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Effect of Waste Paper Sludge Ash on Engineering Behaviors of Black Cotton Soils

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Abstract: In this paper present investigation is to assess the usefulness of industrial waste as a soil admixture, and focused to improve the compressive strength of the black cotton soil. Waste paper sludge ash (WPSA) is waste product from the Paper mill industries. The WPSA can produce a cementitious material because WPSA contains a large amount of CaO while it is pozzolanic material. WPSA is incinerated from waste paper sludge. In this present study the soil sampling was done on 2 different sites as per IRC recommendations. The soils were classified as CH as per Indian Standard Classification System. Different percentages of waste paper sludge ash i.e. 4%, 6%, 8%, 10 and 12% were used to stabilize the black cotton soil. The soil was evaluated using physical and strength performance tests such as specific gravity, plasticity index, compaction, California bearing ratio (CBR) and unconfined compressive strength test (UCS). From the results it is observed that at the optimum percentage of 8% WPSA shows improvement in unconfined compressive strength (UCS) from 165 KN/m^2 to 417.5 KN/m^2 and 138 KN/m^2 to 349.5 KN/m^2 for soil samples 1 and 2 respectively. Furthermore California bearing ratio (CBR) values improved from 5.1 % to 26.4 % and 3.8 % to 18.6 % for soil samples 1 and 2 respectively.

Keywords: *Waste paper Sludge Ash, Soil Stabilization, Unconfined compressive strength, California bearing ratio*

1. Introduction

Urbanization and industrial developments to be concentrate on construction techniques of highways, railways, airports and residential buildings in India. For these constructions should need good soil conditions for foundation techniques and embankments and pavements. The expansive soils are problematic soil for construction and expansive soils are most commonly available in most of the places in India. Especially expansive soils are mainly undergoes swelling and shrinkage problems when water content changes in that soil. Due to high swelling and shrinkage issues pose big problems to the buildings and structures. Stabilization on expansive soil using admixtures is a good solution for the swelling and shrinkage issues. Stabilization controls the swelling and shrinkage effects on foundation and structures. Laboratory work carried by adding admixture WPSA to the black cotton soils at various dosages for this experimental study.

The shear strength of the soil possesses both cohesion and internal friction. Compaction gives strength to the soil increasing the load bearing capacity and factor of safety to soil becomes stable. Chemically modified the soil by adding lime, cement, flyash and lime-pozzolana mixes were used effectively. Waste Paper Sludge Ash is a waste by-product from paper mill industries, which produce paper. It is estimated that about millions of tons of WPSA is being produced from different paper industries in India consuming health issues and environmental hazards. In this way WPSA to use as stabilization material to constructs the embankments and roads.

Neva Elias (2015) presented the effect of waste paper sludge on plasticity, free swell index, compaction, unconfined compressive strength and CBR in soft clayey soil. Compressive strength was increased by adding 5% WPS about 314 KN/m^2 to 496KN/m^2 and 284 KN/m^2 to 590 KN/m^2 of 7 days 28 days curing period respectively. Furthermore UCS values increased 107.9% by using 5% of WPS in 28 days curing.

Dilip Kumar Talukdar et al. (2015) examined the effect of Waste Paper Sludge in three different Clay soil. The study includes Atterberg limits, the compaction, and swelling properties of three types of expansive soils. Compaction Characteristics, Strength Characteristics and CBR values were analysed for soil treated with (0%,5%,10%,15%) of Waste paper sludge and Decrease in plasticity index, maximum dry density, and increase in OMC, CBR values were observed in Soil treated with Lime Sludge. It increases the CBR values with addition of lime mud in all types of soil samples. At 15%addition of lime sludge, the increase in CBR is 19.76% for S1 for soil S2 and S3 the increase is 23.90% and 9.33% respectively.

Norazlan K et.al (2012) presented the effect of WPSA on unconfined compressive strength and California bearing ratio of sandy clay soil. WPSA consist of 62.39% CaO, 23.25% of SiO_2 and 5.26% of Al_2O_3. It

is concluded that increase in WPSA content improves unconfined compressive strength content about 2 times by the addition of 10% WPSA. The addition of 10% WPSA were increased the CBR value about 1.5times in unsoaked condition and 3.6 times in soaked condition compared with untreated soil sample.

Anupam et.al (2010) studied the efficiency of FA, RHA, and BA in increasing the load bearing capacity of medium compressible clay soil underlying a road to be constructed. The admixtures were mixed with the soil at 5 percent equal intervals up to 35% replacing the soil by part. Shrinkage limit, OMC and CBR increased and MDD decreased with addition of these admixtures and cured for 3-28 days. The author concluded that RHA was a more efficient admixture to stabilise expansive soil than BA and FA and suggested to perform intensive laboratory study to validate the results.

However, these techniques are successful only to a partial extent and hence the attempts to devise better techniques are still going on. In the present work an attempt is made using WPSA for the two expansive soils collected from Salem and Ariyalur in Tamilnadu. The compressive strength characteristics of two expensive soils are presented and discussed. Also, the characteristics like liquid limit, plastic limit, and compaction characteristics obtained for heavy compaction such as OMC and MDD are presented and discussed. The CBR results under soaked condition unsoaked condition with different curing periods also presented.

1.1. Soil Samples

Tests on two different soil samples are conducted in this paper. The strength characteristics of two soil samples are determined by various tests. Soil sample 1 is collected from Periyanayakkanpalayam village, Coimbatore, Tamilnadu and the soil sample 2collected from village Ariyalur, Tamilnadu.

1.2. Admixtures

Waste Paper Sludge Ash (WPSA) is the admixtures used to stabilize the soil in this paper. WPSA is obtained Waste paper sludge from Paper industry. Waste Paper sludge ash (WPSA) is incinerated from Waste paper sludge. The WPSA in this project is collected form SPB Paper Mill, Erode. And WPSA is incinerated in sewage plant Ambathur.

1.3. Methodology

The proportions of Waste Paper Sludge Ash used along with the soils in the study are 4%, 6%, 8%, 10% and 12% with different curing periods. The following tests were conducted on the soil samples mixed at different proportions of WPSA the liquid limit and plastic limit tests were conducted as per IS: 2720 (Part 5)- 1985. Heavy compaction test was carried out according to IS: 2720 (Part 8)- 1983. Unconfined compressive strength tests were conducted at OMC and MDD as per IS: 2720 (Part 10)- 1991. The California Bearing Ratio tests were conducted as per IS: 2720 (Part 16)- 1987.

1.4. Experimental investigation

Most of stabilization has to be undertaken in black cotton soils in order to achieve desirable engineering properties. The following basics properties (Atterberg's limit, compaction, UCC, CBR) of soil sample were investigated has been obtained from the campus of SRM University Kattangulathur. The results of the experiments conducted to determine the basic properties of soil samples 1 & 2 were tabulated in Table 1.

Table 1: *Physical properties of the soils used in the study*

Properties		Results	
		Soil 1	**Soil 2**
Specific gravity (%)		2.83	2.75
Free swell test (%)		70	55
Liquid limit (%)		57	67.5
Plastic limit (%)		26.5	31
Plasticity index (%)		30.5	36
Shrinkage limit (%)		11.5	14
Maximum dry density (g/cc)		1.63	1.8
Optimum moisture content (%)		18	14
UCS value (KN/m^2)		165	138
CBR value (%)		5.19	3.6
Grain size distribution	Sand (%)	16	22
	Silt (%)	20.16	21.84
	Clay (%)	63.84	56.16
Soil classification		CH	CH

2. Results and discussions

IS heavy compaction, unconfined compressive strength, unsoaked CBR tests were conducted with different percentages of Waste Paper Sludge Ash as admixtures in expansive soil for finding optimum percentage of additives.

2.1. Compaction characteristics

The variations of compaction characteristics such as OMC and MDD for the expansive clay treated with WPSA are presented in the Figures 1 & 2. From the figures, it can be seen that there is increases in OMC and decreases in MDD values with increase in percentage of WPSA. It is also observed that the clay samples when replaced with 8% of WPSA yielded MDD of 1.54 g/cc at OMC of 21.5% and MDD of 1.75 g/cc at OMC of 17.5% for soil samples 1 & 2 respectively.

2.2. Unconfined compressive strength

The unconfined compressive strength tests were conducted on the optimum from standard compaction. The size of the samples prepared was 38 mm diameter and 76 mm length. The variations of UCS for all samples are presented in Figures 3 and 4. It can be

seen that the UCS of the clay samples have increased with the percentage of WPSA with different curing periods of 3 days, 7 days,14 days and 28 days. The UCS values at 8% addition of WPSA to clay were 417.6 KN/m^2 and 349.5 KN/m^2 for soil samples 1 and 2 respectively at 28 days of curing. As compared to the untreated soil, the percentage increases in UCS at 8% addition of WPSA is 2.53 times and 2.5 times for soil sample 1 and 2 respectively. Thought the increase in strength is marginal with the addition of WPSA, there is a good control over the plasticity characteristics of clay. The curing results represent the continuous pozzalonic reaction occurred due to the lime content present in the Waste paper sludge ash.

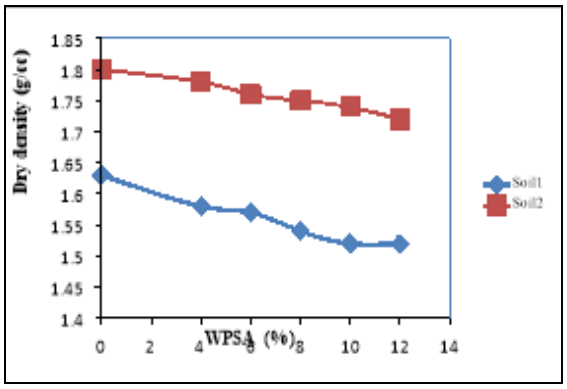

Figure 1 *Influence of WPSA on MDD for Soil sample 1 and 2*

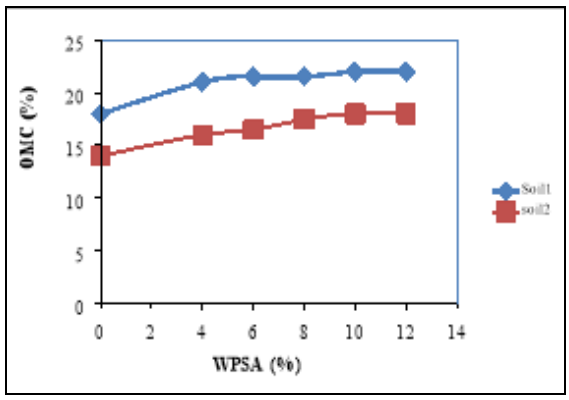

Figure 2 *Influence of WPSA on OMC for Soil sample 1 and 2*

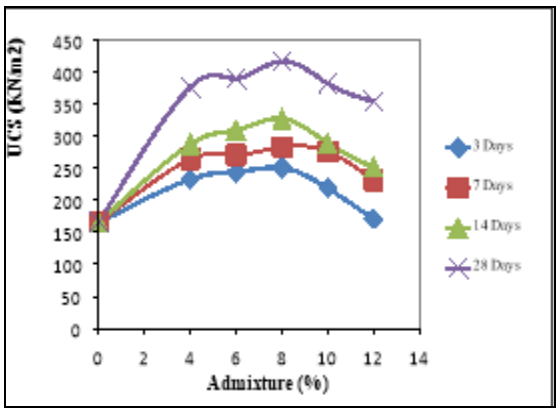

Figure 3.*Influence of WPSA on UCS for Soil 1*

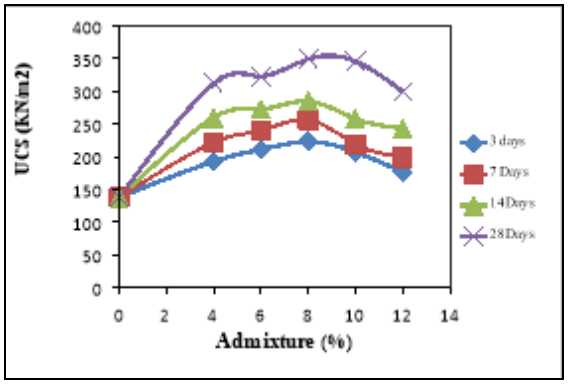

Figure 4 *Influence of WPSA on UCS for Soil 2*

2.3. California Bearing Ratio

CBR test results of WPSA treated soils are presented in Figures 5 and 6. From this plot, it is observed that as the percentage admixture such as WPSA increases, the CBR also increase is found at 8% of WPSA with different curing periods of 3 days, 7 days and 14days. The range increase in CBR corresponding to 8% WPSA addition to the soil are 5 times of both soil sample 1 and 2 respectively.

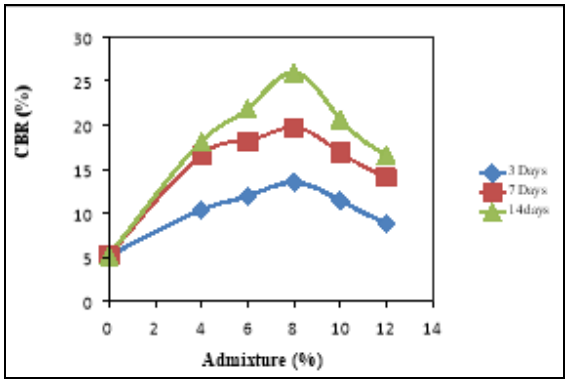

Figure 5 *Influence of WPSA on CBR for Soil 1*

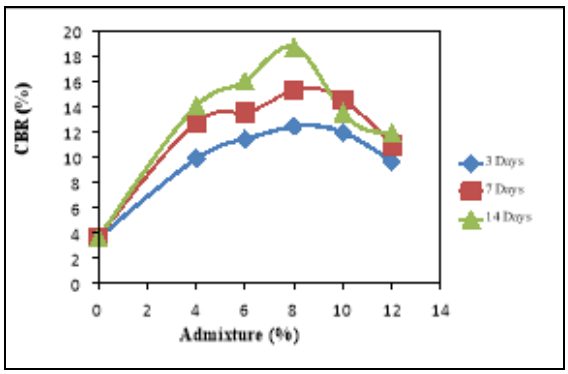

Figure 6 *Influence of WPSA on CBR for Soil 2*

3. Conclusion

The following conclusions were can be drawn from the experimental work carried out investigation for soil sample 1 and 2. Waste Paper Sludge Ash has a very high CaO content. It can be used alone to improve problematic clayey soils that contains high levels of natural pozzolanic material.

When Waste Paper Sludge ash is added to the Black cotton soils Unconfined compressive strength and California bearing ratio values have increased.The suitable percentage of WPSA were found to be for 8% to stabilize the clay of highly compressibility the compressive strength of virgin soil is 165 KN/m^2 increases to 417.6 KN/m^2 for soil sample 1 and compressive strength of treated soil sample 1 is increased up to 2.53 times compared with untreated soil sample 1. And the compressive strength of virgin soil is 138 KN/m^2 increases to 349.5 KN/m^2 for soil samples 2 and compared with untreated soil samples the treated soil samples were increased up to 2.5 times of unconfined compressive strength treated with WPSA.

The addition of 8% WPSA was increases the strength unsoaked CBR values improved from 5.19 % to 25.98 % for soil sample 1 and the strength increased up to 5 times compared with untreated soil sample 1. And unsoaked CBR values improved from 3.6 % to 18.6 % for soil samples 2 and the strength increased up to 5.23 times of CBR values treated with WPSA for soil samples 2.

This WPSA can be used as additive without adding any other additives for stabilization. The use of WPSA as additives contributes good alternate additive for cement and lime.It will reduce the construction cost and solve disposal problems and tends to be an eco-friendly stabilization method.

4. Acknowledgements

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