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Research Article

EFFECT OF DIFFERENT CURING PERIOD ON CEMENT, LIME-STABILIZED EXPANSIVE SOIL USING RICE HUSK ASH AND STONE DUST AS ADDITIVES

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ABSTRACT

Expansive soils occurring in arid and semi-arid climate regions of the world cause serious problems to civil engineering structures. Several attempts are being made to control the swell-shrink behavior of these soils. The major environmental challenge is the disposal of the byproduct solid wastes. Waste materials such as Rice Husk Ash and Stone Dust are selected as additives to the soil. The admixture improves the geotechnical properties of joint mixture. (Soil-lime-rice husk ash and soil-lime-stone dust, Soil-cement-rice husk ash and soil-cement-stone dust). In this context an attempt is made to study expansive soil mixed with Rice Husk Ash (RHA) and stone dust. In the present study by taking earlier study results of lime and cement stabilization percentage as 8% and to that RHA and stone dust was mixed in increments of 2% ranging from 2 to 12% are added and subjected to different curing periods such as 7, 14, 28 and 56 days was studied by conducting unconfined compressive strength (UCS) studies on the samples for various curing periods. There was a considerable increase of UCS from 0 to 7 days and the constant rate of increase in strength from 7 days to 28 days may be attributed to reaction between RHA – Lime-Cement and CaOH present in natural soil as soon as flocculation starts i.e. 7 days and was primarily dominated by lime content and curing. Addition of RHA and Stone dust further improved strength of the mix.

INTRODUCTION

Expansive soils always create problem for lightly loaded structure, by consolidating under load and by changing volumetrically along with seasonal moisture variation. As a result the superstructures especially pavements usually counter excessive settlement and differential movements, resulting in permanent damage. Even when efforts are made to improve swelling soil, the lack of appropriate technology sometimes results volumetric change that are responsible for billion dollars damage each year. These methods range from mechanical to chemical stabilization. Basic purpose of researchers and these methods was to check the scope of improving bearing capacity and reduce expansiveness by adding additives. In these additives various waste materials like, stone dust, Rice husk ash, fly ash, GGBS, waste plastic rich in silica have been proven to be the efficient admixtures and this utilization also reduces the potential of environmental pollution and disposal of waste.

The main objective of this research is to utilize stone dust and Rice husk ash as additives to cement and lime stabilized expansive soil and check for the strength gain. By performing unconfined strength studies for different curing periods. There by utilizing them in the construction of roads and hence reduce in the exploitation of raw materials and the mitigation of threats to the environment by stone dust and RHA.

LITERATURE REVIEW

The stabilization process aims at increasing the soil strength and reducing its permeability and compressibility. The stabilization processes may include mechanical, chemical, electrical or thermal processes [1]. Methods of stabilization may be grouped under two main types: (a) modification or improvement of a soil property of the existing soil without using any admixture and (b) modification of the properties with the help of admixture. The examples of the first type are compaction and drainage, which improve the inherent shear strength of soil. The examples of the second type are stabilization with admixtures like cement, lime, bitumen, fly ash, stone dust, rice husk ash GGBS and chemicals. In the past few years, utilization of byproduct industrial solid wastes has been the focus of many researches [2, 3, 4, 5, 6, 7, and 8]. Many of the byproduct solid wastes have been recommended to be used as construction materials, especially for road construction. In a study made on the effect of quarry dust on three types of soils (Red earth, kaolinite and Cochin marine

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clay) [9], to improve the geotechnical properties of soils for highway construction, It was observed that, addition of quarry dust improved the CBR value of soil and the optimum proportion being 40% of quarry dust to 60% of soil. In a study conducted California Bearing Ratio (CBR) and static and cyclic triaxial tests on the four most frequently encountered local materials—fly ash, coarse sand, stone dust, and river bed material (RBM)—for their use in the sub base layer of a flexible pavement[10],it was found that CBR of stone dust was the maximum value of all, but its behavior under dynamic load in triaxial tests was inferior when compared with other materials. When compaction, swelling and unconfined compression strength obtained on expansive clays mixed at different proportions of fly ash and stone dust observed that at optimum percentages, i.e., 30% stone dust and 25% fly ash, it is found that the swelling of expansive clay is almost controlled and also noticed that there is a marked improvement in the strength of soil. In another study [11], the combination of stone dust and fly ash is more effective than the addition of stone dust alone to the expansive soil in controlling the swelling nature. The combination of 20% stone dust and 25% fly ash was found to be more effective. In an investigation made to study the effect of stone powder and lime on the strength, compaction and CBR properties of fine grained soil[12], it was found that when stone powder and lime were added at specific percentages (10%, 20% and 30%) by weight of soil and mixed with the optimum moisture content obtained from the compaction test results revealed that the addition of 30% stone powder has increased the angle of internal friction (φ) by about 50%and reduced cohesion by about 64%. The addition of 30% of lime has decreased the friction angle and cohesion by 57% and 28%, respectively. The maximum dry density and optimum moisture content decreased slightly by addition of 30% stone powder, however, the addition of 30% lime decreased the maximum dry density and optimum moisture content by 19% and 13.5%, respectively. The CBR values have increased from5.2 to 16 and 18 by the addition of 30% stone powder and lime, respectively. In studies made by researchers on expansive soil treated by cement with rice husk ash[13],[14] it was concluded that At specific cement contents, the results indicates a decrease in the MDD with increasing RHA contents, to the minimum at 6% RHA, after which there was a slight increase to 8% RHA. The initial decrease in the MDD may be attributed to coating of the soil cement by the RHA which result to large particles with larger voids and hence less density. The increase in density from minimum at 6% RHA content to 8% Ash content could be due to molecular rearrangement in the formation of "transitional Compounds" which have higher densities at 8% RHA content .UCS improvement due to increase in RHA must have resulted from the pozollanic reaction between the lime liberated from the hydration reaction of cement and the pozollanic RHA to form secondary cementitious materials[15],[16]. The effects of various mix proportions of lime and rice husk ash on geotechnical properties e.g. Atterberg limits, compaction characteristics, unconfined compressive strength, CBR and swelling of lateritic soils [17]showed that these lateritic soils stabilized with lime – RHA mixtures can be used in highway construction. Also well-burnt RHA passed through 425 μ was used in this investigation for convenient mixing with clay and compaction. In a study on the influence of different mix proportions of lime and RHA on compaction, strength properties, CBR values and durability characteristics of soil, addition of RHA enhanced not only the strength but also the durability, soaked and unsoaked CBR value of lime stabilized soil considerably[18].

Methodology of Experimentation

The following materials are used for experimental work. Materials used in the study were expansive soil, locally available lime, cement, rice husk ash and stone dust.

Expansive Soil

The expansive soil used in the current study was collected from a depth of 2.0m below the ground level beside highway from Amalapuram, West Godavari district, A.P. The liquid limit of soil is 86.27% and its plasticity index is 50.27%, which are high and show that soil has high potential for volume change. A free swell index of soil 140% indicates a soil of high degree of expansiveness.

Lime & Cement

Lime used for the current work is a commercial lime available in the local market & Cement used in the present investigation is a commercial, ordinary Portland 53 grade Cement.

Rice Husk Ash

Rice husk ash used for study was brought from local hotel after it was completely burnt. The hotel is situated 4 km away from R.V.R&J.C College of Engineering, Chowdavaram, Guntur.

Stone Dust

Stone dust was collected from Vasundhara stone crusher situated 1.0 km away from R.V.R&J.C College of Engineering Chowdavaram, Guntur.

Test Conducted

UCS test was conducted on different samples for different curing periods.

Preparation of UCS Specimens

- The soil collected from the site was pulverized with wooden mallet break lumps and then air-dried in an oven at 105^oC for 24 hours.
- Lime was sieved to make it is free from lumps.
- The optimum content of lime i.e. 8% and 8% cement from the studies made by [24] was mixed with the soil.
- Additives stone dust and rice husk were air dried for 24 hours and sieved from 425micron IS sieve was used.
- The required content of additives was mixed to the soil in increments of 2%, due care was taken to ensure uniform coverage.
- Due care was taken to ensure a uniform soil-lime-additive mixture, soil-cement-additive mixture. Desired quantity of soil-lime-additive mix, soil-cement-additive mixture was taken in UCS mould and compacted to required thickness at its OMC.

Unconfined compression strength test was conducted on soil mixed with lime and cement separately with varying additive content from 2%-12% with an increment in the 2% for various curing periods.

The samples thus made for UCS are wrapped by means of polethyne cover for moisture recovery and then cured in desiccators for a period of 7, 14, 28 and 56 days.

RESULTS AND DISCUSSIONS

The physical chemical composition and engineering properties of expansive soil RHA and stone dust, and UCS variations with different percentages of additives at different curing periods are shown in the respective tables and graphs.

Table 1 Physical and Engineering Properties of Soil

S.No	Constituents	(%)
1	Silica – SiO2	90.23
2	Alumina – Al_2O_3	2.54
3	Carbon	2.23
4	Calcium Oxide – CaO	1.58
5	Magnesium Oxide – MgO	0.53
6	Potassium Oxide – KaO	0.39
7	Ferric Oxide -Fe_2O_3	0.21

Table 2 Physical and Engineering Properties of Stone Dust

S.No	Property	Value
1	Specific gravity	1.67
2	Particle size distribution a) Sand (%) b) Silt (%) c) Clay (%)	 24 3.2 72.8
3	Liquid limit (%)	86.27
4	Plastic limit (%)	36
5	Plasticity index (%)	50.27
6	IS classification of soil	CH
7	Maximum dry density (kN/m^3)	14.4
8	Optimum moisture content (%)	23

Table 3 Physical and Engineering Properties of RHA

S.No	Property	Value
1	Specific gravity	1.95
2	IS Soil classification	SM
3	Maximum dry density (kN/m^3)	7.3
4	Optimum moisture content (%)	70

Table 4 Chemical Composition of RHA

S.No	Property	Value
1	Specific gravity	2.77
2	Particle size distribution Gravel size (%) Sand size (%) Silt size (%)	 3% 81% 16%
3	IS Soil classification	SM
4	Maximum dry density (kN/m^3)	20.1
5	Optimum moisture content (%)	9.4

A graph (Figure-1) was drawn showing variation of UCS with different curing periods for different Percentages of RHA.

From Figure 1it can be seen that at 8% of lime initial UCS value was 89.21kN/m^2, on addition of RHA there was an increase of UCS to 110.65kN/m^2, 128.61kN/m^2,and 121.55kN/m^2, 135.64kN/m^{2}for7, 14, 28and56days of curing i.e. increased by 24%, 36%, and 44% and 48% for 7, 14, 28 and 56 days. The considerable increase of UCS from 0 to 7 days and the constant rate of increase in strength from 7 days to 28 days may be attributed to reaction between RHA - Lime and CaOH present in natural soil as soon as flocculation starts i.e. 7 days.

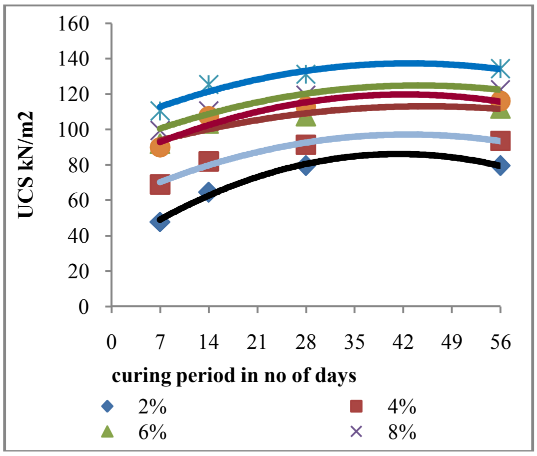

Figure 1 Variation of UCS with different curing periods for different Percentages of RHA

And also binding effect which results in strength increase is primarily dominated by lime content and as the hydration of lime is depended on curing and RHA further improves strength. A graph was drawn **(Figure-2)** showing variation of UCS with different curing periods for different percentages of stone dust.

Table 5 Variation of UCS with Different Curing Periods for Different Percentages of RHA

CURING PERIOD	RHA% 2%	4%	6%	8%	10%	12%
7	61.5	87.6	100.5	110.9	99.6	77.06
14	63.5	89.2	103.4	112.4	102.6	101.5
28	65.5	93.2	107.6	115.3	105.1	83.6
56	68.1	95.1	110.1	118.5	108.3	85.7

CURNG PERIOD	STONE DUST 2%SD	4%SD	6%SD	8%SD	10%SD	12%SD
7	103.7	114.9	123.9	142.6	136.0	121.4
14	105.2	116.4	127.2	143.6	140.5	123.7
28	109.7	122.9	130.5	148.5	141.5	127.9
56	128.2	136.8	147.7	164.1	150.4	131.3

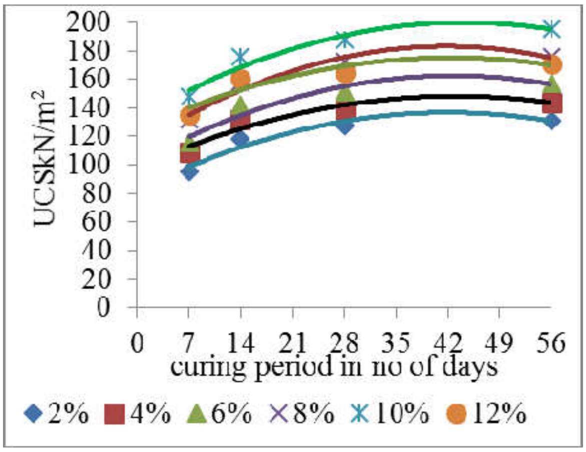

Figure 2 Variation of UCS with different curing periods for different percentages of Stone Dust

From Figure- 2 it can be seen that at 8% of lime the initial UCS value was 89.21 kN/m^2, on addition of stone dust there was an increase of UCS to 148.27 kN/m^2, 175.36 kN/m^2, 187.33 kN/m^2, 195.45kN/m^{2}for7, 14, 28and56days of curing i.e. increased by 89%, 96%, 109%, 112% for 7, 14 and 28 and 56 days.

The considerable increase of UCS from 0 to 7 days and there after minor increase in strength from 7 days to 28 days and 28 to 56 days may be attributed to the reason that cementitious products are formed at an early stage i.e. as soon as flocculation is completed due to lime-clay reaction notably during the first seven days of curing, followed by a reduced rate of increase in strength compared to that of 0 to 7 days. Addition of stone dust further improves the strength due to pozolona present in it.

Similar trend of increase in UCS as stated above was also observed when different percentages of RHA and stone dust was added to cement and is shown in Table -5 and Table-6

Variation of UCS with Different Curing Periods for Different Percentages of Stone Dust

CONCLUSIONS

- Curing period had a considerable effect on strength of the soil mixture.
- There was a considerable increase in strength from 0 to 7 days and there was minor increase in strength from 7 to 28 days and 28 to 56 days. As cementitious products are formed at an early stage i.e. as soon as flocculation is completed.
- RHA and stone dust also prove to be cheaper and efficient substance for soil stabilization.

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