Compression Characteristics of Silt-Bentonite Mixtures in Liners

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Abstract: ***For liners, strength is necessary in achieving the durability and preventing from the mechanical shocks occurred. The silt and bentonite are mixed together and various proportions of the mixtures are studied for the compactions characteristics. If the bentonite and soil mixed together in the preparation of liner, the waterproofing capacity of bentonite helps to decrease the permeability of the mix proportion and also fill the pores of the mix. The soil acts as a sealant when the strength reduced in the mix. Obtained results from the different mix proportions shows that up to the weight of 20% bentonite the dry density decreases and also the increase in moisture content observed as per the increase in bentonite.***

Keywords: Compaction, Silt-Bentonite mixtures, Strength

I. INTRODUCTION

Engineered containment systems are the modern landfills which have been designed to minimize the impact of solid waste on the environment and human health. The modern landfills are provided with a liner system for isolating the landfill contents from the environment and also for protecting the soil and ground water from pollution originating in the landfill. An important threat caused to the ground water posed by modern landfills is leachate. Leachate and landfill gases are the important constituents formed inside the landfill. Leachate is the liquid compound that formed as the reactions occurred inside the landfill. It varies widely in its composition regarding to the type of wastes that present in the landfill and age of the landfill. It mainly contains both suspended and dissolved material. Like leachate, the landfill gases are also formed due to chemical reactions produced by the wastes inside the landfill. The leachate may move from the landfill and contaminate the ground water and soil, which results in the risk to all living beings.

For retarding the entry of leachate liners are provided. In engineered landfills, compacted clays containing low permeability are used in the liner systems. When these types of soils are not available, then medium to high plastic clays or commercially available are taken. For natural liners, bentonite is added to the natural soils or used as alone. Bentonite is not available easily at all areas and also its increased usage may cause reduction in strength due to its expansive nature. Low permeability and adequate strength must be possessed by the liner for its performance and durability. Permeability ranges below 10^{-7} cm/sec or 10^{-7} cm/sec and also a strength range of 200kN/m² or more should be achieved by a liner as per the conditions taken for the liner.

This study details about the compaction characteristics of silt-bentonite mixtures and also the strength obtained by performing unconfined compressive strength tests.

II. LITERATURE REVIEW

Kenney et al. (1992) recommended that in the absence of impervious soils, compacted mixtures of bentonite and sand have been used to form barriers to fluids. Low hydraulic conductivity requires continuity of the bentonite matrix within the mixtures and this in turn requires both adequate bentonite distributions. In well-compacted mixtures containing upto 20% bentonite in dry mass, sand forms the load-supporting framework and gives the mixtures dimensional stability at the macro level.

Blatz et.al(2002) studied about the strength and stiffness of compacted sand-bentonite. Sand-bentonite mixtures were prepared for testing the compaction and triaxial tests and various results had

obtained .By increasing suction ,the strength and stiffness of the buffer both increases non linearly. Also the strength and stiffness values of the specimen depends both the initial suction after compaction of specimen and the initial suction after compaction of specimen also increases in dry density associated with shrinkage during drying.

Boscov et.al (2009) studied the geotechnical properties of silty soil mixed with bentonite for liner construction. The properties studied include permeability, compressibility,shear strength and expansibility characteristics. Here only 5% bentonite were added to the soil and various characteristics was determined. Permeability requirements was identified without any loss of shear strength. Also the mixture contain higher expansibility than the natural soil. Swelling pressure contain an important aspect on the expansion behaviour.

Puri et.al(2013) conducted study on the bentonite-silt mixtures as seepage barriers in liner systems. Permeability and compaction characteristics of different percentages of bentonite-silt were tested. The soil were added to the bentonite clay by weight with ranges of 3%,6%,9%,12% and 15%..The results shows that significant decrease in values of permeability was observed for both types of silt-bentonite mixtures with increase in percentage of bentonite clay as an additive.In the case of compaction, values of maximum dry density increases and optimum moisture content decreases for both types of silt with increase in percentage of bentonite as an additive.

III. MATERIALS

The soil with high silt content used as the major substance of liner material and the bentonite used as the additive material.

The soil has collected from Ramankary, Alappuzha. The major properties related to the soil are shown in the table 1.

Silty soil

The soil has collected from Ramankary, Alappuzha. The soil obtained was in dark texture .The soil collected containing high silt content. The major properties related to the soil are presented in the Table 1.

TABLE 1: Basic properties of soil

Properties	Values
Specific gravity (IS 2720 PART 3)	2.18
Liquid limit (%) (IS 2720 PART 5)	79%
Plastic limit (%) (IS 2720 PART 5)	49.8%
Plastic index (%) (IS 2720 PART 5)	29.2%
Shrinkage limit (%) (IS 2720 PART 5)	19.92%
IS Classification	MH
Natural moisture content (%)	115%
Optimum moisture content (%) (IS 2720 PART 7)	31.29
Maximum dry density (g/cc) (IS 2720 PART 7)	1.35
Percentage of clay (IS 2720 PART 4)	18
Percentage of silt (IS 2720 PART 4)	72.525
Percentage of sand (IS 2720 PART 4)	9.48
UCC strength (kg/cm^2) (IS 2720 PART 10)	0.34
Free Swell Index	3.92%

Bentonite

The bentonite clay was taken from Associated Chemicals-Kochi. It is high compressible clay type. The important properties are detailed in the Table 2.

TABLE 2: Properties of Bentonite

Properties	Values
Specific gravity (IS 2720 PART 3)	2.59
Liquid limit (%) (IS 2720 PART 5)	336
Plastic limit (%) (IS 2720 PART 5)	40
Plastic index (%) (IS 2720 PART 5)	296
Shrinkage limit (%) (IS 2720 PART 5)	10
IS Classification	CH
Optimum moisture content (%) (IS 2720 PART 7)	36.65
Maximum dry density (g/cc) (IS 2720 PART 7)	1.257
Percentage of clay (IS 2720 PART 4)	73
Percentage of silt (IS 2720 PART 4)	27
Coefficient of Permeability, k (cm/sec)	1.7×10^{-9}
UCC strength (kN/m^2) (IS 2720 PART 10)	31.38

Silt-Bentonite mixture

The silt and bentonite mixed together to form different mixtures shown in the table. Silt varied about 50 to 90% by weight and bentonite varied from 10 to 50% by weight.

Table 3: Mix Proportion

Mix Proportion
90S:10B
80S:20B
70S:30B
60S:40B
50S:50B
S-Silt, B-Bentonite

IV. EXPERIMENTAL INVESTIGATION

1. Compaction test

The compaction tests on the silt-bentonite mixture was done by using the IS light weight compaction test. The relationship between the dry density and the moisture content for the silt-bentonite mixtures within silt content 50 to 90% and bentonite content 10 to 50% by weight was measured.

2. Unconfined compressive strength test

The conventional unconfined compression strength testing apparatus was used for the testing purpose. The compressive strength test details about the strength achieved for each proportion, the strength obtained were found out.

V. RESULTS AND DISCUSSIONS

1) Effect of maximum dry density on various mixtures

At a bentonite content of 20%, the maximum dry density increased and reached its higher value. On this condition the hydraulic conductivity also decreases. The bentonite occupies will be confined in the intergranular voids of the soil particles. Once the void spaces formed between the individual soil particles get completely filled by the bentonite, again the addition of bentonite occupies the space outside the void space and decreases the density after absorbing water [1].

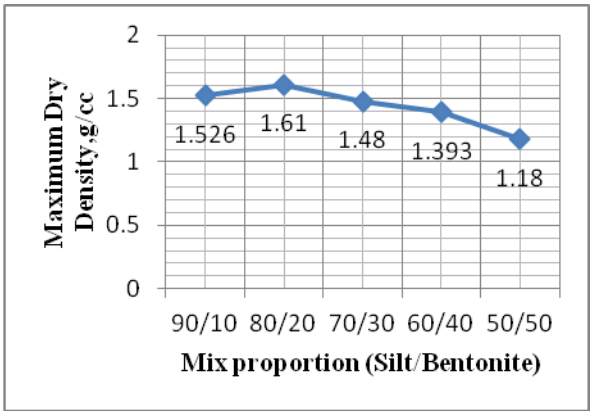

Fig 1: Variation of maximum dry density with different proportion

2) Effect of optimum moisture content on various mixtures

The optimum moisture content increased on each point as the increase in the amount of bentonite content. Due to the hydration of bentonite the optimum moisture content get increased as per the increase of bentonite fraction. In the case of larger bentonite fraction, the soil particles are dispersed in the bentonite matrix. For smaller amounts of bentonite the mixture the properties of granular soils, while for the higher bentonite contents there is a gradual transition of the typical behavior of plastic clays
[1].

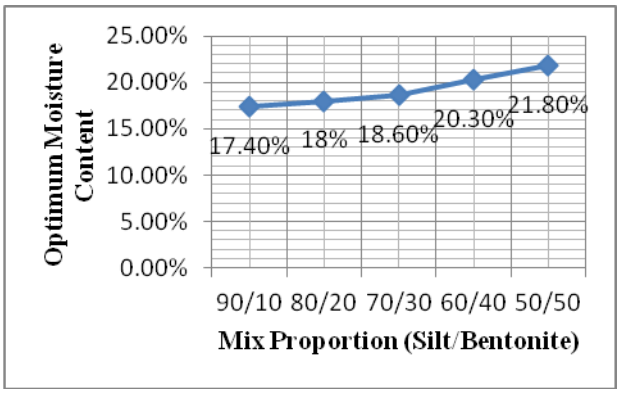

Fig 2: Variation of optimum moisture content with different proportion

3. Effect of Unconfined compressive strength

The purpose of compaction is to reduce the hydraulic conductivity of the soil liner. The installation procedure of liners usually focuses on the energy delivered to the soil, water content at compaction and the dry unit weight. Water content at compaction is an important parameter which can influence the hydraulic properties of liner materials. (Bagchi.A 1994)

Soils compacted at water contents dry of optimum tend to have a relatively high hydraulic conductivity whereas soils compacted at a water content wet of optimum lead to have a lower hydraulic conductivity. The obtained results denotes that up to 20% bentonite the strength becomes high and after that for each bentonite amount, the strength gets decreasing.

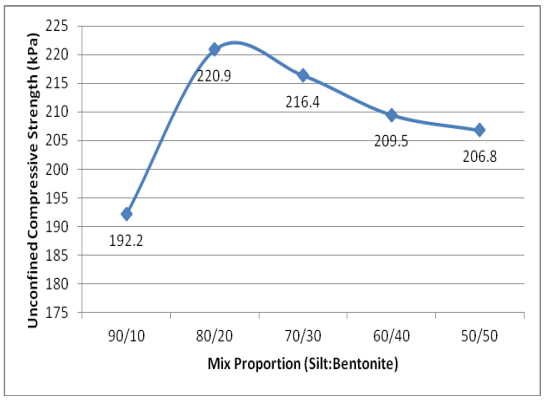

Fig 3: Variation of Unconfined compressive strength for different proportion

VI. CONCLUSION

- With a dry density of 1.61g/cc and the increasing bentonite content, the hydraulic conductivity decreased and makes a suitable mix proportion for the liner composition.
- The unconfined compressive strength value obtained from the 80% soil with 20% bentonite.
- From the results shows, as the increase in bentonite content, the optimum moisture content also increases.

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