EFFECT OF SEA WATER ON THE GEOTECHNICAL PROPERTIES OF COHESIVE SOIL

Amar Prit Singh Arora[1], Koushik Das[2], Debankar Sengupta [3] and Joyanta Maity[4]

[1,2,3]B.Tech. student, Dept. of Civil Engineering, MSIT, Kolkata-150
[4]Assistant Professor, Dept. of Civil Engineering, MSIT, Kolkata-150.

Abstract – *The percolation of sea water in the ground affects the various geotechnical properties of the soil located in the coastal areas. It changes the behavior of soil and also creates geotechnical problems increasing the alkalinity and TDS value of groundwater. This study deals with the effect of salinity of groundwater on some properties of clayey soil. Properties obtained from tests carried out on samples mixed with water containing different salt contents are compared with those obtained from tests carried out on samples mixed with pure water (tap water). Two sets of samples of the clay soil were tested. One was mixed with pure water (pure water clay soil) and the other was mixed with salty water. Various tests to measure the Atterberg limits, Compaction Characteristics and Optimum Moisture Content were performed. From the test results, it is observed that due to increase in soil salinity, the Atterberg's limits value decreases and shear strength parameters are increases.*

Key Words: Compaction Characteristics, Atterberg Limits, Optimum Moisture Content.

1. INTRODUCTION

Due to sea water intrusion in seashore areas, the soil gets affected and causing disturbances in construction of superstructure and forming soil salinization. Soil salinization is the method in which free salts are accumulated in soil which leads to the degradation of soil and vegetation. The extent of modification not only depends on nature of contaminant but also the type of soil such as the chemical composition, physical nature and mineralogical properties. The Soil - Salinity interactions changes the soil behaviour and also leads to various geotechnical problems. The change in geotechnical behaviour of soil is mainly due to types of cations in saline water and types of clay mineral in soil layers.

Further, seawater has a strong impact on the engineering behaviour of different clayey soil samples, especially on the montmorillonite clay. In fine grained soil the geotechnical behaviour of soil depends on chemistry of pore fluid. Due to excessive pumping of ground water, saline water intrusion takes place in coastal regions causing remarkable alterations in geotechnical properties of soils.

In coastal regions of India, mainly pertaining to the Bay of Bengal coastal area, the soils there are prone to massive change in their geotechnical properties than the rest part of India. The varying change in the dry densities, liquid and plastic limits and the optimum moisture content leads to the change in the behaviour of the soil structurally. The natural arrangement of the package of soil is affected to some extent due to the presence of salinity in the groundwater table. In this paper, the effect of seawater on geotechnical behaviour of cohesive soil has been studied.

2. REVIEW OF PAST WORKS

The effect of adding saline water to cohesive soil has been studied extensively by several researchers on the basis of experimental results. Aksoy et. al. (2008) conducted Liquid limit, Shrinkage limit and Plastic limit test to study the behavior of clays with addition of seawater. The test results were analyzed and found that seawater effect is negligible on tested consistency limits and compressibility characteristics of soils when they have liquid limits up to 110%. Nikhil Kumar et. al. (2011) studied the effect of Atterberg's limit and results discussed that Low influence of salinity on plastic limit can arise little moisture of soil, at this condition that lead to decrease the interaction between soil and solute in water. But in the liquid limit, in which soil moisture is higher, the effect of salinity will be more. The plasticity gradually decreases with the increase in the salt concentrations. The Plasticity is decreased due to the salt content increment. Fatahi et. al. (2011) studied the Atterberg's limit on various kaolinite, bentonite and sand mixtures using salt water, the results inferred was the liquid limit of kaolinite clay decreases by both water salinity. For pure kaolinite an increase in water salinity from 0 to 200gm/liter NaCl, results in 6% decrease in Liquid limit. Similarly, the bentonite showed same as of kaolinite clay. Nearly 50% and 70% of decrease in liquid limit occurs with 20% and 5% salt concentration increase for kaolinite and bentonite. Ivasuc et. al. (2012) studied the seawater influence on the behavior of the expansive clays. In this study the rate of change in liquid limit of clayey soils when exposed to natural seawater with respect to distilled water. The four clayey soil samples were gathered with different mineralogy and plasticity characteristics and tested to determine liquid limit in the presence of distilled water, tap water and seawater. The results showed that the liquid limit decrease in presence of seawater; values of all liquid limits in seawater are lower than those in tap water and the difference is seen more clearly in Bentonite sample. Mahmoud et.al. (2013) experimented on effect of salinity of groundwater on the geotechnical properties of some Egyptian clay. The test results showed the effect of groundwater salinity on the tested samples. The plasticity index decreased from 26 for pure water clay soil to 24.96 for clay soil mixed with 80% salt. The optimum moisture content increased from 14.25% for pure water clay soil to 16.5% for clay soil mixed with 100% salt. Decrease in the maximum dry density is observed for clay soil mixed with salty when compared with pure water clay soil. Ajalloeian et.al. (2013) found that the the Atterberg limits decreased due to the presence of saline water on fine grained soil as opposed to tap water. Otoko (2014) also experimented on this related theme and found that the maximum dry density decreased due to the presence of saline water from the Atlantic Ocean for clayey soils. Anandha narayanan et.al. (2014) found that sea water increases the maximum dry density and decreases the optimum moisture content. Mahmoud et. al. (2016) studied the effect of Atterberg's limit on expansive clayey sample, where the sample is passed through Distilled water, tap water, treated waste water and seawater. The results show a clear change in the liquid and plastic limits after using different water types in mixing with expansive clay soils. It has been observed that there is a significant change in plastic and liquid limit due to use of different water samples. Liquid limit decreases from 70% by using distilled water to 68%, 61% and55% when using tap water, treated waste water and sea water, respectively. Also, plastic limit decreases from 43.36% when using distilled water to 41.8%, 39.3% and 35.78% when using tap water, treated waste water and sea water, respectively. The reduction in plastic limit is due to the ions present in seawater is replaced by the cations present in the hydrous layer surrounding the clay layer and thus reducing the net electrical charge forming flocs. The floc behaves as silt particles which is less plastic in nature particles, establishment of bonding between them and formation of salt crystals in pores of soil.

In this present study, an experimental investigation is done to ascertain the change in Atterberg limits and Compaction characteristics due to use of different sources of water (tap water and sea water).

3. MATERIALS AND METHODOLOGY

3.1 MATERIALS USED

A. SOIL:

Locally available clayey soil collected from Uchhepota, near Kolkata, West Bengal, was used in this experimental study. As per I.S. Classification (IS 1498, 1970), the soil is classified as "ML" (Inorganic low compressible silt). The physical properties of soil as determined in the laboratory are given in Table 1.

B. SEA WATER

To observe the effect of seawater on index properties of clayey soil, sea water has been collected from Bay of Bengal near Digha of East Midnapur district in West Bengal. Atterberg's limit test and Light compaction Proctor test has been done to determine the change in Atterberg limits and Compaction characteristics of clayey soil by using sea water.

Table 1: Physical Properties of Soil

PROPERTIES	VALUES
IS Classification	ML
Specific Gravity	2.38
Liquid Limit (%)	34.00
Plastic limit (%)	15.90
Plasticity Index	18.10
Maximum Dry Density (gm/cc)	1.778
Optimum moisture content (%)	13.4
Unsoaked CBR (%) at OMC	2.94

3.2 METHODOLOGY

A systematic experimental programme was undertaken to observe the variation in Atterberg Limits and optimum moisture content and maximum dry densities. For this Atterberg Limits test and Standard Proctor Test have been conducted as per IS codal provision and respective curves were plotted to determine the Optimum Moisture Content and corresponding Maximum Dry Density for cohesive soil.

4. RESULTS AND DISCUSSION

In this present study, Atterberg Limits test and Standard Proctor Test have been conducted for sea water mixed clayey soil as per IS codal provision to see the effects on Atterberg limits and Compaction characteristics due to mixing of sea water. The test results are given in Table 2.

Table 2: Test results of clayey soil with Tap and Sea water

Type of water	Tap water	Sea water
Liquid Limit (%)	34.00	29.80
Plastic limit (%)	15.90	19.40
Plasticity Index	18.10	10.40
Maximum Dry Density (gm/cc)	1.778	1.815
Optimum moisture content (%)	13.4	12.8

A. EFFECTS ON ATTERBERGS LIMIT

To observe the effect of sea water on index properties of clayey soil, Atterberg's limit test has been done as per IS codal provision. Liquid limit, and Plastic limit have been determined on both tap water and seawater collected from Bay of Bengal sea near Digha of East Midnapur district in West Bengal. The test results are given in Table 2 and observed that there is remarkable seawater effect on tested consistency limits and compressibility characteristics of soils.

The liquid limit has decreased by 13.5 percent with saline water. Due to reduce of liquid limit with increase in salinity water, plastic index also has decreased to a great extent.

B. EFFECT ON COMPACTION CHARACTERISTICS

To observe the effect of seawater on compaction characteristics of clayey soil, Light compaction Proctor test has been done on both tap water and seawater as per IS codal provision. The Dry Density vs Moisture Content Curve for both tap water and sea water is shown in Fig. 1.

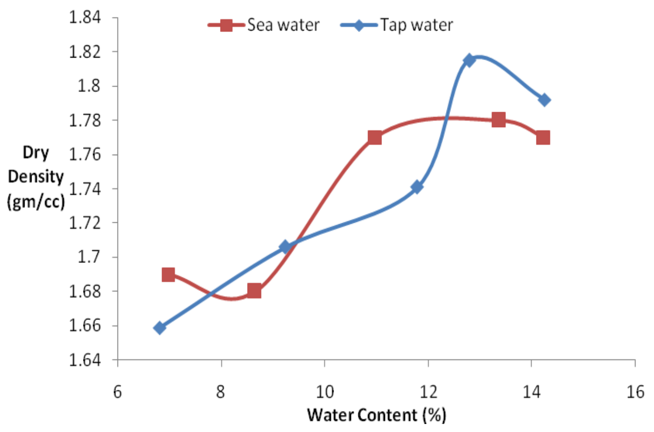

Fig 1: - Dry Density vs Moisture Content Curve for both tap water and sea water

The test results of compaction test are also given in Table 2 and found that there is remarkable change in compaction characteristics of soils when tested with seawater. Maximum dry density of clayey soil increases in presence of sea water on comparing with results obtained from tap water. On the other hand, Optimum Moisture Content of clayey soil decreases in case of sea water.

4. CONCLUSION

The purpose of this study is to see the effects of sea water intrusion in the geotechnical behavior of clayey soil. On the basis of systemic experimental investigation on Compaction Characteristic and Atterberg's limits of cohesive soil, following conclusions can be drawn.

a) Atterberg's Limits such as Liquid Limit decreases in presence of sea water. Further, plasticity index also decreases to a great extent due increase in salinity in water. The decrease in Atterberg's limit is due to higher cation valance and increasing salt concentration.

b) Maximum dry density of clayey soil increases in presence of sea water comparing with the results obtained from tap water.

c) Optimum Moisture Content of clayey soil decreases in case of sea water.

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BIOGRAPHIES

Amar Prit Singh Arora, B.Tech. Student, of C.E. Dept., Meghnad Saha Institute of Technology, Kolkata.

Koushik Das, B.Tech. Student, of C.E. Dept., Meghnad Saha Institute of Technology, Kolkata.

Debankar Sengupta, B.Tech. Student, of C.E. Dept., Meghnad Saha Institute of Technology, Kolkata.

Joyanta Maity, PhD (JU) is Assistant Professor of C.E. Dept., MSIT, Kolkata. His research interests include ground improvement techniques, use of alternative materials and use of natural geo-fibers in Civil Engineering.