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COMPARARTIVE STUDY OF PHYSICAL AND INDEX PROPERTIES OF CLAY- SAND LINERS

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ABSTRACT

Liners are constructed from naturally occurring earthen material. Soil Liners are needed to prevent the penetration of landfill leachate in to the soil. One of the requirements of modern sanitary landfill is that a soil liner be placed on the top of the existing soil, since it will minimize or eliminate water percolation. Of the different liner materials presently in use, the local availability of suitable clayey soils in many regions makes use of the soil liner as an economically attractive design alternative. Natural clay deposits when compacted can provide an effective hydraulic barrier in many situations such as environment and containment projects, waste disposal in landfill and earthen embankment and sometimes even used for disposal of hazardous wastes. Though the compacted clay liners possess advantages such as low permeability and large capacity of attenuation, they have high shrinkage and high expansive potential causing instability problem. To overcome that, some proportions of sand are added to the clayey soil. The main purpose of this work is to study the index properties such as atterberg limits, specific gravity, permeability and strength characteristics such as compressive strength, maximum dry density and shear strength parameters of CLAY- SAND LINERS. Also to reduce permeability, mineral admixture SILICA FUME is added to the clay-sand mixture. We used silica fume of proportions 15% and 25% by weight of clay-sand mixture and the test results show that the compacted clay-sand samples with 15% silica fume exhibit quite low permeability and significantly high compressive strength as compared to clay-sand samples.

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INTRODUCTION

The demand for liners in environmental and containment project is growing. The liner system utilise natural material such as clay and sand. The main requirements of liners are to ensure the minimisation of pollutant migration, low swelling and shrinkage. Clay sand mixtures are commonly used as a liner or barrier material in various engineering applications such as construction of hydraulic barriers and waste containments. Permeability and Compressive Strength are important properties of clay-sand mixtures and are often required for the design of the liners.A series of atterberg limits, specific gravity, direct shear test, standard proctor test, unconfined compression strength test, falling head permeability test were conducted on raw clay, raw sand, mixture of clay-sand (with proportions of 80% clay-20% sand and 50% clay-50% sand), mixture of clay- sand with silica fume of 15% and 25% to determine the factors influence their compressive strength and permeability characteristics.

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MATERIALS AND PROPERTIES

Clay

The clay selected for the study is the clay from Chitteri Lake, Vellore. Owing to high initial moisture content, it was dried first and then broken into pieces in the laboratory. The properties of clay were determined by standard test procedures.

Table 1. Physical properties of raw soil sample

PROPERTIES	VALUES
Specific gravity	2.47
Angle of internal friction (Ø)	24.34°
Cohesion (c)	0.3 Kg/cm^2
Optimum moisture content (OMC)	16%
Maximum dry density	1.65g/cc
Liquid limit (W_L)	39%
Plastic limit (W_P)	23.35%
Plasticity index (I_P)	15.65%

Sand: The sand selected for the study is from Palar River, Vellore. The properties of sand were determined by standard test procedures. The sand was found to be poorly graded as per IS specifications.

Table 2. Physical properties of Sand

Properties	Values
Gravel	3%
Course sand	41%
Medium sand	48%
Fine sand	8%
Silt and clay	0.35%
Angle of internal friction (Ø)	31.5°
Cohesion (c)	0 Kg/cm^2
Uniformity coefficient(C_u)	2.89
Coefficient of curvature(C_c)	0.962
Fineness modulus	3.75

Silica fume: The silica fume used in the present study is the by-product from silicon and ferro-silicon industry. It was purchased from Arslent Marketing Pvt Ltd. Chennai, which supplies high quality minerals products. The silica fume which we obtained is grey in color.

Table 3. Properties of silica fume

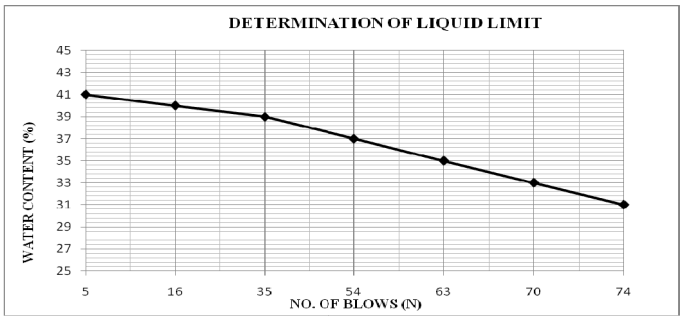
Properties	Value
Silicon dioxide, SiO_2	96.65
Aluminum Oxide, Al_2O_3	0.23
Ferric oxide, Fe_2O_3	0.07
Calcium oxide, CaO	0.31
Magnesium oxide, MgO	0.04
Potassium oxide, K_2O	0.56
Sodium oxide, Na_2O	0.15
Sulfur trioxide, SO_3	0.17
Size	0.15µm-1.0 µm
Specific gravity	2.2 to 2.3

Raw Sand

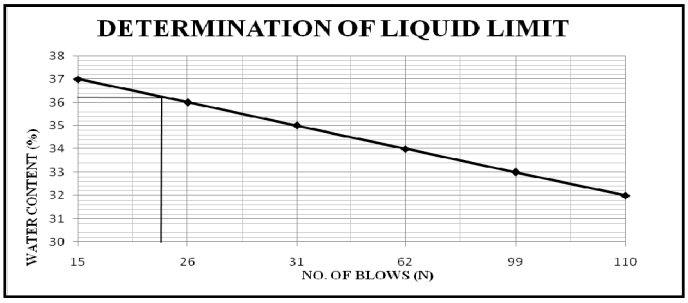
Raw Clay

Silica Fume

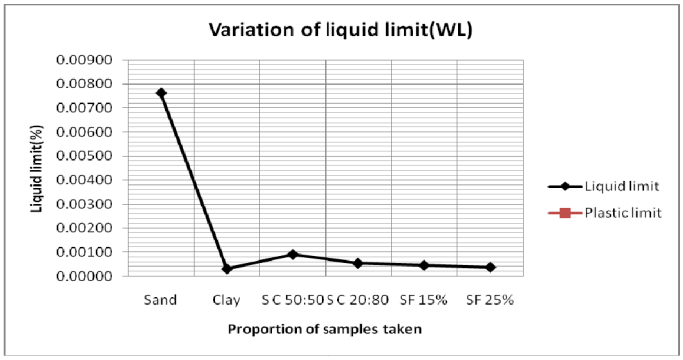
Figure 1. Raw materials



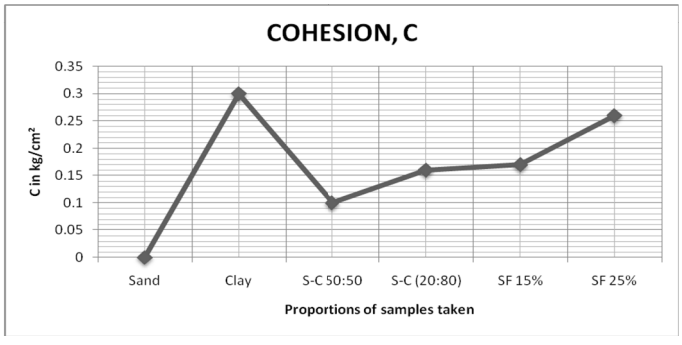
Graph 1. Determination of liquid limit for Clay-Sand (80:20) with 15% silica fume



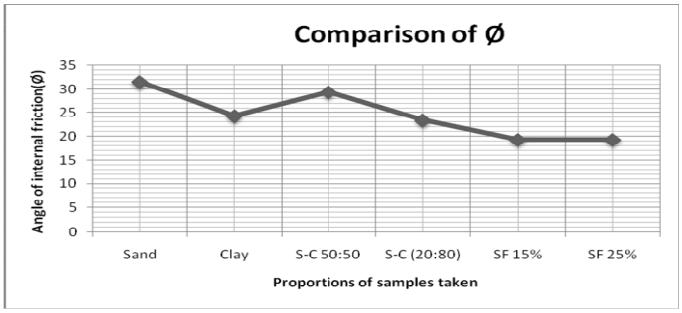
Graph 2. Determination of liquid limit for Clay-Sand (80:20) with 25% silica fume



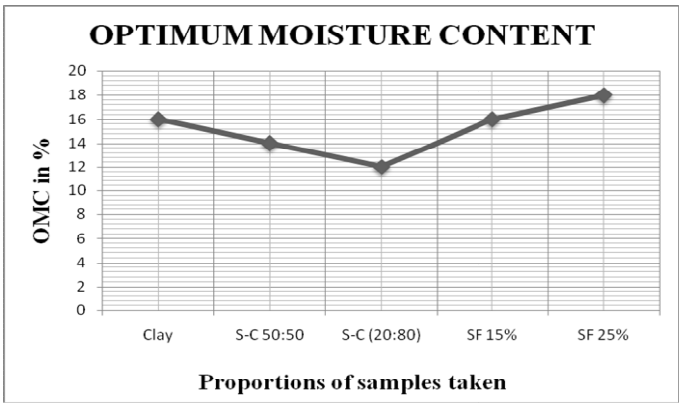
Graph 3. Variation of liquid limit



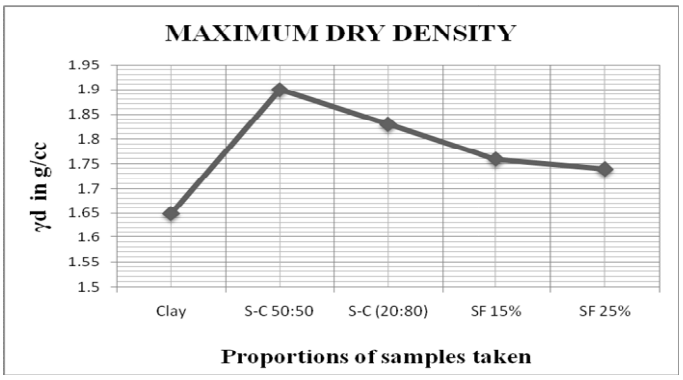
Graph 4(a). Comparison of cohesion value



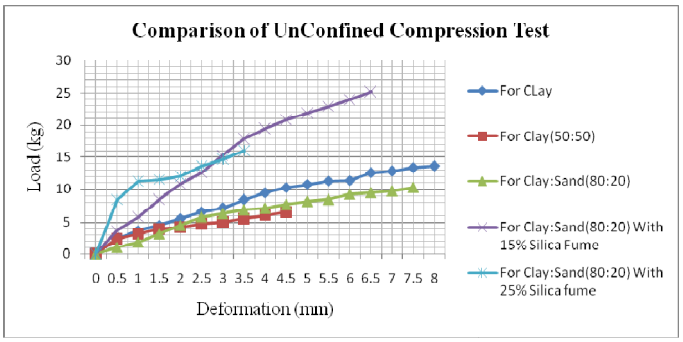
Graph no 4(b). Comparison of angel of internal friction



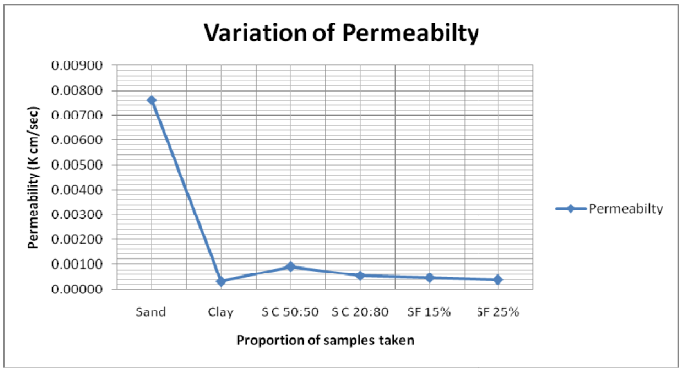
Graph No 5(a). Comparison of OMC



Graph 5(b). Comparison of Maximum Dry Density



Graph 6. Comparison of unconfined compression test



Graph 7. Variation of permeability

DISCUSSION

The various tests were conducted on the collected soil sample from Vellore, Tamil Nadu. From the test results the various index properties of the collected soil sample were determined, and the type of soil is "poorly graded soil". For the raw sand, Cohesion of soil sample is found to be nil and Angle of an internal friction is 31.5°,Co-efficient of permeability is 7.63 × 10^-3 cm / sec.For the raw clay, Cohesion of soil sample & Angle of internal friction are found to be 0.3 kg/cm^2&24.3°, Liquid limit & Plastic limit are 40.9 % &23.38 %. OMC & Maximum dry density are 16% & 1.66 g/cc, Unconfined compressive strength& Shear strength are 99.04 kN/m² &49.52 kN/m², Co-efficient of permeability is 3.2 × 10^-4 cm / sec. Clay and Sand are mixed with two proportions as 1:1 & 4:1 to study the permeability of the clay.For1:1 clay sand proportion, Cohesion of soil sample & Angle of internal friction are found to be 0.1 kg/cm^2&29.19°, Liquid limit & Plastic limit are 22.5 % &20 %. OMC & Maximum dry density are 14% & 1.9 g/cc, Unconfined compressive strength& Shear strength are 63.42 kN/m² &31.71 kN/m², Co-efficient of permeability is 9.2×10^-4 cm / sec.For4:1 clay sand proportion, Cohesion of soil sample & Angle of internal friction are found to be 0.16 kg/cm^2&24.23°, Liquid limit & Plastic limit are 36.2 % &19.68 %. OMC & Maximum dry density are 14% & 1.83 g/cc, Unconfined compressive strength& Shear strength are 99.04 kN/m² &49.52 kN/m², Co-efficient of permeability is 5.54×10^-4 cm / sec. From the test results, we have found 4:1 clay-sand proportions works better. Thus, the silica fume is added to the above mentioned proportion as 15% and 25% by the weight of the soil sample. For 4:1 clay-sand proportion with 15% silica fume, Cohesion of soil sample & Angle of internal friction are found to be 0.17 kg/cm^2&19.3°, Liquid limit, Plastic limit & Shrinkage limit are 39.4 % , 17.61 % & 18.12%. OMC & Maximum dry density are 16% & 1.76 g/cc, Unconfined compressive strength & Shear strength are 242.6 kN/m² &121.3 kN/m², Co-efficient of permeability is 4.68 ×10^-4 cm / sec.For 4:1 clay-sand proportion with 25% silica fume, Cohesion of soil sample & Angle of internal friction are found to be 0.26 kg/cm^2&19.3°, Liquid limit, Plastic limit & Shrinkage limit are 36.2 %, 19.16 % & 21.49 %. OMC & Maximum dry density are 18% & 1.74 g/cc, Compressive stress & Shear strength are 134.96 kN/m² & 67.48 kN/m², Co-efficient of permeability is 3.9×10^-4 cm / sec.

CONCLUSION

From the work we conclude that,

- The direct shear test results showed that the obtained angle of internal friction (Ø) value does not change when silica fume is added and is maximum for raw sand. The cohesion value (c) remained maximum for the raw clay.
- From the Standard proctor test results, the optimum moisture content increases for increase in silica fume percent and maximum dry density decreases.
- From the Unconfined Compression test results, the unconfined compressive strength and the shear strength are maximum for clay-sand (80:20) with15% silica fume sample.
- From the Falling Head Permeability test results, the minimum value of k is achieved in raw clay. The k value of clay-sand (80:20) with25% Silica fume mixture shows nearby value to the raw clay.
- Thus, 4:1 clay-sand proportion with 15% silica fume can be made effective for the use of landfill liners.

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