LABORATORY STUDIES ON THE PROPERTIES OF BLACK COTTON SOIL AND SILTY SOIL BY THE ADDITION OF GLASS FIBERS

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Abstract: *Engineering properties of soils play vital role in civil engineering construction works in road work, foundations, embankments and dams. Soil reinforcement has been introduced into the field of geotechnical engineering for many years in order to improve the properties of ground soil in specific engineering projects. Though some research have been done with a few types of soil, still the volume of study is rather scanty compared to other soil reinforcing materials. Traditional geosynthetics such as geotextile, Geogrid etc. have proved to be efficient, and are increasingly used in geotechnical engineering. In contrast, the use of glass fibers in soil needs further investigation. Black cotton soil and silty soil stabilized with procured glass fiber at proportions of 0.0%. 0.5%, 0.1%, 1.5%, 2.0%, by weight. Tests such as particle size analysis, compaction, California bearing ratio (CBR) and Unconfined Compression test were carried out on the unstabilized (control) soil samples. Thereafter, the compaction and CBR tests were carried out on stabilized soil samples. The results showed an improvement in the soil maximum dry density and CBR on addition of the glass fibers. Estimating The glass fibers had optimum effect on the soils samples. Therefore, incorporating glass fiber into the soils in the required quantity will enhance soils CBR and density.*

Keywords: California bearing ratio (CBR)

1. INTRODUCTION

A developing country like India which has a large geographical area and population, demands infrastructure i.e. network of roads and buildings. Everywhere land is being utilized for various structures from ordinary house to sky scrapers, bridges to airports and from rural roads to expressways. Almost all the civil engineering structures are located on various soil strata. Soil can be defined as a material consisting of rock particles, sand, silt, and clay. It is formed by the gradual disintegration or decomposition of rocks due to natural processes that includes disintegration of rock due to stresses arising from expansion or contraction with temperature changes. Weathering and decomposition from chemical changes that occur when water, oxygen and carbon dioxide gradually combine with minerals within the rock formation, thus it is breaking down to sand, silt and clay. Transportation of soil materials by wind, water and ice forms different soil formations such as those found in river deltas, sand dunes and glacial deposits. Temperature, rainfall and drainage play important roles in the formation of soils as in the different climatic regions. Under different drainage regimes, different soils will be formed from the same original rock formation.

In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favour. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement.

1.1 SOIL STABILIZATION

In general, soil stabilization consists of two elements, which are to increase the stiffness of soil and to maintain stiffness by maintaining correct moisture content. This practice can be used to lower the compressibility of soil and therefore reduce the settlement when structures are built on it. The term soil stabilization means the improvement of the stability or bearing power of the soil by the controlled compaction, proportioning and/or the addition of suitable admixture or stabilizers. Soil stabilization is the alteration of soil to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub grade to support pavements and foundations.

1.2 Principles of Soil Stabilization

- Evaluating the soil properties of the area under consideration.
- Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilization.
- Designing the Stabilized soil mix sample and testing it in the lab for intended stability and durability values.

1.3 Modification by Inclusion and Confinement

Sometimes different fibres are also used as reinforcements in the soil. The addition of these fibres takes place by two methods.

- Oriented fiber reinforcement
- Random fiber reinforcement
- Oriented fiber reinforcement: The fibers are arranged in some order and all the fibers are placed in the same orientation. The fibers are laid layer by layer in this type of orientation. Continuous fibers in the form of sheets, strips or bars etc. are used systematically in this type of arrangement.
- Random fiber reinforcement: This arrangement has discrete fibers distributed randomly in the soil mass. The mixing is done until the soil and the

reinforcement form a more or less homogeneous mixture. Materials used in this type of reinforcements are generally derived from paper, nylon, metals or other materials having varied physical properties. Randomly distributed fibers have some advantages over the systematically distributed fibers. Somehow this way of reinforcement is similar to addition of admixtures such as cement, lime etc .Besides easy to add and mix, this method also offers strength isotropy, decreases chance of potential weak planes which occur in the other case and provides ductility to the soil.

1.4 Glass fibers

Glass fibers one such fiber having a durable, inert nature possessing high tensile and compressive strength. It is extremely strong and robust material. Glass fibers are among the most versatile industrial materials known today, and it is found in the form of mesh. Fiberglass is a lightweight, extremely strong, and robust material. Glass fibers are among the most versatile industrial materials known today. From observation fact that glass fibers have a tendency to absorb water.

The manufacturing process for glass fiber reinforcements begins with raw materials, which are basically minerals. We mix those minerals based on the recipe of the glass formulation. The three main ingredients used to make glass are silicon dioxide (SiO_2), lime (calcium oxide or CaO) and aluminium oxide (Al_2O_3). Changing the mix of those components and other minerals will result in significantly different glasses. E-glass (with good electrical insulation properties, hence the name) is a commonly used glass on the market. Other glasses (alkali-resistant glass [AR] for cement or high-performance glasses) are also available in the OCV™ product line.

2. Objective of the present study

1. To assess the properties of black cotton soil and silty soil.
2. To study the compaction characteristics of black cotton soil and silty soil mixed with various percentages (0.5%,1.0%,1.5%,2.0%) of glass fibers.
3. To study the California bearing ratio (CBR) values of black cotton soil and silty soil mixed with various percentages (0.5%,1.0%,1.5%,2.0%) of glass fibers.
4. To determine the optimum glass fiber content of both black cotton soil and silty soil.

3. LITERATURE REVIEW

Vikas Rameshrao Kulkarni et al (2014),

An Attempted to study the effective utilization of industrial wastes such as blast furnace slag and glass fibres as stabilizing agents. The effect of blast furnace slag and glass fibres on certain properties of soil such as Optimum moisture content (OMC), Maximum Dry Density (MDD), Differential free swell and California Bearing Ratio (CBR) had been studied. It has been evaluated by experiments conducted on the samples by using blast furnace slag, 6mm and 12mm glass fibres. A number of CBR tests were carried out on black cotton soil by varying percentage of blast furnace slag (0%, 5%, 10%, 5%, 20% 25%, 30%)and glass fibre with different length (6mm & 12mm) and proportions (0%, 0.25% 0.50%, 0.75%, 1.00% and 1.25% by weight of dry soil with optimum percentage of slag). mixing of optimum percentage of slag and varying percentage of 12mm glass fibre soil lead to an increase in maximum dry density and CBR value increases for soaked condition, mixing of soil with 12mm fibre with soil had been better performance as compared to 6mm fiber.

Md. Mujaheduddin et al (2018), in the present study The experiments are done in the laboratory by blending the optimum % of ground granulated blast furnace slag, ordinary Portland cement of 0.3%, 0.6%, 0.9% and 1.2% and the glass fibre 0.25%, 0.5%, 0.75% and 1% were used with black cotton soil to know their effects on it. OMC, MDD results were found out in the laboratory. The UCS is checked at 3, 7 and 14 days of curing period for the mix proportions having highest values of MDD. From the results and experimental work, The black cotton soil blended with GGBS, GF & OPC shows higher MDD values than the soil mixed with GGBS & GF alone.

Gbenga Matthew Ayininuola et al (2018), In this study, the Main goal of the research was to ascertain glass fiber performance as a stabilizer by measuring its effects on lateritic soil (through a comparison of the properties of the soil with and without the addition of the glass fiber) and determine appropriate quantities of the glass fiber required for adequate stabilization of the lateritic soil. Soil samples were obtained from borrow pits at Ajibode and Chapel both located in the University of Ibadan, Ibadan, Nigeria and stabilized with obtained glass fiber at proportions of 0.4%. 0.8%, 1.2%, 1.6%, 2.0%, 2.5% and 3.0% by weight. Tests such as particle size analysis, compaction and California bearing ratio (CBR) were conducted on the unstabilized (control) soil samples. Thereafter, the compaction and CBR tests were carried out on stabilized soil samples. The results of this study clearly shows that an improvement in the two soils maximum dry density and CBR on addition of the glass fibers. It was concluded that when optimum value of glass fiber was exceeded, the excess formed spongy spot in the soil matrices that constituted a weak portion and hence the decrease in CBR obtained. The glass fiber helped to hold the soil particle together and hence improved the bonding forces among the soil particles.

4. MATERIALS USED

4.1 Soil

In the present study black cotton soil and silty soil are used. Soil samples were obtained from Raichur and belgum. The properties of black cotton soil and silty soil are presented in table 1.

Table–1: Properties of soils

Soil type	Black cotton soil	Silty soil
Particle Size Distribution		
Gravel, %	0	0
Sand, %	20.96	13.74

Silt and Clay, %	78.42	86.26
Atterberg's Limits		
Liquid limit, %	71	45
Plastic Limit, %	34.01	29.79
Plasticity Index, %	37.29	15.21
Modified Compation results		
Maximum Dry Density, gm/cc	1.51	1.81
Optimum moisture content, %	25.44	14.17
Heavy compaction CBR		
Unsoaked CBR, %	6.05	5.59
Soaked CBR, %	1.40	1.16
Unconfined Compressive Strength, kg/m2	163.5	124

4.2 Fibres

In this study, the glass fibers are obtained from Maharashtra. Glass fiber is a lightweight, extremely strong, and robust material. Glass fibers are among the most versatile industrial materials known today. from observation fact that glass fibers have a tendency to absorb water. Properties of glass fibers are presented in table 2.

Figure-1: Glass fibers

Table-2: Properties of glass fibers

Property	Specifications
Size	12mm
Diameter	14microns
Moisture	0.9%
Specific Gravity	2.68
Softening Point	8450C

5. EXPERIMENTAL INVESTIGATIONS

The experimental work is carried out in three stages, in the first stage tests like Wet sieve analysis and Atterberg limits tests (Liquid Limit and Plastic Limit) were conducted on soil obtained for investigation. Second stage consists of determining maximum dry density and optimum moisture content for black cotton soil and silty soil with varying percentages of Glass fibres by Modified proctor compaction method and California Bearing Ratio (CBR) test were conducted.

In order to determine the optimum glass fiber content, the black cotton soil and silty soil is treated with 0%, 0.5%, 1.0%, 1.5% and 2% of glass fibers by dry weight of soil. The stabilized samples can be tested with various types of laboratory tests such as Heavy compaction test and California bearing ratio test. To evaluate the optimum glass fiber content.

5.1 Modified Proctor compaction test

The test is conducted as per IS 2720 (Part 8)-1980. The black cotton soil and silty soil is treated with Glass fibres of 0.5%, 1.0%, 1.5% and 2.0% by dry weight of soil. The Modified Proctor test was conducted to determine the optimum moisture content (OMC) and maximum dry density (MDD) of black cotton soil and silty soil.

Figure-2: Modified Proctor compaction test

The results of Modified proctor test was conducted to determine the optimum moisture content (OMC) and maximum dry density (MDD) for black cotton soil treated with varying percentage of Glass fibres (0.5%, 1.0%, 1.5% and 2.0%) are shown in table 3.

Table-3: Variation in OMC and MDD of Black Cotton Soil with Varying Percentages of glass fibres

Percentage of Glass fibres	OMC (%)	MDD (gm/cc)
0	25.44	1.51
0.5	31.81	1.48
1.0	31.83	1.47
1.5	24.15	1.63
2.0	32.46	1.51

The results of Modified proctor test was conducted to determine the optimum moisture content (OMC) and maximum dry density (MDD) for silty soil treated with varying percentage of Glass fibres (0.5%, 1.0%, 1.5% and 2.0%) are shown in table 4.

Table-4: Variation in OMC and MDD of silty Soil with varying Percentages of glass fibres

Percentage of Glass	OMC (%)	MDD (gm/cc)
0	14.17	1.81
0.5	11.45	1.84
1.0	12.13	1.77
1.5	9.97	1.79
2.0	16.67	1.72

5.2 California bearing ratio test

CBR value of the soils is determined by test procedure as per IS 2720 (Part 16)-1987 (reaffirmed 1997). The equipment's used in the test are CBR equipment consisting of 15.2 cm dia 17.8cm height compaction mould with collar and spacer disc 15.1 cm dia 6.14cm height, Compaction rammer, Surcharge weights, Compression machine equipped with CBR penetration piston and Balances-one with capacity 10Kg sensitive to 1g. The results of California bearing ratio test values presented in table 5, 6 and shown in chart 1 and 2.

Figure-3: California bearing ratio (CBR)

Table 5 CBR test results on Black cotton soil Specimens treated with optimum glass Fibres for heavy compaction

Percentage of Glass fibres	CBR % (unsoaked)	CBR % (soaked)
0	6.05	1.40
0.5	8.85	3.26
1.0	9.31	5.59
1.5	10.24	6.98
2.0	7.92	6.05

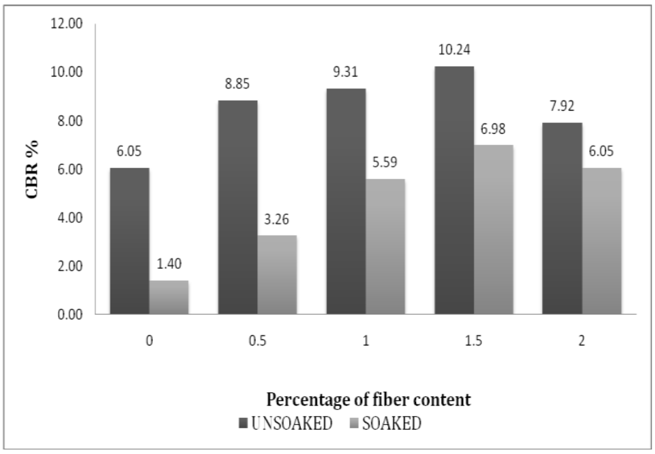

Chart-1: CBR test results on Black cotton soil specimens treated with optimum glass fibres for heavy compaction

Table 6 CBR test results on silty soil specimens treated with optimum glass fibres for heavy compaction

Percentage of Glass fibres	CBR % (unsoaked)	CBR % (soaked)
0	5.59	1.16
0.5	8.38	6.52
1.0	7.92	5.12
1.5	7.45	5.59
2.0	6.98	3.03

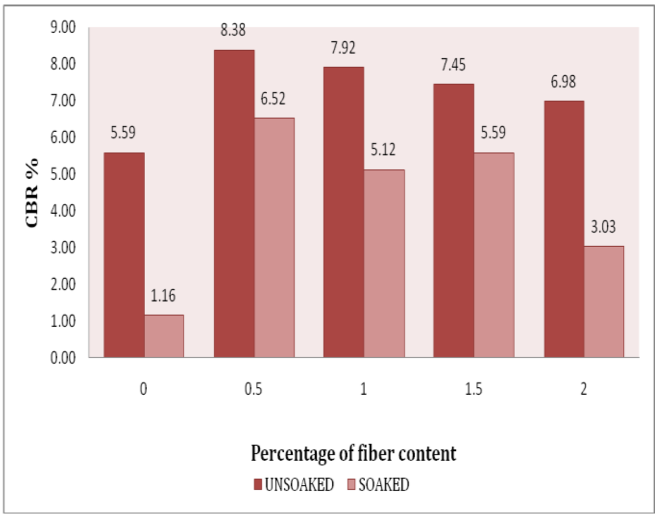

Chart-2:CBR test results on silty soil specimens Treated with optimum glass fibres for heavy compaction

6. CONCLUSONS

1. There is substantial increase in Maximum dry density with increase in addition of fibers upto 1.5% by weight in black cotton soil and 0.5% by weight in silty soil beyond which it decreased in both black cotton soil and Silty soil.
2. Black cotton soil stabilized with optimum content of 1.5% glass fibres imparts higher strength in terms of California bearing ratio when compared to untreated soil.
3. Silty soil stabilized with optimum content of 0.5% glass fibres yield substantial strength in terms of California bearing ratio when compared to untreated soil.
4. Based on the laboratory studies carried out, it can be concluded that the black cotton soil and silty soil stabilized with optimum content of 1.5% and 0.5% of glass fibres is superior and performing best results respectively.

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