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Study on Strength Characteristics of Soil with Agro Waste

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Abstract

Background/Objectives: Soil stabilization is one of the methods used when the given site conditions does not have desirable strength characteristics to support structures, railways and roads. It is the process for improving the soil properties by methods of mechanical or chemical, to produce an soil material which has all the required engineering properties. Application of solid waste disposal (Industrial or Agro waste) for soil stabilization is a significant which serves various benefits to the environment. **Methods/Statistical Analysis:** In this study the properties of weak soil is improved with the addition of Rice Husk Ash (RHA) of varying percentages of 3, 6, 9 and 12%. The sample was compacted at maximum dry density with the addition of OMC. A series of laboratory experiment has been conducted on expansive soil blended with Rice Husk Ash in 3%, 6%, 9%, 12% and 15% by weight of dry soil. **Findings:** Unconfined compressive and CBR values of soil increased with the addition of rice husk ash. From the UCC test result, showing that the percentage increase in UCS is 242% and the decrease in swell value from 75 to 45 for the addition of 12% RHA. The study giving the most relevant results by addition of Rice Husk Ash (RHA) upto12% in soil sample. Variations in mineralogical composition analysed by SEM and XRD studies clearly indicate the variation in soil structure formation, due to the chemical reactions initiated by the agro waste mixed in soil. **Application/ Improvement:** The Rice Husk Ash has a potential to improve the strength characteristics of expansive soil and it reduces the swelling potential of soil. Use of RHA in soil stabilisation is economic; eco friendly and it also solve the disposal problem.

Keywords: Agro Waste, Free Swell, Rice Husk Ash , UCS

1. Introduction

For any foundation structures, the soil around it plays a very critical role to provide a strong support. The sub grade soils show different properties and its factors which affect their behavior is varying place to place. Among the soils, to work with problematic soils, needs more attention to make it proper for construction activities. Many techniques are there to improve the soil suitability, some of which were so effective in soils which are mainly depending on the types of structure which are planned to construct over the field. The soil stabilization with the use of chemical additives[1–7] renders the soils capability required for the specific engineering projects. Now the researchers have more focused on the use of potentially cost effective and locally available waste materials from industries[8–12] and agricultural[13,14] fields to improve the properties of deficient soils to minimize the cost of construction and also suggests an alternative method for its disposal effects. The utilization of industrial waste materials as stabilizing agent proved a satisfactory solution, for minimising the problems associated with the soils. In this study agricultural waste, Rice Husk Ash (RHA) was used as a pozzolanic material for stabilizing the expansive clayey soils. The sustainability of stabilized clays were analysed by conducted studies on the strength characteristics as well as Microstructural changes influenced due to the treatment.

2. Material Properties

The present investigation have been made on the soil obtained from Chennai in Tami Nadu, India at a depth

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of 0.6 m to 1.1 m. The soil lumps were broken in to small pieces, dried, pulverized and passed through IS 425 micron sieve before being used in this investigation[15]. The various tests carried out on the virgin soils in the laboratory for obtaining geotechnical properties in accordance with Bureau of Indian Standards (BIS)[16–20] include: Sieve analysis, specific gravity, Atterberg's limits, free swell index, Proctor compaction and Unconfined compressive strength test and it is given in Table 1. Based on the test results of grain size analysis and Atterberg's limit the soil is classified as high compressible clays (CH) as per IS soil classification system[21]. Well burnt Rice Husk Ash (RHA) passing through IS 425 micron sieve was the soil stabilizer used for the stabilization in this work. The chemical composition of obtained for raw soil and rice husk ash is given in Table 2.

3. Experimental Study

In this Experimental study, the clay sample is mixed with different percentages of RHA (i.e., 3, 6, 9, 12 and 15 %) by weight of dry soil. The constant volume mould consists of steel split mould with internal diameter 38 mm and the

Table 1. Properties of soil sample

Parameter		Symbol	Value
Particle size distribution Sand Silt Clay		 S M C	 13 29 58
Specific gravity		G	2.47
Compaction Characteristics	OMC	w	18%
	MDD	γ_d	1.68g/cc
Free swell Index		FI	75%
Liquid limit		W_l	52%
Plastic limit		W_p	20.7%
Plasticity index		I_p	31.3
Shrinkage limit		W_s	8.5
Unconfined Compressive Strength (UCS)		q_c	1.66kg/cm^2
California Bearing Ratio		CBR	2.8%

Table 2. Chemical composition of soil and RHA samples

Chemical composition	SO_3	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	LOI
Soil	0.34	67.09	11.47	6.22	0.89	1.88	9.45
RHA	0.12	88.87	0.42	1.53	1.08	1.55	4.09

height of 76 mm. The volume of steel mould was calculated knowing the volume and the density required, the weight of the soil sample mixes are determined were prepared with its Optimum Moisture Content (OMC). Three identical samples were prepared for each mix and cured by sand curing. For studying the effect of curing periods on the strength of the soil samples, tests were conducted at varying curing periods, i.e., 3, 7, 14, 28 and 60 days. Scanning Electron Microscopic analyses were also did on the treated and cured sample to obtain the microstructural variation of treated soil samples at different curing periods.

4. Results and Discussion

The most common and acceptable method to determine the strength of stabilized soil is Unconfined Compressive Strength (UCS) and it is the one the important test used for the determination of the required amount of additive to be used in stabilization of soil[22]. Unconfined compression experiments were conducted on the soil specimens at a constant strain rate of 1.25 mm/min according to IS:2720 (Part - X)[23]. The UCS tests results obtained for the untreated and treated soil samples are tabulated in Table 3. Figure 1 and 2 showing the stress strain variation of untreated and treated samples at different curing

Table 3. UCS (kg/Sq.cm) values for RHA treated soil sample

Days	RHA (%)					
	0	**3**	**6**	**9**	**12**	**15**
0	1.68	-	-	-	-	-
3	-	3.5	4.6	4.9	5.2	4.7
7	-	4	4.52	4.95	5.6	4.85
14	-	4.3	4.9	5.13	5.63	4.95
28	-	4.6	4.95	5.3	5.7	5.2
60	-	4.9	5.03	5.4	5.75	5.25

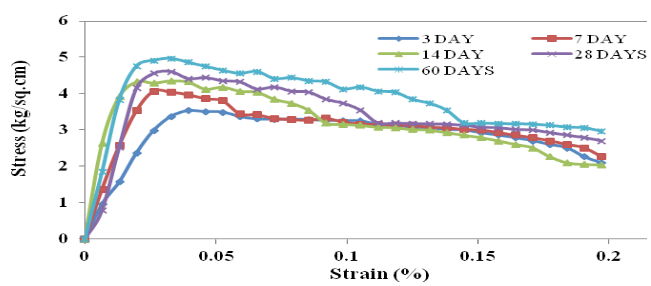

Figure 1. Stress strain characteristics of soil treated 3% RHA for varying curing periods.

periods and varying RHA content. The Figure 3 shows the variation in Increasing the percentage of UCS value with RHA from 3% to 15% was investigated and it is shown in Figure 3.

From the stress-strain characteristic curves, it was observed that the stress increased rapidly and reached peak at lesser strain and decrease a little further it sustain for longer strain and there after soil brittles. The UCS value is increased with increasing curing period and percentage of RHA addition. From the UCS value the Percentage Increase (PI) was calculated using following relationship.

PI_{UCS} = UCS value (Treated-Untreated)/Untreated UCS value of the soil

The PI_{UCS} is calculated using the above relationship for soil sample and the values are given in Table 4. From the Table 4 the rate of increase is observed to be more in the initial period than in the later stages and liner increment further, and it is independent to percentage of Rice Husk

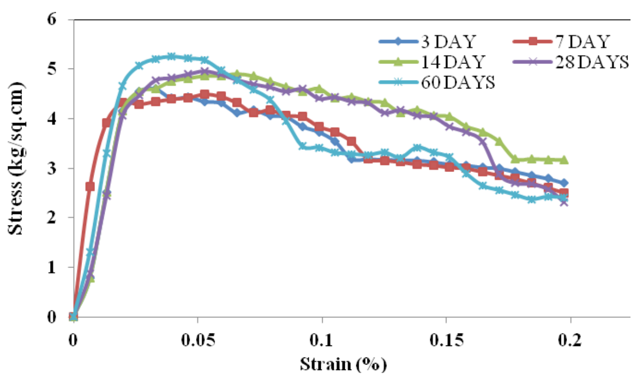

Figure 2. Stress strain characteristics of soil treated 6% RHA for varying curing periods.

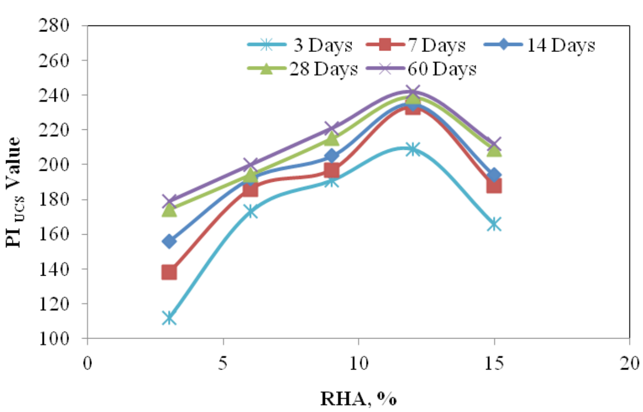

Figure 3. Effect of percentage of stabilizer on PI_{UCS} values for soil sample.

Ash added to soil, and curing period. Table 4 shows the percentage increase in the UCS value when compared to untreated soil. The maximum value obtained for 12% of RHA at 60 days curing period. From Figure.3, it was observed the mixing of RHA more than 12% decreases the rate of increase in the UCS value and it may be due to the excess amount of RHA in the soil develop the feeble bonds between the cementitious compounds and the soil.

Free swell index test was also conducted for the RHA treated soil sample in accordance with IS: 2720 (Part 40) to to estimate the expansive nature of soils. Free swell index was conducted on the pulverized soil obtained after conducting the UCC test. Table 5 shows the free swell test result for RHA treated soil. The effect of curing period and percentage of additive on the free swell index of the RHA treated soil sample can be observed from Table 5 and it is evident that swell potential is decreased with both increase in percentage of RHA and curing period.

To analyse the fabric arrangement, surface characteristics, orientation of particle and bonding pattern etc., SEM analysis has been conducted on the soil and vari-

Table 4. Percentage Increase (PI) in the UCS values for soil sample

Days	RHA %				
	3	6	9	12	15
3	112	173	191	209	166
7	138	186	192	233	188
14	156	192	205	235	194
28	174	194	215	239	209
60	179	200	221	242	212

Table 5. Free swell index for soil sample

Days	RHA %					
	0	3	6	9	12	15
0	75	-	-	-	-	-
3	-	70	70	60	55	50
7	-	65	65	55	55	50
14	-	60	60	50	50	45
28	-	50	50	50	50	45
60	-	50	45	45	45	40

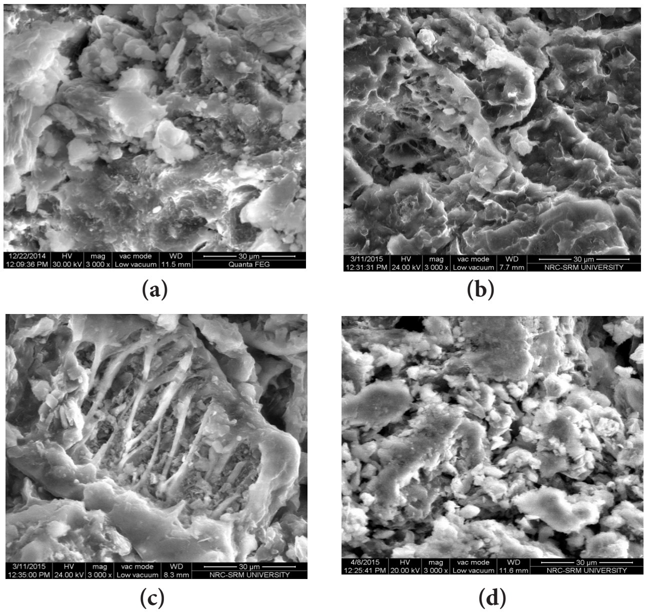

Figure 4. Scanning electron micrographs of soil and RHA treated soil. **(a)** Untreated. **(b)** Soil treated with 3% RHA at 7 days curing period. **(c)** Soil treated with 9% RHA at 7 days curing period. **(d)** Soil treated with 3% RHA at 7 days curing period.

ous combination of RHA treated soil samples and some typical micrographs are given in Figure 4. It is seen that the gel formation and change in soil microstructure.

5. Conclusion

Based on the results of laboratory study, the following conclusions are drawn:

The unconfined compressive strength of the soil samples treated with RHA increases the development in strength of soil with varying curing periods and the percentage increase is about 242% with the addition 12% of RHA at 60 days curing period.

The UCS of soil is increasing with the inclusion of RHA and increasing curing periods but the percentage increase is decreases after the addition of 12% RHA.

The swelling characteristic of the soil is reduced from 75 to 40 with an addition of 15% RHA.

Scanning electron micrographs show the process of change in soil microstructure during pozzolanic reactions.

The application of RHA as an additive material to improve the strength of soil and acts as low cost alternate material in soil stabilisation.

6. References

1. Sherwood P. Soil stabilization with cement and lime. State of the art review. London: Transport Research Laboratory, HMSO; 1993.
2. Bell FG. Lime stabilisation of clay minerals and soils. Engineering Geology. 1996 Jun; 42(4):223–37.
3. Lees G, Abdelkader MO, Hamdani SK. Effect of the clay fraction on some mechanical properties of lime-soil mixtures. The Journal of the Institution of Highway Engineer. 1982 Nov; 29(11):2–9.
4. Hunter D. Lime-induced heave in sulphate-bearing clay soils. ASCE Journal of Geotechnical Engineering. 1988 Feb; 114(2):150–67.
5. Frydman IR, Ehrenreich T. Stabilization of heavy clay with potassium chloride. Journal of Geotechnical Engineering. 1978 Dec; 8(2):95–108.
6. Al-Mukhtar M, Lasledj A, Alcover J. Behaviour and mineralogy changes in lime-treated expansive soil at 20°C. Applied Clay Science. 2010 Oct; 50(2):191–8.
7. Bell FG. Lime stabilization of clay minerals and soils. Engineering Geology. 1996 Jul; 42(4):223–37.
8. Gupta S, Seehra SS. Studies on lime-granulated blast furnace slag as an alternative binder to cement. Highways Research Board. 1989; 38:81–97.
9. Krishnan KD, Ravichandran PT, Janani V, Annadurai R, Gunturi M. Soil stabilisation using phosphogypsum and flyash. International Journal of Engineering Trends and Technology. 2014 Mar; 9(14):1–4.
11. Horpibulsuk S, Phetchuay C, Chinkulkijniwat A. Soil stabilization by calcium carbide residue and fly ash. Journal of Materials in Civil Engineering. 2012 Feb; 24(2):184–93.
12. Ravichandran PT, Krishnan KD, Janani V, Annadurai R, Gunturi M. Soil stabilization with phosphogypsum and fly ash – micro level study. International Journal of Chem Tech Research. 2015 Feb; 7(2):622–8.
13. Krishna TM, Beebi SdS. Soil stabilization by groundnut shell ash and waste fiber material. International Journal of Innovations in Engineering and Technology. 2015 Jun; 5(3):52–7.
14. Ezekiel AA, Dada O. Michael, potentials of groundnut shell ash for stabilization of ekiti state soil, Nigeria. Journal of Multidisciplinary Engineering Science and Technology. 2015 Aug; 2(8):1–4.
15. IS:2720 (Part 1), Methods of test for Soil: Preparation of dry soil sample for various tests. New Delhi: Bureau of Indian Standards; 1983.
16. IS:2720 (Part 5), Methods of tests for Soil: Determination of Atterberg's limits. New Delhi: Bureau of Indian Standards; 1985.
17. IS:2720 (Part 6), Methods of tests for Soil: Determination of shrinkage factor. New Delhi: Bureau of Indian Standard; 1972.

18. IS:2720 (Part 7), Methods of tests for Soil: Determination of water content-dry density relation using light compaction. New Delhi: Bureau of Indian Standards; 1980.
19. IS:2720 (Part 40), Methods of Tests for Soil: Determination of free swell index of soil. New Delhi: Bureau of Indian Standards; 2002.
20. IS:2720 (Part 16), Methods of tests for Soil: Laboratory determination of CBR. New Delhi: Bureau of Indian Standards; 1987.
21. IS:1498, Classification and identification of Soils for general engineering purposes. New Delhi: Bureau of Indian Standards; 1970.
22. Singh G, Singh J. Highway engineering. Nai Sarak, Delhi, India: Standard Publishers Distributors; 1991.
23. IS:2720 (Part X), Methods of tests for Soil: Determination of unconfined compressive strength. New Delhi: Bureau of Indian Standards; 1973.