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Geotechnical Characterization of Dispersive Soil Stabilized with Lime and Palm Oil Fuel Ash

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Abstract—*The utilization of agro waste as construction material is increasing and this trend is expected to continue in the years ahead because of technical advancement and to decrease environmental pollution by using these wastes as supplementary material in the field of construction. One of the agro wastes is palm oil fuel ash (POFA) which is identified as pozzolanic material.*
Dispersive soils are found in many parts of the world and are highly susceptible to erosion when are in contact with water due to the presents of exchangeable cations. The failures associated with this type of soil are piping and internal erosion due to dispersion of soil. These soils cannot be identified by visual classification, Atterberg's limits or particle size analysis. Dispersive soils are identified by pinhole test, crumb test and double hydrometer test. So, these soils are identified and stabilized.
In this investigation, the effectiveness of agro waste by-product namely POFA has stabilizing agent in addition to lime is used to stabilize and to reduce the percentage dispersion. Treatment to dispersive soil using lime and POFA are carried singly and simultaneously. There by, the optimum percentage of lime and POFA signally and simultaneously were found by the results based on double hydrometer test and unconfined compressive test. It was found that lime and POFA mixture performed in a better way compared to lime and POFA alone.

Keywords: *Crumb test, Dispersive soil, Double Hydrometer test, Erosion, Lime, Pinhole test.*

1. INTRODUCTION

In developing countries like India the effective use of supplementary materials in the field of construction is increasing to reduce the cost of construction and environmental effects. One of the agro waste used in this study is Palm Oil Fuel Ash (POFA) is the product of burning palm oil husk and palm oil kernel shell in the palm oil mill. It contains pozzolanic properties and cementitious behavior. By recycling of POFA it is in a way helping our country in solving the problems of excessive emission of palm oil waste.

Dispersive soil is found in many parts of the world and is susceptible to erosion failure. The presence of dispersive soil poses a risk to the stability of the structure. Before, these soils were not used for embankment constructions, and this made work more difficult and expansive, but now dispersive soils are used in constructions after chemical treatment. These soils are characterized by an unstable structure, easily flocculated in water, and very erodible. These soils usually contain high percentage of exchangeable sodium ions which is susceptible to replacement by calcium and aluminum ions. Dispersive soils are identified by double hydrometer test based on percentage dispersion.

2. DISPERSION PHENOMENON

The clay fraction in dispersive soil comes in contact with water behaves like a single grained particle with less electrochemical attraction and does not adhere with other particles. The internal particle repulsive force exceeds the Van der wall attraction and the detached clay particles are carried away causing internal erosion in earthen dams. The dispersiveness of soil is mainly due to the presence of sodium ions in the soil structure and not due to the presence of sodium in the pore water.

The erosion occurs due to the fluid flow on the surface is large enough to cause particle removal from the surface. The resistance to erosion is offered by the self-weight of the sediment i.e. gravity forces for non-cohesive soils in cohesive soil the structure and interaction between pore and eroding fluid at the surface is the phenomenon involved in soil erosion. The factors that affect the critical shear stress required to initiate erosion are clay, pH, organic matter, temperature water content, thixotrophy and type and concentration of ions in the pore and eroding fluid. Due to osmotic pressure induced in clay particles leads to swelling of clay surface because of difference in concentrations of pore and eroding fluid. The interparticle force of attraction reduces and causes erosion. The erosion is accelerated by a process called slaking in partially saturated soils. The slaking is due to excess air pressure in the capillaries because of surface tension force in partially saturated soil.

3. DEGREE OF DISPERSION BY DOUBLE HYDROMETER TEST

The double hydrometer test or soil conservation service (SCS) has identified as one of the most appropriate method for classifying dispersive soils. The procedure involves the determination of percentage of particles in the soil that are finer than 0.005 mm using the standard hydrometer test. A parallel test is carried out without dispersing agent. The quantity of fines finer than 0.005 mm in the parallel test is expressed as a percentage of this fraction determined in the standard test, which is defined as percentage dispersion. The criteria for evaluating the degree of dispersion using results from the double hydrometer test are shown in Table 1.

Table 1: Degree of dispersion from double hydrometer test

% Dispersion	Degree of dispersion
<15	Non dispersive
15 to 30	Slightly dispersive
30 to50	Moderately dispersive
>50	Highly dispersive

4. MATERIALS AND METHODS

Soil sample was collected from the failure positions of Tumkur canal region located at Tumkur district, Karnataka, India. The sample collected from site was air dried and passed through 475 microns IS sieve. The properties are shown in Table 2. It has sand as major constituent followed by silt and clay with group symbol 'SM'.

The additives used are lime and palm oil fuel ash. POFA is collected from Godrej palm oil mill located at Elure, Andhra Pradesh. The material is air dried and passed through 425 microns IS sieve was used in the experiment. The concentrations of lime used are 2, 3, 4 and 5 percent by dry weight of soil. The concentrations of POFA used are 8, 10, 12 and 14 by dry weight of soil. The soil specimens were cured for 1, 3, and 7 days. The experiments were conducted to determine the Atterberg's limits, compaction characteristics, and unconfined compressive strength. The tests were carried out as per relevant IS codes of practice and standards.

Table 2: Properties of soil

Sl. No	Parameters	Symbol	Value
1	Grain size distribution	Coarse sand (%)	3
		Medium sand(%)	20
		Fine sand (%)	38.5
		Slit(M) (%)	25.5
		Clay(C) (%)	13
2	Liquid limit %	Wl	41
3	Plastic limit%	Wp	23.80
4	Plasticity Index%	Ip	17.20
5	Shrinkage Limit %	Ws	22
6	Specific Gravity	G	2.63
7	Optimum Moisture Content	OMC	14
8	Maximum Dry Density	Ɣd max	1.78g/cc
9	Unconfined Compressive Strength	qu	1.71 kg/cm2
10	Percentage dispersion	36%	
11	Degree of dispersion	Moderately dispersive	
12	Soil classification	Silty Sand (SM)	

5. RESULTS AND DISCURSION

The results of double hydrometer test, compaction characteristics, unconfined compressive strength and California bearing ratio are discussed separately in the following section.

5.1 Double Hydrometer test

The double hydrometer is conducted on dispersive soil and the results are shown in Fig. 1. The results indicate that the percent of dispersion was 36%. Thus it indicates that this soil's degree of dispersion is moderately dispersive.

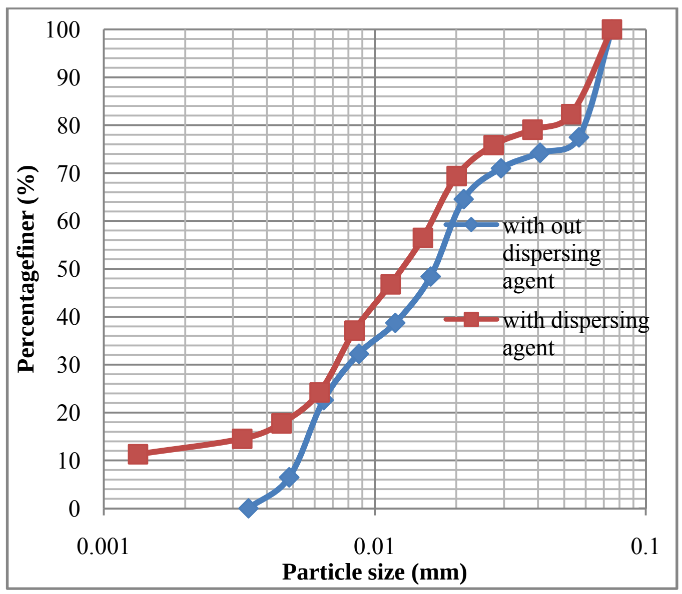


Fig. 1: Doule hydrometer test for soil

5.2 Unconfined compressive strength

The unconfined compressive strength for soil is carried out with lime. The concentration of lime used are 2, 3, 4 and 5 percent. The results shows that with the increase in lime content the strength of the soil increases and there is a gradual increase in the strength when the lime content is increase above 3 percent, the percentage increase in strength is less when the lime content is increased from 3 percent to 5 percent. Here the optimum percent of lime is 3 percent because if the lime content is increased above the optimum it acts as a filter and also increases the cost of stabilization. There fore it is advised to use 3 perent lime for stabilizing dispersive soil. Fig.

2 shows the variation in strength of dispersive soil with respect curing period when treated with lime alone.

The unconfined compressive strength for soil is carried with POFA alone. The concentration of POFA used are 8, 10, 12 and 14 percent. The results with the increase in POFA content the strength starts increasing and at 14 percent POFA the strength is decreasing resulting in the optimum POFA concent is 12 percent. But the percentage in strength is less and it is not suggested for stabilization of dispersive soil using POFA alone. Fig. 3 shows the variation in strength of dispersive soil with respect to curing period when treated with POFA alone.

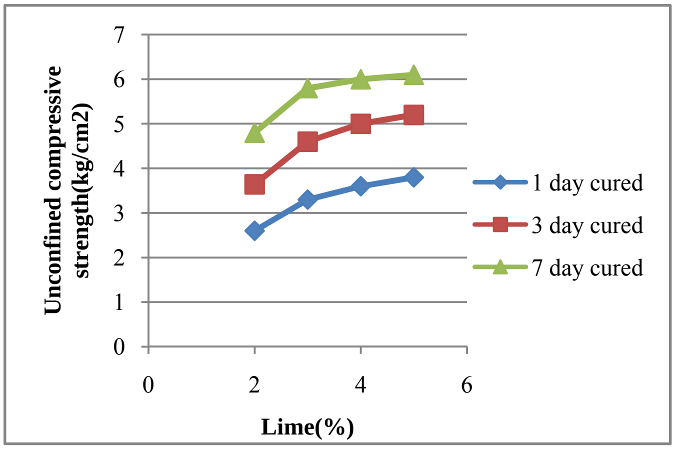


Fig. 2. Unconfined compressive strength of dispersive soil treated with lime

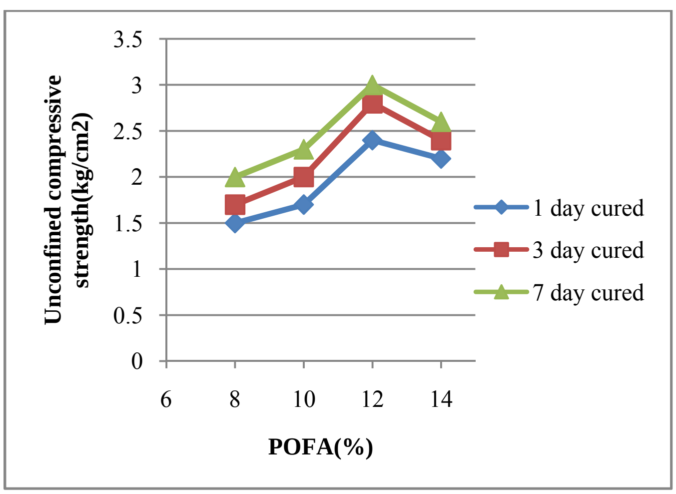


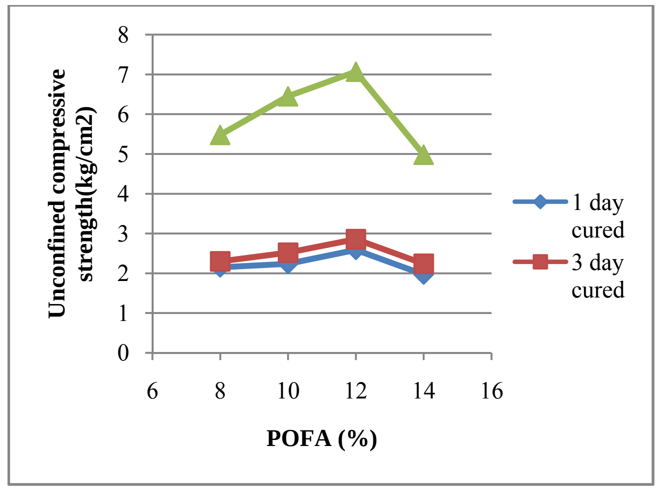
Fig. 3: Unconfined compressive strength of dispersive soil treated with POFA.

Fig. 4 shows the unconfined compressive strength of 3 percent lime and in variation in POFA percentage. The results showns that with increase in POFA content the strength increases upto 12 percent POFA and then starts decreasing due to excessive amount of POFA. The strength increase in more than the strength increase when treated with lime. The rate of increase is more for 7 days curing.

6. CONCLUSION

The following conclusion can be drawn from this paper are as follows:

1. The optimum percentage of lime is 3 percent with can be used for the treatment of dispersive soil.
2. The optimum percentage of palm oil fuel ash is 12 percent, but it is not suggested for stabilizing the dispersive soil alone. It is advised to use the POFA as the suppelmentary material to induse the cementanious reaction in lime stabilization.
3. Use of POFA in lime stabilization gives better results and is economical.



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