Mitigating the Problems Associated with Construction in Expansive Soils using Bagasse Ash and Waste Plastic

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Abstract- *Analysis and assessment of expansive soils is of utmost importance while founding the structures, as these soils undergo large volumetric changes even due to small fluctuations in water content. The volumetric changes are very large in magnitude and they are responsible for distress to structures. The amount of damage caused by expansive soils is alarming. Hence an economical, effective and sustainable technique of mitigating the problems was initiated in this study to assess the efficacy of agriculture waste material like bagasse ash and an equally cheap binder in different combinations blended to expansive soils. Also plastic wastes have become one of the major problems for the world. The harmful gas which is being produced by this agent leads to tremendous health related problems. So, effective engineering implementation of this has become one of the challenging jobs for engineers. This study also chose to ascertain that plastic wastes can be used in stabilization of problematic soil along with another locally available waste i.e. Bagasse Ash. A series of tests will be done on expansive soil – bagasse ash – lime – waste plastic with varying percentages of the chosen materials for stabilization. The results yielded at the utilization of bagasse ash and waste plastic have solved the problem of construction in expansive soil to major extent parley giving a sustainable solution for waste disposal.*

Keywords- Expansive soil, Bagasse ash, Lime, Shredded Waste Plastic, Stabilization

I. INTRODUCTION

Expansive soils are residual soils left at the place of their formation after chemical decomposition of rock groups like basalt and trap and those that experience significant volume changes associated with changes in water contents. It expands when water is added and shrinks when they dry out. An expansive soil expands due to the presence of highly reactive clay minerals such as Montmorillonite, Illite etc. This continuous change in soil volume can cause light structure built on this soil to move unevenly and crack. This damage is more than twice the damage from floods, hurricanes, tornadoes, and earthquakes and combined (Jones and Holtz,1973).

Expansive soil, also called shrink-swell soil is a very common cause of foundation problems. The expansion potential of any particular expansive soil is determined by the percentage of clay and the type of clay in the soil. During periods when the moisture in the expansive soil is being removed, either by gravitational forces or by evaporation, the water between the clay sheets is released, causing the overall volume of the soil to decrease or shrink. As the moisture is removed from the soil, the shrinking soil can develop gross features such as voids or desiccation crack. These shrinkage cracks can be readily observed on the surface of bare soils and provide an important indication of expansive soil activity at the property.

India is the second largest sugar producing country in the world. It has 20% of the total sugar industry in the world and accounts for about 15% of the global production (Solomon 2011). Bagasse is one of the prominent wastes produced during the manufacture of sugar. It is a fibrous matter remained after extraction of juice from sugar cane. Sugar industry in India produces about 90 MT of bagasse per year (Pappu et al. 2007). The bagasse is used as a fuel in the same sugar industry for generation of steam and electricity. The ash produced in this process is called as bagasse ash which possesses the properties of a pozzolanic material (Janjaturaphan and Wansom, 2010; Paya et al.; 2002). Bagasse ash and lime sludge are disposed unscientifically which not only takes a lot of valuable space near to the industry for their disposal but also create a lot of geo-environmental problems.

The positive effects of addition of industrial wastes like fly ash, rice husk ash, ground granulated blast furnace slag, cement kiln dust etc. to expansive soil with and without a binder Pandian and Krishna,2003;Nalbantoglu, 2004;Misra et al.2005;Sharma et al.,2008; Cokca et al.,2009 ; Srivastava et al. (1997) had studied the microstructure and fabric of fly ash and lime sludge stabilized expansive soil through SEM analysis. Osinubi and Thomas (2007) had studied the influence of three compactive efforts on strength properties of bagasse ash treated black cotton soil. Osinubi et al. (2009) had also studied the effect of bagasse ash on different engineering

properties lime stabilized expansive soil. Ijimidiya and Osinubi (2011) had studied the attenuative capacity of compacted black cotton soil treated with bagasse ash.

II. METHODOLOGY

Expansive Soil

The Clay that has been used in this study was a typical BC soil collected from Odalarevu near Amalapuram, East Godavari District. The soil used for the investigation was dried, pulverized and then sieved through 4.75mm size sieve. The properties of black cotton soil experimented, based on relevant I.S. code provisions are given in the Table 1 below.

Table -1: Physical properties of Black Cotton Soil

S.No	PROPERTIES	VALUE
1	Specific gravity	2.63
2	Differential free swell (%)	160
3	**Atterberg limits** Liquid limit (%) Plastic limit (%) Plasticity index (%)	 83.6 33.8 49.8
4	IS soil classification	CH
5	O.M.C. (%) M.D.D. (g/cc)	30.4 1.5
6	Un soaked C.B.R (%)	1.98
7	Soaked C.B.R (%)	0.7
8	Cohesion (C_u), (kpa) Angle of internal friction ($Ø_u$).(degrees)	52 0

Bagasse Ash

Bagasse is a residue obtained from the burning of bagasse in sugar producing factories. Bagasse is the cellular fibrous waste product after the extraction of the sugar juice from cane mills. It is currently used as a bio fuel and in the manufacture of pulp and paper products and building materials. For each 10 tons of sugarcane crushed, a sugar factory produces nearly 3 tons of wet bagasse which is a by-product of the sugar cane industry. When this bagasse is burnt the resultant ash is bagasse ash. Western Maharashtra is having maximum number of sugar factories, these factories faces a disposal problem of large quantity bagasse. The effective utilization of these waste products is a challenging task for a researcher through economical and environmental impact. This material contains amorphous silica which is indication of cementing properties, which can develop good bonding between soil grains in case of weak soil.

Lime

The Commercial Birla lime taken from market for the purpose of Stabilizing Soil, Which imparts cementing property to the soil mix. It is a white amorphous solid, high melting point of 2600^{o}C and highly stable even fusion cannot decompose it.

Plastic Material

The plastic bags were sourced from a local supermarket and shredded into strips of varying lengths and widths using a laser cutting machine. The bags were labeled as high density polyethylene (HDPE) according to the plastics identification code by the American Society of the Plastics Industry (SPI). The density was measured as 743 kg/m3 with an average thickness of 40 μm and a tensile modulus of 389.7MPa. The tensile strength obtained for the plastic material varied between 15 MPa and 20 MPa. Both the solid strips and perforated strips were included in the testing regime. For perforated strips, the laser cutting machine was used to make perforations of different diameters on the strips.

III. RESULTS AND DISCUSSIONS

In the laboratory, various experiments were conducted by replacing different percentages of Baggasse Ash (BA)in the expansive soil and also further stabilizing it with lime as a binder. Compaction, Strength and CBR tests were conducted with a view to determine the optimum combination of Baggasse Ash (BA) as replacement in expansive soil ,with the inclusion of Waste Plastic and Lime as a binder. The influence of the above said materials on the Compaction and Strength characteristics were discussed in following sections. In the laboratory, all the tests were conducted per IS codes of practice.

Effect of % Baggasse Ash Replacement on the Strength Characteristics of Expansive Soil

The percentage of Baggasse Ash (BA) was varied from 0% to 30% with an increment of 10% .From the above graphs, it was observed that the treatment as individually with 20%BA has moderately improved the expansive soil. It can be inferred from the graphs, that there is a gradual increase in maximum dry density with an increment in the % replacement

of BA up to 20% with an improvement of about 2% and it was about 25% for strength characteristics. The addition of BA had mobilized little amount of friction to the pure Clayey soil without friction.

Table -2: Table showing the results of the tests conducted on Expansive soil replaced with different % of Baggasse Ash

E.S + B.A	MDD	OMC	DFS
100+0	1.50	30.4	160
90+10	1.51	31.2	141
80+20	1.52	31.8	114
70+30	1.51	32.7	87

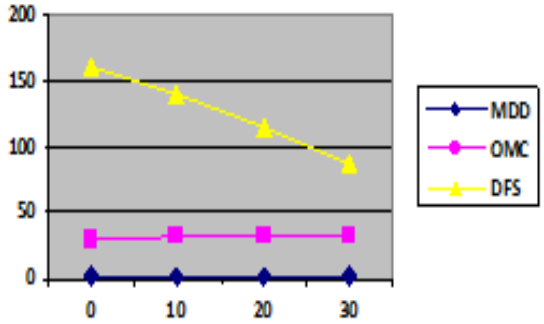

Chart -1: Plot showing the variation of Various Properties with % of Baggasse Ash as replacement in Expansive soil

Effect of Waste Plastic Strips on the Strength Characteristics of Expansive Soil + Baggasse Ash Mixes

The influence of Waste Plastic on the Compaction and Strength characteristics of expansive soil + Baggasse Ash (BA) mixes are clearly presented for different percentages of Waste Plastic respectively. The percentage of Waste Plastic was varied from 0%, to 2% with an increment of 0.5%.In the laboratory, tests were conducted by blending different percentages of waste plastic to expansive soil + Baggasse Ash (BA) mixes with a view to determine its optimum blend. It is observed from the graphs, that there is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the waste plastic content from 0% to 2% with an improvement of 126% for cohesion, 8 times for friction angle and about 3 times for soaked CBR respectively.

Table-3 Above Table showing the results of the tests conducted on Optimum Mix of Expansive soil, Baggasse Ash stabilized with Waste Plastic

80+20 +Waste Plastic	OMC	MDD	C	Ø	UN Soaked	Soaked
0	31.8	1.52	58	1^0	2.20	0.87
0.5	31.7	1.53	59	3^0	2.82	1.06
1	31.6	1.54	68	6^0	3.35	1.40
1.5	31.4	1.53	67	5^0	3.18	1.32
2	30.9	1.52	60	4^0	3.02	1.26

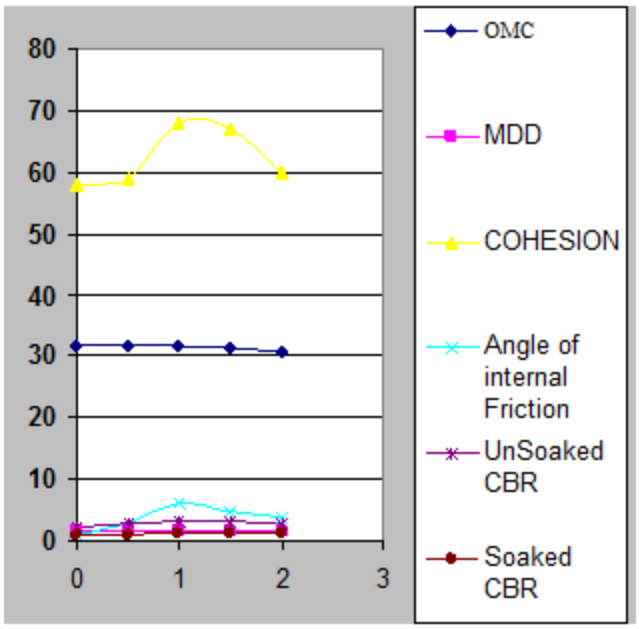

Chart -2: Plot showing the variation of Various Properties with Optimum Mix of Expansive soil, Baggasse Ash stabilized with Waste Plastic

Effect of Lime Content on the strength Characteristics of expansive Soil + Baggasse ash + Waste Plastic Mixes

The percentage of Lime was varied from 0%, to 6% with an increment of 3%.In the laboratory, tests were conducted by blending different percentages of lime to expansive soil + Baggasse Ash (BA)+ Waste Plastic mixes with a view to determine its optimum blend. It is observed from the graphs, that there is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the lime content from 0% to 6% with an improvement of 126% for cohesion, 8 times for friction angle and about 3 times for soaked CBR respectively. From the

above results it is evident that the addition of lime to the BA–Expansive soil mix had improved its Compaction and Strength characteristics.

Finally from the above discussions, it is clear that there is improvement in the behavior of Expansive soil stabilized with Baggasse Ash (BA) + Waste Plastic + lime. It is evident that the addition of Baggasse Ash (BA) and Waste Plastic to the virgin Expansive soil showed an improvement in Compaction and Strength characteristics to some extent and on further blending it with lime, the improvement was more pronounced. This made the problematic expansive soil which if not stabilized is a discarded material, a useful fill material with better properties. The Baggasse Ash (BA) and Waste Plastic replacement in the expansive soil has improved its strength and upon further blending with lime, the strength has further improved and also these materials has imparted friction to the clayey soil. It can be summarized that the materials Bagggasse Ash (BA) ,Waste Plastic and lime had shown promising influence on the Strength and Penetration properties of expansive soil, thereby giving a two-fold advantage in improving problematic expansive soil and also solving a problem of waste disposal.

Table-4 Above Table showing the results of the tests conducted on Optimum Mix of Expansive soil, Baggasse Ash and Waste Plastic stabilized with Lime.

BG + ES + WP + Lime	OMC	MDD	C	Ø	Un Soaked	Soaked
0	31.6	1.54	68	6^0	3.35	1.40
3	31.6	1.56	79	6^0	4.81	1.96
6	30.9	1.58	88	7^0	5.80	4.12

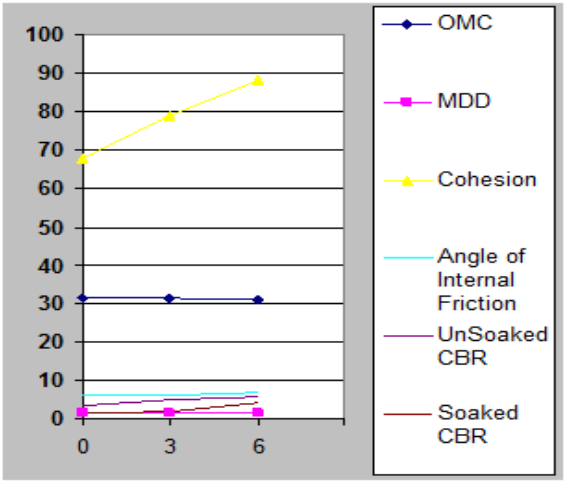

Chart -3: Plot showing the variation of Various Properties with Optimum Mix of Expansive soil, Baggasse Ash and Waste Plastic stabilized with Lime

III. CONCLUSIONS

- From the laboratory studies, it is observed that the Expansive Soil chosen was a problematic soil having high swelling, and high plasticity characteristics.
- It was observed that the treatment as individually with 20% BA has moderately improved the expansive soil.
- There is a gradual increase in maximum dry density with an increment in the % replacement of BA up to 20% with an improvement of about 2% and it was about 25% for strength characteristics.
- There is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the Waste Plastic strips from 0% to 2% with an improvement of 126% for cohesion, 8 times for friction angle and about 3 times for soaked CBR respectively.
- There is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the lime content from 0% to 6% with an improvement of 126% for cohesion, 8 times for friction angle and about 3 times for soaked CBR respectively.
- It is evident that the addition of Baggasse Ash (BA) to the virgin Expansive soil showed an improvement in compaction, strength and penetration characteristics to some extent and on further blending it with lime, the strength mobilization was more pronounced**.**
- Finally it can be summarized that the materials Baggasse Ash (BA) ,Waste Plastic and lime had shown promising influence on the strength characteristics of expansive soil, thereby giving a two-fold advantage in improving problematic expansive soil and also solving a problem of waste disposal.

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