Stabilization of Expansive Soil using Sugarcane Straw Ash (SCSA)

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Abstract-*India is having around 50 million hectares of land which are covered with expansive soils. These expansive soils are very hard when dry, but loses its strength completely in wet condition. These expansive soils poses several problems for the civil engineers. Various methods are adopted to improve the engineering characteristics of expansive soils. Soil stabilization is one of the important features for construction because it improves the engineering properties of soil such as strength, durability and volume stability. In this paper, sugarcane straw ash is used at varying percentage and at varying curing periods to stabilize the soil. Various geotechnical laboratory tests like Unconfined Compression Test (UCS), California Bearing Test (CBR) and Free Swelling Index Test (FSI) were carried by varying the percentage of sugarcane straw ash (5%, 10% and 15%) at varying curing periods (3, 5 and 7 days). It is found that 10 % increase in the percentage of sugarcane straw ash increases the UCS and CBR value with increasing curing periods.*

Keywords: Expansive Soil, Soil Stabilization, Sugar cane Straw Ash, Durability

1. INTRODUCTION

Waste material is a challenge for the cities authorities in almost all the developing countries mainly due to the generation of wastes. The rapid growth of industrialization and urbanization has resulted in generation of large amounts of wastes all over the world. Though growth of industry is necessary for the development of the country but its negative impacts on the environment cannot be ignored. Today the whole world is facing a serious problem in disposing the various generated wastes.

It is well known that the needs for transportation system is increasing day by day with the increase in the number of populations and also the maintenance of the existing ones. The highway engineers are facing serious problems in finding the suitable materials for road constructions. In India expansive soils covers about 50 billion hectares of land. These expansive soils have a propensity to swell and shrink with the variation in moisture content, hence they are also known as swelling soils or shrink swell soils. As a result of alternate swell and shrink significant distress occurs in the soil and causing severe damage to the overlying structures as well as to the roads. During monsoon's these soil imbibe water, swells and become soft while in dry seasons, these soils shrinks and becomes harder due to expulsion of water by evaporation. The most available soils do not have the adequate engineering properties to bear the expected wheel load. Owing to this fact, many researches have been carried out to improve the engineering properties of soils. These leads to the concept of Soil Stabilization. Soil stabilization is a process which is used to improve the soil characteristics and its economy. Stabilization, in a broad sense, includes numerous methods implement for modifying the properties of a soil and improves the engineering properties and performance of soil. Generally, the stabilization concept can be dated 5000 years ago. Treated earth roads were used in ancient Mesopotamia and Egypt, and that the Greek and Roman used soil-lime mixtures (*McDowell, 1959*). The first experiments on soil stabilization were achieved in USA with sand/clay mixtures around 1906. In the 20th century especially in the thirties, the soil stabilization relevant to road construction was applied in Europe (*Kezdi, 1979*). The expansive soils may be stabilize by either removing or replacing by good or better quality material or treated using additive. Many researchers have used various waste materials like fly ash, rice husk ash, stone dust etc. for improving the properties of soil. In this paper, sugarcane straw ash is used as a stabilizer to improve the properties of the expansive soil and to use it in road construction. Sugarcane straw ash is a major byproduct in the manufacture of sugar in the sugar industries. Proper disposal of sugarcane waste has been a major concern. Several researches have been conducted in order to make sugarcane straw a useful material. Some of the researches show that the sugarcane straw ash contains high amount of silicon dioxide (SiO_2) which makes it a highly pozzolanic material (*Martirena et al., 1998 and Paya et al., 2002*). The research of *Villar-Cocin a et al. (2003)* studied the pozzolanic behaviour of a mixture of sugarcane straw with 20 and 30% clay burned at 800 and 1000^{o}C and calcium hydroxide and proposed akinetic–diffusive model for describing the pozzolanic reaction kinetics. *Amu et al., (2011)* studied the geotechnical properties of lateritic soil using sugar cane straw ash as stabilizer. They found that there is an increase in the value of OMC, CBR and UCS on addition of 8 % sugar cane straw ash. They further concluded that sugar cane straw ash can be used as an effective soil stabilizer. Similarly, *Ogunribido (2012)* also studied the potentials of sugar cane straw ash for lateritic soil stabilization. The conclusion made by Ogunribido is somewhat different from Amu at al. He concluded that sugar cane straw ash is not a good stabilizer for lateritic soil. Many researchers have also studied the use of sugarcane bagasse ash as a stabilizing material (*Gandhi, 2012, Kiran and Kiran, 2013, Kharade et al., 2014*) which is basically a residue obtained from the burning of bagasse in sugar producing industries. With the tremendous increase in the population the amount of wastes generated increases at an alarming rate. Hence, emphasis is given on the use of industrial and agricultural wastes to reduce the problem of waste dumping. In this paper, an attempt has been made to improve the geotechnical properties of expansive soil using agricultural wastes like sugar cane straw ash. The main objective is to study the geotechnical behavior of the soil by adding sugar cane straw ash as additives at varying percentages and at varying curing periods.

2. MATERIALS AND METHODS

The materials used in the study were soil sample, water and sugarcane straw ash. The soil sample was collected from Gorchuk from a depth of 2 m below the natural ground level. They were kept safe and dry in jute bags. They were air dried for two weeks to allow elimination of water which may affect sieve analysis. They are then sieved with 4.76mm IS Sieve to obtain the final soil samples for the tests. Sugarcane straws were collected from Kampur co-operative Sugar Mill, Nagaon. The straws were spread out on the ground and air dried to facilitate easy burning. After air drying, the sugarcane straws were burnt into ash and collected in polythene bags, stored under room temperature until used. The SCSA was sieved through 90μ IS Sieve to get the very fine ash. The chemical composition of SCSA is given in Table 1. The following engineering tests were performed by varying the percentage of sugarcane ash (5%, 10% and 15%) at varying curing periods (3, 5 and 7 days): Sieve Analysis, Atterberg Limit Tests, Proctor Test, Unconfined Compression Test (UCS), California Bearing Ratio Test (CBR) and Free Swelling Index Test (FSI). The procedure of the various engineering tests mentioned above is strictly followed according to the Indian Standard Codes. The Table 2 shows the various tests along with their respective IS Codes.

TABLE 1: Chemical Composition of SCSA

Compound	Percentage
SiO_2	48.65
Al_2O_3	1.22
CaO	4.52
Fe_2O_3	2.85
MgO	1.46
Na_2O	0.52
K_2O	4.12
SO_3	1.53

TABLE 2: Engineering Tests with IS Codes.

Name of Tests	Indian Standard Codes
Sieve Analysis	IS: 2720 (Part 4) – 1985
Atterberg Limit Tests	IS: 2720 (Part 5) – 1985
Proctor Test	IS: 2720 (Part 7) – 1980
Unconfined Compression Test	IS: 2720 (Part 10) – 1991
California Bearing Ratio	IS: 2720 (Part 16) – 1987
Free Swelling Index Test	IS: 2720 (Part 40) – 1977

3. RESULTS AND DISCUSSION

The results for the various tests conducted on the soil sample is given in Table 3.

TABLE 3:. Physical Property of Soil Sample

Test	Parameters	Description
Sieve Analysis	Sand	13.52 %
	Clay	86.48 %
Atterberg Limits	Liquid Limit	72.5 %
	Plastic Limit	25.7 %
	Plasticity Index	46.8 %
Classification of Soil		CH
Free Swell Index	FSI value	45.8 %
Unconfined Compressive Strength	UCS value	78.3 KN/m^2
California Bearing Ratio	CBR value	2.5 %
Proctor Test	MDD	1.32 kg/cm^3
	OMC	26.5 %

The soil sample is treated with 5%, 10% and 15% of sugarcane ash and UCS, CBR and FSI tests were carried out to find the property variation of the soil. The following are the comparison curves for the various types of tests.

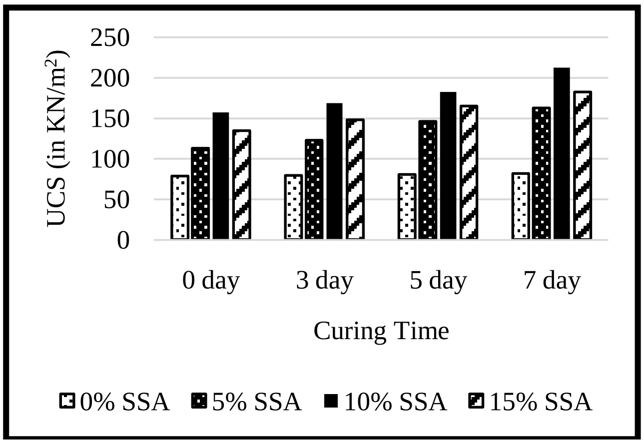

Figure 1. Unconfined Compressive Strength versus curing time

Figure 1 shows the comparison chart for UCS value for varying percentage of SSA and at varying curing periods. From the graph, it is found that with the increase in the curing time the UCS value increases but the increase is more with 10 % of SSA. The UCS value for 10 % of SSA is found to be 212.5 KN/m^2. Figure 2 shows the CBR value for 2.5 mm penetration for varying percentage of SSA and for varying curing periods. From the graph, it is found that there is also an increase in the value of CBR with increasing percentage of SSA. It is found that 10 % addition of SSA gives the maximum value of CBR when compared with the untreated soil. On increasing the value of SSA beyond 10%, the UCS and CBR value decreases. This indicates that higher compaction effort would be required to achieve desired degree of compaction with increasing percentage of SSA beyond 10%.

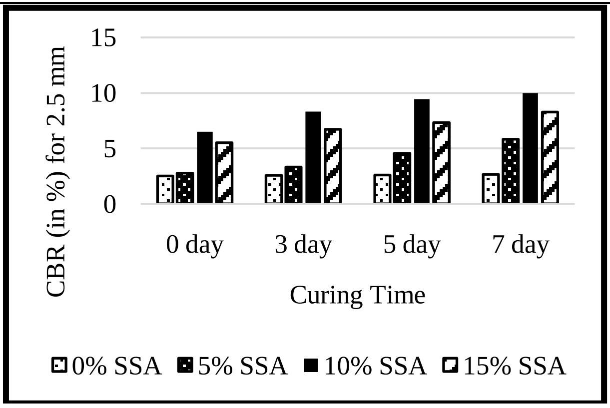

Figure 2. California Bearing Ratio versus curing time

Figure 3 gives the comparative values of FSI for different percentage of SSA and for different curing periods. It is found that the swelling nature of the expansive soil decreases with the increase in the percentage of SSA and with increasing curing period. With the increase in the percentage of SSA and with increasing curing period some form of cementation occurs leading to the decrease in the swelling character of the soil.

Hence, it can be said that the optimum percentage of sugarcane straw ash (SSA) to be used as soil stabilizer is found to be 10 % having a curing period of 7 days. The optimum percentage of SSA for CBR value is further used to find the total thickness of the pavement assuming a vehicle intensity of 1200 vehicles/day. The result is shown in the figure 4.

From figure 4 it is found that with the increase in the curing time the total thickness of the pavement reduces by about 50 % thereby reducing the cost of construction.

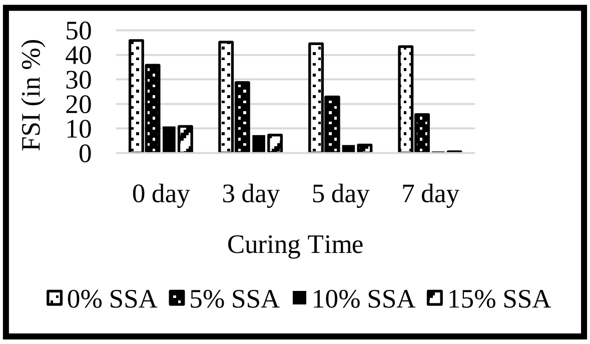

Figure 3. Free Swelling Index versus curing time

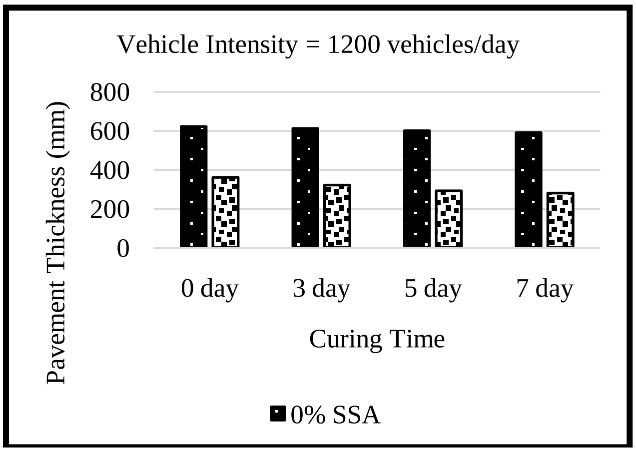

Figure 4. Pavement thickness versus curing time

4. CONCLUSION

Indian soil comprises of large volume of expansive soil. These expansive soil pose a serious threat to the civil engineers. These expansive soils has to be stabilized to minimize the problem faced during construction of roads and buildings. Various techniques are done to stabilize the expansive soils which were found to be very expensive. Hence, cost effective methods are getting more and more popular. These cost effective methods are basically the utilization of the various waste materials like industrial waste, agricultural waste, etc. for stabilization of soil. The utilization of these waste materials not only reduces the cost but also reduces the problem of waste dumping. In this paper, sugarcane straw ash (SSA) is mixed with soil by varying the percentage of SSA and with varying curing periods. The following are the conclusions drawn from this paper:

- With the increase in the curing period, the UCS value increases. The increase of the UCS value is more significant for 10 % addition of SSA.
- The CBR value also increases with the increase in the curing period. The maximum CBR value is obtained for 10 % addition of SSA and decreases with further increase in the percentage of SSA
- The swelling property reduces with the increase in the percentage of SSA and with increasing curing period. The swelling index found to be zero for 10 % addition of SSA.
- The 10 % addition of SSA reduces the thickness of the pavement by 50 % thereby reducing the cost of construction.
- The optimum percentage of sugarcane straw ash (SSA) to be used as soil stabilizer is found to be 10 % having a curing period of 7 days.

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