STABILIZATION OF SOFT CLAY SOIL BY USING POND ASH & WOVEN GEOTEXTILE

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Abstract— *Now a day's expansive soils are a worldwide problem for civil engineers. Over the last few years, the construction of highways and roads has taken a boost. This requires a huge amount of natural soil to excavated or to be deposited which is an environmental issue and economical too. This issue motivates in development of alternative methods and thus leads to the reuse of suitable industrial by products. Pond ash is one such by product. Expansive nature of black cotton soil generates lot many problems in pavement construction. Thus for good performance and long life of road it is important to improve the properties of black cotton soil. This study deals with improving the properties of black cotton soil through addition of Pond ash .which is an environmental friendly option. Soil stabilization is the way used to reduce problems in expansive soils. The present project describes about the properties of expansive soil with Pond Ash. Pond Ash is used as an additive material for stabilizing the soil. Stabilizing the soil by adding Pond Ash improves the soil strength and reduces swell and shrink. The main aim of this project is to study the effect of Pond Ash on expansive soil for road construction. The laboratory tests are carried to determine the index properties and engineering properties of soil sample. The soil samples are prepared with different proportions of Pond Ash as 10%, 20%, 30%, 40%, 50%, and 60%.Soil alone is strong enough in compression but comparatively weak in tension. Reinforcing soil is the technique where tensile elements are placed in the soil to improve stability and control deformation. The geotextiles are used as reinforcement; their prime role is to provide tensile strength to soil at strain level which is compatible with the performance of the soil structure. In this we used woven geotextiles to check for CBR and strength parameters.*

Keywords— Stabilization, Expansive soil, swell&shrink, strength, pond ash, woven geotextile, CBR.

1. INTRODUCTION

The soils which show volumetric changes due to changes in their moisture content are referred to as swelling soils. Some partially saturated clayey soils are very sensitive to variations in water content and show excessive volume changes. Expansive soils are those which swell considerably on absorption of water and shrink on removal of water. Expansive soils have considerable strength when in dry state, but the strength goes on reducing on absorbing water. The amount of volume change in expansive soil is related to initial dry density, water content, amount of clay fraction and type of clay mineral.

Shrinkage and swelling characteristics of expansive soils are mainly due to the presence of montmorillonite mineral. It is reported that damage to the structures due to expansive soils has been the costliest natural hazard in some countries. In the United States damage caused by expansive clays exceeds the combined average annual damage from floods, hurricanes, earthquakes, and tornadoes (Jones and Holtz, 1973). Documented evidence of the problems associated with expansive clays is worldwide, having occurred in such countries as the United States, China, Australia, India, Canada, and regions in Europe. (Popescu, 1986) It is reasonable that studies on the problem of expansive soils become more important day by day if the durative deficit of world resources and economy is taken into consideration (cited in Ipek, 1998).

2. EXPERIMENTAL INVESTIGATIONS

Various such as differential free swelling, specific gravity, sieve analysis, Atterberg's limit (liquid limit & plastic limit), OMC & MDD, CBR and strength tests have been performed to find out the engineering properties of expansive soil as well as soil mixed with pond ash. The percentage of pond ash may have varied from 0% to 60% at 10% interval.

2.1 Material Used

- **Expansive Soil –** Soil sample for the present work is collected from kanuru place surroundings Krishna district in Andhra Pradesh.
- **Pond Ash –** Pond ash used in this study was collected from ash pond of NTTPS thermal power plant ibrahimpatnam, Vijayawada.
- **Woven geotextile-** The geotextile used for the test purpose was collected from ENFIBRE INDUSTRIES, TADEPALLIGUDEM

2.2 Differential free swell

The objective of this test is to find out the free swell index of soil. The test results were obtained on the basis of IS 2720 (Part40) 1977. The test results are shown in Table 1 and graphical representation is also shown in fig.1.

TABLE 1
FREE SWELL INDEX OF BCS WITH DIFFERENT % OF PA

Test Specimen	Distilled water (V_d) ml	Kerosene (V_k) ml	Free swell index (%)	Percentage decrease
BCS	12	8	50%	-
BCS + 10% PA	12	8.5	41.17%	8.83%
BCS + 20% PA	11.5	8.5	35.29%	14.71%
BCS + 30% PA	10	8	25%	25%
BCS + 40% PA	10	8.5	17.64%	32.36%
BCS + 50% PA	10	9	11.11%	38.89%

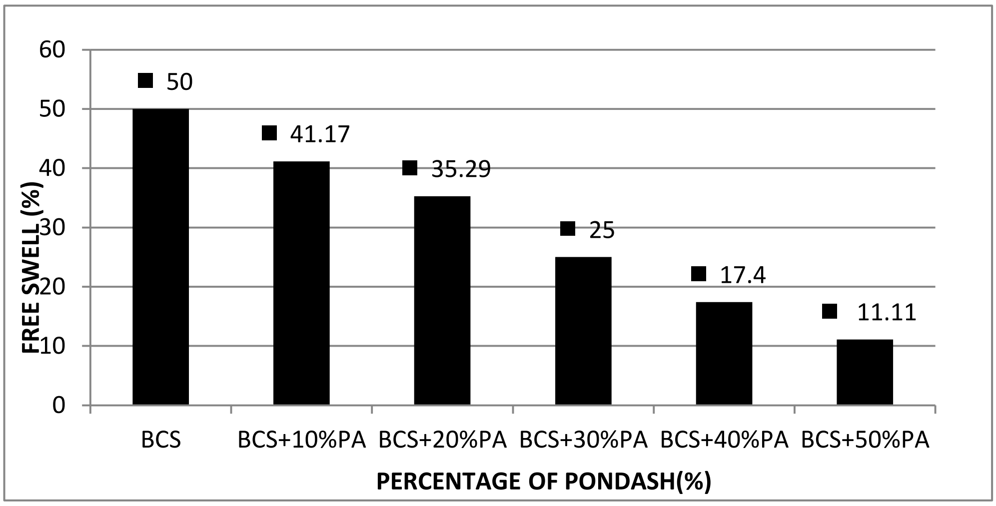

Fig.1 free swell index

2.3.1 Specific gravity of black cotton soil IS2720 (part 3) – 1980

TABLE 2
SPECIFIC GRAVITY OF BCS

Weight of empty density bottle (W_1 g)	27
Weight of density bottle+ soil (W_2g)	37
Weight of density bottle+ soil + water (W_3 g)	83
Weight of density bottle + water (W_4 g)	76.7
Specific gravity (G_S)	2.7

CALCULATIONS:

Specific gravity of the soil (G_s) = (W2-W1) / ((W2-W1)-(W3-W4))
= (37-27) / ((37-27)-(83-76.7))
= 2.7

2.3.2 Specific gravity of pond ash IS2720 (part 3) – 1980

TABLE 3
SPECFIC GRAVITY OF PA

property	Sample 1	Sample 2	Sample 3
Weight of empty density bottle (W_1 g)	2.02	2.14	2.08
Weight of density bottle+ soil (W_2g)	4.4	4.31	4.34
Weight of density bottle+ soil + water (W_3 g)	7.26	7.34	7.07
Weight of density bottle + water (W_4 g)	6.318	6.214	6.401
Specific gravity (G_s)	1.66	1.61	1.69

Specific gravity of pond ash = 1.65.

2.4 Sieve analysis of Black cotton soil IS2720 (part 4) – 1985

TABLE 4
SIEVE ANALYSIS OF BCS

Sieve size	Particle size	Weight retained	% weight retained	Cumulative % weight retained	% finer
4.75	4.75	0	0	0	100
2.36	2.36	8	0.8	0.8	99.2
1.18	1.18	70	7.0	7.8	92.2
600	0.6	85	8.5	16.3	83.7
425	0.425	93	9.3	25.6	74.4
300	0.3	180	18.0	43.6	56.4
150	0.15	172	17.2	60.8	39.2
75	0.075	33	3.3	64	35.9
Pan	<0.075	359	35.9	100	0
					581

Fineness modulus of the soil = 581/100 = 5.81%

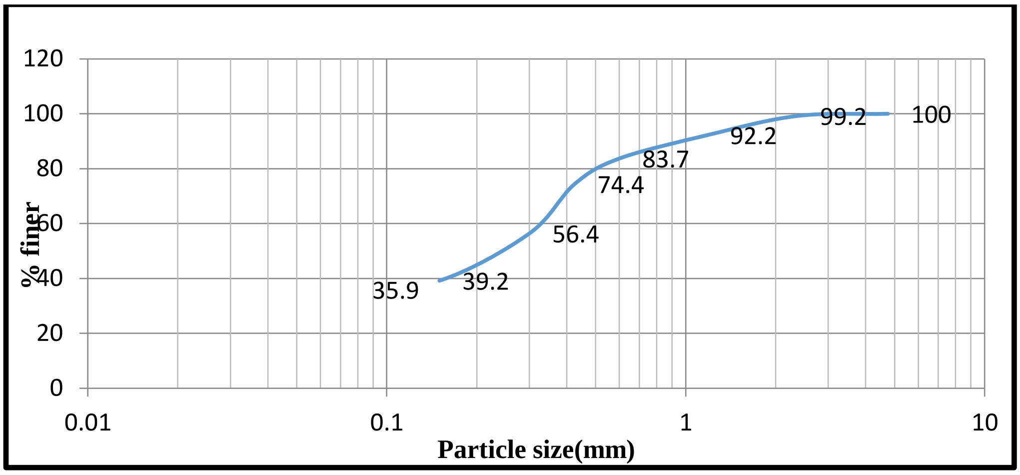

Fig.2 Particle size distribution curve

2.5 Attereberg's limits Is 2720 (part 5)

In Atterberg's limit test, mix specimen of the Black cotton soil with different percentage of pond ash. The results of Atterberg's limit are shown in table 5.

TABLE 5
ATTERBERG'S LIMITS OF BCS WITH DIFFERENT % OF PA

Test specimen	Liquid limit (%)	Plastic limit (%)	Plasticity index (%)
Black cotton soil (BCS)	46.62%	22.44%	24.18%
Pond ash (PA)	35.9 %	Non - plastic	Non – plastic
BCS + 10% PA	40%	20.34%	19.66%
BCS +20% PA	36.20%	18.66%	17.54%
BCS + 30 % PA	35.8%	18.45%	17.35%
BCS + 40 % PA	31.2 %	18.14%	13.06%
BCS + 50 % PA	27.90%	17.86%	10.04%

From table 5 the value of liquid limit & plasticity index continuously decreases from 46.62% to 27.90% & 24.18 to 10.04 % respectively in mix specimen. The graphical representation of liquid limit & plasticity index of mix specimen shown in fig 4 & 5.

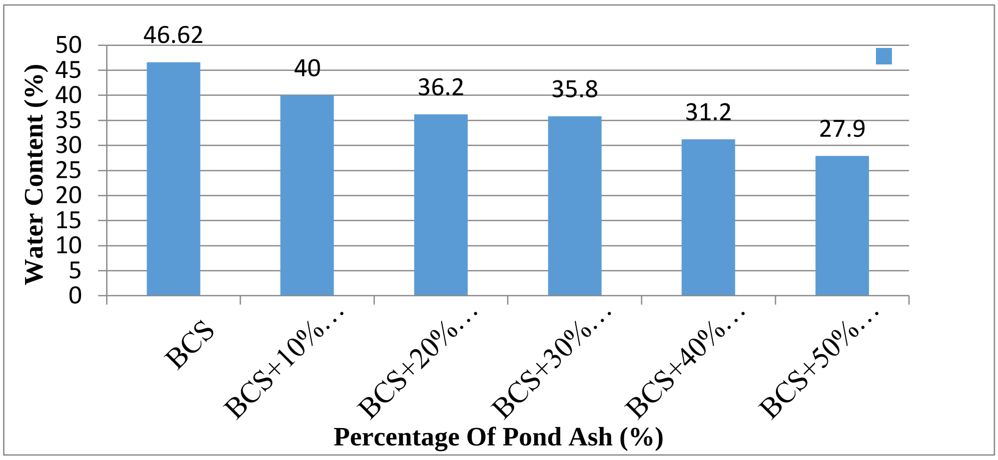

Fig 4 Liquid Limit of BCS+different % of PA

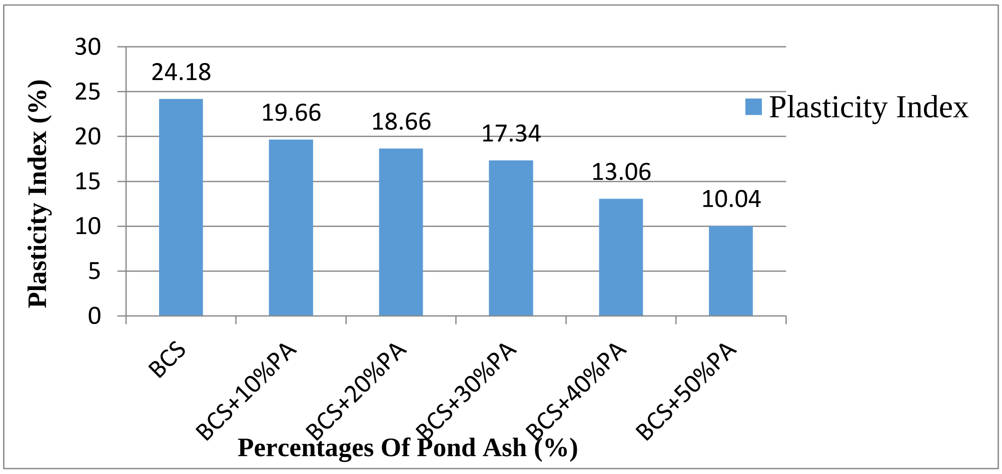

Fig 5 Plasticity index of BCS+ different % of PA

2.6 Modified proctor compaction test IS 2720 (Part 40)

The objective of the test is to find out optimum percentage content and maximum dry density of black cotton soil with different percentage of pond ash. The results of modified proctor test are shown in table 6.

TABLE 6

MODIFIED PROCTOR TEST OF BCS+ DIFFERENT % OF PA

Different Percentages (%)Of Pond Ash	Maximum Dry Density(g/cc)	Optimum Moisture Content (%)
BCS	1.570	12.22
BCS + 10% P.A	1.628	11.6
BCS + 20% P.A	1.706	10.4
BCS + 30% P.A	1.720	9.7
BCS + 40% P.A	1.80	9.3
BCS + 50% P.A	1.728	9.65
BCS + 60% P.A	1.692	10.12

From table 6 it is observed that the maximum dry density increases with increasing the percentage of pond ash upto 40% and then decreases. The maximum dry density of soil is 1.80g/cc determined. The graphical representation of modified proctor test is shown in figure 6.

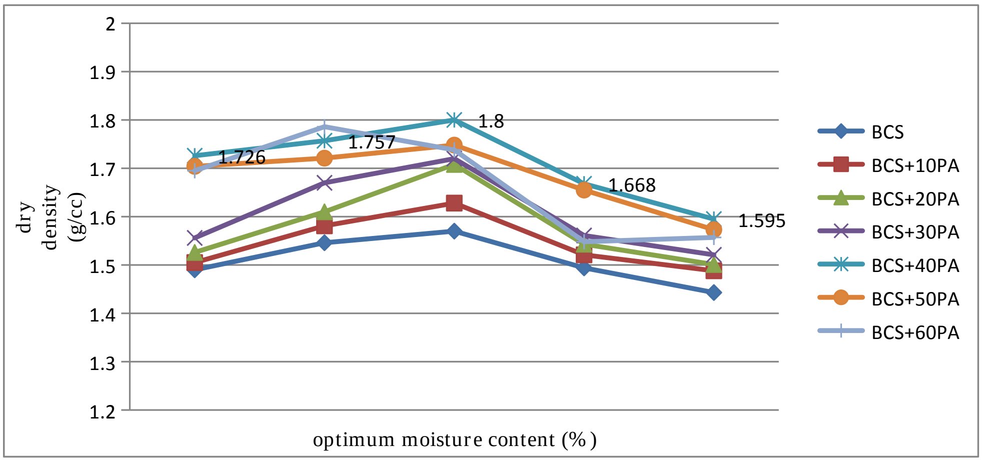

Fig6 MDD vs OMC of all BCS+ different % of PA

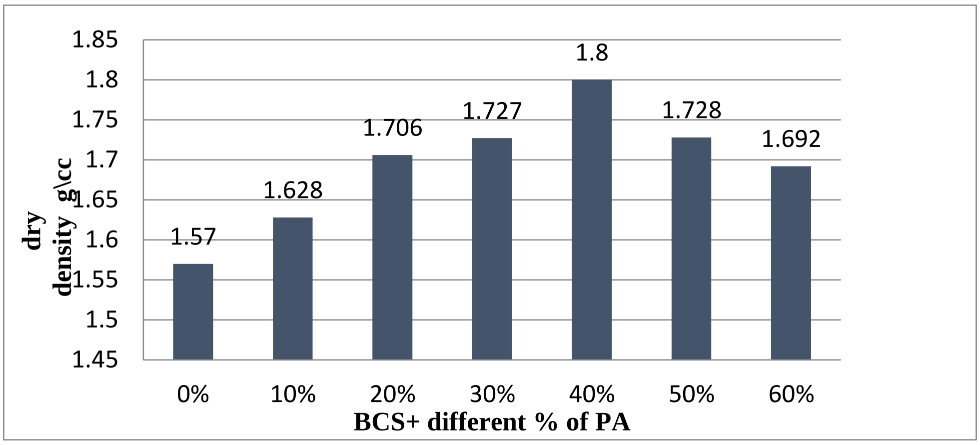

Fig7 Maximum dry density(g/cc) of BCS+different % of PA

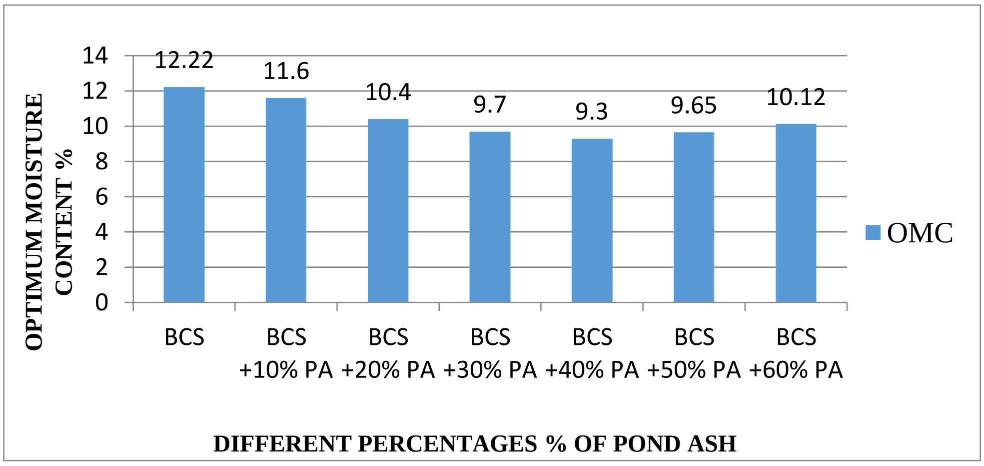

Fig8 OMC of BCS+different % of PA

From the graph it was very clear that for the 40 % of Pond Ash the Maximum Dry Density of 1.80 g/cc was obtained at an optimum moisture content of 9.3 %.

2.7 CBR TEST IS 2720 (Part 16)

California bearing ratio is the ratio of force per unit area required to penetrate in to a soil mass with a circular plunger of 50mm diameter at the rate 1.25mm/min. CBR method is recommended by IRC 37-1970, is generally structural elevation of sub grade soil in India. The sample obtained from sub grade soil is compacted to maximum dry density at optimum moisture content and CBR value for these samples determined.

TABLE 7
CBR OF BCS+ DIFFERENT % OF PA

Details of the specimen	Soaked 2.5mm	Soaked 5.0mm	Unsoaked 2.5mm	Unsoaked 5.0mm
Black cotton soil (BCS)	5.52%	5.02%	7.54%	7.03%
BCS + 10% PA	11.56%	10.72%	13.57%	12.39%
BCS + 20% PA	16.08%	15.41%	18.09%	17.76%
BCS + 30 % PA	21.66%	20.10%	23.62%	22.78%
BCS + 40 % PA	27.64%	25.80%	29.15%	28.48%
BCS + 50 % PA	25.63%	24.12%	27.14%	26.47%
BSC + 60% PA	24.12%	23.12%	25.63%	24.79%

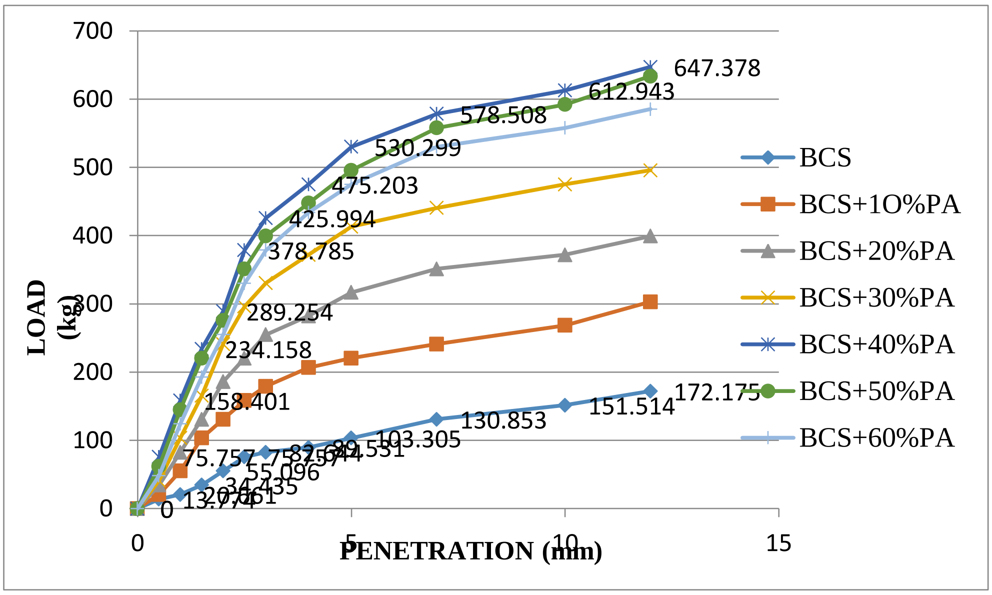

Fig 9 All Soaked CBR % of BCS+ different % of PA

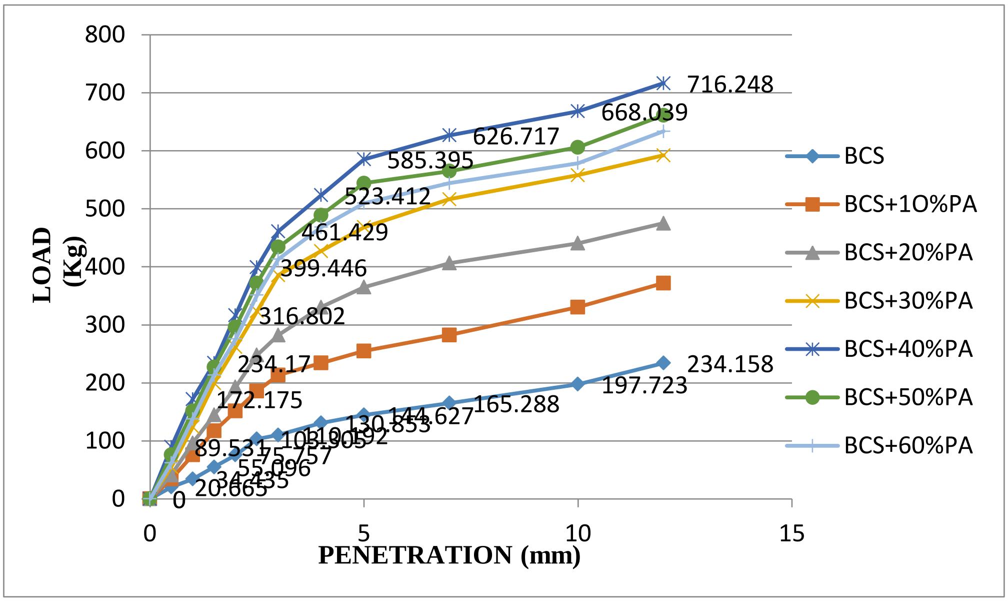

Fig 10 All Unsoaked CBR % of BCS+ different % of PA

TABLE 8
PROPERTIES OF UNREINFORCED SOIL+ 40 % Of PA

Property	Values
Free Swell Index	17.64 %
Liquid limit	31.02 %
Plastic limit	18.14 %
Optimum Moisture Content (OMC)	9.3 %
Maximum Dry Density(MDD)	1.80 g/cc
CBR Value (soaked)	27.648 %
Type of soil (As per ISSCS)	Intermediate compressible clay (CI)

The maximum CBR value is taken for the design of flexible pavement. From above graph results the maximum value of Soaked CBR is 27.648 % for black cotton soil with 40% pond ash. As per IRC, the minimum CBR value of soil in the sub base of any flexible pavement is minimum 20% to 30% on an average (soaked condition).

Our test samples CBR value is 27.648%, so there is a need of stabilization of soil. For this stabilization we are placing geotextile layers at various depths for the increment of CBR value as geotextile layers are good in carrying the tensile strength and it acts as reinforcement for the taken soil layer. Besides not only as reinforcement, but it also acts as separator, drainage layer, erosion control etc. But our aim is to impart an additional CBR value to the taken soil sample.

Some of the properties regarding geotextile were collected. The geotextile used in this study was woven geo textile. The geotextiles are used as reinforcement; their prime role is to provide tensile strength to soil at strain level which is compatible with the performance of the soil structure.

TABLE 9
PROPERTIES OF GEO TEXTILE

Property	Value
Colour	White
Thickness	0.3mm
Tensile strength (wrap/weft) (kN/m^3)	35/30
Mass per unit area	165GSM
Puncture strength(N)	450

Fig 11 Woven geotextile

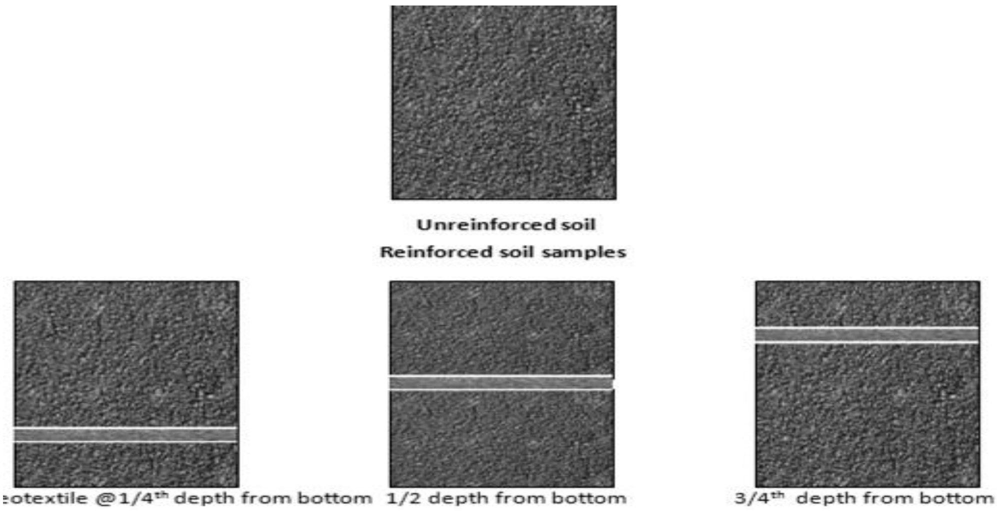

Figure 12 Geotextile mechanism

As per above mechanism the Geo textiles were placed at different depths with black cotton soil + 40% of pond ash.

TABLE 10
ALL SOAKED & UNSOAKED CBR VALUES OF BCS+ 40% OF PA+GEOTEXTILE @ DIFFERENT DEPTHS.

Details of the specimen	Soaked	Unsoaked
Unreinforced Soil (CBR 2.5)	27.648 %	29.15 %

Unreinforced Soil (CBR 5.0)	25.805 %	28.48 %
Geotextile @ 1/4th depth from bottom (CBR 2.5)	33.68 %	35.69 %
Geotextile @ 1/4th depth from bottom (CBR 5.0)	32.17 %	34.18 %
Geotextile @ 1/2 depth from bottom (CBR 2.5)	38.70 %	41.72 %
Geotextile @ 1/2 depth from bottom (CBR 5.0)	36.52 %	40.21 %
Geotextile @ 3/4th depth from bottom (CBR 2.5)	44.74 %	46.75 %
Geotextile @ 3/4th depth from bottom (CBR 5.0)	42.89 %	45.24 %

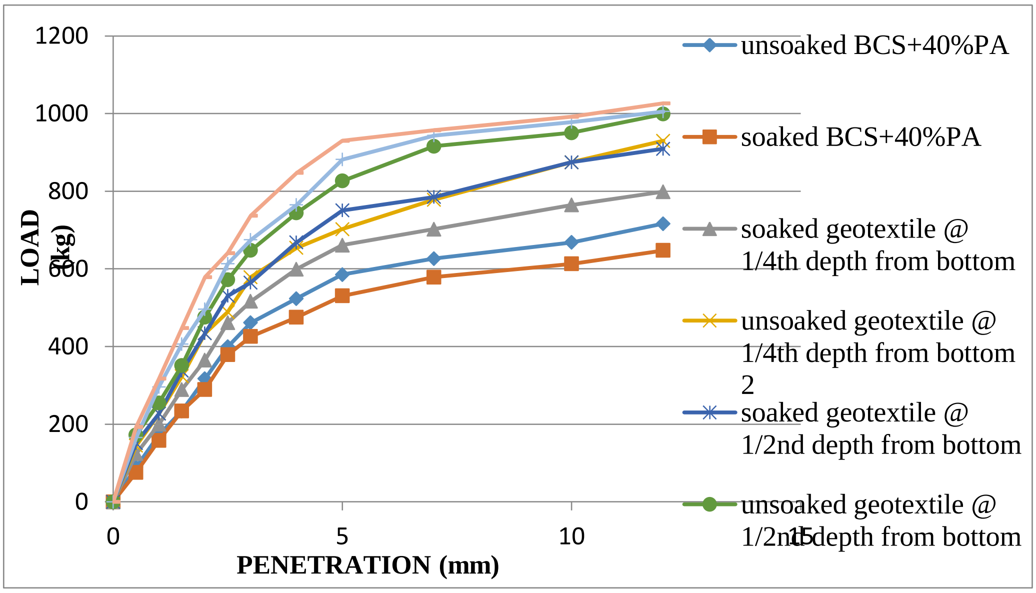

Figure 12 All soaked and unsoaked CBR % of BCS+40% 0f PA+ Woven geotextile at different depths.

TABLE 11

SOAKED CBR VALUES OF COMPOSITE WOVEN GEOTEXTILE PLACED AT DIFFERENT DEPTHS FROM BOTTOM

Soil specimen	Soaked CBR value (%)	Increased in soaked CBR value w.r.t CS
Control Specimen (C.S)	5.52 %	-
BCS & 40 % Pond Ash	27.648 %	22.128 %
Soil + 40% PA+geotextile layer at D/4 from bottom	33.68 %	28.16 %
Soil + 40% PA+geotextile layer at D/2 from bottom	38.70 %	33.18 %

Soil + 40% PA+geotextile layer at 3D/4 from bottom	44.74 %	39.22 %

Thus from the above table, the placement of a composite geotextile at a depth of 3D/4 from bottom increases the soaked CBR value by 39.22 %. We had compared only soaked CBR because they were used in the design of any flexible pavement.

3. CONCLUSIONS

- The basic engineering properties of the Black Cotton Soil and pond ash are studied.
- The BCS has been tested by adding 0%,10%,20%,30%,40%,50% of pond ash to soil, thus the free swell index values decreases as 50%,41.17%,35.29%,25%,17.64%,11.11% respectively.
- Thus The differential free swell index decreases by increasing the percentage of pond ash.
- Therefore, the soil is having high degree of expansiveness and the value is 50%. This degree of expansiveness, decreases from 50 % to 17.64 %.This is meant, when 50% pond ash is added in clay, the expansiveness decreases about 32.36%.
- From the test, the liquid limit values of BCS with 0%, 10%, 20%, 30%, 40%, 50% of pond ash are 46.62%, 40%, 36.25%, 35.8%, 31.2%, 27.9% respectively.
- From the test results the type of soil as per ISSCS that we are using for this test is Intermediate Compressible Clay (IC) because it's liquid limit (46.62%) (Which is in between 35-50% - intermediate Compressible) and it's Ip (24.18%) < (Ip)A (17.65Clay)
- From the compaction test of black cotton soil, the maximum dry density is 1.57g/cc and its moisture content is 12.22%.
- The maximum dry density values of BCS With 10%, 20%, 30%, 40%, 50% and 60% of pond ash are 1.628g/cc, 1.706g/cc, 1.72g/cc, 1.80g/cc, 1.728g/cc and 1.738g/cc respectively.
- The moisture content values of BCS with 10%, 20%, 30%, 40%, 50% and 60% of pond ash are 11.6%, 10.4%, 9.7%, 9.3%, 9.65% and 7.24% respectively.
- From the tests, it is clearly seen that the dry density increases by addition of pond ash & eventually moisture content is decreases.
- The CBR tests of BCS for soaked and unsoaked are conducted for different percentages of pond ash.
- From the soaked CBR test of black cotton soil at 2.5mm is 5.52% and at 5mm is 5.02%
- From the unsoaked CBR test of black cotton soil at 2.5mm is 7.54% and at 5mm is 7.03%.
- The soaked CBR values of black cotton soil increases with increasing the percentage of pond ash from 5.52% % to 25.12 %.
- The Unsoaked CBR values of black cotton soil increases with increasing the percentage of pond ash from 7.54 to 25.63%.
- The CBR Tests are conducted on BCS + 40 % of pond ash + woven geo textile is placed at different heights from bottom.
- CBR Value increases with addition of woven geotextile at different depths (D/4,D/2 &3D/4).
- Out of 3 trial depths(D/4,D/2 &3D/4), it was observed that 3D/4 gives the maximum soaked CBR value of 44.74 % .
- Out of 3 trial depths(D/4,D/2 &3D/4) , it was observed that 3D/4 gives the maximum soaked CBR value of 46.75%.

- From a comparative study CBR % increased by 39.22 % that of unreinforced soil (3/4)th depth From this comparison it is very clear that by using a composite geotextile layer is much more economical and gives more strength to the soil sample.

- As per IRC, CBR method of flexible pavement design states that pavement thickness is inversely proportional to CBR value, so from this relation the inclusion of geotextile layer can decrease the pavement thickness.

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