Stabilization of Kaolinite Clay using Glass Fibres of Different Length

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***Abstract*- Construction of roads and other civil engineering structures on a weak soil is very risky due to its high compressibility, low shear strength, and high permeability. In such situations, it is general practice to modify the soil properties by blending with different materials such as lime, cement and fly ash or by reinforcing the soil. Soil reinforcement has been carried out since many decades due to its ease in application, good performance and cost effectiveness. Short discrete fibres made of polymeric or natural material have also been used to improve the shear strength of soil. A number of laboratory experimental studies have been carried out on soils mixed with artificial and natural fibres. In this study, glass fibre is added as a reinforcement material. Glass fibre is a material consisting of numerous extremely fine fibres of glass. This study was conducted to find the variations in strength characteristics with the addition of glass fibres of different length.**

Keywords: Weak soil, glass fibre, fibre reinforced, stabilization

I. INTRODUCTION

The presence of plant roots is a natural means of incorporating randomly oriented fibre inclusions in the soils. The plant fibres improve the strength of the soils and the stability of natural slopes. One of the main advantages of randomly distributed fibres is the maintenance of strength isotropy and absence of potential failure plane that can develop parallel to oriented reinforcement. A wide range of reinforcement has been used to improve soil performance. Necessity of increasing the soil strength has evinced increased interest in identifying new available resources for reinforcement. Short discrete fibres made of polymeric or natural material have also been used to improve the shear strength of soil. Randomly distributed fiber reinforcement technique has successfully been used in a variety of applications such as slope stabilization, road subgrade and sub base etc. This is a relatively simple technique for ground improvement and has tremendous potential as a cost effective solution to many geotechnical problems. Using fibers ranging from steel bars, polypropylene, poly-ester, glass fibers, and biodegradable fibers such as coir and jute, has been proven to be particularly effective for soil reinforcement.

Glass fiber (also spelled glass fibre) is a material consisting of numerous extremely fine fibers of glass. Glass makers throughout history have experimented with glass fibers, but mass manufacture of glass fiber was only made possible with the invention of finer machine tooling. In 1893, Edward Drummond Libbey exhibited a dress at the World's Columbian Exposition incorporating glass fibers with the diameter and texture of silkfibers. This was first worn by the popular stage actress of the time Georgia Cayvan. Glass fibres can also occur naturally, as Pele's hair.

Glass wool, which is commonly known as "fiberglass" today, however, was invented in 1938 by Russell Games Slayter of Owens-Corning as a material to be used as insulation. It is marketed under the trade name Fiberglas, which has become a genericized trademark.

Glass fiber is commonly used as an insulating material. It is also used as a reinforcing agent for many polymer products to form a very strong and light fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), popularly known as "fiberglass". Glass fiber has roughly comparable properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle.

Kaolinite is a clay mineral, part of the group of industrial minerals, with the chemical composition $Al_2Si_2O_5(OH)_4$. It is a layered silicate mineral, with one tetrahedral sheet linked through oxygen atoms to one octahedral sheet of alumina octahedra.Rocks that are rich in kaolinite are known as kaolin or china clay. Kaolinite has a low shrink–swell capacity and a low cation-exchange capacity (1–15 meq/100 g). It is a soft, earthy, usually white mineral (dioctahedral phyllosilicate clay), produced by the chemical weathering of aluminium silicate minerals like feldspar. In many parts of the world, it is colored pink-orange-red by iron oxide, giving it a distinct rust hue. Lighter concentrations yield white, yellow or light orange colors. Alternating layers are sometimes found, as at Providence Canyon State Park in Georgia, United States. Commercial grades of kaolin are supplied and transported as dry powder, semi-dry noodle or as liquid slurry.

II. MATERIALS AND METHODOLOGY

A. Materials used

1) Soil: Processed Kaolinite clay collected from English clay factory,Kochuveli ,Thiruvananthapuram district was used for study As per the results of initial tests soil was classified as CH. Intial properties of the soil were found and are listed in Table 1.

TABLE 1**:** GEOTECHNICAL PROPERTIES OF SOIL

ENGINEERING PROPERTIES	**VALUES**
Specific gravity	2.6
Liquid limit (%)	83%
Plastic limit (%)	32.50%
Shrinkage limit (%)	22
Plasticity index (%)	50.50
Maximum dry density (g/cc)	0.943g/cc
Optimum moisture content (%)	63.4%
Unconfined compressive strength	0.94 kg/cm^2
Soil classification	CH

2)Glass fibre: Glass fiber is a material consisting of numerous extremely fine fibers of glass. Glass wool, which is commonly known as "fiberglass" today, however, was invented in 1938 by Russell Games Slayter It is much cheaper and significantly less brittle.Glass fiber is commonly used as an insulating material.It is also used as a reinforcing agent for many polymer products to form a very strong and light fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), popularly known as "fiberglass" Glass fibre used for the experiments was taken from a local shop in Karunagapally, Kerala. The properties of glass fibre are as shown in table 2.

Fig.1. glass fibre

TABLE 2: PROPERTIES OF GLASS FIBRE

Length	500mm
Composition	54% Sio2,15% Al2O3,12% Cao
Density	2.6mg/m^3
Compressive Strength	5000mpa
Hardness	6000mpa
Tensile Strength	2050 Mpa

B. Methodology

Standard Proctor Compaction and UCC tests were conducted to obtain the strength characteristics of soil (0%, 0.1%,0.3%, 0.5%, 0.75%, 1%). Glass fibre was added to the soil in different proportion and its optimum water content was found out. UCC tests were conducted at that optimum water content of each proportion. The tests were conducted using glass fibres of length 5cm and 2.5cm.Then results obtained were analysed, compared and concluded.

III. RESULTS AND DISCUSSIONS

A. Variation of OMC and MDD with change in percentage of glass fibre of length 5cm and 2.5cm

OMC of the Kaolinite clay were found to be decreasing in both cases (at 5cm and 2.5 cm length glass fibre). As the glass fibre is a synthetic fibre, it did not absorb water. So optimum moisture content will decrease gradually. The OMC of soil in two conditions did not had much difference. The values were almost similar.

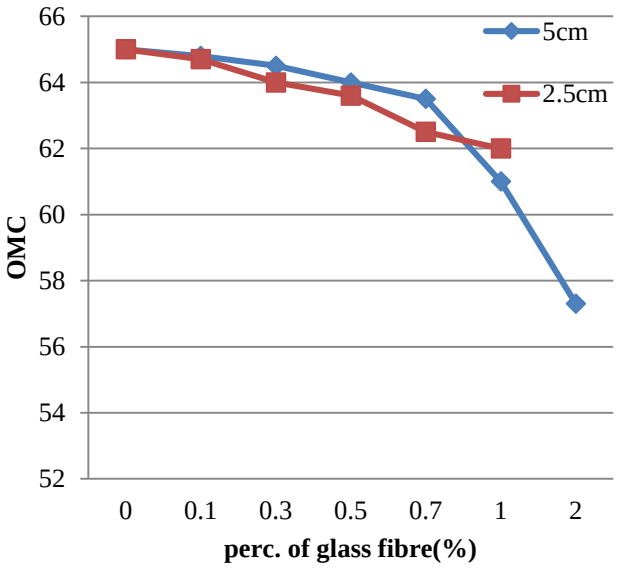

Fig.2. graph of OMC and perc. of glass fibre

B. Variation of UCC value with change in percentage of Glass fibre of length 5cm and 2.5cm

When comparing both cases, we can found that by using 5cm length glass fibre ,the UCC strength obtained was very much higher than that of using 2.5 cm glass fibre. At optimum point, UCC value was found to be 2.14 kg/cm^2 when 5cm glass fibre was used. When 2.5cm length glass fibre was used ,at optimum point UCC value was found to be 0.98 kg/cm^2 only. So it is suitable to use 5cm length fibre for obtaining higher strength.

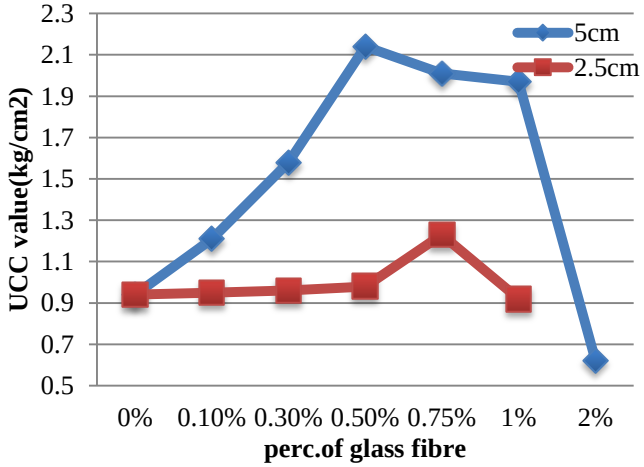

Fig 3.graph of ucc value and perc.of glass fibre

Fig.4 failure pattern before and after fibre reinforcement

IV.CONCLUSION

By analyzing the results from the experiments ,it is concluded that the glass fibre is an effective material used for the stabilization of kaolinite clay.When fibres of two length (5cm and 2.5cm fibre) were tested to determine the change in characteristics of the clay, it is found that glass fibre with 5cm length is effective in all cases. The UCC value increased highly when 5cm was used. The use of 2.5cm fibre increased these characteristics but it was not up to that of 5cm length fibre. So 5cm length fibre is more recommended than 2.5cm fibre.

Availability, economical benefits, easy to work and rapid to perform and feasibility of using in all weather conditions are the general advantages of fiber composite soils. The technical benefits of using fibers in soil reinforcement include: preventing the formation of the tensile cracks, increasing hydraulic conductivity and liquefaction strength, reducing the thermal conductivity and weight of building materials, restraining the swelling tendency of expansive soils and decreasing the soil brittleness. The application of synthetic fibers in geotechnical engineering is feasible in six fields including pavement layers (road construction),retaining walls, earthquake engineering, railway embankments, protection of slopes and soil-foundation engineering.

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