm^2/kg for stress level 4.0-8.0 kg/cm^2, 1.39-1.74 × 10^{-2} cm^2/kg for stress level 2.0-4.0 kg/cm^2, 2.02-3.40× 10^{-2} cm^2/kg for stress level 1.0-2.0 kg/cm^2, 2.31-3.58 × 10^{-2} cm^2/kg for stress level 0.5-1.0 kg/cm^2. For stress level 4.0-8.0 kg/cm^2 all the values of mv for 0-7.5% blending fall in the same range (0.91-1.01 × 10^{-2} cm^2/kg). For stress level 0.5-1.0 kg/cm^2 there is increase in value of mv. For stress level 1.0-2.0 kg/cm^2 and 2.0-4.0 kg/cm^2 there is decrease in mv value with addition of salt in lower concentration, however the value increases with addition of higher percentage of salt. The results are presented in Fig.5.

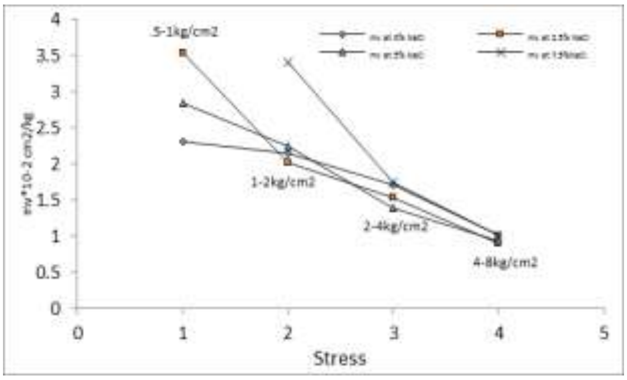

Fig. 5 Coefficient of volume compressibility (m_v) with increase of NaCl at different load increment

3.2.3 Compression Index (C_c):

Compression Index (C_c) is equal to the slope of the field consolidation curve plotted to a logarithmic scale of pressure p in the linear range. Numerically is equal to the change in voids ratio for one log cycle of pressure change. The capability of soils to bear loading are different depending on soil type. Fine grained soils have a relatively smaller capacity in bearing of load than the coarser grained soil. Hence fine grained soils have greater degree of compressibility. All the experimental unblended and blended soils belong to medium soft group category having medium compressibility and plasticity. Literature survey [5] reported that these soils should possess C_c value in the range of 0.15-1.0. From the results of this research it is clear that the samples follow the same trend and the range of C_c is 0.165-0.192. Initially for 2.5% salt blended sample shows a slight decrease in the value and then at higher % of salt there is a slight increasing trend. The results are presented in Fig. 6

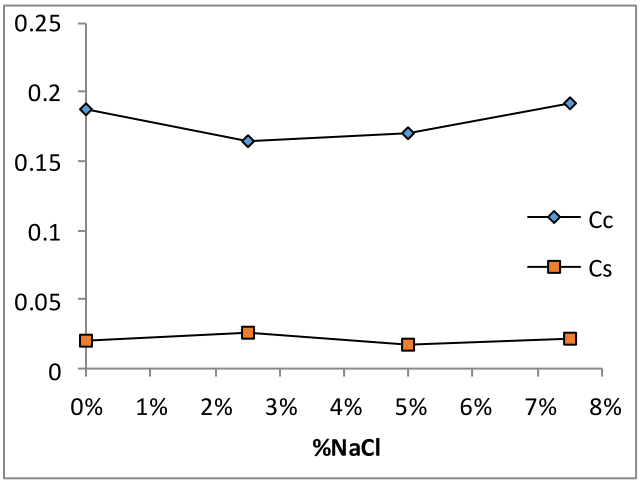

Fig. 6 Compression Index (C_c) and Swelling Index (C_s) with NaCl

3.2.4 Swelling Index (C_s):

This is equal to the slope of swelling (unloading) curve of e plotted against log p. It is obtained in a similar manner to the compression index. The range of Cs is 0.018-0.026. There is a slight increase at lower salt percentage and then there is slight decrease at higher percentage of salt. The results are presented in Fig. 6.

IV.CONCLUSION

Soil compressibility is one of the important properties of the soil. Volume changes in soils are important because of their consequences in terms of settlement due to compression. Compressibility can be ascertained by analyzing results of Atterberg Limits and Laboratory Consolidation test.

It has been observed there are appreciable changes in compressibility properties when treated with salts.

The influence of pore fluid chemistry on the engineering behaviour of clay soil in many respects is still unclear and is even controversial in some cases. However, modification in all the engineering properties and behaviour have been reported in literature and explained in most cases in the light of change in thickness in diffuse double layer with the addition of salt in soil. Changes in fine grained soil behaviour due to contaminants can be explained by changes in diffuse double layer theory and fabric changes. According to Gouy-Chapman theory by increasing the ion concentration, the thickness of diffuse double layer decreases which leads to flocculation of the clay particles [6].

It has been observed that Liquid limit and Plastic Limit both decrease with increase of salt percentage.

Plasticity Index decreases with addition of salt at lower concentration and the value increases at higher percentage of salt.

It has been revealed from experimental values that C_v decreases with addition of salt. However increase in salt percentage dose not differ much in C_v value.

There is no effect in volume compressibility with addition of salt for higher stress level i.e., 4.0-8.0 kg/cm^2. For stress level 0.5-1.0 kg/cm^2 there is increase in value of mv. For stress level 1.0-2.0 kg/cm^2 and 2.0-4.0 kg/cm^2 there is decrease in mv value with addition of salt in lower concentration, however the value increases with addition of higher percentage of salt.

Initially for 2.5% salt blended sample shows a slight decrease in C_c value and then at higher percentage of salt there is a slight increasing trend.

C_s value remains more or less same with addition of salt. However there is a very slight increase in Cs value at lower salt percentage and then there is slight decrease at higher percentage of salt.

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