Stabilisation of Expansive Soil Using Wheat Husk Ash and Sugarcane Straw Ash

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Abstract : Soil is the basic of every civil engineering construction, thus soil plays an important role in every field of civil engineering. In India expansive soil is popularly known as black cotton soil and it is the most problematic soil when it comes to construction. Expansive soil is rich in montmorillonite which causes shrinkage and swelling. Thus it is need for civil engineers to improve the properties and strength of expansive soil. Around 70% of land in India is agricultural land and amount of waste collected from the agricultural land is also more. Thus it is necessary to dispose the waste material occurring from agricultural lands. Some organic waste can be used as stabilizers because of their contents and the properties it holds. Along with it safe disposal of industrial waste also become a basic need. Currently disposal of industrial waste is a big concern, also agricultural waste disposal is also a problem.

In this project a brief research is done in which industrial waste such as sugarcane straw ash (SCSA) and agricultural waste such as wheat husk ash (WHA) both used as soil stabilizers in expansive soil to improve the strength of soil by defusing various percentage of WHA & SCSA such as 3%, 5%, 7%, 9% and 11% and conducting tests such as Atterberg's limit, Standard proctor test, CBR test, UCS test. The main objective of soil stabilization is to increase shear strength and decrease the compressibility of the expansive soil. These tests are experimented and proved by the standard tests IS 2720 and finally concluded that test results improve the geotechnical properties of the soil.

IndexTerms **- California bearing ratio, unconfined compression test, wheat husk ash, sugarcane straw ash.**

I. INTRODUCTION

In civil engineering, soil is defined in various ways. By engineers soil is considered as a complex material obtained by the weathering of rocks. Generation of soil is the result of the geological cycle which is continuously occurring on the Earth. The formation of soil cycle is a series of action such as weathering, transportation, deposition, and upheaval. Soil is naturally occurring, relatively unconsolidated, un cemented, loose, weakly cemented mineral particles which shows characters like organic and inorganic. Soil consist of numerous particles like gravel, rocks, sand, silt, clay, loam, humus.

In the geotechnical engineering, foundation is the lowermost structure which is in direct contact with the soil. In many situations like service road layers, foundation layers construction materials like soil cannot be utilized or used directly as it gives unstable strength. Due to the increasing price of land and tall buildings in huge demand it is necessary to use stabilizers with soil at sites. Thus it has became a basic need to develop the quality soil in long term.

The soil used in this research work is expansive soil which is also called as black cotton soil. This name is given to this soil because production of cotton in this type of soil is highest. Because of swelling and shrinkage nature BC soil is also named as expansive soil. The BC soil is mainly consist of a mineral called as montmorillonite. Montmorillonite absorbs water easily and shows swelling and shrinkage property.

Therefore the BC soil used in this research work is collaborated with industrial waste and agricultural waste namely sugarcane straw ash and wheat husk ash to reduce the effect of particles which are accountable for high percentage of cracks and expansiveness. hence it is harmful and difficult to use soil directly for the purpose of construction. Thus it is must to improve the properties of already present soil and change the a soil which is non expansive in nature. For this industrial waste utilization is based as it solve its dumping problem too. The high cost particles are explore with agricultural and industrial are used to civilize the soil from site having mucilage value and the process used is called as soil stabilization. The utilization of agricultural as well as industrial waste as the stabilizer to soil and considering the main purpose to remold the engineering properties of soil and to make it to give good quality to the lower layer of the road construction.

Road surface should be smooth and unyielding to enable free movement of vehicles. Road is very important for all human. Road pavement should provide good support in all seasons. Road pavement is of two types flexible pavement and rigid pavement. India, being the seventh largest country in the world, it requires a, network of structures and roads to serve its large population. The land available for any construction is very less because of increasing modernization and urbanization. For such type of large structures for road surfaces, a large amount of construction materials like stone aggregates binders, suitable land are required. This will impose heavy pressure on limited resources and therefore, for the continuous development, the use of waste material and locally available materials need to be encouraged so as to save the natural resources for coming generation. Waste material like industrial, building, household, agricultural etc. it includes plastics, glass, recycled aggregate, coal ash, stone quarry, geo-naturals, fibers and polythene bags. Use of the waste material to enhance the strength of sub grade soils is by using any one or composite material of lime, fly ash, coir fiber etc. This will result in decrease in the saving of construction materials and overall thickness of pavement. Literature suggests that in recent times, materials like fly ash, cement, lime have been executively used in the construction of highways and the embankments. From centuries, soil, stones, aggregates, bitumen, sand, cement are usually adopted for construction of road. As the naturally available materials are finite in nature thus their quantity reduces gradually.

1.1 Soil stabilization

Stabilization consist of different methods which are used to change the properties of the soil to develop the performance of soil in preference of engineering. Process of stabilization has been adopted for various engineering works, among them the general application is the construction of air-field pavements and roads, where the primary aim is to improve the stability and strength of

the soil and thus minimize the construction cost by using locally available materials at best. Stabilization of the soil is the process by which the stability and strength of the soil mass is developed and increased.

Generally there are two main types soil stabilization -

- modify or improve existing soil properties without any admixture.
- modify the soil properties of using admixtures.

1.1.1 Mechanical stabilization:- Sand and clay behaves almost opposite to each other and it is possible to obtain the good properties of both by suitably mixing both the soils together. Mechanical stabilization is used in preparing base course of roads.
Mechanical stabilization consist of :-

(a) The grading of the soil particles.
(b) Compacting the soil to improve the stability and strength.

1.1.2 Chemical stabilization:-

(a) reduction of the permeability of soil
(b) improve shear strength
(c) increase bearing capacity

1.2 Scope of the work and Objective

The primary aim of sol stabilization by agricultural waste is to achieve a good bearing capacity of soil by improving its strength, thus to get a desirable development by using industrial as well as agricultural waste and thus reducing the problem of waste disposal.

The basic aim of study is to compare the behavior of BC soil & the geotechnical properties before and after the addition of the soil stabilizers such as SCSA and WHA, there by observing the change in the shear strength, CBR value and consistency of soil. Another objective of the study is to take locally available material as industrial waste & agricultural waste as soil stabilizers. To check the difference in the strength of soil at various water content.

The primary objective of this series study is to increase the quality of soil by using sugarcane straw ash & wheat ash as stabilizers Both the physical & chemical properties of the soil were improved by adding those stabilizer.

In this research the stabilization of BC soil using SCSA & many attempts where made to increase the BC soil strength by using SCSA with many chemical activities. Thus it as observed that the, utilization of SCSA has improved the properties of soil.

II. MATERIALS

2.1 Expansive soil -

Expansive soil is highly expansive, sticky & plastic formed from the weathering action of deposits derived from volcanic rocks. Expansive soil have great affinity towards moisture and it is characterized by swelling and shrinkage. A structure supported on expansive soil under goes vertical movement which in most cases is non uniform leading to sever cracks and even to structural failure of the super structure. Shrinkage means reduction of volume when water content is reduced. Shrinkage produces tensile stresses within the soil leading to wide surface cracks in the soil reaching several meters in depth. On saturation these soils become very weak and unstable and have very low bearing capacities. Black cotton soil are found usually in partly saturated state near the ground surface with water content ranging from 20-40%, in dry condition the soil appears very stiff and show cracks. On saturation these soil soften to a large degree.

2.1.1 Features of expansive soil

• Expansive soil is mainly used for cotton production.
• BC soil is mostly found in Deccan region.
• It is a well-developed soil which has a profile with clearly defined horizons.
• It has high water retaining capacity.
• Swelling and shrinkage are the main characteristics of BC soil.
• BC soil has self ploughing characteristic because BC soil has great capacity to hold the water.
• BC soil is rich in minerals like lime, iron, potassium, calcium, magnesium & aluminum.
•It is deficient in phosphorous, organic matter and phosphorous. It is in deep black to light black colour.
• Texture of BC soil is clayey.

2.1.2 Problems concerned with BC soil

Difference of moisture content in expansive soil, undergoes mainly two types of problems. In any civil engineering structure they are Swelling – because of increase in moisture content, a volume of soil increases and it is referred as swelling. ex- formation of heave shrinkage – because of decrease in the moisture content decreasing the volume of soil is called as shrinkage ex- settlement in the foundation.

2.1.3 Characteristics of black cotton soil :-

Characteristics	Range
Density	1300-1750 kg/m3
Natural water content	20-40%
pH value	9-Aug
Fines	70-100%
Liquid limit	50-120%
Plastic limit	20-60%
Plasticity index	30-60%

Shrinkage index	9-18%
Specific gravity	2.6-2.75
Maximum dry density	1350-1600
Optimum moisture content	20-35%
Free swelling	40-180%
Shear strength	5-15°
CBR value	1.2-4
Compression index	0.2-0.5

2.1.4 The chemical composition of BC soil -

Chemical Composition	Range
Organic content	0.2-0.4%
Calcium carbonate, ($CaCO_3$)	5-15%
Silicon dioxide, (SiO_2)	50-55%
Aluminum oxide, (Al_20_3)	3-5%
Montmorillonite	30-50%

2.2 Sugarcane straw ash

Generally sugarcane is utilizes to make sugar by collecting juice from the sugarcane. This process is done by many mills and industries. As there is huge production of sugar because of its daily need and demand, waste generated from the sugar mills and industries is also more. Thus disposal of this waste is big problem. From the crushed sugarcane generally 30% bagasse is produced. As the bagasse contain many fibrous material, some researchers uses it as a stabilizer in the soil. Due to the presence of fibrous material, shear strength of BC soil is increased by reducing void ratio of the soil.

In the manufacturing process of sugar in sugar mills and industries an organic waste is produced generally known as sugarcane straw. For the production of crops, sugarcane straw is used as an organic fertilizer. SCSA contains micronutrients such as Cu, Mn, Zn and Fe. Because of the nutrients and their properties SCSA is used as stabilizer in the soil. In general, soil does not possess enough geotechnical properties in its natural form. So as to make the less productive soil useful and to meet the geotechnical design criteria, researchers are now focusing more on how to use the low cost material which are locally available at various agricultural fields and industries so as to enhance weak soil properties and thus to reduce the total construction cost of project.

2.2.1 Sugarcane straw ash has following chemical composition as follows

Compound of SCSA	Value in %
SiO_2	70.2
Al_2O_3	1.93
Fe_2O_3	2.09
CaO	12.2
MgO	1.95
K_2O	3.05
NaO	----

2.2.2 Steps of sugarcane to sugarcane straw ash

2.3 Wheat husk ash (W

The ash collec… process wheat husk is burned in un- controlling burning atmosphere. Materials such as vague silica, luculent silica, remains of carbon and un- burned husk present in the ash formed after the calcination process.

The ash collected from the wheat husk has some good pozzolanic properties. It comes under cementitious material, as it is aluminous or siliceous material which has either small amount or no cementitious value but when ash is in powdered form, it reacts chemically with calcium hydroxide when there is some moisture at ordinary temperature to make compounds which has some cementitious properties. Due to its properties, wheat husk ash is used for many applications. Wheat husk ash possess high calorific value of 3.5 KCal/g. Generally the outgrowth of WHA is present in agricultural field, thus after the extraction of grain, farmers burn this waste product.

In this research project, how the wheat husk ash affect the soil is analyzed. From the nearby agricultural field wheat husk is collected and then to make it into fine ash, it is burned at 600°C. Presence of silica makes the soil more fertile and because WHA has a good amount of silica, it is used as a stabilizing material. The waste material collected after the burning process of crop waste when wheat is processed from paddy. Generally 20-25% of wheat husk is produced from paddy. And after burning process almost

25% husk becomes ash. The nature of wheat husk ash is non-plastic. As the burning temperature changes, the properties of WHA also changes.

2.3.1 Chemical properties of wheat husk ash as follows:-

Compounds in WHA	Value in %
SiO_2	43.22
K_{2O}	11.3
MgO	0.99
Fe_2O_3	0.84
Na_2O	0.16
Cr_2O_3	0.0004
CaO	5.46
MnO_2	0.02

III. EXPERIMENTAL RESULTS AND DISCUSSION

3.1 Atterberg's Limit

Wet soil has ability to mould in any shape is called as plasticity of soil. This ability of soil is due to clay minerals present in it. So that when soil is in wet condition it is attracted towards water molecules. thus we can say that this plasticity is obtained by absorbed water. In Atterberg's limit tests shows the soil has plasticity & clay minerals are also present in it & has suitability for enhancement. In this research, plastic limit test is carried out for various percentage of WHA and SCSA using casagrande's apparatus. Observation table is as follow:

Table 3.1 Atterberg's limit of BC soil with SCSA and WHA

Percentage of addition (%)	Expansive soil & different percentage of SCSA and WHA		
	Liquid limit	Plastic limit	Plasticity index
0	54	21.45	32.55
3	35	19.65	15.35
5	38	20.77	17.23
7	40	21.64	18.36
9	28	20.95	7.05
11	30	20	10

Fig 3.1 Plastic limit v/s Liquid limit

3.2 Standard Proctor Test

Standard proctor test is performed to find out the correlation between optimum moisture content and maximum dry density. Enhancement in MMD was seen at 3%, 5% and 7% including addition of SCSA &WHA but with further increase in SCSA& WHA maximum dry density decreases. The decrease in OMC is due to specific gravity of SCSA which replaces higher specific gravity of BC soil because its fibrous nature. Observation table is as follows:

Table 3.2 MDD & OMC using different percentage of SCSA and WHA

Percentage of addition (%)	Expansive soil		Expansive soil & SCSA & WHA	
	MDD (g/cc)	OMC (%)	MDD (g/cc)	OMC (%)
0	1.405	21.60%	---	---
3	--	--	1.218	30.76
5	--	--	1.323	29.73
7	--	--	1.476	26.15
9	--	--	1.298	23.61
11	--	--	1.226	20.59

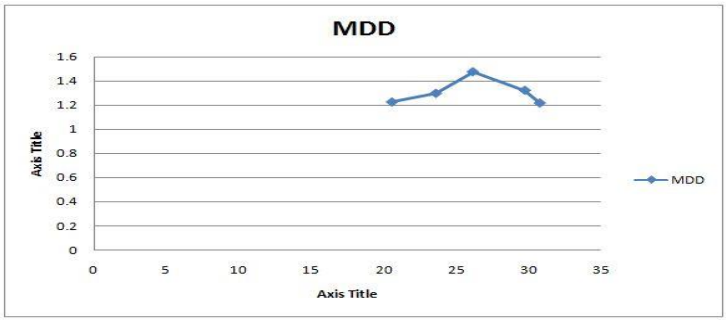

Fig. 3.2 Compaction curve

3.3 California Bearing Ratio (CBR) test

Bearing capacity and shear strength of soil are derived from CBR value. For the calculation of CBR test two types of tests are conducted. Soaked soil sample is taken to give improved CBR value. Observation table is as follows:

Table 3.3 : Effect of soaked SCSA and WHA on CBR value

Percentage of addition (%)	Expansive soil + various percent of WHA & SCSA CBR value soaked
3	13.47
5	17.28
7	29.63
9	25.12
11	21.25

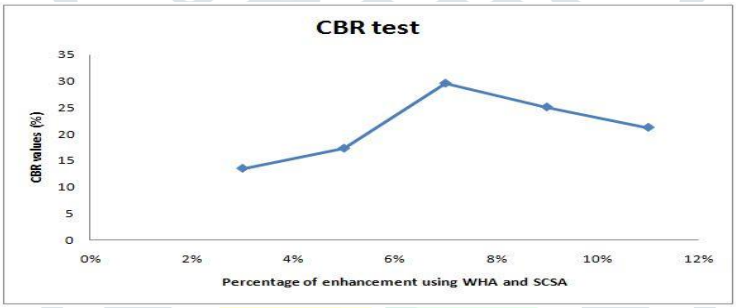

Fig. 3.3 CBR test

3.4 Unconfined compressive strength

To determine the undrained shear strength, compressive strength test was performed. The soil sample is prepared as per the requirement. Wheat husk ash and sugarcane straw ash was added with soil for improvement of quality of the soil. Maximum strength was observed at 7% was about 356.15. Observation table is as follows :

Table 3.4 : UCS test with different perentage of SCSA and WHA

Percentage of Addition (%)	Expansive soil & various percentage of WHA and SCSA UCS values
3	288.07
5	298.54
7	356.15
9	265.09
11	234.11

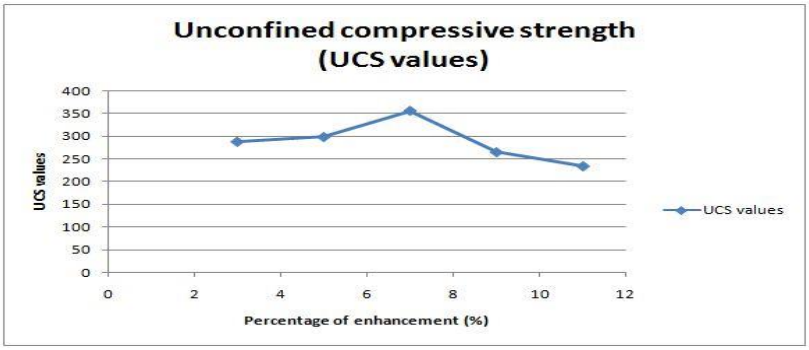

Fig. 3.4 UCS test

IV. CONCLUSION

This study shows that using various percentage of SCSA & WHA, expansive soil shows more accurate results compared to individual addition of stabilizers to the BC soil. After adding stabilizers to experimentation it was cleared that for the infra structure development and pavement structuring the BC soil can be used successfully. Based on results and observation made in this research following conclusions are made. Because of the fibrous nature of expansive soil, the collected soil has less specific gravity. The mixing of different percentages of SCSA and WHA gives increasing values of maximum dry density (MDD) for the 3%, 5% and 7% and further in proportion of both ashes, there is decrease in MDD because of stiffness of the soil. At 7%, OMC

was achieved and after adding stabilizer soil shows decrease in OMC. The OMC achieved at 7% is used in various projects as index. The Atterberg's limits of BC soil gives that, obtained BC soil has highly plasticity in nature because it shows plasticity index more than 20. The addition of both the ashes at 7% to black cotton soil, gives clayey nature as its plasticity index lies between 15-100. Thus this mixture of expansive soil with WHA and SCSA is useful for pavement purposes.

For the construction of sub base material for building many engineers and researchers use CBR value broadly. CBR value is mainly used to know the shear strength and bearing capacity of the soil. The test results shows maximum value at 7% enhancement of WHA and SCSA then further decline. The reduction in value is basically due to variation in OMC which affect the decrease in CBR value. To find the shear strength of soil, UCS test was conducted. Test results shows that there is gradual increase in strength when ashes are added and highest value is achieved at 7%. After that it shows decrease in value with further addition of ashes.

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