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A LABORATORY STUDY ON SOIL REINFORCED WITH FLY ASH COLUMNS WITH AND WITHOUT ENCASEMENT OF NON WOVEN GEOTEXTILE

Shivani More[1], Tejas Hirlekar[2], P. Kousitha[3]

[1,2] *Undergraduate, Dept. of Civil Engineering, Datta Meghe College of Engineering, Airoli, Navi Mumbai, India*
[3] *Assistant Professor, Dept. of Civil Engineering, Datta Meghe College of Engineering, Airoli, Navi Mumbai, India*

Abstract - *Several foundation techniques have been put to use in order to stabilize expansive soil and counteract various problems posed by expansive soils. Expansive soils can cause heavy economic losses and pose a source of risk to the population. Expansive soils can be stabilized by reducing its swell-shrink properties and improving its load bearing capacity by addition of by-products and use of geotextiles. Stabilization can be done by using lime, fly-ash which have been put to use. This paper presents a new technique in which fly-ash column (FAC) is reinforced with lime and encased by non-woven geo-textile (Polyester) in black cotton soil (BC). Preliminary tests and California Bearing Ratio test were performed on BC soil in which FAC reinforced with lime encased with non-woven geo-textile (NWG) is introduced. Strength carrying capacity of BC soil was improved and swell-shrink properties were considerably reduced when BC soil was introduced with FAC reinforced with NWG. Experimental laboratory results on expansive BC soil in soaked and un-soaked conditions are presented.*

Key Words: **Expansive soil, Black Cotton Soil (BC), CBR test, Fly-ash columns, Soaked and un-soaked conditions, Non-woven geo-textile (Polyester).**

1. INTRODUCTION:

The main aim is to determine which of the soaked and un-soaked conditions gives the best possible combination of greater strength, workability, high load carrying capacity and reduced swell-shrink properties. The best combination can be further used in the stabilisation of expansive soils. Stabilisation by using various additives like lime, cement, calcium chloride and fly ash have been previously put to use and met with considerable success. Encasement of fly ash columns in BC soil with NWG will further enhance the strength of the soil and increasing effective stress carrying capacity of the soil.

1.1) Test materials:

1.1.1) Expansive soil:

Expansive soil (BC soil) used for experimental work has been collected from Satara city, Maharashtra, India from a depth of 1.5-4.5 meter below the ground level. Soil is classified as fine grained soil, which is further classified as MH-CH as per Cassangrande's plasticity chart (IS-1498-1970). The basic engineering properties of BC soil have been listed in Table 1.

Table 1: Properties of Black Cotton Soil

Properties Of Soil Tested	
INDEX	VALUE
Specific gravity, Gs	2.65
Plastic limit, wp (%)	40
Liquid limit, wl (%)	82
Free swell index (%)	115
Optimum moisture content , w opt(%)a	35
Maximum dry density, pd ,max $(KN/m3)a$	12
Particle size distribution (%)	
Clay (<0.002 mm)	60
Gravel (>4.75 mm)	2
Silt (0.002 to 0.74 mm)	22
Sand (0.74 to 4.75mm)	8

1.2) Fly ash:

Fly ash for the study has been supplied by NTPC Limited. Class C fly ash was used in the present study, as it is both pozzolanic and self-cementing in nature. The chemical properties and physical properties of fly ash have been listed in table 2 and table 3 respectively.

Table 2: Chemical Properties of Fly Ash

Chemical Properties of Fly Ash		
SR NO	**DESCRIPTION**	**COMPOUNDS BY WEIGHT %**
1.	SiO_2	22.56
2.	$Al_2\ O_3$	12.35
3.	TiO_2	0.15
4.	Fe_2O_3	3.0
5.	$MnO, MgO, CaO, K_2O,$	Traces
6.	*LOI*	50.55
7.	H_2O	8.62

Table 3: Physical Properties of Fly-Ash

Physical Properties of Fly-Ash		
SR NO	**DESCRIPTION**	**COMPOUNDS BY WEIGHT %**
1.	Sand (%)	6.5
2.	Silt (%)	14.5
3.	Clay (%)	76
4.	Specific Gravity	2.71
5.	Liquid Limit (%)	67
6.	Plastic Limit (%)	25
7.	Shrinkage Limit (%)	10
8.	Max. Dry density $(\frac{kN}{m^3})$	16.5
9.	Optimum-Moisture Content (%)	25

1.1.3) Lime:

Lime which is an excellent binding material was collected from a local hardware shop in Mumbai. 5% of the lime was used in present study for the purpose of adhering and binding materials together. Another significant objective of using lime was to increase the strength of the BC soil due to pozzolanic action between lime and water.

1.1.4) Non- woven geo-textile:

NWG is a fabric like material made from long fibres, bonded together by chemical, mechanical, heat or solvent treatment. NWG used in the present study is polyester and was supplied by JKD Horitech, Byculla, Maharashtra, India . NWG is highly used as soil stabilisers and foundation stabilisers in the present study. The main aim of using NWG in the study is that it has high water percolation capacity due to which the pore water pressure of the soil reduces and effective stress increases considerable.

2.) EXPERIMENTAL INVESTIGATION:

2.1) Preparation of specimen:

The tests have been conducted based on Optimum moisture content (OMC) and Maximum dry density (MDD) in the specimen of diameter 75mm and height of 20mm. The soil sample used was the one passing through 4.75mm and soil was oven dried. The capacity of the specimen was 5kg. Surcharge weights, sufficient to produce intensity of loading equal to weight of base material is placed on the specimen. A seating load of 2.5kg was placed below the surcharge weights. Now the specimen was compacted under the loading and 8 different trials were performed.

2.2) Test conducted :

First of all, preliminary tests like liquid limit, plastic limit, free swell index and Unconfined Compression Test (UCS) were performed. Liquid limit test was carried out using Cassagrande's apparatus on 3 soil samples and average of the 3 readings was obtained to obtain final liquid limit. Plastic limit was performed on 3 soil samples by rolling them into threads of 3mm diameter and the results of the above 3 samples were obtained by observing the crack and then oven drying the samples and then average of the 3 samples was found out to obtain the final plastic limit. The free swell index reading has been recorded over 24hours on BC soil, 2 specimens of 10grams soils were prepared by putting kerosene in one test tube and distilled water in the other upto 100ml mark. Specimens were under observation for 24hours and the results were obtained. In order to choose best material for an embankment and to obtain shear parameters of cohesive soil, strength test i.e. UCS test was performed. Unconfined compression strength (qu) of soil was found to be 0.57kg/cm2 and shear strength of soil was (qu/2) =0.285 kg/cm2.

After Preliminary test, Secondary test i.e. CBR test was performed on 8 different trials. A 5kg sample of BC soil was filled in a cylindrical mould of internal diameter 150mm and height of 175mm, provided with a detachable extension collar of 50mm height and detachable perforated base plate, in 3 layers. A spacer disk having 148mm diameter and 47.7 mm height was placed above base plate. After every layer compaction of soil was done by rammer of weight 2.6kg, having a free fall of 31cm giving 56 blows. Entire process was repeated on each of the 3 layers. Seating load and surcharge load of 2.5kg each and 147 mm in diameter

having central hole of 53mm diameter are placed onto the surface of the soil. Apparatus of CBR test was as per IS:2720 (Part 16).Plunger is to be seated under load of 4kg so that full contact is obtained between plunger and the surface of specimen. Application of load is done on plunger so that penetration is approximately 1.25mm per minute. CBR values at penetration of 2.5 mm and 5 mm are calculated and load penetration curve is plotted with penetration values on x-axis and load values on y-axis.

3. RESULTS AND DISCUSSIONS:

Basic soil characteristics of the soil and fly ash were obtained by performing preliminary tests. Entire project was carried out in 8 trials and CBR test was performed on all the 8 trials to obtain the best possible results. The trials are as follows:

1. CBR Test on Black cotton soil (un-soaked).
2. CBR Test on Black cotton soil (soaked)
3. CBR Test on Black cotton soil (comparison)
4. CBR Test on Black cotton soil reinforced with fly ash column (un-soaked)
5. CBR Test on Black cotton soil reinforced with fly ash column (soaked)
6. CBR Test on Black cotton soil reinforced with fly ash column (comparison)
7. CBR Test on Black cotton soil reinforced with fly ash column and some lime content (un-soaked)
8. CBR Test on Black cotton soil reinforced with fly ash column and some lime content (soaked)
9. CBR Test on Black cotton soil reinforced with fly ash column and some lime content (comparison)
10. CBR Test on Black cotton soil reinforced with fly ash column and some lime content encased with geotextile (un-soaked)
11. CBR Test on Black cotton soil reinforced with fly ash column and some lime content encased with geotextile (soaked)
12. CBR Test on Black cotton soil reinforced with fly ash column and some lime content encased with geo-textile (comparison)

CBR TEST RESULTS:

1) COMPARISON:

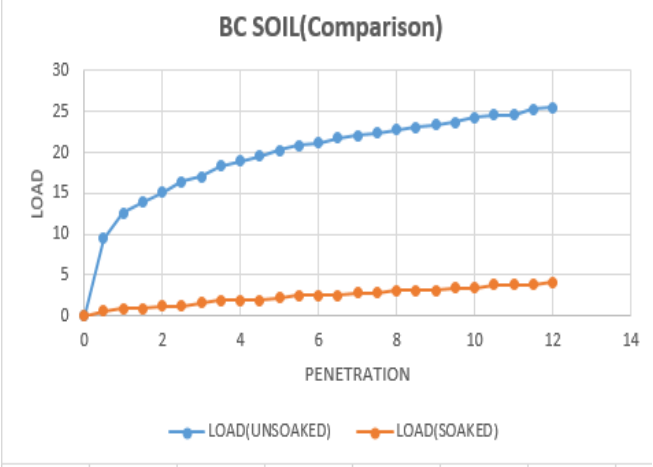

Chart 1: Comparison of BC soil

Comparison of BC soil		
Penetration	Un-soaked CBR value	Soaked CBR value
2.5mm	0.993	0.090
5mm	0.850	0.107

Table 4: Comparison of BC soil

Discussions from above test: From the above tests it was seen that the load bearing capacity of BC soil in un-soaked condition is more than that of soaked condition.

2) COMPARISON:

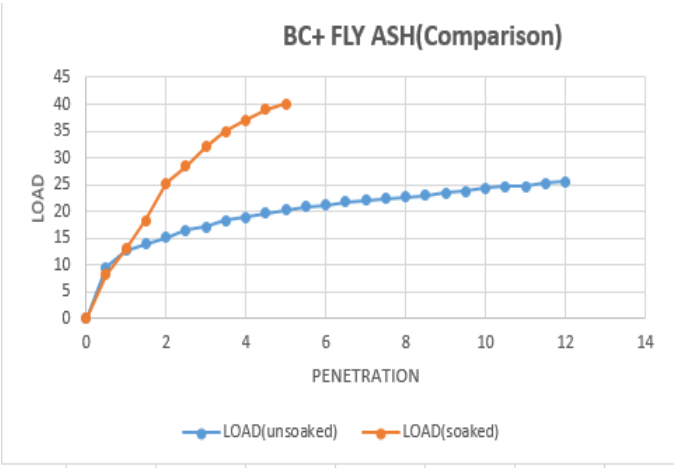

Chart 2: CBR on BC soil reinforced with fly ash columns (comparison)

Table 5: CBR for BC soil reinforced with fly ash columns (comparison)

CBR for BC soil reinforced with fly ash columns (comparison)		
Penetration	Un-soaked CBR value	Soaked CBR value
2.5mm	1.196	2.070
5mm	0.983	1.946

Discussions from above test: From the above tests it was seen that the load bearing capacity of BC soil reinforced with fly-ash columns in soaked condition was more than that of the un-soaked condition.

3) COMPARISON:

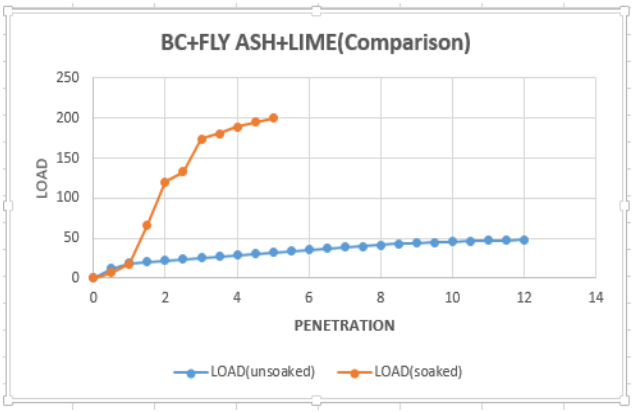

Chart 3: CBR test on BC soil with fly ash columns with lime content (comparison)

CBR test on BC soil with fly ash columns with lime content (comparison)		
Penetration	Un-soaked CBR value	Soaked CBR value
2.5mm	1.710	6.470
5 mm	1.560	3.280

Table 6: CBR test on BC soil with fly ash columns with lime content (comparison)

Discussions from above test: From the above tests it was seen that the load bearing capacity of BC soil in soaked condition was further increased on adding some lime content in fly-ash columns, due to pozzolanic action.

4) COMPARISON

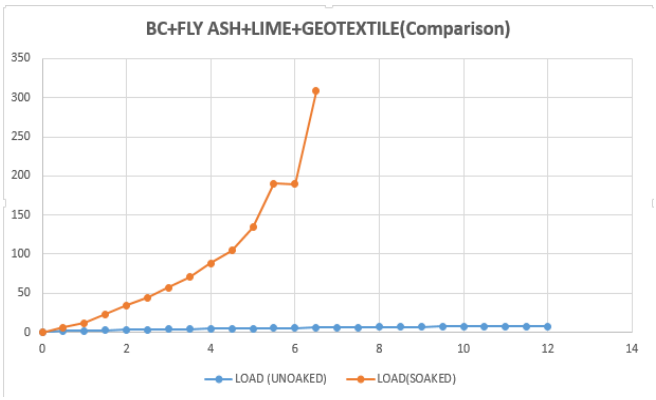

Chart 4: CBR Test on BC soil with Fly Ash columns with lime content and encased with geotextile (comparison)

CBR Test on BC soil with Fly Ash columns with lime content and encased with geotextile (comparison)		
Penetration	Un-soaked CBR value	Soaked CBR value
2.5 mm	0.250	10.850
5mm	0.245	9.730

Table 7: CBR Test on BC soil with Fly Ash columns with lime content and encased with geotextile (comparison)

Discussions from above test: From the above tests it was seen that in soaked condition the load bearing capacity increased drastically as it was encased with geotextile.

4. CONCLUSION

1. After conducting various tests on black cotton soil, it was observed that the soil is highly expansive and possess alternate swell- shrink properties.
2. On reinforcing BC soil with fly ash columns it was observed that the rate of drainage of the soil was accelerated.
3. Due to this the pore water pressure of the soil was reduced and effective stress carrying capacity of the soil increased as the water percolated into the columns on application of load.
4. In worst conditions i.e in soaked condition it was observed that the strength was comparatively less than in un-soaked condition.
5. When lime was added to the fly ash columns the load carrying capacity of the soil increased.
6. In soaked condition for fly ash mixed with lime, it was observed that the strength of the soil increased as compared to un-soaked condition. This is due to pozzolonic action between lime and water.

7. When soil reinforced with fly ash column mixed with lime and encased with polyester, it was observed that the strength of the soil further increased as compared to the previous three cases in un-soaked condition.
8. While in soaked condition the strength carrying capacity of the above case was further increased.
9. So from the above results we came to the conclusion that the last case gave the highest strength and workability .Hence this method can be adopted further for soil stabilization.

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