INFLUENCE OF TEPMERATURE AND CHEMICAL EXPOSURE TIME ON LIQUID LIMIT OF BENTONITE HYDRATED WITH INORGANIC SALT SOLUTIONS

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1. INTRODUCTION

Geosynthetic clay liners (GCLs) are widely being used in municipal solid waste (MSW) landfills as a part of bottom liner system. The biodegradation of waste inside MSW landfills produces leachate which is highly contaminated by many organic and inorganic pollutants. In addition to this, it causes a rise in temperature inside the landfill which is expected to be as high as 60 ^{0}C near the bottom liner (Yoshida et al., 1996; Rowe, 2005; Yesiller and Hanson, 2005; Koerner and Koerner, 2006). The exposure of bentonite component of GCL to chemicals present in landfill leachate for long time accompanied by elevated temperature can alter its performance as liner material. This study investigated the effect of such inorganic cations, chemical exposure time and temperature on liquid limit of bentonite. Liquid limit is chosen as representative parameter as it can be correlated to many other engineering properties such as hydraulic conductivity, free swell, shear strength and compressibility of soil (Sharma and Lewis, 1994; Jefferson and Rogers, 1998; Abdullah et al., 1999; Arsan and Yetimoglu, 2008). Thirteen solutions including deionized water (DI water) and twelve salt solutions of four major exchangeable cations (Na^+, K^+, Ca^{2+}, Mg^{2+}), each at three different concentrations (0.01M, 0.1 M, 1M), were selected as hydrating liquids. Tests were performed at three different temperatures (20 ^{0}C, 40 ^{0}C and 60 ^{0}C) and at three different chemical exposure times (24h, 72h and 120h). The results showed that the type and concentration of cation has significant effect on liquid limit of bentonite. Liquid limit decreased slightly with increase in temperature. Chemical exposure time was found to have little effect on liquid limit of bentonite.

2. MATERIALS DESCRIPTION

2.1 Materials

Study was carried out on commercially available Na-bentonite extracted from GCL Bentofix® . The bentonite passing US sieve no. 200 (75 μm) was oven dried at 105 ^{0}C for subsequent testing.

2.2 Hydrating Liquids

Since four major exchangeable cations in bentonite are Na^+, K^+, Ca^{2+} and Mg^{2+} (Komine and Ogata 2004), solutions of NaCl, KCl, $CaCl_2$ and $MgCl_2$ were used in this study. Deionized water (DI water) was used as the reference solutions. Concentration of solutions varied from 0.01 M to 1 M. Chemicals used for making solutions were purchased in powdered form and mixed with DI water in specified amount for desired concentrations.

3. TESTING PROCEDURES

The Liquid limit tests were carried out using multipoint test method in accordance with ASTM 4318-10. Initially the samples were prepared at different moisture contents and allowed to hydrate for at least 24 hours in sealed plastic bags. To investigate temperature effects, the samples were hydrated at 20 ^{0}C, 40 ^{0}C and 60 ^{0}C. The tests were then conducted while maintaining the temperature during the test. To investigate the effect of liquid exposure time, samples were allowed to hydrated at room temperature for three specified time periods of 24h, 72h and 120h before performing the tests. The tests were then carried out according to ASTM Standard mentioned above.

4. RESULTS AND DISCUSSION

4.1 Influence of Cation on Liquid Limit

Fig. 1 is showing the effect of cation on liquid limit of bentonite. It was observed that liquid limit decreased with increase in salt concentration irrespectively of the type of cation. The liquid limit was highest (559 %) with DI water. For all type of cations, the liquid limit was found to be similar at very low (0.01M) and very high (1M) concentrations. However, at intermediate concentration (0.1M), both monovalent cations show higher values of liquid limit than divalent cations with highest value of liquid limit obtained for bentonite hydrated with NaCl solution. Both divalent cations showed similar values of liquid limit at all concentrations.

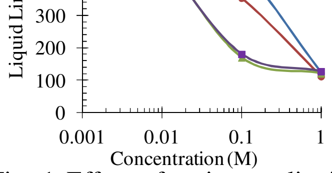

Fig. 1 Effect of cation on liquid limit of bentonite

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4.2 Temperature and Liquid Limit

The effect of temperature on liquid limit of bentonite is shown in Fig. 2. In general, the liquid limit was found to decrease slightly with increase in temperature. DI water showed the highest value of liquid limit (559%) when hydrated

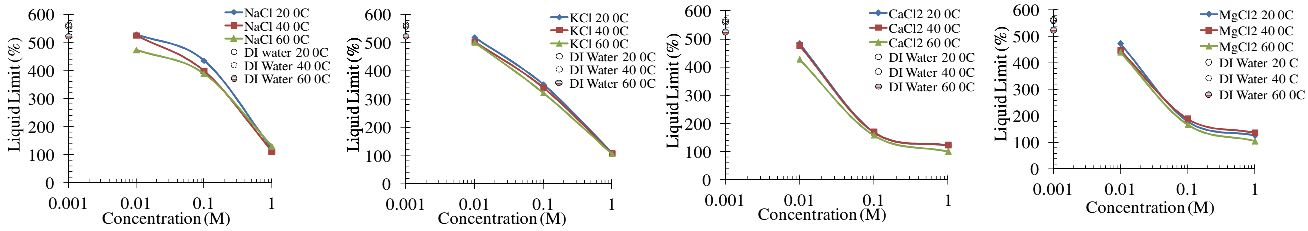

Fig. 2 Effect of Temperature on liquid limit of bentonite

at 20 ^{0}C. The liquid limit was lowest at 60 ^{0}C (524%). A similar behavior of decrease in liquid limit with increase in temperature was found with bentonite hydrated with NaCl solution at low concentrations. However, at high concentration the effect of temperature was not significant. Temperature was found to have insignificant effect on liquid limit of bentonite hydrated with KCl and divalent cation Solutions ($CaCl_2$ and $MgCl_2$).

4.2 Chemical Exposure Time and Liquid Limit

In general, the liquid limit of bentonite was found to increase with increase in chemical exposure time as shown in Fig. 3. The trend is prominent for bentonite hydrated with DI water and low cation concentrations. At intermediate and high

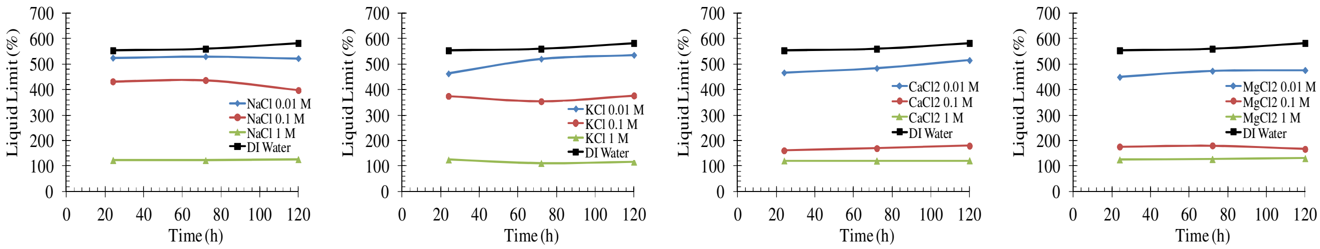

Fig. 3 Effect of Chemical exposure time on liquid limit of bentonite

concentrations, however, the effect is not significant. The study was conducted for maximum duration of 120 h (5 days). It is recommended to carry out the tests for longer durations to simulate the field conditions.

5. CONCLUSIONS

The Study investigated the effect of temperature, cation type, cation concentration and chemical exposure time on the liquid limit of bentonite. It was found that the type and concentration of cation have significant effect on liquid limit of bentonite. Liquid limit was found to decrease with increase with temperature for the temperature range of 20 ^{0}C – 60 ^{0}C. Chemical exposure time was found to have little effect on liquid limit of bentonite for the given time period. It is recommended to investigate the effect of chemical exposure time for longer duration.

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