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Comparative Study on Bearing Capacity on Alkaline Activated and Non-Activated Juliflora Ash in Black Cotton Soil

S.Janaki Raman[1], P.D.Arumairaj[2], Blessanth Jeyaseelan[3],R.Samuvel raj[4]
[1] Assistant Professor,[2] HOD and Prof, [3] PG Student, Department of Civil Engineering,
Karunya Institute of Tech & Sciences, Coimbatore

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Abstract:
Due to modernization, lots of villages become big cities. As a results available portable water becoming a major issue all over the world. Prosopis juliflora is a biological nightmare species, which is having lots of negative effects to the environment. Due to high release of CO2 and higher amount of water absorption through its roots results global warming and drought. So as to use this species into a useful manner to reduce these effects. In this research work bearing capacity of black cotton soil was compared with the addition of different materials. Prosopis juliflora ash is one of the materials which is used to improving the bearing capacity of soil. An experiment has been made to study on improving bearing capacity of black cotton soil by using Prosopis juliflora ash and alkaline activators. Sodium hydroxide and sodium silicate are used as alkaline activators for the stabilization of black cotton soil. Adding Prosopis juliflora ash in soil replacing soil with ash at 15% and 18%, to determine the optimal replacement level and 10% alkaline activators also added to soil sample to check the difference in bearing capacity of black cotton soil. For this research, molarity of sodium hydroxide is fixed as 8M. The results are compared with the soil sample without adding Prosopis juliflora ash and alkaline activators. The results show that, the maximum unconfined compressive strength as well as bearing capacity was found to be at 15% prosopis juliflora ash with alkaline activators. Maximum unconfined compressive strength was obtained as 377kPa. Cured soil specimens having high bearing capacity than those of the soaked and unsoaked specimens.

Keywords: *Bearing capacity, Black cotton soil, Prosopis juliflora, Alkaline activators*

INTRODUCTION

In this century, construction of structures is the main focussing area for urbanization. Substructure is the back bone of every structures. When thesubstructure become weak then the stability of the whole structure will be affected. For a stable substructure means that, the soil beneath the substructure should have bearing capacity to withstand the axial load from the whole structure. Now a day's drought is a common problem faced by all the living creatures. This is due to several human activities as well as by the natural creature itself. Prosopis juliflora is a shrub or small tree in the family Fabaceac. It is native to Mexico but now it spread all over the world. Prosopis juliflora has several negative effects to the environment. This tree produce high amount of CO_2as a result surrounding temperature will increased. If it doesn't have sufficient water it begins absorbing groundwater and if there is no groundwater, it starts

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absorbing humidity from the surroundings, which results global warming. If it cuts, these trees have the tendency to grow back faster. So only one solution is to burn these species. India is the second largest populous country in the world. Prosopis juliflora spread all over India except Jammu and Kashmir, Himachal Pradesh, Arunachal Pradesh and Sikkim. Therefore, only limited area available to dump the produced ash. So, an alternative method should find out to use Prosopis juliflora ash in useful manner.

According to Indian Council of Agricultural Research soils are classified into eight categories. They are alluvial soil, black cotton soil, red soil, laterite soil, mountainous soil, arid soil, saline & alkaline soil and preaty & marshy soil. Black cotton soils are the major group and which occurs mostly in the central & western parts and covered approximately 20% of the total area of India. It has very low bearing capacity and which shows high swelling on wetting and high shrinkage on drying. This is mainly due to the presence of montmorillonite mineral. Due to its poor bearing capacity which possess challenge tocivil engineers to construct structures over black cotton soil.

Soil stabilization is one of the methods to increase bearing capacity. There are several methods are adopting to increase bearing capacity of black cotton soil such as mixing different materials like cement, bitumen, lime, chemicals, geotextile with soil.Geopolymerization is one of the methods to increase the soil bearing capacity. Geopolymer is the combining source materials that are rich in silica and alumina with strong alkali solutions such as potassium hydroxide and sodium hydroxide.Black cotton soil contains more than 75% of silica and nearly 10% of alumina. Addition of strong alkali solutions will increase the bearing capacity of black cotton soil. Comparing strong alkali solutions, sodium hydroxide is cost effective. But chemicals affect the soil properties and which kills microorganisms in soil. So, these methods are not commonly preferred to stabilize black cotton soil.

This present research work aims to increase the bearing capacity of black cotton soil with the combination of Prosopis juliflora ash with minimum quantity of alkaline activators.

MATERIALS USED

India is a vast country which contain lots of different soil classification. Black cotton soil one among the soils which is having low bearing capacity. Soil stabilization is one of the methods to improve the capacity of black cotton soil. In this research work, black cotton soil was collected from Semmadu, Coimbatore. The collected soil was sieved by using 4.75mm Standard sieve for further research. The properties of collected soil details are given in table 1.

Table 1 Properties of soil sample

Properties	Value
Gravel	0%
Coarse sand	0.5%
Medium sand	20%
Fine sand	14.5%

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Percentage of sand	35%
Percentage of silt & clay	65%
D_{10}	0.41
D_{30}	0.32
D_{60}	0.80
Coefficient of uniformity (C_u)	1.98
Coefficient of cohesion (C_c)	0.32
Specific gravity(G)	2.63
Optimum moisture content (γ_d)	15%
IS classification	SC

Prosopis juliflora ash was used for the stabilization of black cotton soil as well as for the formation of geopolymer binder was collected from Tirunelveli, TamilNadu.

A mixture of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) where used as the alkaline activators for the geopolymerization process. Sodium hydroxide solution of required concentration was prepared by mixing NaOH pellets with distilled water. Concentration of NaOH solution was kept as 8M throughout the research work.

MATERIALS PARAMETERS

In this research work tests were carried out in three different ways. Soil bearing capacity was tested without adding any other materials, soil with Prosopis juliflora ash and soil with Prosopis juliflora accompanied with alkaline activators. 15% and 18% Prosopis juliflora ash was mixed with black cotton soil and the capacity were tested. Also, capacity of black cotton soil was tested with the addition of ash and alkaline activators. Totally 10% alkaline activators were used in the soil sample to check the capacity of soil.

EXPERIMENTAL PROGRAM

Basic soil tests were carried out to found the basic properties of soil like moisture content, particle size, silt and clay content, specific gravity, optimum moisture content, liquid limit and plastic limit by using standard procedure given in Indian Standard code (IS 2720). From oven dry test moisture content of the soil sample was obtained as 8.6%. Sand and clay content present in the collected soil sample was obtained as 35% and 65% respectively. Specific gravity of black cotton soil was obtained as 2.63. Standard proctor compaction test was carried out to find out optimum moisture content of the soil sample and the optimum value obtained as 15%. By using Atterberg's limits methodliquid limit and plastic limit were calculated. Liquid limit and plastic limit of the soil sample was obtained as 64% and 32% respectively. Unconfined compression strength was carried out with optimum moisture content of 15% and was obtained as 44kPa for soil alone. California bearing ratio was found as 5.15% at 2.5mm and 4.60% at 5mm penetration respectively.

TESTING METHOD: -

California bearing ratio (CBR): -

California bearing ratio of the soil specimens were found in a CBR testing machine of capacity 2.5kN.CBR test was done as per the test method given in IS 2720 (part 16)-1973.

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CBR mould was placed in the machine and aligned centrally on the base plate of the machine. Load was applied gradually and continuously at a rate of 1.25mm/sec. Load was applied till 1250mm penetration of the 2.5mm plunger into the specimen. Calculated CBR values for soaked and unsoaked samples are given in the Table 2. Same procedure was followed for 7 and 14 days cured samples and the CBR values are given in Table 3.

Table 2 CBR values for soaked and unsoaked samples

Samples	Soil Penetration (in mm)	CBR Value (in %)				
		Only soil	Soil+15% ash	Soil+18% ash	Soil+15% ash+10% alkaline activators	Soil+18% ash+10% alkaline activators
Unsoaked	2.5	5.15	5.77	5.35	6.59	6.18
	5	4.60	5.02	5.22	6.38	5.97
Soaked	2.5	3.12	4.66	3.92	5.17	4.25
	5	2.84	4.10	3.77	4.72	3.94

Table3 CBR values for cured samples

Curing (in days)	Soil Penetration (in mm)	CBR Value (in %)				
		Only soil	Soil+15% ash	Soil+18% ash	Soil+15% ash+ alkaline activators	Soil+18% ash+ alkaline activators
7	2.5	5.21	6.13	5.47	9.79	7.92
	5	4.59	5.88	5.13	9.61	6.64
14	2.5	5.19	6.56	5.88	12.15	9.1
	5	4.70	6.12	5.23	11.22	8.24

Unconfined compression strength (UCS): -

Prepared undisturbed specimens of size 38mm diameter and 76mm length were tested in UCS machine by the test procedure given in IS 2720 (part 10) -1973. Zip lock bags was used to maintain the moisture content of the specimen when it dipped into the water for curing. 7,14,21 and 28 days of cured specimens were tested separately. Load was applied till the specimens fails. Oven dry method was used to confirm the moisture content of the specimens after UCS test. UCS test setup is shown in figure 3 unconfined compression strength of the specimens were found from stress-strain curve and Mohr's circle. Table 7 shows the UCS of the specimen

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Table 7 UCS of the specimens

Strength after	UCS in kPa				
	Only soil	Soil+15% ash	Soil+18% ash	Soil+15% ash+ alkaline activators	Soil+18% ash+ alkaline activators
1 day	42	140	117	266	154
7 day	43	144	118	295	166
14 day	45	146	120	326	175
21day	46	155	125	342	183
28 day	48	175	131	377	202

RESULTS: -

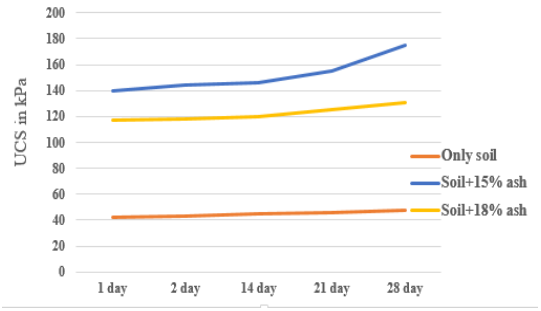

Figure 4 UCS of soil specimens with and without Prosopis juliflora ash

Figure 4 shows the UCS of soil with and without Prosopis juliflora ash in different percentage.

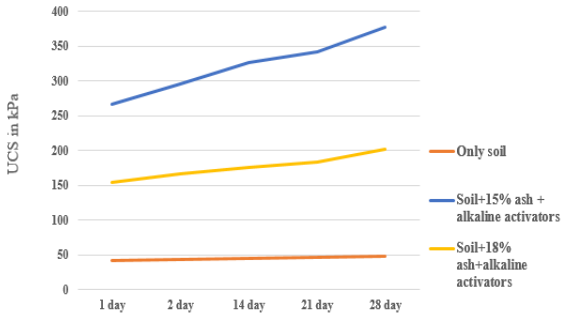

Figure 5 UCS of soil with Alkaline activators and Prosopis juliflora ash

Figure 5 shows the UCS of soil with the addition of alkaline activators and Prosopis juliflora ash in different proportion.

CONCLUSIONS: -

- UCS of soil specimens was found to be maximum at 15% Prosopis juliflora ash with alkaline activators and maximum value of UCS was found to be 377kPa.
- Maximum bearing capacity of soil specimens was found to be at 15% Prosopis juliflora ash with alkaline activators.
- Bearing capacity of the cured specimens were found to be higher than those of the unsoaked and soaked specimens.
- UCS and bearing capacity of soil specimens increases with increases in the number of curing days.

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