Effect on Strength Characteristics of Expansive Soil Using Sisal Fibre and Waste Materials

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Abstract: ***The addition of sisal fibre, bagasse ash and glass powder waste in various proportions with black cotton soil and combination on the above proportion of ingredients is studied. To achieve this goal experimental studies were carried in two phase. In the first phase, the physical properties of soil such as particle size distribution, specific gravity, Atterberg's limits, swelling pressure were determined. In second phase, various tests were performed on black cotton soil using different proportion of sisal fibre, bagasse ash, glass powder waste and from the maximum values of strength test a combination of 0.9% sisal fibre,7% bagasse ash and 14% glass powder waste was also performed. The results indicated that with addition of sisal fibre, bagasse ash and glass powder waste the dry density increased and optimum moisture content was found to be decreasing. The unconfined compressive strength and California bearing ratio values increased with addition of optimum percentage of sisal fibre, bagasse ash and glass powder waste to the mixture of black cotton soil. The best result was obtained for mixture of black cotton soil and optimum dosage of 0.9% of sisal fibre, 7% bagasse ash and 14% glass powder waste.***

Keywords: Sisal Fibre, Bagasse Ash, Maximum Dry Density , Optimum Moisture Content, Stabilization, Black Cotton Soil.

1. Introduction

Soil stabilization is the modification of one or more soil properties so as to produce improvement in soil system that will remain in place under the design use conditions throughout the design life of the project. Soil varies around the globe and their engineering properties are equally variable. Expansive soil or Black cotton soil undergo swell shrink behaviour due to presence of montmorillonite mineral. Highway construction on cohesive or clayey soils has been a challenge to engineers and designers because of its high swelling and shrinkage characteristics which is attributed to presence of inorganic clays of medium to high compressibility, which results in cracks in the pavement structure [6]. Expansive soils have very low shear strength when saturated and exhibit high volumetric change during wetting and drying [9]. These soils are very weak and not fit to construct any structure or pavement above it. The soil property has to be increased before any structure or pavement has to be built over it.

The present study is aimed at determining the behaviour of black cotton soil reinforced by sisal fibre in a random manner. Use of natural material such as jute, coir, sisal and bamboo, as reinforcing materials in soil is predominant for a long time and they have been widely used in many countries like India, Philippines, Bangladesh, etc [6]. The main advantage of these materials is that it is locally available and very cheap. They are biodegradable and hence do not create disposal problem in environment.The strengthening soil with added rods or fibres is not a new concept, even though a systematic study of reinforced earth started only very recently of bricks by adding straw. The practice of building houses on natural fibres reinforced soil and construction of earth walls making use of different types of reinforcing inclusions are age old arts in the villages in tropical Africa and Southern Asia. The use of rope fibres and bamboo strips to strengthen rural road bases. Vertically arranged rectangle grids of bamboo strips and stalks of palm branches were used as central core for mud walls. The walls thus constructed are more resistant to crack propagation than plain unreinforced mud walls.

Bagasse ash is a pozzolanic material which is very rich in the oxides of, silica and aluminum and sometimes calcium. Pozzolans usually require the presence of water in order for silica to combine with calcium hydroxide to form stable calcium silicate, possessing cementitious properties. It is a fibrous material with presence of silica (SiO_2) and it can be made use to improve the existing properties of black cotton soil. Glass is a hard material which is transparent normally fragile and used in our daily life. It is composed mainly of sand (silicate) and an alkali. The physical properties of the crushed glass are that they exhibit high crushing resistance, high permeability and small strain stiffness, these properties could enhance its usage for soil stabilization in geotechnical engineering works, embankment constructions etc.

This research work focus on addition of sisal fibre, bagasse ash and glass powder waste in various proportions with black cotton soil and combination on the above proportion of ingredients. And to quantify and analyze the suitability of sisal fibre, bagasse ash and glass powder waste required to improve the stability and strength of the black cotton soil by proportioning the materials required.

2. Materials and Methods

The materials used and collecting methods for conducting the experiment of stabilization of black cotton soil are explained in details as below.

2.1 Expansive Soil

The black cotton soil for the present study was collected from Nanjangud taluk, Mysore District by using technique of disturbed sampling.

Figure 1: Black cotton soil taken from a depth below 0.5m

2.2 Sisal Fibre

For the present study, sisal fibres were obtained from Tokyo Engineering Cooperation, Coimbatore, and Tamil Nadu. The obtained fibre has off white colour having length 60cm and diameter around 0.2mm fibres. The fibres are cut to pieces of 15mm to 20mm length and are randomly mixed with soil in varying percentages (0.3%, 0.6%, 0.9% and 1.2%) by dry weight of soil

2.3 Bagasse Ash

The Bagasse ash was collected from Bannari Amman Sugar Ltd., Nanjangud Taluk, Mysore district, Karnataka state. Bagasse ashes are randomly mixed with soil in varying percentages (3.5%,7%, 10.5% and 14%). The bagasse ash used in this experiment is having black colour and have a specific gravity of 1.32.

2.4 Glass Powder

The glass powder is obtained from Ashwin Ceramics Manufacturers, Chennai, Tamil Nadu. Waste glass powder is randomly mixed with soil in varying percentages (7%, 14%, 21% and 28%). The glass powder waste has: Colour – white & Specific gravity – 2.60

3. Methodology

The experimental studies were carried in two phase.In the first phase, the physical properties of soil such as particle size distribution, specific gravity, Atterberg's limits, swelling pressure were determined. In second phase, various testswere performed on black cotton soil using different proportion of sisal fibre (0.3%, 0.6%, 0.9% and 1.2%), bagasse ash (3.5%, 7%, 10.5% and 14%), glass powder waste (7%, 14%, 21% and 28%) and from the maximum values of strength test a combination of 0.9% sisal fibre,7% bagasse ash and 14% glass powder waste was also performed.

4. Result and Discussion

To determine the compaction characteristics, penetration resistance and unconfined compressive strength of sisal fibre, bagasse ash and glass waste treated soil various tests were carried out in accordance with the standard procedure. The test results for the various properties are as follows.

Table 1 Properties of black cotton soil
(All the tests are conducted as per IS- 2720 standards)

Name of test	*Test result*
Specific gravity	2.62
Hydrometer analysis	Fine sand fraction = 10% Silt size = 36% Clay size = 54%
Atterberg limits Plastic limit Plasticity index Liquid limit Shrinkage limit Shrinkage ratio Volumetric shrinkage	 29.49% 37.51% 67%. 13.35% 1.89 81.39%
Free swell index	50 %
Modified proctor test OMC Dry density	 21.43% 1.579 g/cc

4.1. Compaction Characteristics of sisal fibre, bagasse ash and glass waste

The variation of MDD and OMC with respect different percentage of sisal fibre is plotted in Figure 2. In the case of sisal fibre reinforced soil it is observed that, as fibre content increases, the OMC decreases and then increase and the maximum dry density increases to its maximum value at 0.9% replacement of sisal fiber. The decrease in maximum dry density can be attributed to the lower density of fibre compared to that of soil. It can be seen that for 0.9% sisal fiber the optimum moisture content is 18.72% and maximum dry density is 1.632g/cc.

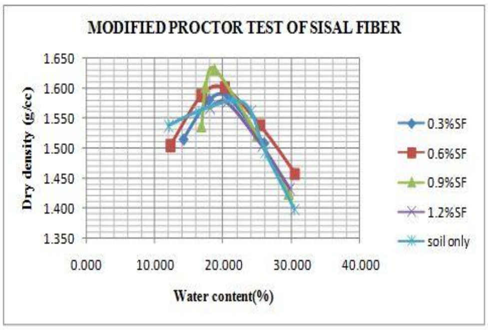

Figure 2: Modified proctor test data for different percentage of sisal fibre

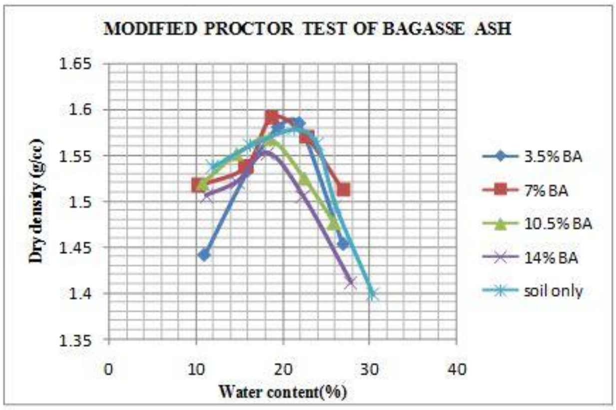

Figure 3: Modified proctor test data for different percentage of bagasse ash

Improvement in the maximum dry density was observed slowly for 3.5% and 7% replacement of bagasse ash, a further increase in blend resulted in the decrease of MDD. This decrease may be due to the replacement of higher specific gravity soil by lower specific gravity bagasse ash and it's fibrous in nature. It was also observed that optimum moisture content decreased as percentage of bagasse ash increase.

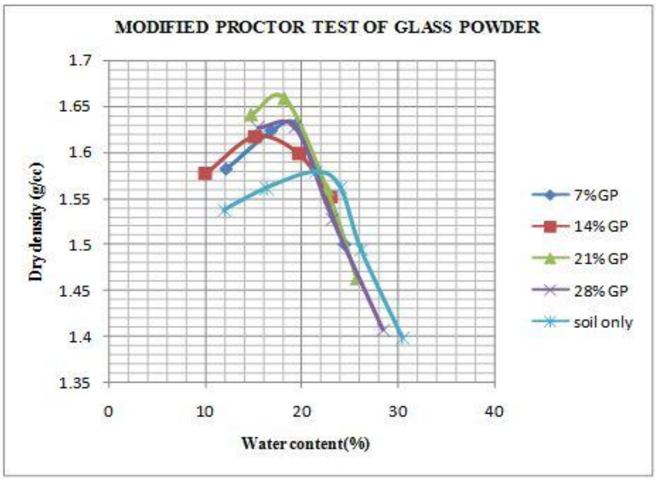

Figure 4: Modified proctor test data for different percentage of glass powder

The results obtained on the dry densities for the soils treated with waste glass powder, showed that as the replacement levels of waste glass powder increase, the dry densities increase with the maximum value achieved at 14% replacement level for waste glass powder. This behaviour is depicted in Figure 4 shows that maximum dry density is for soil treated with 14% waste glass powder is 1.659 g/cc at 18.20% moisture content. As the replacement levels are increasing, the moisture content decrease which is an indication of better performance achieved at 14 % replacement level.

4.2. Unconfined Compressive Strength Characteristics of Sisal Fibre, Bagasse Ash and Glass Waste

The variation of Unconfined Compressive Strength against the fibre contents for the soil reinforced with sisal fibre is shown in Figure 5.The Unconfined Compressive Strength is highest at 0.9% fibre content for all the cases of sisal fibre reinforced soils. In case of sisal fibre, when the fibre content is 0.9%, the Unconfined Compressive Strength increased to 142.021KPa

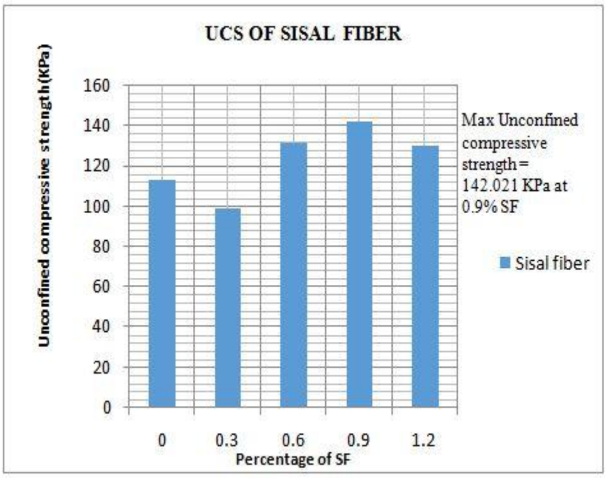

Figure 5: Variation of UCS value for different percentage of Sisal fibre

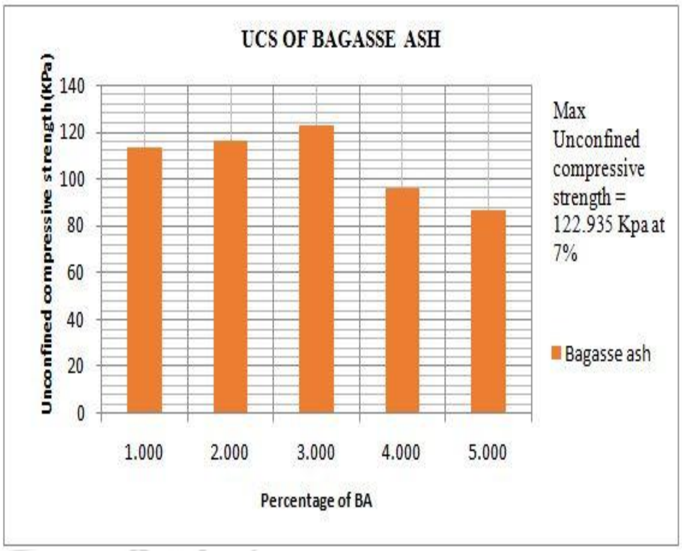

Figure 6: Variation of UCS value for different percentage of Bagasse ash

The results of compressive strength variation are shown in Figure 6. The sample prepared is tested in unconfined compression testing machine. There was a slow increase in strength with increase of percentage of bagasse ash, maximum strength obtained for 7% bagasse ash. Compressive strength then decrease with increase of percentage bagasse ash. This phenomenon may be attributed to grain size effect, specific gravity of both material etc. the maximum value of unconfined compressive strength is 122.935 KPa.

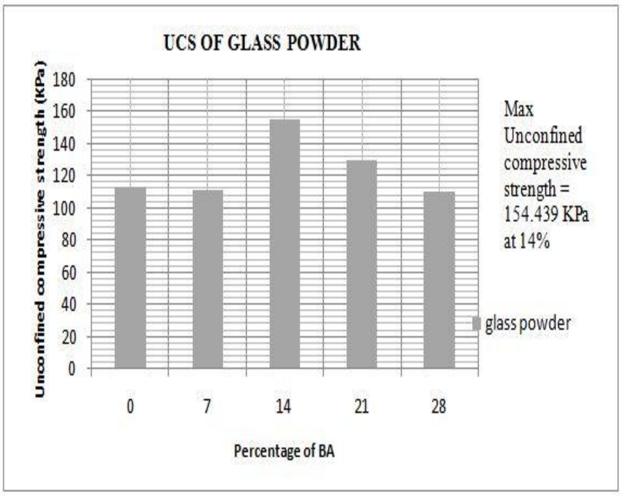

Figure 7: Variation of UCS value for different percentage of Glass powder waste

The variations of UCS for the samples shown in Figure 7, the influence of glass powder waste on the compressive strength is due to effect pozzolanic chemical reaction with Glass powder waste. The UCS value of 154.439 KPa obtained for a combination of 14% Glass powder waste. Also, Wartman et al. (2004) suggested there may be a delay on the impact of WG on strength of fine grained soils until WG particles stops to float in the fine grained matrix and develop particle to particle interactions which subsequently dominate the strength behaviour.

4.3. California Bearing rato test of Sisal Fibre, Bagasse Ash and Glass Waste

Figure 8, shows the variation of CBR value against the fibre contents for the soil reinforced with sisal fibre. The CBR value is highest at 0.9% fibre content, the CBR value increased by 1.85 times over plain soil. The optimum CBR value of 14.21% obtained for 0.50% fibre content for sisal fibre. There is a decrease in the CBR value, when the fibre content increases from 0.50% to 0.75% for sisal fibre.

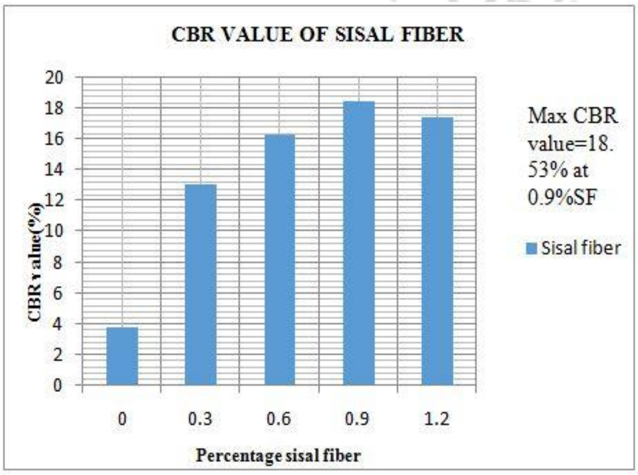

Figure 8: Variation of CBR value with different percentage of Sisal fibre

The unsoaked CBR values give an idea about the bearing ability and strength of soil. It was observed that, CBR values increase rapidly for 3.5% and 7% replacement of bagasse ash, it was further seen that there was a sudden drop to lower values. It was also seen that, as percentage of bagasse ash increases there was a decrease in OMC, which is somehow responsible for the decrease in CBR values. At low energy levels less water is available for controlling hydration, which leads to form weak bonds and resulted in less strength. The maximum increase was observed for 7% replacement of bagasse ash.

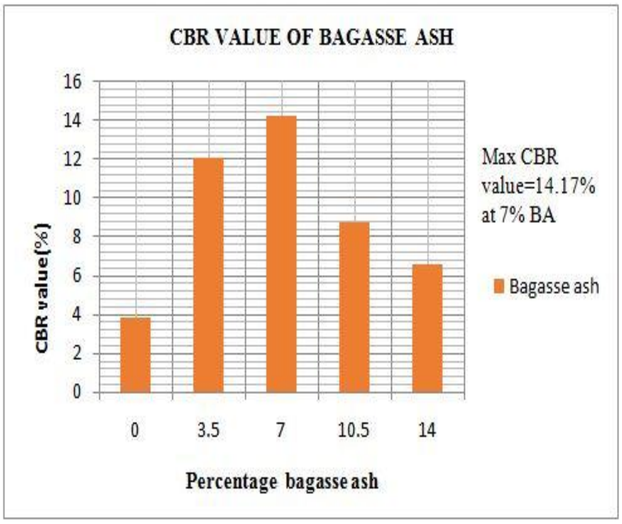

Figure 9: Variation of CBR value with different percentage of Bagasse ash

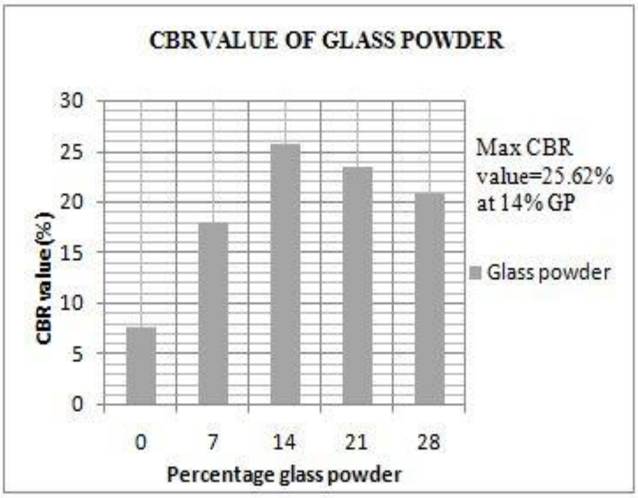

Figure 10: Variation of CBR value with different percentage of Glass powder waste

Figure 10 shows the variation of un-soaked CBR with various percentages of glass powder waste blend. The increase in the CBR value may be attributed to the shear transfer mechanism between soil and Glass powder waste, and the improvement in the strength can be related to the pozzolanic action of glass powder waste. Furthermore, the peak CBR value of 25.62% it can be used as a sub-grade material.

4.4. Variation of CBR, UCC and Compaction test values for optimum dosage

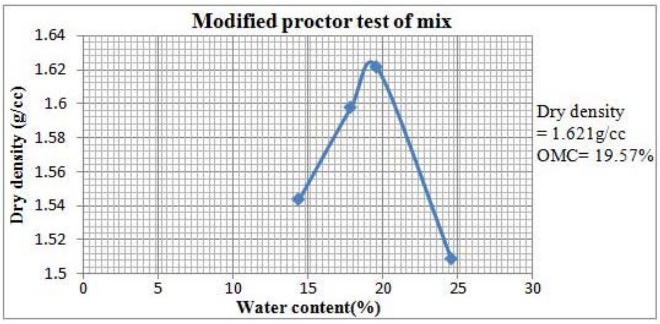

Figure 11: Modified proctor test of mix

The optimum moisture content was obtained as 19.57% and MDD as 1.621g/cc. These values were taken for determining the unconfined compressive strength and California bearing ratio.

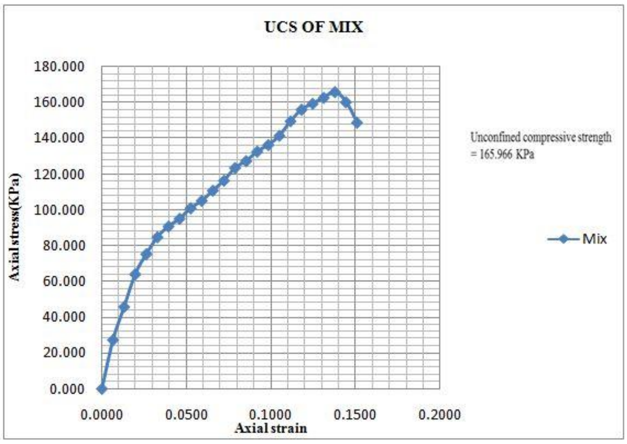

Figure 12: UCS test on the optimum mix

The unconfined compressive strength of the mix was obtained as 165.966 KPa

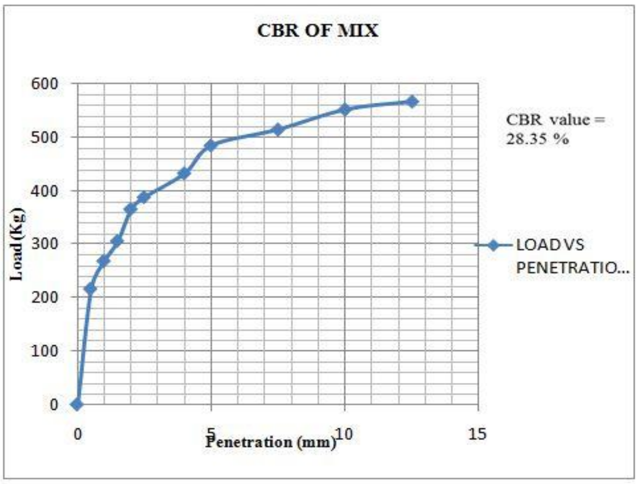

Figure 13: California bearing ratio test of mix

The CBR ratio obtained for optimum dosage of 0.3% by weight of soil by sisal fibre, 7% by weight of soil by bagasse ash and 14% by weight of soil by glass powder waste is 28.35% for unsoaked sample.

5. Conclusion

This project work is done to evaluate the effect of sisal fibre, bagasse ash and glass powder waste on the engineering properties of black cotton soil taken from the Nanjangud taluk, Mysore District, Karnataka State, India. From the experimental work done and further investigations, the following conclusions were drawn:

1) The optimum dosage of 3 material is obtained as 0.9% sisal fiber, 7% bagasse ash and 14% glass powder waste.
2) The results also showed that glass powder waste may be substantially used to improve the Unconfined Compressive Strength (UCS) of treated soils
3) The CBR values obtained for the glass powder waste stabilized soils gave higher values obtained for the untreated soil.
4) The maximum dry density increases and Optimum moisture content decreases with increase in percentage replacement of SF, BA and GP.
5) The optimum dosage of sisal fiber, bagasse ash and glass powder waste is 0.3%, 7% and 14% respectively.
6) At 0.3% replacement of SF, the UCS value increase from 113.114kPa to 142.021kPa, at 7% replacement of bagasse ash , the UCS value increase from 113.114 kPa to 122.935 kPa and for 14% replacement of glass powder waste , the UCS value increases from 113.114kPa to 154.439 kPa
7) The CBR ratio at 0.3% sisal fiber was found to be 2.43 times of the CBR value of soil. The CBR ratio at 7% bagasse ash was found to be1.86 times of CBR value of soil and the CBR ratio at 14% glass powder waste was found to be3.36 times of CBR value of soil.
8) Mix of 0.3%sisal fiber, 7% bagasse ash and 14% glass powder waste has increased the unconfined compressive strength and CBR ratio of the soil. The increase in unconfined compressive strength of about 1.46 times that of the plain soil and CBR ratio is 3.72 times that of the plain soil in so that we can conclude that sisal fiber, bagasse ash and glass powder waste can be used as the stabilizers for the improvement of strength properties of the soil.

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