EFFECT OF SALTS ON THE ATTERBERG LIMITS

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This thesis is dedicated to my father, the late Chandran Krishna, may he rest in peace.

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ABSTRACT

Some of the previous work performed on the effect of salt on the Atterberg limits suggest that the thickness of the diffuse double layer controls the liquid limit of soils. This research had utilized pure clay minerals and combinations of these clays with different cationic species. Very large differences for the liquid limit of bentonite with different saturating cations have been reported in the literature. However, the specimen preparation procedures have not been well documented in the literature and the large differences reported might have been the result of poor or limited specimen control.

A major concern of the present study has been a strict control of the pore water chemistry in the specimens. For this purpose the specimens were repeatedly washed with the corresponding salt solution until the desired concentration was achieved. This fact was monitored by measuring the electrical conductivity of the saturating fluid after each wash. Specimens of a common stock and mixes of this soil with fixed percentages of bentonite were saturated with salts of monovalent, divalent, and trivalent cations and the pore fluid salt concentrations was stabilized to concentrations from

0.001 N to 1N. Furthermore several tests were performed on specimens of identical conditions to gather statistical evidence.

The results in the present study suggest that the saturating cation has very small effects on the Atterberg limits of the soils used. Some effect due to high salt concentrations in the interstitial fluid have been observed. The addition of bentonite to the soil results in a clear increase of the limits of the soil mixture. The contrast in the measured effects of salts and bentonite points towards an explanation of the effects of salts reported in the literature, based on the variable rate of gelation of the soil colloid as a function of salt concentration.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Among the most common tests performed on clayey soils are the Atterberg limits, namely the liquid and plastic limits. These tests are widely used in practice to classify fine grained soils. In the last fifty years, a large body of experience has been accumulated worldwide on these tests and the limits have been correlated to many other soil properties of interest to geotechnical engineering. One of the main advantages is the low cost of the equipment and labor required to perform these tests. Another important advantage is the sensitivity of these tests to some elements or conditions of the soil that have noticeable effects on the outcome of these tests.

It is a well known fact that specimens from the same geologic formation containing different percentages of clays and sands have different Atterberg limits. The specimen with larger amounts of sand has lower values of liquid limit and plasticity index. The limits for these specimens plotted on a Casagrande plasticity chart fall on a straight line parallel to the A-line. The limits, in this case, reflect the presence of different percentages of inert soil particles.

In the same line, the limits determined on two specimens of the same soil containing organic matter in advanced stages of decomposition, with one of the specimens unheated and the other oven dried at $105^{0}C$ are known to be significantly different. Part of the commonly accepted explanation is that oven drying of the soil oxidizes the organic matter that disappears from the system. The organic matter is known to posses large cation exchange capacities to retain exchangeable cations. These cations with their hydration shell provide additional affinity of the soil particle for water molecules. When the organic matter is oxidized, these exchange sites also disappear and, thus, there is a reduction in the limits of the oven dried specimens. In this case, the Atterberg limits reflect a change in the exchange capacity of the particles.

The effect of the cation make-up in the exchange complex has been reported to reflect in the Atterberg limits of the soil. In this case, the liquid limit of sodium montmorillonite is reported as 700 while the liquid limit of calcium montmorillonite is indicated to be only 400. These results indicate that the exchange capacity and the cation make-up on the exchange complex affect the results of the Atterberg limits. The overall purpose of the present study is to further investigate the effect that the cation exchange capacity of the soil and the cation make-up on the exchange

complex have on the Atterberg limits.

The emphasis in the present study has been placed on performing the tests on naturally occurring soil or in soils with properties commonly encountered in natural soils rather than pure clay minerals. A precise and known cation make-up on the cation exchange complex and a knowledge of the salts and the salt concentrations present in the interstitial fluid of the specimen have been major concerns for the preparation of specimens in the present study.

The remainder of this thesis includes a review of pertinent previous work in this area, a detailed purpose and scope of work, a description of the soils used in this study, and the laboratory procedures. A thorough description of all the test results and a discussion of the findings and conclusions are also included. The complete set of all the laboratory data and the reduced results are also included in appendices enclosed at the end of this thesis.