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EFFECT OF RANDOM INCLUSION OF BAMBOO FIBERS ON STRENGTH BEHAVIOUR OF FLYASH TREATED BLACK COTTON SOIL

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ABSTRACT

This paper describes the compaction and strength behaviour of fly ash treated black cotton soil (BC soil) reinforced with bamboo fibers. The optimum percentage of fly ash was found to be 20% by weight of soil. Bamboo fiber of average diameter 0.45 mm and 25 mm length is used in this study. It was randomly included into the fly ash treated soil at four different percentages of fiber content, i.e. 0.25, 0.5, 0.75 and 1% (by weight). The reinforced soil samples were subjected to unconfined compression test and compaction tests. It is found that strength properties of optimum combination of BC soil-fly ash specimens reinforced with bamboo fibers is appreciably better than untreated BC soil. An optimum fiber content of 1% (by weight) is recommended for strengthening flyash treated BC soil.

Key words: bamboo fiber, flyash, maximum dry density, unconfined compressive strength.

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1. INTRODUCTION

Construction of foundation for structures on black cotton soil (BC soil) is highly risky on geo-technical grounds because such soil is susceptible to differential settlements, poor shear strength and high compressibility. Chemical stabilization is one of the oldest methods of stabilization of problematic soil. In recent days it has been investigated that addition of fibers will improve the ductility behaviour of the soil there by reducing the development of crack during shrinkage.

Extensive study has been carried out on the stabilization of expansive soils using various additives such as lime, cement, flyash, industrial waste products etc., and also with random inclusion of fibers such as coir, sisal, polyester fibers etc. Randomly oriented tensile inclusions incorporated into soil to improve its load–deformation behaviour by interacting with the soil particles mechanically through surface friction and also by interlocking. The function of the interlock is to transfer the stress from the soil to the tensile inclusions and to mobilize tensile strength and imparts resistive force.

One of the main advantage of randomly distributed fiber is that the maintenance of strength isotropy and absence of potential planes of weakness that can develop parallel to the oriented reinforcement (Maher and Gray 1990).

The objectives of the present study is to determine the reinforcing effect of randomly distributed, discrete bamboo fibers on the behaviour of flyash treated black cotton soil collected from Tamilnadu. The study focuses on the effect of flyash and fiber content on the unconfined compressive strength and compaction properties of soil.

Several researches have been carried out to investigate and assess the behaviour of treated expansive soil with chemicals and fibers. Lima et al. (1996) observed a large increase in compressive strength with the addition of lime and cement to fiber reinforced soils. Kumar et al. (2005) found that the unconfined compressive strength of highly compressible clay increases with the addition of fibers and further increases when fibers are mixed in clay sand mixtures. Chakraborthy and Dasgupta (1996) found the fiber inclusions increased the strength of raw flyash-soil specimens as well as that of cement stabilized specimens and changed their brittle behaviour to ductile behaviour. They further concluded that the combined action of cement and fibers is either more than or nearly equal to the sum of increase caused by them individually. Kaniraj and Vasant (2001) reported on behaviour of cement-stabilized fiber-reinforced fly ash soil mixtures. Kaniraj and Gayathri (2003) reported on geotechnical behaviour of fly ash mixed with randomly oriented fiber inclusions. Nagu et al. (2008) have investigated on improvements to lime stabilized clayey soil synthetic fiber reinforcement. Pradip and Nagarnaik (2008) have reported on influence of polypropylene fiber and cement addition on behaviour of soil-fly ash mixture. Nisha and Ilamparuthi (2008) have reported on the performance of soil stabilization using various fibers and cementatious materials. In this paper, the effect of bamboo fiber along with flyash addition on compaction and strength behaviour of BC soil has been presented.

2. RESEARCH SIGNIFICANCE

Use of artificial fibers poses the environmental problems. Natural fibers like coir, jute, bamboo and wood pulp can be used as a reinforcing material to soil. In order to increase the effectiveness of the ground improvement method, an attempt is made to study the influence of randomly oriented bamboo fiber reinforcement on compaction and strength properties of flyash treated BC soil.

3. EXPERIMENTAL PROGRAMME

3.1. Materials

The soil used in the study was black cotton soil collected from Tamilnadu. Physical and engineering properties of BC soil are given in Table 1. The flyash used in the study was collected from Mettur thermal power plant, Salem, Tamilnadu. The flyash is classified as Class F flyash as per ASTM C 618 (ASTM 1993). The bamboo fiber was collected from a small scale industry Gandhi park, Coimbatore. The fiber having a length of 25 mm and an average diameter of 0.45 mm were used.

3.2. Laboratory Analysis

Unconfined compression strength test were carried out on cylindrical specimens of 38mm diameter and 76mm height. Compaction tests were performed as per Indian Standard specification for standard proctor compaction test (BIS 1980). Light compaction tests were carried out on the flyash –soil-fiber mixtures. Flyash was added to black cotton soil at 0-25% by dry weight. Test specimens were subjected to compaction tests and unconfined compression tests.

Table1 Properties of Black Cotton Soil

Natural moisture content (%)	30
Liquid limit (%)	61.1
Plastic limit (%)	25.5
Shrinkage limit	12.37
Wet sieve analysis Gravel (%) Sand (%)	 0 42
Hydrometer analysis Silt (%) Clay (%)	 30 28
Plastic index	35.6l
Specific gravity (%)	2.610
Unconfined compression strength. (kg/mm^2)	6.9084
Optimum moisture content (%)	20
Maximum dry density (g/cc)	2.156

Based on the optimum percentage of flyash from unconfined compression test, flyash treated samples were tested with 0.25, 0.50, 0.75, 1.00 and 1.25%. Compaction test were conducted with BC soil with 15, 20 and 25% flyash and 0.25, 0.50, 0.75 and 1% bamboo fibers and also on flyash treated BC soil with different percentages of bamboo fibers (0.25, 0.50, 0.75 and 1%). The details and results of the experimental study and the conclusions from the study are given below.

4. RESULTS AND DISCUSSION

The results are presented in successive sections that detail the data of treated and untreated BC soil.

4.1. Unconfined Compression Tests

The Samples were prepared by mixing black cotton soil with different percentage of fly ash (15%, 20% & 25%) by dry weight of soil. Moist soil fly ash mix was transferred to the mould and unconfined compressive test were conducted. Optimum value of fly ash is found to be 20 % by weight of soil. Fig. 1 shows the unconfined compressive strength of flyash treated BC soil. It is observed that there is a significant effect of fly ash on shear strength parameters of black cotton soil.

Samples were prepared by random adding bamboo fibers 0.25%, 0.5%, 0.75%, 1% & 1.25% by dry weight of soil by mixing black cotton soil with 20% (optimum value) of fly ash (by weight of soil). The fibers were randomly mixed in soil to form homogenous mixture. Moist soil fiber mix was transferred to the mould and unconfined compressive test were conducted.

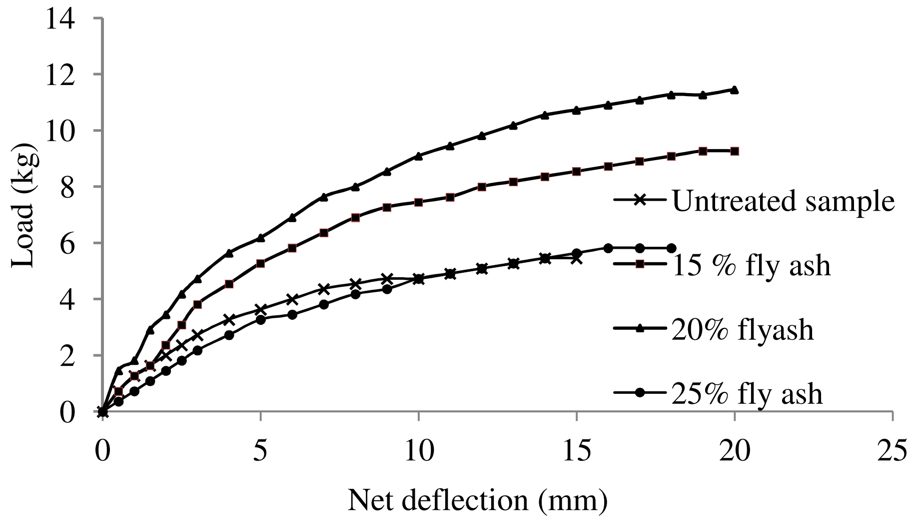

Figure 1 Load Deflection Curve of Black Cotton Soil Mixed With Different Percentage of Fly Ash

It is observed that there is a significant increase in unconfined compressive strength due to the inclusion of bamboo fiber in black cotton soil treated with optimum percentage flyash. The increase in strength is shown in Fig. 2.

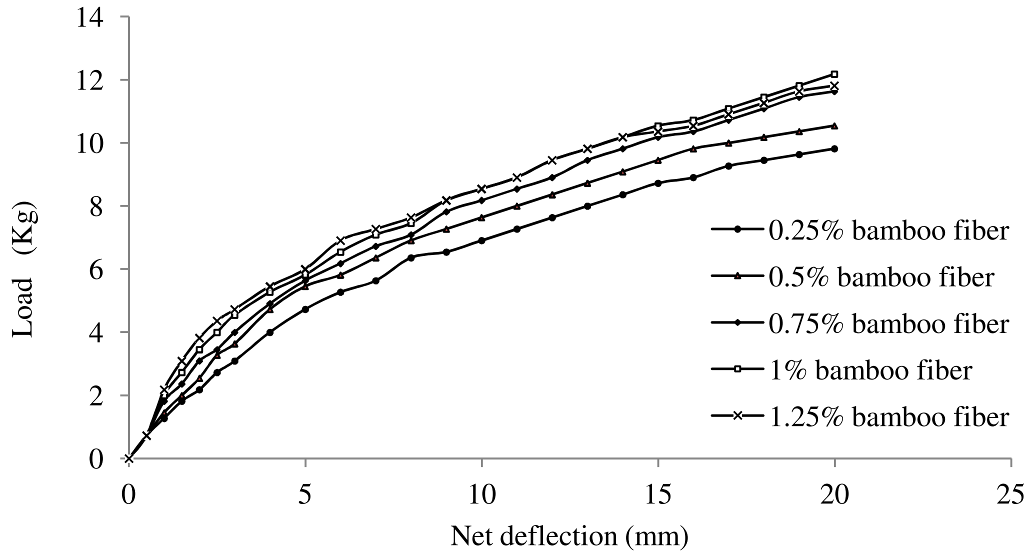

Figure 2 Load deflection curve of black cotton soil mixed with optimum percentage of fly ash and different percentage of Bamboo Fiber

4.2. Compaction Tests

The variation of maximum dry density (MDD) and optimum moisture content (OMC) with respect to the flyash and fiber content is plotted in figure 3, 4, 5, 6 and 7. It has been observed that for a given fiber content in the compaction tests, addition of flyash decreased the optimum moisture content. The decrease in maximum dry density of the treated soil is the reflection of the increased resistance offered by the flocculated soil structure to the compaction effort. The increase in optimum moisture content is due to the additional water held within the flocculated soil structure resulting from flyash interaction. This trend does not change even after the addition of bamboo fiber.

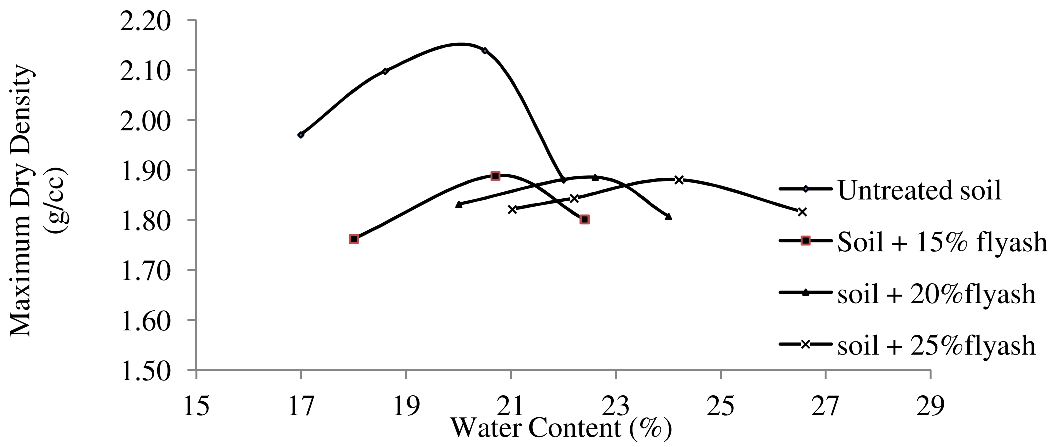

Figure 3 Compaction Curve of Black Cotton Soil with Different Percentage of Flyash

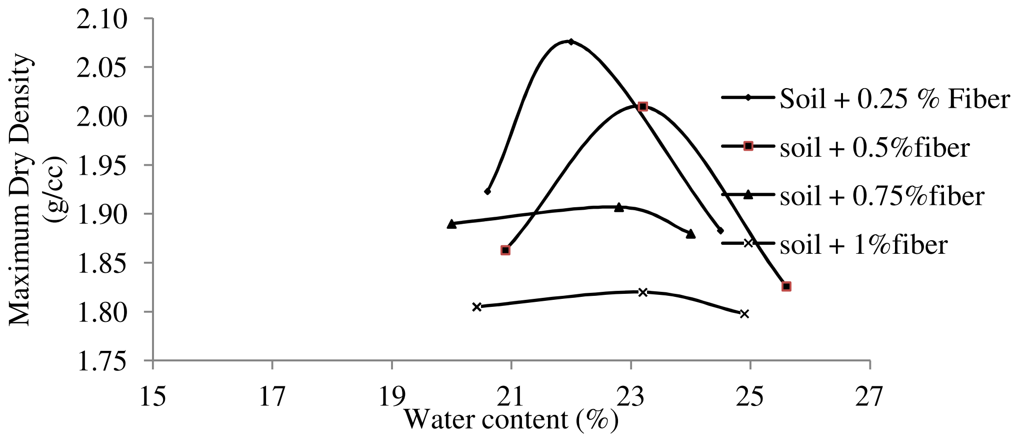

Figure 4 Compaction Curve of Black Cotton Soil with Different Percentage of Fiber

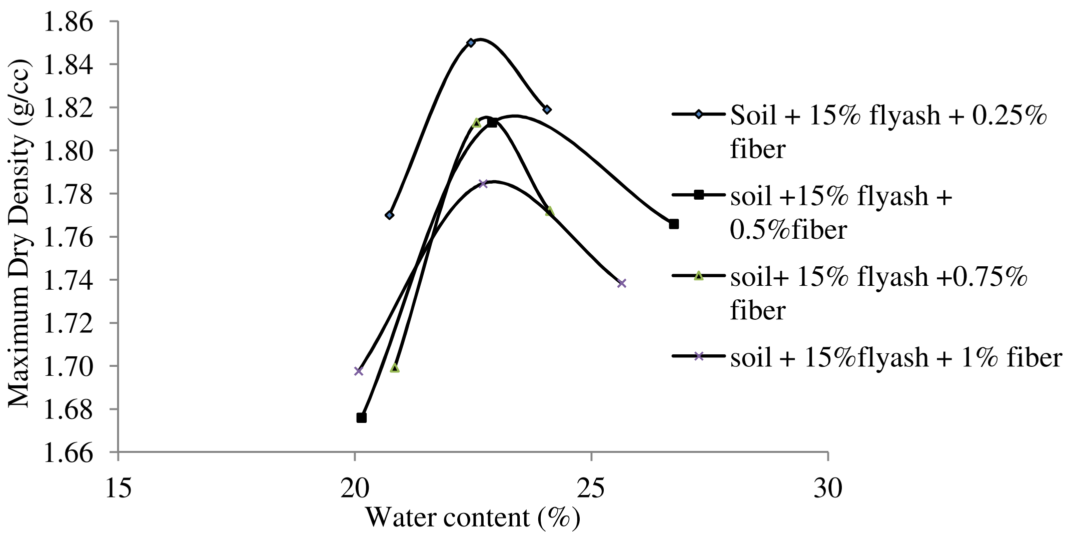

Figure 5 Compaction Curve of Black Cotton Soil with 15% Flyash and Different Percentage of Fiber

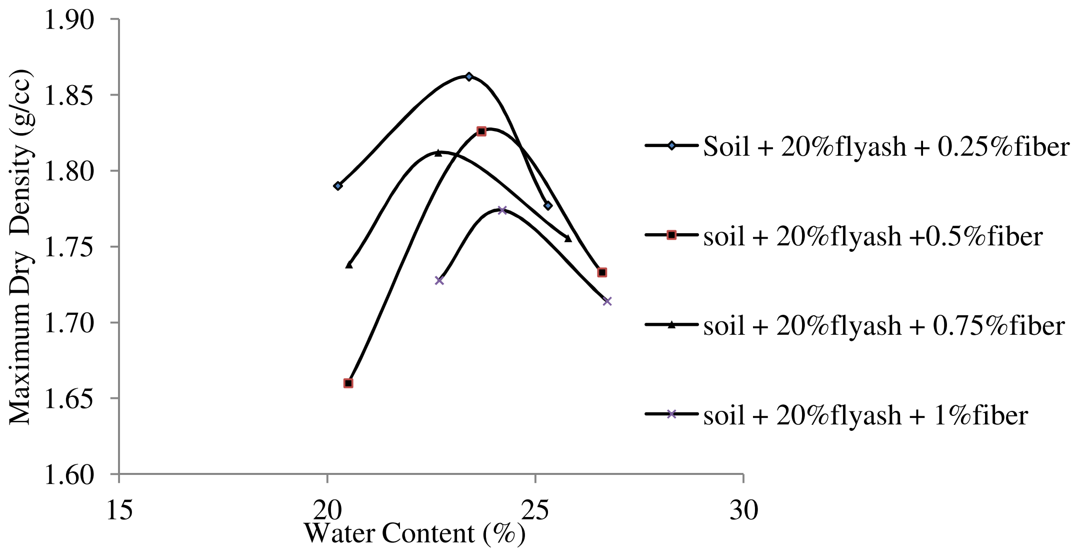

Figure 6 Compaction Curve of Black Cotton Soil With 20% Flyash and Different Percentage of Fiber

Similar conclusions were made by Kaniraj and Vasant (2001), Nataraj and Manis (1997), Kaniraj and (2001), Nataraj and Manis (1997), Kaniraj and Gayathri (2003) on clay soil/flyash with synthetic reinforcement and Ramesh et al. (2010) on lime treated BC soil with coir fiber reinforcement. Figure 3, 4, 5, 6 and 7 shows that an increase in fiber content results in a decrease of maximum dry density and increase in optimum moisture content. The decrease in maximum dry density can be attributed to the lower density of fiber compared to that of soil. Increase in optimum moisture content is due to the additional water being absorbed by the fiber.

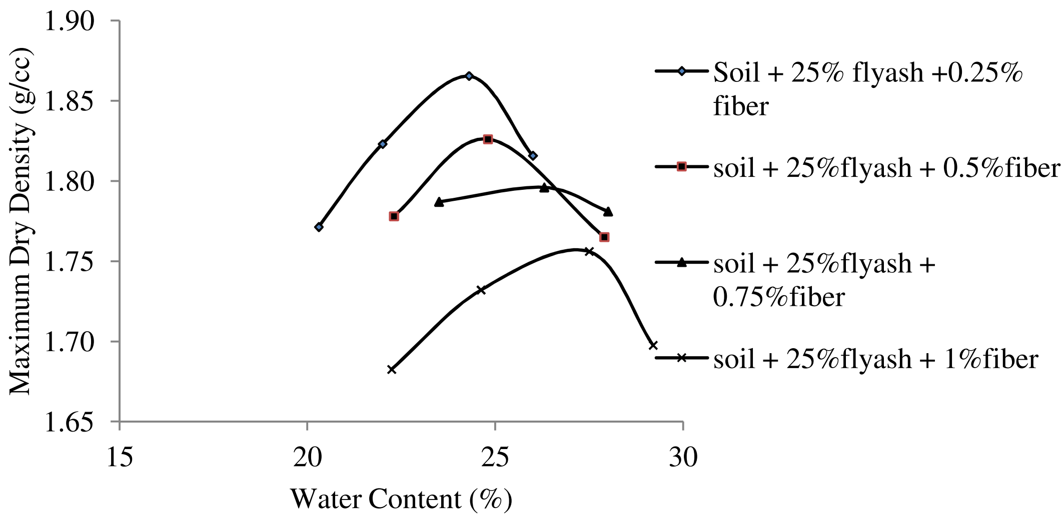

Figure 7 Compaction Curve of Black Cotton Soil With 25% Flyash and Different Percentage of Fiber

5. CONCLUSION

Based on the results presented in this paper, the following conclusions are drawn.

- Addition of flyash to BC soil increases the strength. It has been observed that 20% flyash by weight is found to be optimum.
- Addition of randomly distributed bamboo fiber to BC soil increases the unconfined compressive strength and the optimum percentage of fiber obtained for 20% flyash content is 1% by weight.
- Flyash treated BC soil reinforced with 1% bamboo fiber increases the strength and reduces the brittle behaviour of soil specimen, where as the other percentages of fibers used shows a marginal increase.
- Based on the studies conducted bamboo fiber can be used as a strengthening material for flyash treated BC soil.

Flyash is widely used as a stabilization material for soft soils. Since there is much more flyash that is disposed of rather than utilized, making more productive use of flyash would have considerable environmental benefits, reducing land, air and water pollution. Waste bamboo fibers from cottage industries can also be utilized in stabilization.

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