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STUDY OF STABILIZATION OF SOIL WITH WASTE MATERIAL

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ABSTRACT

For satisfactory performance of a structure, its foundation must satisfy the following three basic criteria:

a) Location and depth criterion
b) Shear failure or bearing capacity criterion
c) Settlement criterion

The properties influencing the above cited criterions i.e. shear strength as well as compressibility can be improved by stabilizing the weaker soil deposits. Generally, soil stabilization has been adopted in various civil engineering works. Some important applications are in foundations, retaining structures, stability of slopes, underground structure, earth dam etc.

KEY WORDS: *Soil stabilization, RICE HUSK ASH, Optimum moisture content*
Sub Area : *Transportation Engineering*
Broad Area :*Civil Engineering*

INTRODUCTIONS

Weak foundation soil conditions can result in inadequate support and reduce structural life. Soil properties can be improved through the addition of chemical or pozzolanic wast materials i.e stabilization. Soil stabilization refers to the procedure in which a soil, a pozzolanic waste material, or other chemical material is added to a parent soil to improve one or more of its properties. One may achieve stabilization by mechanically mixing the natural soil and stabilizing material together so as to achieve a homogenous mixture or by adding stabilizing material to an undisturbed soil deposit and obtaining interaction by letting it permeate through soil voids.

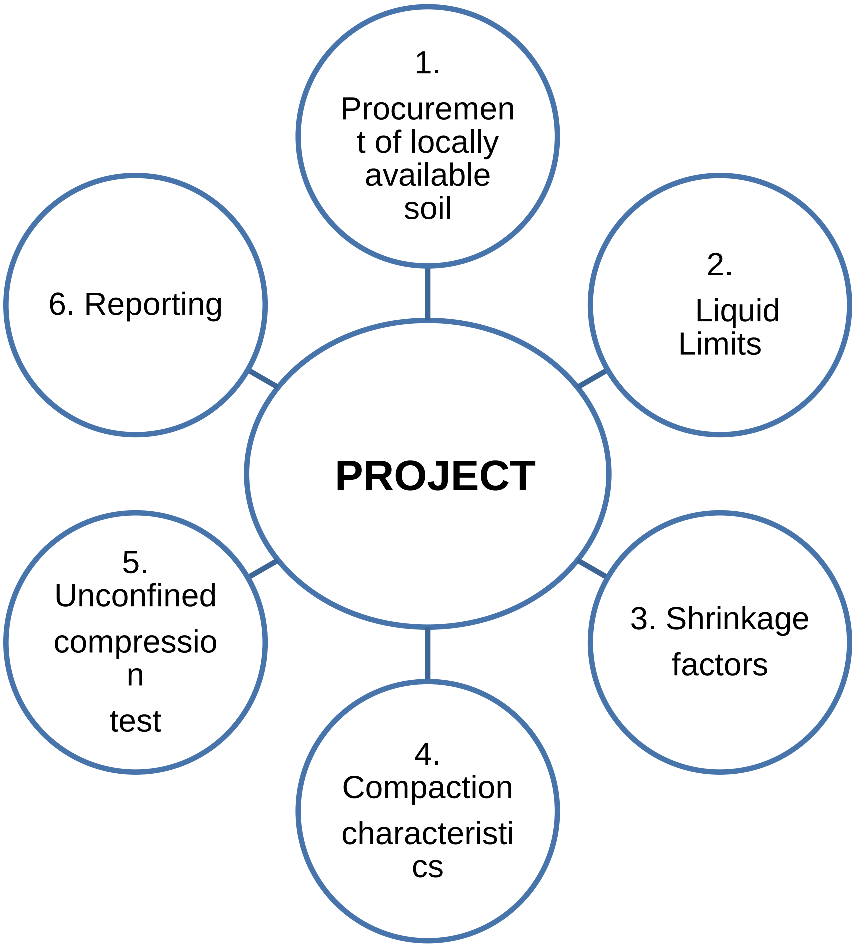
These chemical additives range from waste products to manufactured material which includes Portland cement, Rice husk ash, Fly ash, chemical stabilizers and cement kiln dust. These additives can be used with variety of soils to improve their native engineering properties. The effectiveness of these additives depends on the soil treated and the amount of additive used. The high strength obtained from cement and lime may not always be required, however, and there is justification for seeking cheaper additives which may be used to alter soil properties.

Invariably, any one of two methods is used to accomplish soil stabilization – mechanical and additive. The effectiveness of a stabilization process can be gauged by the uniformity in blending the many materials. Usually, the preferred way of mixing is in a stationary or traveling plant. However other methods like scarifies, plows, disks, graders, and rotary mixers, are also largely practiced. The method of soil stabilization is decided by the amount of stabilizing required and the prevailing conditions.

Therefore, care must be taken to ensure that an accurate soil description and classification is procured in order to select the correct materials and procedures. Mechanical Stabilization is done by mixing soils of two or more gradations to result in a material of the required specifics. This mixing of the soil can take place at the construction site, at a central plant, or at a borrow area. The blended material is then spread and compacted to required densities.

In additive method, an additive is any manufactured or commercial product that can be used to improve the quality of the soil, when added in accurate quantities. Rice husk ash, Fly-ash, Wheat husk ash, alone or in combination, are commonly used additives to stabilize soils. The selection and quantity of additive used depends entirely on the type of soil and the degree of improvement required.

1. Soil stabilization is the process of the improving the engineering properties of soil and thus making it more stable.
2. It required when soil available for construction is not suitable for intended purpose.
3. In broad, the soil stabilization includes compaction, pre-consolidation, drainage and many other processes.
4. A cementing material or a chemical is added to a natural soil for the purpose of stabilization.
5. Soil stabilization is used to reduce the permeability and compressibility of soil mass in earth structures and to increase its shear strength.



LITERATURE REVIEW

Solid stabilizing agent such as cement has long been used to improve the handling and engineering characteristic of soils which ensures that the mixture meets certain durability requirements for civil engineering purposes. The cement requirement for low plasticity soils and sand varies from 3% to 11% by dry weight (PCA, 1963). The use of soil cement as a paving material in the construction of low cost roads dates back to 1920, when the State Highway Department, USA built short sections of roads with soil-cement. To-date thousands of kilometers of road bases has been laid down. The performance of soil-cement bases and sub-bases has been adjudged as more than satisfactory by various research workers and agency like AASHTO and Larsen (1967).

Rice Husk Ash is a pozzolan, which contains as much as 80-85% silica which is highly reactive, depending upon the temperature of incineration (Ravande Kishore, Bhikshma V. and Jeevana P,2011). Pozzolanas are defined as siliceous or siliceous and aluminous materials which in themselves possess little or no cementing property, but will in a finely dispersed form in the presence of water chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties. When water is added to a mixture with pozzolanic material it acts as cement, in some instances providing a stronger bond than cement alone(V.M. Malhotra, P.K. Mehta, 1996 cited in Nick Zemke Emmet Woods, 2009).

The characteristics of the ash are dependent on the components, temperature and time of burning (Hwang, 185 cited in Nick Zemke Emmet Woods, 2009). During the burning process, the carbon content is burnt off and all that remains is the silica content. The silica must be kept at a non-crystalline state in order to produce an ash with high pozzolonic activity. It has been tested and found that the ideal temperature for producing such results is between 600 °C and 700 °C (Nick Zemke Emmet Woods, 2009).

If the rice husk is burnt at too high temperature or for too long the silica content will become a crystalline structure. If the rice husk is burnt at too low temperature or for too short period of time the rice husk ash will contain too large amount of un-burnt carbon. Carbon does not possess pozzolanic properties, thus it does not take part in the strength development process. It acts more or less as filler (Nick Zemke Emmet Woods, 2009).

Research on the potential of using rice husk ash, reveals that some of its physical properties are responsible for the role that rice husk ash plays in improving the material properties and durability of its composite. Some of these physical properties are larger specific surface area, fine particle size etc. (Safiuddin, 1990, cited in Ogah Sylvester Obam and Amos. Y. Iorliam, 2011) Table shows some physical properties of RHA as published by Narayan (Ogah Sylvester Obam and Amos. Y. Iorliam, 2011)

Fly ash is one of the most plentiful and industrial by-products. It is generated in vast quantities as a by-product of burning coal at electric power plants (Senol et al., 2014). Electric utility companies in many parts of the world generate electricity by burning coal which generate an amount of fly and bottom ash. Fly ash generated by coal combustion based power plants Typically fall within the ASTM fly ash classes C and F (Reyes and Pando, 2016).

METHODOLOGY

Liquid limit and plastic limit test

The Liquid limit of fine grained soil is the water content at which soil behaves practically like a liquid, bit has small shear strength. If flow close the groove in just 25 blows in cassagrandes liquid limit device. It is one of the Atterbergs limit. The Atterbergs limits consist of liquid limit and shrinkage limit. As it difficult to get exactly 25 blows in the test. 3 to 4 tests are conducted, and the number of blows (N) required in each test determined. A semi-log plot is drawn between log N and the water content (w).

The Liquid limit is the water content corresponding to N = 25. This index property helps in classification.

The plastic limit of a fine-grained soil is the water content of the soil below which it ceases to be plastic. It begins to crumble when rolled in to threads of 3 mm diameter.

OBSERVATION TABLE

Determination No.	1	2	3
(1).No of blows	30	22	13
(2).Container No.	3	2	16
(3).Mass of container + wet soil, (gm.)	32	35	58
(4).Mass of container + dry soil, (gm)	27	27	45
(5).Mass of water (3) – (4), (gm.)	5	8	13
(6).Mass of container, (gm.)	10	12	19
(7).Mass of dry soil (4)-(6), (gm.)	22	23	39
(8).Moisture content (5)/(7)*100, (%)	29.41	53.33	50

Table1: Liquid Limit Determination

SHRINKAGE LIMIT TEST

To Shrinkage limit is the water content of the soil when the water is just sufficient to fill the pores of the soil and the soil is just saturated. The volume of the soil does not decrease when the water content is reduced below the Shrinkage limit. It can be determined from the following relation –

$W = ((W_1-W_s) - (V_1-V_2)\ Y_w)/W_s)*100$

Where W_1 = Initial wet mass, W_s = Dry mass

V_1 = Initial volume, V_2 = Volume after drying

APPARATUS

1. Shrinkage dish, having a flat bottom, 45 mm diameter and 15 mm height.
2. Two large evaporating dishes about 120 mm diameters, with a pour out and flat bottom.
3. One small mercury dish, 60 mm diameter.
4. Two glass plates, one with prongs, 75*75*3 mm size.
5. Glass cup, 50 mm diameter and 25 mm height.
6. IS sieve 150 micron.
7. Oven.
8. Desiccators.
9. Weighing balance, accuracy 0.01 g.
10. Spatula
11. Straight edge mercury.

Figure3 : Shrinkage test apparatus

Figure4 : Shrinkage dish having wet soil pat

PROCEDURE

1. A shrinkage dish is taken.
2. The Wt. of empty dish is 40 gm is recorded.
3. A soil sample is taken and water mixed into the soil.
4. Wt. of wet soil with dish is 80 gm is recorded. It placed into oven for drying for a period of 24 hours.
5. After drying the Wt. of dry pat with dish is 63 is recorded.
6. After this procedure a weighing dish Wt. is recorded i.e. 40 gm.
7. Mercury is placed in the weighing dish. Wt. of mercury with weighing dish is 375 gm.

8. After this the dry soil pat is placed into the weighing dish, mercury is displaced through weighing dish.
9. The wt of weighing dish with mercury displaced is 335 gm.

Shrinkage limit test (clay+5% rice husk ash)

PROCEDURE

1. A shrinkage dish is taken.
2. The Wt. of empty dish is 40 gm is recorded.
3. A soil sample is taken and water mixed into the mixture of clay and rice husk ash
4. Wt. of wet soil with dish is 80 gm is recorded. It placed into oven for drying for a period of 24 hours.
5. After drying the Wt. of dry pat with dish is 62 is recorded.
6. After this procedure a weighing dish Wt. is recorded i.e. 40 gm.
7. Mercury is placed in the weighing dish. Wt. of mercury with weighing dish is 368 gm.
8. After this the dry soil pat is placed into the weighing dish, mercury is displaced through weighing dish.
9. The wt of weighing dish with mercury displaced is 328 gm.

Determination No.	I
(1). Shrinkage dish No.	1
(2). Mass of dish + wet soil pat, (gm.)	78
(3). Mass of dish + dry soil pat, (gm.)	62
(4). Mass of water, (2) - (3), (gm.)	16
(5). Mass of shrinkage dish empty, (gm.)	40
(6). Mass of dry soil pat (Ws) = (3) – (5), (gm.)	22
(7). Initial water content (w1) = (4) / (5)*100, (%)	40
(8). Mass of weighing dish + mercury (filling shrinkage dish), (gm.)	368
(9). Mass of weighing dish empty, (gm)	40
(10) .Mass of mercury (8) –(9), (gm.)	328
(11). Vol. wet soil pat (V1) = (10)/13.6, (cc.)	24.12
(12). Mass of weighing dish + displaced mercury (by dry pat), (gm.)	323
(13). Mass of mercury displaced (12) – (9), (gm.)	211
(14). Vol. dry pat (V2) = (13)/13.6, (cc.)	15.51

10. Table3: Shrinkage factor determination

Shrinkage limit test (clay+10% rice husk ash)

OBSERVATION TABLE

Determination No.	I
(1). Shrinkage dish No.	2
(2). Mass of dish + wet soil pat, (gm.)	75
(3). Mass of dish + dry soil pat, (gm.)	58
(4). Mass of water, (2) - (3), (gm.)	17
(5). Mass of shrinkage dish empty, (gm.)	41
(6). Mass of dry soil pat (Ws) = (3) – (5), (gm.)	17
(7). Initial water content (w1) = (4) / (5)*100, (%)	41.46
(8). Mass of weighing dish + mercury (filling shrinkage dish), (gm.)	367
(9). Mass of weighing dish empty, (gm)	41
(10) .Mass of mercury (8) –(9), (gm.)	326
(11). Vol. wet soil pat (V1) = (10)/13.6, (cc.)	23.97
(12). Mass of weighing dish + displaced mercury (by dry pat), (gm.)	295
(13). Mass of mercury displaced (12) – (9), (gm.)	183
(14). Vol. dry pat (V2) = (13)/13.6, (cc.)	13.45

Table4: Shrinkage factor determination

UNCONFINED COMPRESSION TEST

OBSERSERVATION AND CALCULATIONS

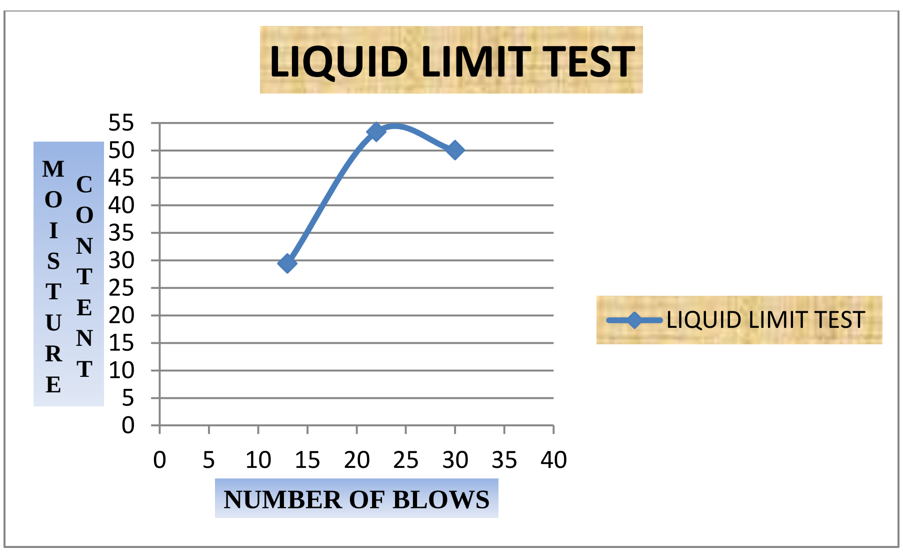
CLAY + 20% RICE HUSK ASH

i. Type of specimen – Undisturbed/Remoulde = Remoulde
ii. Least count of deformation dial gauge (mm/divn.) = 0.01
iii. Proving ring constant (N/divn.) = 20

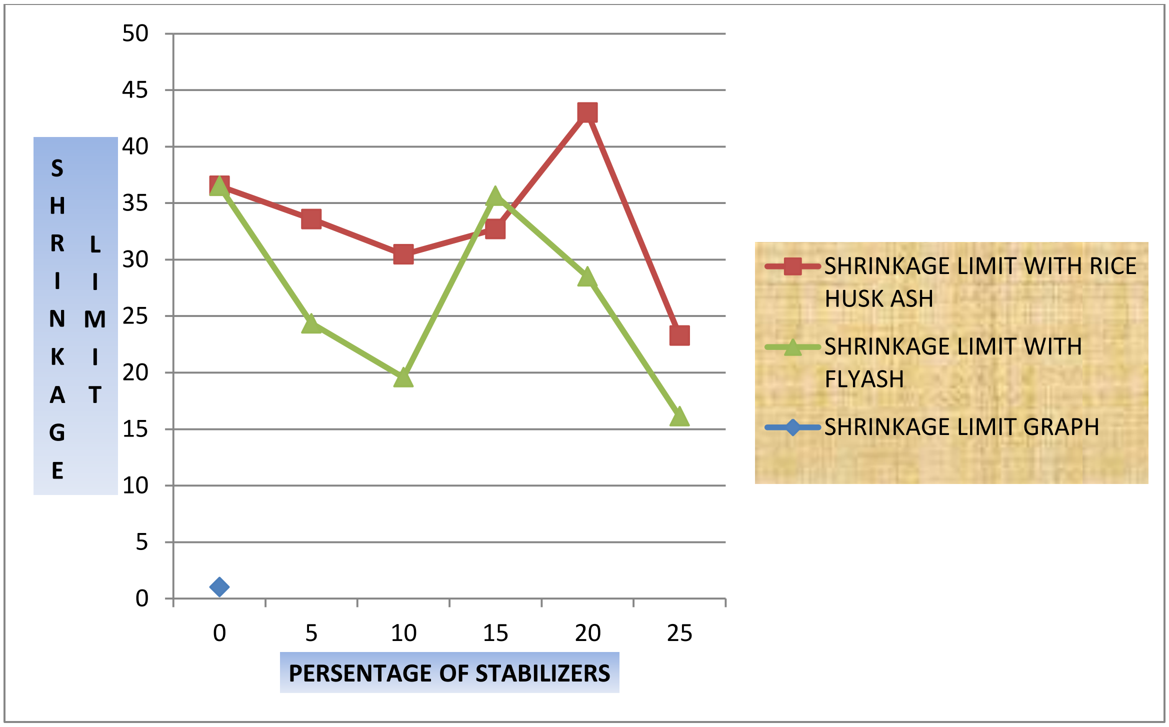
Table5: UNCONFINED COMPRESSION DATA

ANALYSIS OF TEST RESULTS

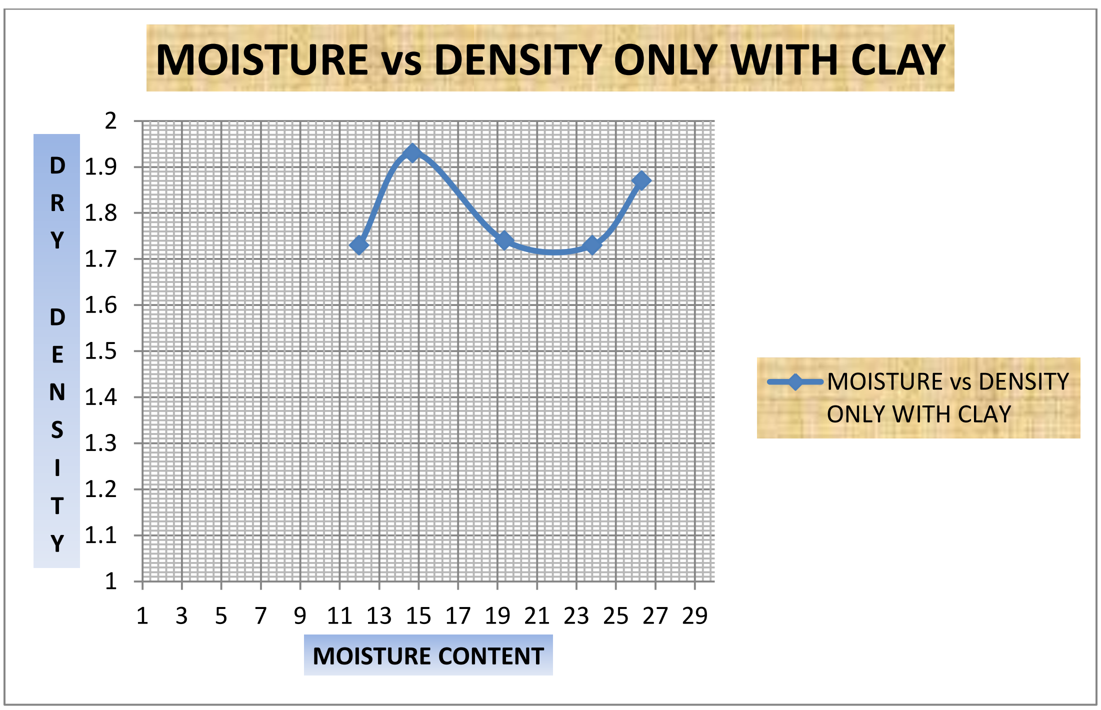
S.No.	Elapsed Time (sec.)	Deformation (delta L)		strain	Corrected area	Load		Compress-ive stress ,q (N/cm*cm)
		(divn.)	(m.m)			(divn)	(N)	
(1)	(2)	(3)	(4)=(3) *L.C.	(5)	(6)	(7)	(8)= (7)*(iii)	(9)=(8)/(6)
1.	30	04	0.04	0.000526	11.35	0.04	0.8	0.07048
2.	30	08	0.08	0.00105	11.35	0.08	1.6	0.14096
3.	30	13	0.13	0.00171	11.36	0.14	2.8	0.24648
4.	30	16	0.16	0.00210	11.37	0.18	3.6	0.31662
5.	30	18	0.18	0.00236	11.37	0.22	4.4	0.38698
6.	30	21	0.21	0.00276	11.37	0.26	5.2	0.45734
7.	30	38	0.38	0.00500	11.39	0.32	6.4	0.56190
8.	30	40	0.40	0.00526	11.40	0.36	7.2	0.63158
9.	30	43	0.43	0.00566	11.41	0.42	8.4	0.73619
10.	30	49	0.49	0.00645	11.42	0.50	10.0	0.87566
11.	30	58	0.58	0.00763	11.43	0.56	11.2	0.97988
12.	30	72	0.72	0.00947	11.44	0.64	12.8	1.11888
13.	30	83	0.83	0.01092	11.46	0.70	14.0	1.22164
14.	30	100	1.00	0.01315	11.49	0.74	14.8	1.28808
15.	30	130	1.30	0.01710	11.54	0.78	15.6	1.35181
16.	30	170	1.70	0.02230	11.60	0.80	16.0	1.37931
17.	30	226	2.26	0.02970	11.69	0.80	16.0	1.36869
18.	30	286	2.86	0.03763	11.78	0.80	16.0	1.35823
19.	30	350	3.50	0.04605	11.89	0.82	16.4	1.37931
20.	30	390	3.90	0.05131	11.95	0.90	18.0	1.50627
21.	30	406	4.06	0.05342	11.98	0.92	18.4	1.53589



Graph 1: Moisture content Vs No. of blows



Graph 2: Shrinkage Limit Vs percentage of Stabilizers



Graph 3: Dry density Vs water content

CONCLUSION

1. Values of optimum moisture content (OMC) and maximum dry density (MDD) for parent clay were found to be 14.71% and 1.93 g/cc. It was observed that with increase in percentage of rice husk ash as stabilizer the value of OMC increases from 14.71% to 32.5% and value of MDD decreases from 1.93 g/cc to 1.54 g/cc. On the other hand, when fly ash was mechanically mixed with parent clay, no significant changes were observed in the values of OMC and MDD.

2. 2. A series of unconfined compressive strength tests were conducted to determine the strength characteristics of parent clay treated with various percentages of pozzolanic wastes as per specifications of IS: 2720 (Part 10) (1973).
3. A considerable decrease in values of shrinkage limit was observed when soil was stabilized with fly ash and rice husk ash.

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