Stabilization of Black Cotton Soil Using Pili and Lime

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Abstract

Black cotton soil is a highly clayey soil. They are found in many parts of the world, such kind of soil generally consists of active clay minerals. Geotechnical engineers face various problems while designing foundation, because the black cotton soil possess poor bearing capacity and excessive settlement. To overcome those problems researches concentrated on soil improvement techniques by adding fibers. The main objective of our project is to investigate the use of pili (human hair) and lime in geotechnical applications and to evaluate the effects of pili and lime with black cotton soil. The various percentages of pili (0.5%, 1%, 1.5%, 2%) and lime (3%, 6%, 9%, 12%) are mixed with black cotton soil to enhance the ground improvement. This project includes testing and comparison of Atterberg's limit, Standard Proctor Compaction, Unconfined compressive strength by curing of normal black cotton soil with stabilized black cotton soil and determining optimum dosage of lime and pili to be added to soil.

Keywords

Black Cotton Soil, Pili (Human Hair), Atterberg's limits, Shear Strength

1 Introduction

In this advanced age of science and technology, man has made rapid strides in all fields since the ancient ages. Right from the dark ages till the present information age, man has grown by leaps and bounds and has tried to come around all kinds of problem encountered by him. From an engineering point of view, especially from a geotechnical perspective, land use for development work has brought to the fore, the problem of acute land shortage. This has led to the reclamation of unusable land for development activities. Ground improvement technology has been the driving force that has brought about this revolution in reclamation of unusable land, which has leads to a sudden spurt in developmental activities. However, as all human technologies, since times immemorial have proven to have their own drawbacks in most of the cases. Similarly, this technology, through beneficial in several way, had environmental impacts. With rapid urbanization and industrialization, this technology became the driving force for all land reclamation work. By the usage of techniques like cement grouting, lime columns, reinforcing by fibres and stabilizing by lime are known to have great impact in environment sustainability [1]. The most common purpose of stabilization is to improve the strength and bearing characteristics of the soil by locally available materials and reduce the construction cost and virgin materials usage in construction.

Soil stabilization by lime aims to improve the resistances to softening and binding of the soil particles together. The simplest stabilization processes are compaction and drainage (when water drains out of wet soil it becomes stronger). The other process is by improving gradation of particle size and further improvement can be achieved by adding binders to the weak soils [2]. Soil stabilization also prevents road failure from water penetration or heavy frosts by helping in preventing water from soaking into treated layer.

The properties of black cotton soil has been changed due to the addition of lime. [2] Various tests were conducted on both soil and lime and concluded that lime acts as a good stabilizer to improve the properties of black cotton soil. The liquid limit and plastic limit of soil decrease with addition of lime which helps to gain more strength at initial stage itself. The relative decrease in the plasticity index increase the workability of soil. The shrinkage limit increases with addition of lime. Addition of lime increases the compaction parameters, by increasing the maximum dry density with decrease in optimum moisture content.

The addition of lime and polyester fiber has decreased the optimum moisture content and increased maximum dry density [12]. The compressive strength and shear strength has increased. The increment in the CBR value by using polypropylene fibre has been recorded [13]. Hence the lime and fiber can be used for soil stabilization.

The addition of lime, jaggery and gallnut powder has increased strength of the soil [8]. The characteristics of soil has been changed due to the addition of this materials. The soil has been stabilized in the greater manner by the effect of curing. Due to curing the strength gain was in the range of 26% to 56% over period of 28 days.

The UCC strength of soil has increased maximum with addition of human hair at 2% [11]. This clearly indicates that the human hair fiber could be used in the improvement of cohesive soils properties. The black cotton soil have attained the maximum strength of nearly 45.9% by addition of human hair [15].

In this study, an attempt has been made to explore the possibilities of using natural materials like human hair and stabilized soil by usage of lime. Human hair fibers can be added to soil as a stabilizing agent. Hair as a cheap stabilizing agent is abundantly available. This study aims at comparing hair stabilized soil with lime stabilized soil and to test the suitability of human hair as a sustainable source of soil stabilization.

2 Experimental Procedures

2.1 Materials Used

Black cotton soil is a soil which has high content of clay which showed in Fig.1. Due to shrink nature of soil it has high volumetric changes hence it is not suitable for construction [10, 14]. It swells and shrinks excessively due to the presence of fine clay particles. Hence black cotton soil must be treated by using suitable admixtures to stabilize it.

Calcium oxide is a white crystalline solid with a melting point of 257ºc. By using lime in the method of soil stabilization it mainly increases strength and reduces the swell or shrinks property [9]. Fig 2 implies the lime which used for study.

Fig. 1 Black Cotton Soil (BCS)

The light weight, strength and deformation properties of fibers make them effective materials in various foundation engineering applications. Human hair fibers were used throughout this study to stabilize the soil. They consist of fibers of varying length (4-40mm) and diameter (40-110μm). Scanning electron microscope analysis was conducted to obtain the average diameter of human hair fiber. Fig. 3 shows the hair used for study.

Fig. 2 Lime

Fig. 3 Pili (Human Hair)

2.2 Sample Preparation & Atterberg's Limits

The samples were prepared by adding lime of 3%, 6%, 9% and 12% by weight of soil. But further additions may decreases the plasticity of soil and excessive lime treatment contribute to brittle failure characteristics of soil that leads to rapid and great loss in strength when failure occurs. So, it was decided to stop with 12% lime. Lime was added to the dry mixture soil at different percentages and were tested as per IS specification [3-5]. When lime was mixed in moist stage segregation occurred. All mixing was done manually and proper care and time were spent for preparing homogenous mixture at each stage of mixing. It was found that the lime could be mixed with soil more efficiently in the dry state than in moist state. The parameter of concern in fiber selection was fiber content by weight of soil. Samples were prepared by adding fiber content of 0.5%, 1.0%, 1.5% and 2.0% by weight of soil. The mixing of soil was very difficult beyond 2.0% as the same stick together

to form lumps. This also caused pockets of low density. So, it was decided to stop with 2.0% fiber content. Fibers were added to the moist mixture soil at different percentages and were tested as per IS specification. When fibers were mixed in dry soil segregation and floatation occurred. All mixing was done manually and proper care and time were spent for preparing homogenous mixture at each stage of mixing. It was found that the fibers could be mixed with soil more efficiently in the moist state than in dry state.

The soil sample is placed on the evaporating dish and thoroughly mixed with water using spatula until the mass becomes a thick paste of putty like consistency. The Casagrande's device is checked to have a correct fall of 10 mm and placed a portion of the prepared paste over the brass cup. Four trials are made so that the no. of blows are more than 25 in two cases and less than 25 in other two cases. The moisture content corresponding to 25 no. of blows will give the liquid limit for the sample. The Fig. 4 shows the experimental carryover of liquid limit. Similarly Fig.5 shows the plastic limit setup. With respect to the shrinkage dish shrinkage is obtained and it implies in Fig. 6.

Fig. 4 Determination of Liquid Limit

Fig. 5 Determination of Plastic Limit

2.3 Standard Proctor's Compaction Test

As per IS Specification [6] for the various mix proportions the standard proctor compaction test was done to obtain the optimum moisture content(OMC) and maximum dry density (MDD). Experimental setup was showed in Fig.7.

Fig. 6 Determination of Shrinkage Limit

Fig. 7 Determination of OMC & MDD

2.4 Unconfined Compression Test

Remoulded soil specimen (38 mm dia) were prepared and it is centrally mounted in the unconfined compression tester [7]. The Fig.8 shows the experimental setup of soil sample in Unconfined Compression testing machine and curing of soil samples in various proportions of lime and pili.

a) b)

Fig. 8 Unconfined Compressive Strength a) Experimental Setup b) Curing of Samples

3. Results and Discussions

3.1 Variation on Atterberg's Limits

The Fig.9 and Fig. 10 shows the results obtained for BCS and optimum mixture of BCS and 6% of Lime.

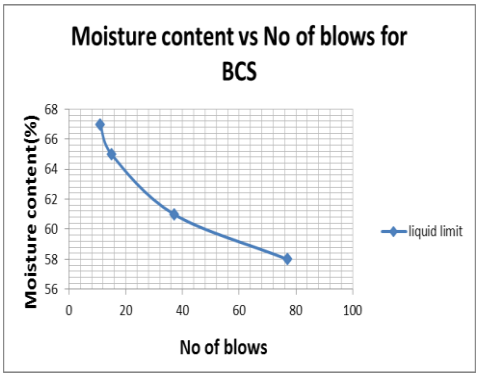

Fig. 9 Liquid Limit for BCS

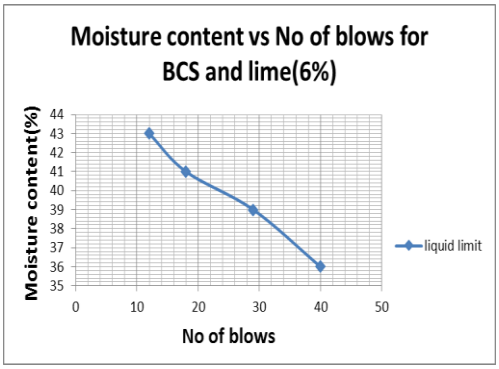

Fig. 10 Liquid limit for BCS with Lime (6%)

3.2 Compaction Characteristics

The Fig 11 and Fig 12 shows the results for the determination of Optimum moisture content and maximum dry density for BCS and for optimum mixture of BCS with 6% of Lime Content.

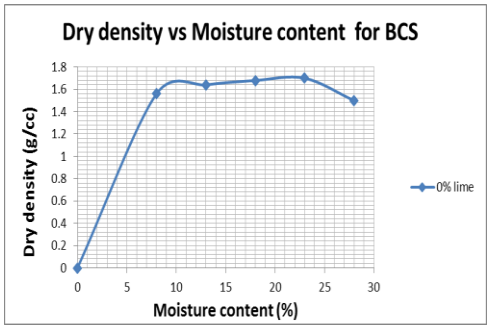

Fig. 11 Standard Proctor Compaction for BCS

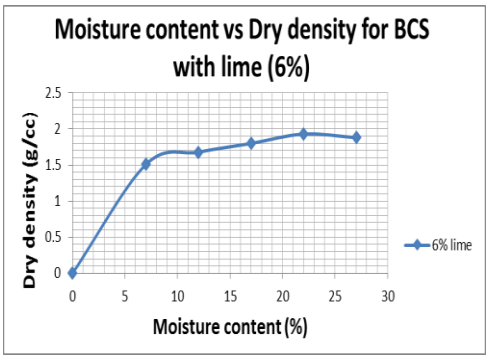

Fig. 12 Standard Proctor Compaction for BCS with Lime (6%)

3.3 Unconfined Compression Test

The UCC test was conducted for various mix proportions of BCS with lime and pili. The Fig. 13 shows the stress strain characteristics of BCS and the Fig. 14, Fig 15, Fig. 16 & Fig. 17 shows the stress strain behaviour of BCS and lime of various proportion on Zero days, 7 days, 14 days and 28 days curing respectively.

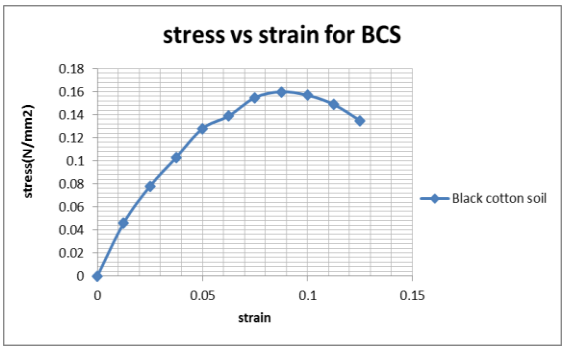

Fig. 13 Unconfined Compressive Strength for BCS

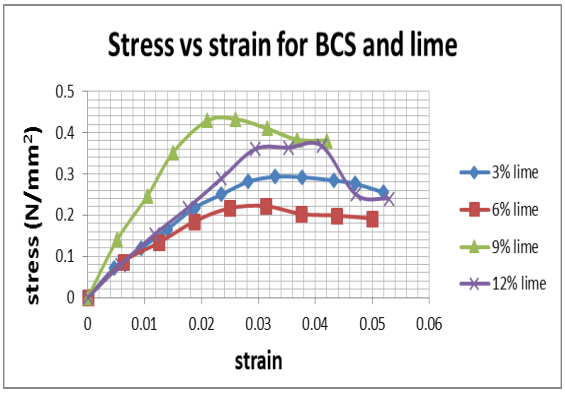

Fig. 14 Unconfined Compressive strength for BCS with lime (0^{th} day curing)

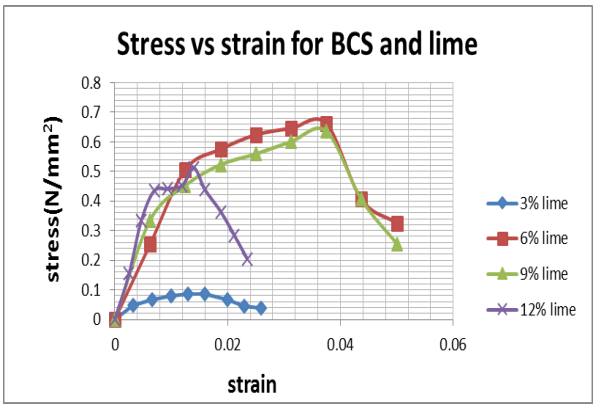

Fig. 15 Unconfined Compressive Strength for BCS with lime (7th day curing)

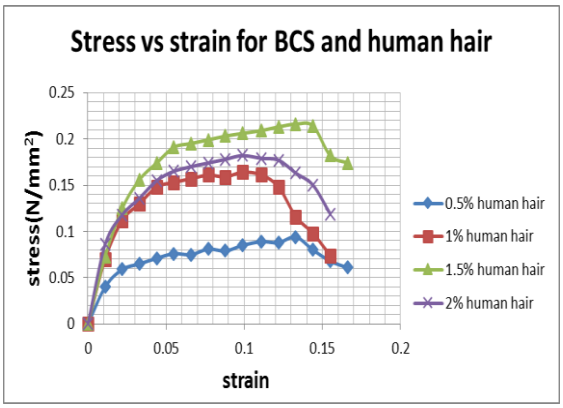

Fig. 14 Unconfined Compressive Strength for BCS with Human hair

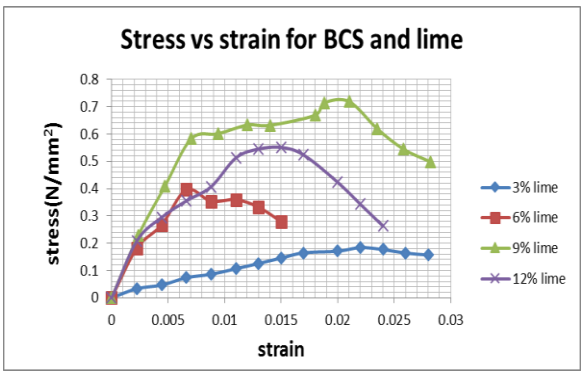

Fig. 16 Unconfined Compressive Strength for BCS with Lime (14th day curing)

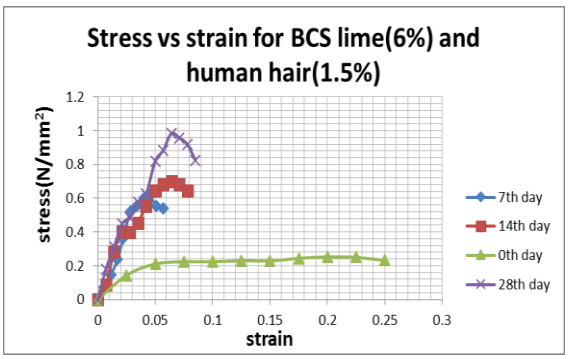

Fig 19. Unconfined Compressive Strength for BCS with lime (6%) and Human hair (1.5%)

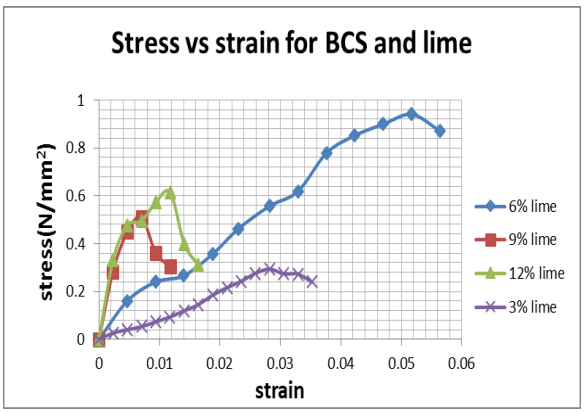

Fig. 17 Unconfined Compressive Strength for BCS with Lime (28th day curing)

As a natural fiber the pili is used to mix with BCS in various proportions. The Fig. 18 shows the unconfined compressive strength for a various proportionate mixtures and Fig. 19 shows the unconfined compressive strength at various stages of curing for an optimum mixture of pili as 1.5% and lime as 6%. Human

4 Conclusion

The study has been successfully conducted to access the geotechnical properties of black cotton soil to be improved with lime and pili. Based on the experimental result the following conclusions have been made.

The liquid limit value is decreased from 62.9% to 39% on addition of 6% of lime. This decrease in the liquid limit is due to the cementitious property of lime.The plastic limit value is decreased from 37.5% to 33.33% with the addition of 6% of lime. The plasticity index of the soil is reduced from 25.4 to 5.67 with the addition of 6% of lime. The shrinkage limit of the soil is increased from 16.22% to 18.38% with the addition of 6% of lime. The Optimum dosage of lime to be added is 6%. The Unconfined compressive strength is increased from 0.16 N/mm^2 to 0.94 N/mm^2 with the addition of 6% lime. The Unconfined compressive strength is increased from 0.16 N/mm^2 to 0.984 N/mm^2 with the addition of lime of 6% and human hair of 1.5%. Hence the natural fibre Pili can be used as a good reinforcing fibre as well as posses good bearing characterictics by combining with lime in suitable proportions.

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