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PERFORMANCE EVALUATION OF CLAY SOIL BY THE ADDITION OF SILICA FUME AND SISAL FIBRE

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ABSTRACT *- In this modern era of world, where infrastructure projects are fast developing and construction technology had reached heights, still civil engineers find it difficult when it comes to construction on soft soils. This is due to their low bearing capacity and high volumetric change when it comes in contact with water. The shear strength problem of soft clay can be addressed by different stabilization techniques. In this experimental study, the strength parameters and optimum moisture content for achieving maximum dry density of the clay soil have been studied with the inclusion of sisal fibres and silica fumes in varying proportions.Unconfined compression strength (UCS) test has been conducted to investigate the strength of natural clay and clay modified with silica fume (5%, 10%, 15%) and sisal fibres (0.25%, 0.5%, 0.75%) separately and combination of all the materials by varying the proportion of sisal fibre for each proportion of silica fume. The optimum moisture content and maximum dry density were derived from standard proctor test performed with miniature compaction apparatus.The test results indicated that increase in silica fume content decreases the maximum dry density from 1.81g/cc to 1.613 g/cc similarly there is a decrease in maximum dry density from 1.81g/cc to 1.61g/cc when sisal fibre content is increased. The optimum moisture content shows slight variation when there is addition of sisal fibres and silica fume and was found to be around 16.67 %. When strength parameter is considered, maximum strength of 98.05 kPa is achieved when 15% silica fume and 0.75% sisal fibre is added with clay sample.*

Keywords : silica fume, sisal fibre, miniature compaction, unconfined compressive strength, stabilization

INTRODUCTION

In the fast growing world every piece of land has been driven under maximum utilization. So there arises a challenge in constructing buildings on clay soils. This cause give rise to the stabilization of clayey soil as there is a need for its utilisation. It involves mechanical stabilisation, chemical stabilisation and physical stabilisation. Physical stabilisation involves blending of two or more soil sample and some additives to improve the bearing capacity of the soil. In this work the strength of clay soil by reinforcing it with waste products such as silica fume and natural fibres like sisal fibres is studied.

Silica fume is the by product obtained from the smelting process in the silicon and ferrosilicon alloy formation industry. Silica fume has been recognised as a pozzolanic admixture that is effectively enhances the soil properties. Increasing the quantity of silica fume found to reduce the permeability of soil due to its high fineness. Silica fume is popularly called micro silica or silica dust and less popularly called volatilized silica. Considering the health issues of using this material in soil which, can be negotiated as the silica fume is amorphous not crystalline in form. Silica fume (SF)comprises of more than 90% SiO_2.The main advantage of using Silica Fume is increased toughness and lower permeability.

Sisal Fibre is a natural fibre obtained from sisal plant which is botanically known as *Agave sisalana*. It can be cultivatable almost any kind of soil excluding clay. These plants have rigid long leaves having fleshy pulp with straight fibre. The fibres are scrapped out of the plant by the process called decortication. In this process the leaves are beaten to left with the longitudinally tough fibres from the pulp. Then the fibres are collected and stored in dry conditions. Traditionally the fibres have been used in ropes and twine. Nowadays studies have been carried out to strengthen the clay soil with the naturally available sisal fibres due to its abundance of production and availability at effective rates.

MATERIALS

CLAY

The clay soil in this project is taken from a site near Bannari Amman Institute of Technology, Sathyamangalam, Tamilnadu. The maximum Dry Density and the Optimum moisture content (OMC) obtained for the clay are 1.81g/cc &14.29 % respectively. The clay is classified as CH with liquid limit of 51% and plastic limit of 27%.

SILICA FUME

The bulk density and the specific gravity of the silica fume are generally 130 to 600 kg/$m^3$and 2.2 to 2.3. The nitrogen adsorption method can be used to find the specific surface area of silica fume which is generally 15000 to 30000 m^2/kg.

SISAL FIBRE

The sisal fibre is obtained from Perundurai, Erode, Tamilnadu and cut to 15 mm length and used in different percentages.

METHODOLOGY

PREPARATION OF SAMPLE

The sample is prepared from clay soil passing through 425-micron sieve. The maximum dry density and the optimum moisture content of the sample is obtained from laboratory miniature compaction test. In this experimental study, a series of combination of materials is made and their unconfined compression strength is tested. The combination of materials are: (i) clay and silica fumes with varying silica fume content as 5%, 10% and 15%. (ii) clay and sisal fibre with varying fibre content as 0.25%, 0.5% and 0.75% by taking the length of the fibre 15mm has a constant. (iii) clay, silica fume (5%, 10% and 15%) and sisal fibre with varying fibre content as 0.25%, 0.5% and 0.75% for each variation in silica fume content.

The inclusion of the materials mentioned above are taken as percentage of total weight of the sample, and the individual weight of the silica fume and sisal fibre are replaced to the weight of the clay soil. So that the total weight of sample for all combination of the composite soil sample is equal.

RESULTS AND DISCUSSION

MINIATURE PROCTOR TEST

Miniature proctor test is done to assess the amount of compaction and water content required. The dry density initially increases with an increase in water content, until the maximum dry density is obtained. Upon further increase of water content, dry density decreases. The water content corresponding to maximum dry density(MDD) is the optimum moisture content (OMC).

The maximum dry density and the optimum moisture content (OMC) obtained for the virgin clay sample are 1.81g/cc and 14.29%.

The variation of MDD and OMC for all the modified clay samples were given in the graph below

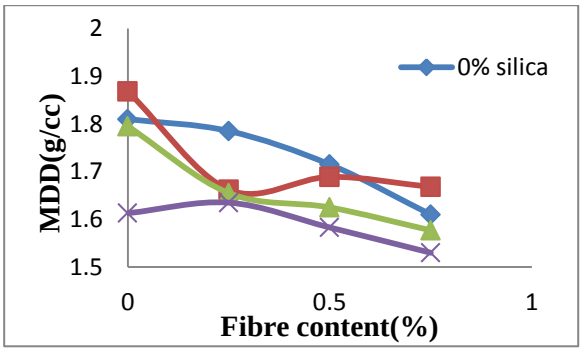

FIG 1:Effect of silica fume & sisal fibre on MDD.

From the above graph, it is evident that increase in silica fume content decreases the MDD and increase in fibre content causes the MDD to get decreased. In the 5% silica fume and fibre modified clay sample, the MDD is maintaining around 1.6 g/cc. In the 10% and 15% silica fume and fibre modified clay sample the MDD is decreased from 1.655 g/cc to 1.577 g/cc and 1.635 g/cc to 1.53 g/cc respectively. The decrease in MDD may be due to the lesser unit weight of admixtures compared to clay particles.

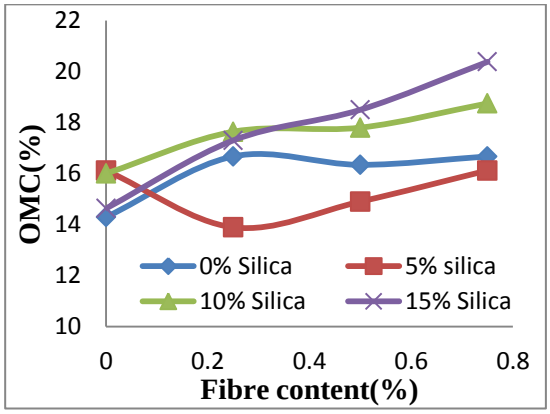

FIG 2: Effect of silica fume & sisal fibre on OMC.

The graph indicates that increase in fibre content causes the OMC to increase. For silica-modified clay sample the OMC decreases from 16.12% to 14.63%. For all 5%,10% and 15% silica and fibre modified clay mixture the OMC increases from 13.89% to 16.12% ,17.64% to 18.75% and 17.3% to 20.38% respectively. The slight increase in OMC might be due to the water absorption of fibre and fineness of silica fume.

UNCONFINED COMPRESSION TEST

The effect of silica fume and sisal fibre on shear strength is studied by unconfined compression strength test.

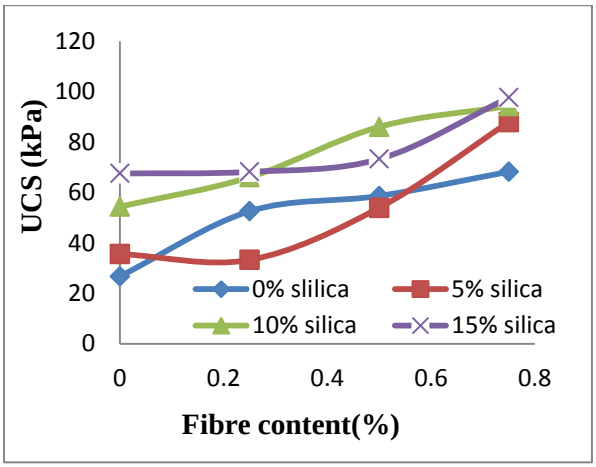

Fig 3: Effect of silica fume and sisal fibre on UCS

The UCS value of natural clay soil is observed has 26.37kPa. On addition of silica the value of UCS increases upto 67 kPa. For 5% silica and fibre modified clay the UCS value initially starts decreasing and then increases with increase in fibre content. The UCS value increases for both 10% and 15% silica and fibre modified clay sample. The maximum value of UCS is observed has 98 kPafor the 15% silica + 0.75% sisal fibre mixture.

CONCLUSIONS

- The silica fume, sisal fiber and silica fume–sisal fiber mixtures increased the UCS. Although the UCS values of all modified clayey soil samples increased with increasing silica fume and fiber content, it was observed that the maximum UCS value was obtained by addition of 15% silica fume–0.75% fiber mixture.
- There is a slight increase in OMC on addition of Silica fume and sisal fibre when compared with OMC of the natural soil.
- It has been concluded that there is a decrease in MDD on addition of both silica fume and sisal fibres.
- The modification of clay soils by waste materials like silica fume and naturally available sisal fibre can be an innovative method to enhance its strength.

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