EFFECT OF SAMPLE PREPARATION ON COEFFICIENT OF CONSOLIDATION OF BC SOILS

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**ABSTRACT:** The geotechnical properties of the clays depend on the nature and type of pore fluid in its contact. Variations in consolidation properties of clays are due not only to the mineralogical content but also to the changes in the pH of the pore solutions, mode of preparation of the specimens. In this paper the influence of alkaline solutions *vis-a-vis* slightly acidic salt solutions is investigated on liquid limit and consolidation properties of two black cotton soils with varying montmorillonite content. It is observed that the alkaline solutions increase the liquid limit at low concentrations while acidic solutions cause a decrease. Compression index qualitatively follows the liquid limit values in the variation. The coefficient of consolidation, though decreases essentially with pressure, varies with the concentration of the solution as well as the mode of sample preparation.

1. **INTRODUCTION**

Due to increased industrialization the soil pollution and its influence on the geotechnical properties has been the area of focus for the researchers. The effects of pollutants on clays are complex due primarily to ion exchange or nature of pore fluid. Spillage of caustic soda in aluminum industry causes substantial heaving of the foundation soil, especially the BC soils. Black cotton soils of India containing montmorillonite as the principal clay mineral, show a wide range in their clay content and hence their activity. Their Liquid Limit (LL) is found to vary from 50% to 120% in different regions of Deccan plateau. Their behaviour, especially in the presence of different contaminant is under investigation. The compressibility of clays depends on its moulding water content and nature of pore fluid. It is observed in this investigation that the behaviour of two BC soils is qualitatively same and the pH of the solution has a greater bearing on the altered geotechnical properties.

2. **LITERATURE REVIEW**

The volume change behaviour of illite with electrolytes was investigated. (Sivapullaiah *et al.* 2001). It was observed that the electrolyte solutions decrease the swelling of illites but increase their compressibility. The consolidation behaviour of the bentonite compacted at proctor optimum conditions in different electrolyte solutions was reported by Sivapullaiah *et al.* (2000). Atterberg limits have been used as indicator of clay behaviour (Arason *et al.* 2008). Studies were carried out by Van Paassen (2002), Di. Maio (1996) and Schmitz *et al.* (2003) on the influence of electrolyte solutions on liquid limit. Reduction in liquid limits of bentonite and colclay with NaCl, KCl, and CaCl₂ solutions at different concentrations were reported. Effect of clay mineralogy on coefficient of consolidation (Cᵥ) was reported by Robinson & Allam (1998). It was observed that while the Cᵥ increase with pressure for illite and quartz, it decreases for montmorillonites. The compressibility of Kaolinite with different pore fluid was investigated by Chen *et al.* (2000).

3. **PRESENT INVESTIGATION**

The present investigation focuses on the behaviour of two black cotton soils with different activity, in the presence of acidic and basic solutions contaminants.

3.1 **B.C. Soils**

Two black cotton soils obtained from different regions having liquid limits of 66% and 84%. These soils are referred hereafter as S1 and S2 respectively. The geotechnical properties of these soils are presented in Table 1. Both the soils are classified as CH on the plasticity chart.

<table>
<thead>
<tr>
<th>Tests</th>
<th>S1</th>
<th>S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity (Gs)</td>
<td>2.7</td>
<td>2.67</td>
</tr>
<tr>
<td>Liquid Limit (%)</td>
<td>66</td>
<td>84</td>
</tr>
<tr>
<td>Plastic Limit (%)</td>
<td>30</td>
<td>37</td>
</tr>
<tr>
<td>Plasticity Index (%)</td>
<td>36</td>
<td>47</td>
</tr>
<tr>
<td>Fine Fraction (&lt;75μ, %)</td>
<td>98</td>
<td>99</td>
</tr>
<tr>
<td>Clay fraction (&lt;2μ, %)</td>
<td>27</td>
<td>33</td>
</tr>
<tr>
<td>Activity</td>
<td>1.33</td>
<td>1.42</td>
</tr>
</tbody>
</table>
3.2 Chemical Fluids

The isolated solutions used as pore fluids consist of two salt solutions, Sodium Chloride (NaCl) and Potassium Chloride (KCl), and two alkaline solutions Sodium Hydroxide (NaOH) and Potassium Hydroxide (KOH). The composition of the pore fluid was varied by using different concentrations of these salts while deionised water was also used for comparison. The chemicals were purchased from a single manufacturer with trade name “NICE ™ chemicals”, for uniformity and purity.

3.3 Experimental Program

The ionic strength was varied by preparing solutions at different concentrations, i.e. 0.01N (Normality), 0.1N, 0.5N, 1.0N, 2.0N. The tests were conducted with deionised water (DW), representing zero concentration. The soils were soaked with DW and different concentrations of chemicals separately for 24 hours, allowing the soil to interact with the solution. Liquid limit was determined using Casagrande's apparatus (BS 1377-Part II–1990). The percentages of clay fraction present in these soils were determined by pipette analysis. The consolidation tests were performed on soils soaked with the electrolyte solutions, before and after the preparation of sample for oedometer test. The samples prepared by two modes are:

3.3.1 Type I Specimens

The specimens of soils S1 and S2 were soaked with deionised water and molded in oedometer ring with initial water content corresponding to their liquid limits w.r.t. deionised water. The pore fluid of a known concentration was then passed through the sample in the oedometer and loading was done with load increment ratio of two, at every 24 hours.

3.3.2 Type II Specimens

The specimens were soaked with the pore fluid of known concentration and molded in oedometer ring with initial water content corresponding liquid limit of the soil sample with respect to that concentration of pore fluid. The same pore fluid was passed through the sample in the oedometer and loading was done with a load increment ratio of two at every 24 hours.

4. DISCUSSION ON TEST RESULTS

4.1 Influence of pH

Figure 1 shows the variation of pH of the electrolyte solutions at respective concentrations. NaCl and KCl decrease slightly and assume a constant pH slightly less than 7. The pH of NaOH and KOH increases suddenly for small concentrations and becomes constant at higher concentrations after some increase. The pH of the solutions mixed with the soils in 1:5 ratios showed almost the similar value of pH as that of solution stand alone.

![Fig. 1: pH vs. Conc. of Pore Fluids](image)

4.2 Influences on Liquid Limit

Figure 2 shows the variation of liquid limit wrt concentrations of pore solutions. Liquid limit decreases exponentially with increase in the concentration of NaCl and KCl solutions whereas in the presence of NaOH and KOH it increases at small concentrations (0.01N, 0.1N & 0.5N) and then decreases at larger concentrations. The decrease in the liquid limit values for concentrations larger than 1N is practically insignificant.

![Fig. 2: LL vs. Conc. of Pore Fluids for S1&S2](image)

4.3 Influence on Compression Index

Figure 3 and Figure 4 shows the plot of compression index vs. concentration of pore solutions. It is noted that the compression index of S1 and S2 both decrease with increasing concentration for NaCl and KCl. However NaOH and KOH shows an increase in Cc values at lower concentrations which decreases further with increase in
concentrations. Thus the $C_c$ of soils in the presence of alkaline solutions is higher than that with slightly acidic salt solutions having same cations. It is also note here that while $C_c$ values for NaCl and KCl in type II specimens is higher type I for all concentrations. But with NaOH and KOH solutions $C_c$ for type II specimens is lower than NaCl and KCl for higher concentrations.

Figures 5 to 8 shows the variation of coefficient of consolidation with the effective pressure for soil S1 & S2 for both type I and type II specimens. The concentrations of 1N and 0.5N are typically plotted to represent the behavioral trend.

Figure 5 indicates that the $C_v$ for NaOH and KOH are higher than NaCl and KCl respectively, for both type I & II specimens, the type II $C_v$ being higher.

Comparing the results of Figure 5 and 6, it is observed that at a given effective pressure, $C_v$ values increase with increase in the concentration of solution for both type I & II specimens.

Similar observations are made with soil S2 and are presented in Figure 7 and Figure 8.
5. CONCLUSIONS

The results of investigation are summarized as below:

1. The liquid limit of BC soils are sensitive to the changes in the cations and anions present in the pore fluids.
2. The liquid limit values reduce exponentially in the presence of salt solutions having acidic pH while showing an increase at lower concentrations of basic solutions which further decreases at higher concentrations.
3. The compressibility of soils is influenced by the mode of preparation of specimens in oedometer test.
4. The adsorption of OH\(^{-}\) ions increase the compressibility of soils.
5. The compression index decreases with increasing concentrations of acidic salt solutions. But basic solutions at lower concentrations cause compression index to increase.
6. The coefficient of consolidation of type II specimens is higher than type I indicating that the rate of consolidation is higher for presoaked samples than post soaked with solutions.
7. The two soils show similar behaviour despite having different properties. This may be due to the same mineral i.e., montmorillonite in them in different proportion.

REFERENCES