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Research Paper

Effect of waste synthetic bag pieces on the CBR value of expansive Soil

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Expansive soils such as black cotton soil which are widely distributed in India have a tendency for volume changes due to change in moisture content. Also exhibits very low bearing capacity and high compressibility. Stabilization of such soil by admixture is used commonly now days. But no mix is suitable to improve all the types of soil. But it is obvious that depending on type of soil & type of admixture the optimum mix can be designed. In this paper a mix has been designed to improve the bearing capacity of soil by using fly ash and lime mixture, reinforced with waste synthetic bag pieces. Various tests are carried out to determine the CBR value and other soil properties with and without using any admixture and reinforcement. The maximum value of CBR was found to be23.82% for 2.5 mm penetration and 22.21% for 5 mm penetration, when waste synthetic bag pieces of size 2 cm * 2 cm were used at a proportion of 0.1%.

1 Introduction

Rapid urban and industrial growth demands more land for further development. In order to meet this demand land reclamation and utilization of unsuitable and environmentally affected lands have been taken up. These unsuitable grounds when stressed due to loading tend to deform. On the other hand as the world population grows, so do the amount and type of waste being generated. The creation of non decaying waste materials, combined with a growing consumer population, has resulted in a waste disposal crisis. One solution to this crisis lies in recycling waste into useful products or utilizing this waste for some engineering solution.

Expansive soils such as black cotton soil which are widely distributed worldwide have a tendency for volume changes due to change in moisture content. Such soil possess swelling and shrinking nature due to the presence of montmorillonite clay mineral and also has low shear strength due to which construction and maintenance of structures under goes many

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difficulties. The lack of availability of higher quality materials and the added costs for these materials is challenge for engineers. In present era the complete removal and replacement of such soil with another good quality soil is very costly and uneconomical.

These, hitherto useless lands for construction can be converted to be useful by adopting one or more ground improvement techniques [1].Therefore, to make these unsuitable soils, useful for the construction, their bearing capacity must be improved. Ground improvement construction methods are used to improve unsuitable subsurface soils to improve the performance of embankments or structures and to reduce the shrinkage and swelling of soils [2]. The ground can be improved by adapting certain ground improvement techniques. Vibro-compaction increases the density of the soil by using powerful depth vibrators [3]. Vacuum consolidation is used for improving soft soils by using a vacuum pump [4]. Preloading method is used to remove pore water over time [5]. Heating is used to form a crystalline or glass product by electric current. Ground freezing converts pore water to ice to increase their combined strength and make them impervious [6]. Vibro replacement [7] stone columns improve the bearing capacity of soil.

Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation [8]. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project [9]. Various admixtures are used to improve the soil stabilization [10]. Fly ash which is a waste produced from the coal fired thermal power station is also commonly used to improve its stability [11]. However in this paper author used fly ash along with lime and synthetic jute bag pieces to improve the bearing capacity of black cotton soil. The main purpose of reinforcing the soil by waste cement bag fibers was to improve its stability by increasing its bearing capacity and shear strength when subjected to critical and complex loading conditions which results in settlement and lateral deformation of soil.

2 Materials and Methods

For carrying out various studies the different materials used are Soil, Fly ash, Lime and waste synthetic bag pieces. The basic properties of these materials are as described below:

2.1 Soil

Soil used in the resent study was collected from Beltarodi road, Nagpur (India). This soil was black cotton soil and it was tested for its Liquid limit, Plastic limit and Shrinkage limit, Particle size distribution by sieve analysis, Proctor compaction test, Shear strength, California bearing ratio (CBR) test etc.

2.2 Fly ash

Sample of the raw coal fly ash was collected from Unit 7 of Electrostatic Precipitator (ESP) hopper number 5 at Koradi, Nagpur District, Maharashtra, India and it was used without any pre treatment. The fly ash used in the present study was characterized by its chemical composition and size distribution analysis. The particle size distribution of the fly ash was done by passing it over the standard size sieves as per Indian standard [12].

2.3 Waste Synthetic bag pieces

Synthetic pieces were obtained from the waste synthetic cement bag, which are made of strong and flexible cast polypropylene. These empty cement bags were washed with clean running water and dried at room temperature, were cut into the pieces of various sizes of 1cm*1cm, 2cm*2cm, 3cm*3cm and 4cm*4cm pieces to carry out various investigations. The thickness of the synthetic bag pieces was found to be 0.03 mm.

2.4 Experimental

The black cotton soil used in the present study was mixed with the fly ash and lime and its CBR value was determined in the laboratory. The investigations on the improvement of CBR value of the mixture by adding the synthetic bag pieces were studied. The effect of size of synthetic bag pieces and variation in their proportion were also studied.

3 Result and Discussion

3.1 Characterization of fly ash

The chemical composition of fly ash was found to be: SiO_2 (62.6%), Al_2O_3 (24.41%), Fe_2O_3 (4.04), TiO_2 (0.69%), CaO (0.35), MgO (0.54), Na_2O (0.27%), K_2O (0.21%), SO_3 (0.84%), P_2O_5 (0.037%), MnO (0.28%) and Loss on Ignition (1.27%). It was observed from the chemical composition of the fly ash that SiO_2 and Al_2O_3contents make up about 85% of the total content and $Fe_2O_3$is the third largest constituent in the fly ash which was about 4% of the total amount. The particle size distribution was done using standard method by passing the fly ash over the standard size molecular sieves. It was found that 91.12 % fly ash particles have size below 75 μm.

3.2 Characterization of soil

To carry out the size analysis of the soil, sieve analysis of the soil was carried out. As per the analysis it was found that no gravel content in the soil whereas from the results it was clearly seen that the soil contains 25 % of sand and 75% clay and silt. As per IS classification soil was classified as inorganic clay of medium compressibility [13].

Table 1: Characterization of Soil

Sr. No.	Laboratory Test	Result
1	Specific Gravity	2.58
2	Liquid Limit	48.5 %
3	Plastic Limit	34.29%
4	Plasticity Index	14.21%
5	O.M.C.	22.65 %
6	M.D.D.	1.65 gm/cc
7	Angle of internal friction (μ)	17 degree
8	Cohesion (C)	0.89 kg /sq. cm.
9	C.B.R.	3.64 %

3.3 Soil Mix properties and Mix Identification

The black cotton soil used in the present study was mixed with the fly ash in the ratio of 50:50. To further improve its CBR value, 6% lime was added in the mix [14]. This mixture was tested for various soil properties and its CBR value [15] and the results obtained are tabulated in Table 2.

Further improvement of CBR value by considering the optimum mix obtained from the above reference (50% B. C. soil + 50% fly ash +6% lime) was used with waste synthetic bag pieces. To carry out various investigations, the pieces were cut into various sizes of 1 cm * 1 cm, 2 cm * 2 cm, 3 cm * 3 cm and 4 cm * 4 cm and used as reinforcement in the above mix. Their proportion was varied as 0.05%, 0.1%, 0.15% and 0.2% as shown in Table 3.

Table: 2 Properties of mix containing Soil and Fly ash (50:50) and 6% lime

Sr. No.	Laboratory Test	Result
1	Liquid Limit	37.12 %
2	Plastic Limit	32.51 %
3	Plasticity Index	4.21%
4	O.M.C.	14.68 %
5	M.D.D.	1.71 gm/cc
6	Angle of internal friction (μ)	51.3 degree
7	Cohesion (C)	0.74 kg /sq. cm.
8	C.B.R.	16.63 %

Table 3:- Waste Synthetic bag pieces proportion in Soil Mix (50% B. C. soil + 50% fly ash + 6% lime)

Sr. No.	Mix Identification		Waste synthetic bag pieces	
			Size	Proportion by wt %
01	M-1	-	-	-
02	M-2	M2-a	1 cm * 1 cm	0.05
		M2-b	1 cm * 1 cm	0.10
		M2-c	1 cm * 1 cm	0.15
		M2-d	1 cm * 1 cm	0.20
03	M-3	M3-a	2 cm * 2 cm	0.05
		M3-b	2 cm * 2 cm	0.10
		M3-c	2 cm * 2 cm	0.15
		M3-d	2 cm * 2 cm	0.20
04	M-4	M4-a	3 cm * 3 cm	0.05
		M4-b	3 cm * 3 cm	0.10
		M4-c	3 cm * 3 cm	0.15
		M4-d	3 cm * 3 cm	0.20
05	M-5	M5-a	4 cm * 4 cm	0.05
		M5-b	4 cm * 4 cm	0.10
		M5-c	4 cm * 4 cm	0.15
		M5-d	4 cm * 4 cm	0.20

3.4 Effect of synthetic bag pieces on CBR value

The optimum soil mix was reinforced with waste synthetic bag pieces of various sizes and in various proportions as mention above. These mixtures were tested for the CBR value with 2.5 mm penetration and 5.0 mm penetration. The graphs were plotted between CBR value and various mixes i.e. M-2, M-3, M-4 and M-5. And for different percentage of pieces are shown in Fig. 1, Fig.2, Fig.3 and Fig.4 respectively.

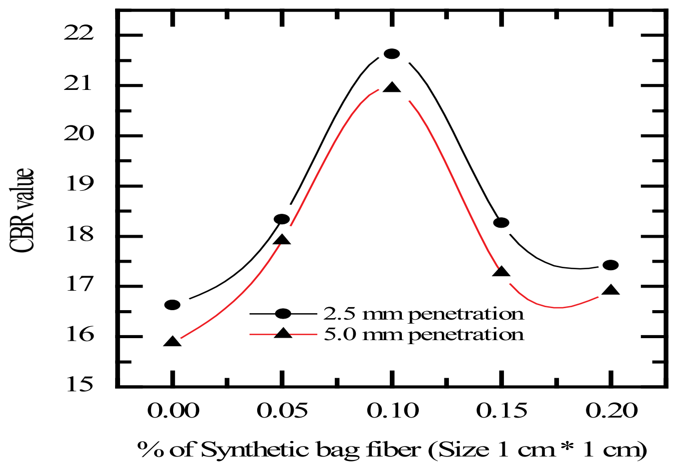

Fig. 1 –Variation of CBR value against % of waste Synthetic bag pieces (Size 1 cm * 1 cm)

It can be seen from the Fig. 1, that the CBR value which was just 16.63% forM-1,hasbeen increased upto a value of 21.63% for M1-b (0.1 % waste synthetic bag pieces).Further increase in the proportion of synthetic pieces decreased the value of CBR. Therefore, maximum value of CBR was achieved when 0.1% synthetic pieces of size 1 cm * 1 cm were used.

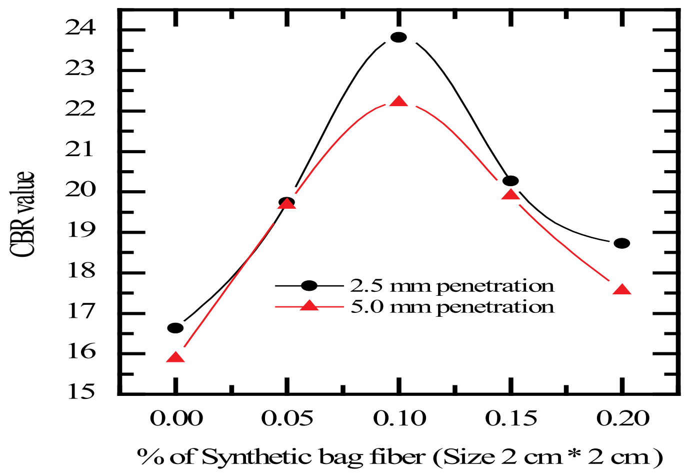

Fig. 2–Variation of CBR value against % of Waste Synthetic pieces (Size 2 cm * 2 cm)

It was observed from the Fig. 2, that CBR value increases with the increase in the proportion of synthetic bag pieces up to certain limit and after that CBR value starts decreasing with the increase in the proportion of synthetic bag pieces. For M3-b Mix (0.1 % waste synthetic bag pieces), maximum value of CBR was found to be 23.82%.

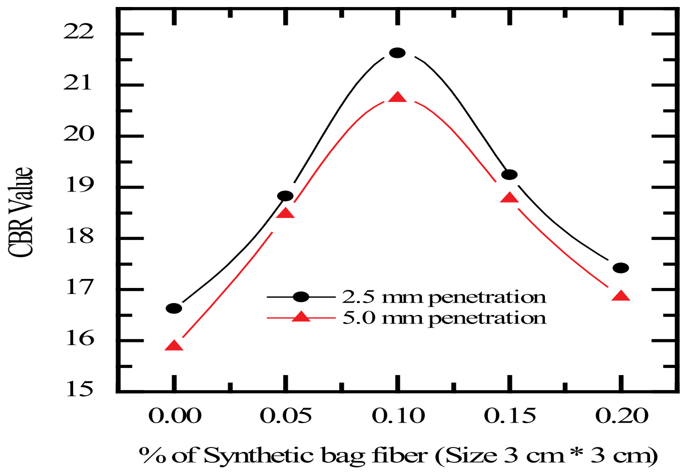

Fig. 3–Variation of CBR value against % of waste synthetic bag pieces (Size 3 cm * 3 cm)

It is depicted from the Fig. 3, that the maximum value of CBR is achieved for M4-b was found to be 21.63% .

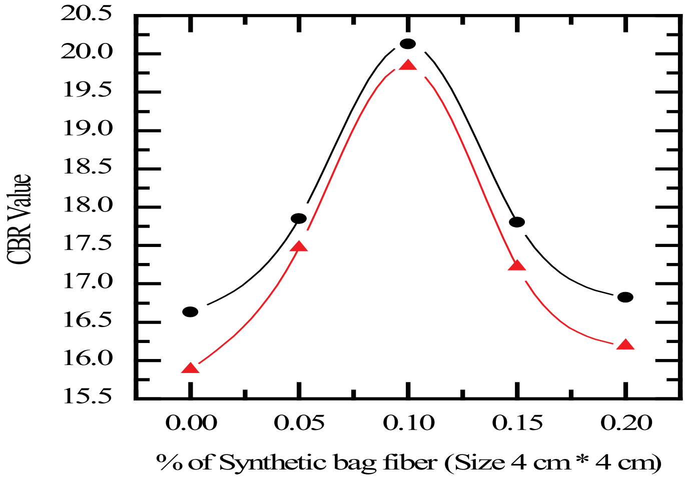

Fig. 4–Variation of CBR value against % of waste Synthetic bag pieces (Size 4 cm * 4 cm)

It can be seen from the Fig. 4, that the CBR value which was just 16.63% without any synthetic bag pieces has increased up to a value of 20.13% when 0.1 % synthetic bag pieces of size 4 cm * 4 cm were added to this mixture. Further increase in the proportion of synthetic bag pieces decreased the value of CBR. Therefore, maximum value of CBR was achieved when 0.1% synthetic pieces of size 4 cm * 4 cm were used.

By comparing the maximum value of CBR for the different sizes of synthetic bag pieces, it is observed that the most favourable ground stabilization condition could be achieved when synthetic bag pieces of size 2 cm * 2 cm were used at a proportion of 0.1%. Under these conditions the maximum value of CBR was found to be 23.82%

4 Result and Discussion

From the laboratory investigations carried out it can be concluded that synthetic bag pieces which area waste material can be effectively used for ground improvement. The most favourable ground stabilization condition could be achieved when synthetic bag pieces of size 2 cm * 2 cm were used at a proportion of 0.1%. Under this condition the maximum value of CBR was found to be 23.82%, which has been increased around 43% for soil mix without reinforcement. Whereas the value CBR of this mix is around 550% more than the pure black cotton soil. On the other hand the relative increase on adding 0.1% Waste synthetic pieces in soil it is found that, there is considerable increase in CBR value. As the material is waste and biodegradable therefore can be suggested to used for the construction of roads like village roads, temporary roads etc.

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