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Efficiency Of Randomly Distributed Fibers (RDFS) & Alkali Activated Rice Husk Ash (ARHA) In Stabilizing Swell Soils

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Abstract - In India, expansive soils popularly known as black cotton soils are highly problematic, as they swell on absorption of water and shrink on evaporation thereof. Because of this alternate swell and shrinkage, distress is caused to the foundations of structures laid on such soils. Understanding the behaviour of Swell Or expansive soil and adopting the appropriate control measures have been great task for the geotechnical engineers. Extensive research is going on to find the solutions to black cotton soils.

Stabilization of soil improves its engineering properties. Chemical & Mechanical stabilization processes are used in this research. Use of Agricultural industrial wastes Rice Husk Ash (RHA) &RDFs with alkali activator stabilize the problematic soils; and making it suitable for foundation soils. Here Sodium Hydroxide and Sodium Silicates were used as activators.

A study is carried out for improvement of strength criteria is ascertained by conducting Unconfined Compressive Strength(UCS)&California Bearing Ratio (CBR) tests on samples for the efficiency of Sodium based alkaline activators with Rice Husk Ash and Randomly Distributed Fibers (Nylon)..

The results clearly indicates that 30% Rice Husk Ash with 10% alkali activator and 1% fiber dosage have noticeable influence on UCS & CBR values of expansive soils. The effectiveness of this binder is observed by conducting UCS, CBR tests on optimum Results of soil samples at 7,14, 28 days. Hence this idea gives us a twofold advantage of utilizing an Agricultural Industrial wastes to stabilize the soils and making it as a sustainable stabilization for Swell soils.

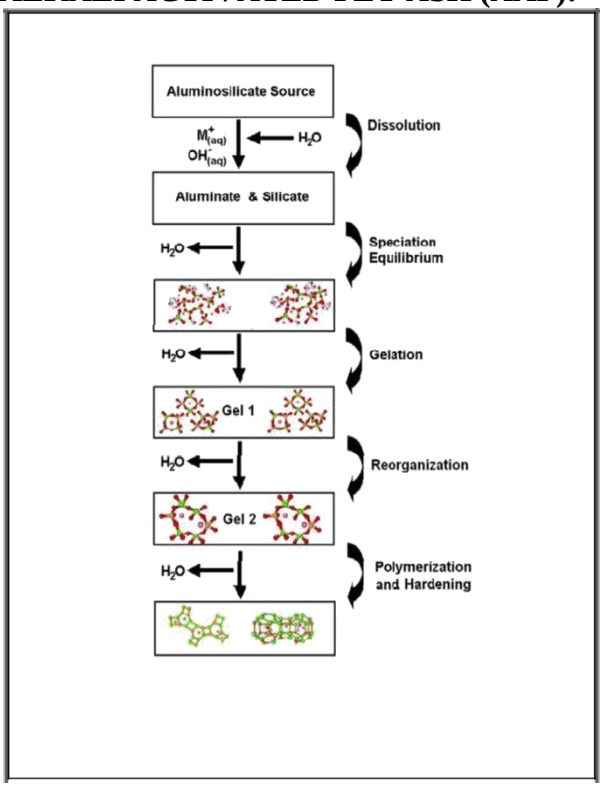
1.INTRODUCTION

Expansive soil is one among the problematic soils that has a high potential for shrinking or swelling due to change of moisture content. swelling soils can be found on almost all the continents on the Earth. Destructive results caused by this type of soils have been reported in many countries. In India, large tracts are covered by expansive soils known as black cotton soils. The major area of their occurrence is the south Vindhyachal range covering almost the entire Deccan Plateau. These soils cover an area of about 200,000 square miles and thus form about 20% of the total area of India. These soils are rich in lime, iron, magnesia and alumina but lack in the phosphorus, nitrogen and organic matter. The primary problem that arises with regard to expansive soils is that deformations are significantly greater than the elastic deformations and they cannot be predicted by the classical elastic or plastic theory. Movement is usually in an uneven pattern and of such a magnitude to cause extensive damage to the structures resting on them. In this work it is attempted to study the effect of additives like –Sodium alkali Activated Rice husk ash‖ (ARHA) with randomly distributed fibers to improve the properties of Swelling/Expansive soil.

SOIL STABILIZATION:

Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils

ALKALI ACTIVATED FLY ASH (AAF):



Conceptual model for alkaline activation processes

RICE HUSK ASH (RHA):

Preparation of alkali-activated rice husk ash by using sodium silicate and 10, 12.5 and 15 molal sodium hydroxide solutions.

Evaluation of California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) of Alkali activated Rice husk ash with randomly distributed fibre on an interval of 7, 14, 28 days (mixed with 20, 30 and 40% rice husk ash with total solid to activator ratio ranging from 0.05 to 0.15 and 0.5, 1, 1.5% of fibre.)

Properties	Test Results
Specific gravity	2.4
Liquid Limit (%)	49.4
Plastic Limit (%)	24.97
Plasticity Index (%)	24.43
Water Content (%)	30.16
Optimum Moisture Content (%)	14
Maximum Dry Density (g/cc)	1.51

Rice Husk Ash (RHA):

Chemical Composition of RHA

Chemical Parameters	Composition Value (%)
Silica	90.8
Aluminium	3.5
Ferric Oxide	1.32
Calcium Oxide	1.57
Magnesium Oxide	1.2
Sodium	0.15
Potassium	0.24
Loss on Ignition	0.67

Properties of Expansive Soil:

S. No	Property	Value
1	**Grain size distribution** Sand size(%) Silt &clay size(%)	9 **91**
2	**Atterberg limits** Liquid limit (LL)(%) Plastic limit (PL)(%) Plasticity index (PI) (%)	 74.5 31.2 43.3
3	**Compaction properties** Optimum Moisture Content, O.M.C.(%) Maximum Dry Density, M.D.D (g/cc)	 26.4 1.44
4	**Specific Gravity (G)**	2.61
5	**IS Classification**	CH
6	**Soaked C.B.R (%)**	1.68
7	**Differential free swell (%)**	115
8	**Shear Strength Parameters** Cohesion (C) (KPa) Angle of internal friction (ø)	 52 0º

Geotechnical Properties of RHA:

Nylon Fiber:

Nylon is a manufactured fibre in which the fibre forming substance is a long-chain synthetic polyamide in which less than 85% of the amide-linkages are attached directly (- CO-NH-) to two aliphatic groups

The material was announced in 1938 and the first nylon products; a nylon bristle toothbrush made with nylon yarn (went on sale on February 24, 1938) and more famously, women's stockings (went on sale on May 15, 1940).

Nylon fibres are now used to make many synthetic fabrics, and solid nylon is used as an engineering material.

Nylon is a synthetic polymer, a plastic, invented on February 28, 1935 by Wallace Carothers at the E.I. du Pont de Nemours and Company of Wilmington, Delaware, USA.

The fibre used for testing has been taken from CHAMARLAKOTA East Godavari district of Andhra Pradesh. The type of fibre used in this study is short Nylon fiber.

MIX PROPORTION USED

Details of the alkaline activator mixed soils specimens

S	Name of the mix	Particulars of the mix
1	ES+RHA (20%) +S (5%)	Soil +20% RHA + 5% alkali by weightof total solids
2	ES+RHA (20%) +S (10%)	Soil +20% RHA + 10% alkali by weightof total solids
3	ES+RHA (20%) +S (15%)	Soil +20% RHA + 15% alkali by weightof total solids
4	ES+RHA (30%) +S (5%)	Soil +30% RHA + 5% alkali by weightof total solids
5	ES+RHA (30%) +S (10%)	Soil +30% RHA + 10% alkali by weight of total solids
6	ES+RHA (30%) +S (15%)	Soil +30% RHA + 15% alkali by weight of total solids
7	ES+RHA (40%) +S (5%)	Soil +40% RHA + 5% alkali by weight of total solids
8	ES+RHA (40%) +S (10%)	Soil +40% RHA + 10% alkali by weight of total solids
9	ES+RHA(40%)+S(15%)	Soil +40% RHA + 15% alkali by weight of total solids

Fibers by Weight of Soil sample mixtures:
0, 0.5, 1.0, 1.5 Percentage of fibre dosage on the optimum value of strength of soil samples.

SOIL PROPERTIES:

1. Plastic Limit:
2. Liquid Limit:
3. Differential Free Swell(DFS)
4. Compaction Properties

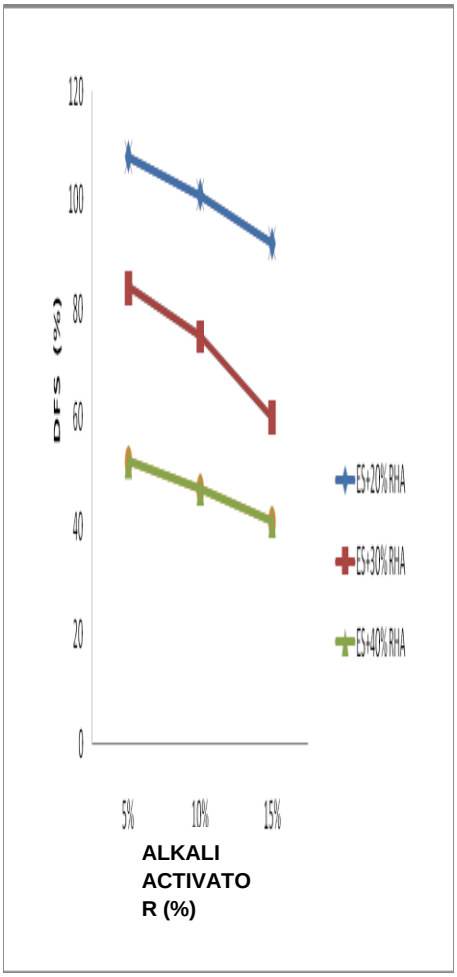
LABORATORY TEST RESULTS ON SOIL STABILIZATION WITH ARHATREATED SAMPLES:

Soil ,Rice husk Ash , 5%,10%,15% of alkali by weight of total solid Mixtures for DFS, LL, PL, PI, OMC, MDD

Mix proportion	DFS %	LL (%)	PL (%)	PI (%)	OMC (%)	MDD(g /cc)
Untreated Expansive soil	115	74.5	31.2	43.3	26.4	1.44
ES+RHA (20%) +S (5%)	108	71.8	32.4	41.4	26.9	1.45
ES+RHA (20%) +S (10%)	101	70.4	33.0	37.4	27.3	1.46
ES+RHA (20%) +S (15%)	92	69.0	34.3	34.7	27.6	1.45
ES+RHA (30%) +S (5%)	84	67.1	36.1	31.0	28.0	1.48
ES+RHA (30%) +S (10%)	75	61.6	36.9	24.7	28.3	1.52
ES+RHA (30%) +S (15%)	60	57.2	38.0	19.2	28.5	1.51
ES+RHA (40%) +S (5%)	52	53.5	38.7	14.8	28.9	1.50
ES+RHA (40%) +S (10%)	47	51.0	39.2	11.8	29.2	1.49
ES+RHA (40%) +S (15%)	41	50.4	39.5	10.9	29.8	1.48

- ES+RHA (30%) +S (10%) has given optimum results. Hence for the optimum mix Nylon Fibres are added and find out the details of mix how strength Varies based on the UCS &CBR values.

Effect of Additives on DFS:

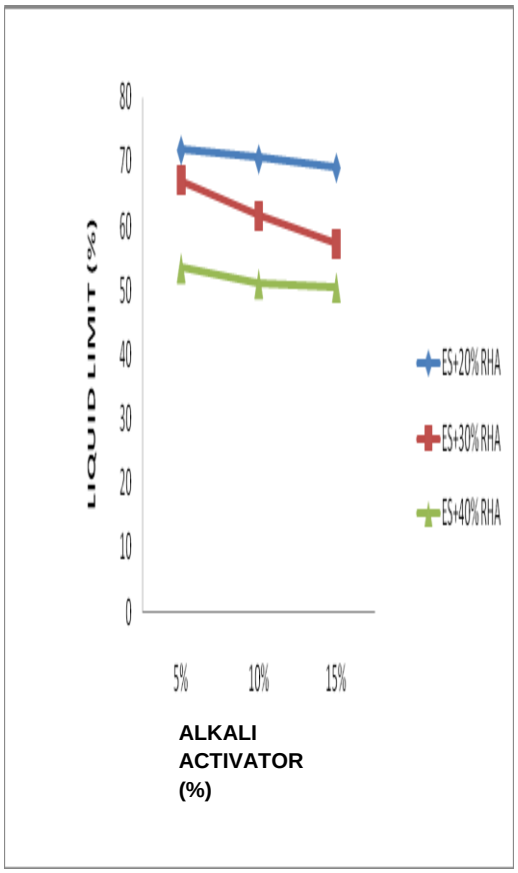


From the above graph, it can be noticed that the percentage of DFS gradually decreases with the increase in the percentage of Alkali activator at any composition of ES & RHA (20, 30, 40%)

Effect of Alkali Activator on LL Values of Expansive Soil Mixtures

Effect of Additives on LL:

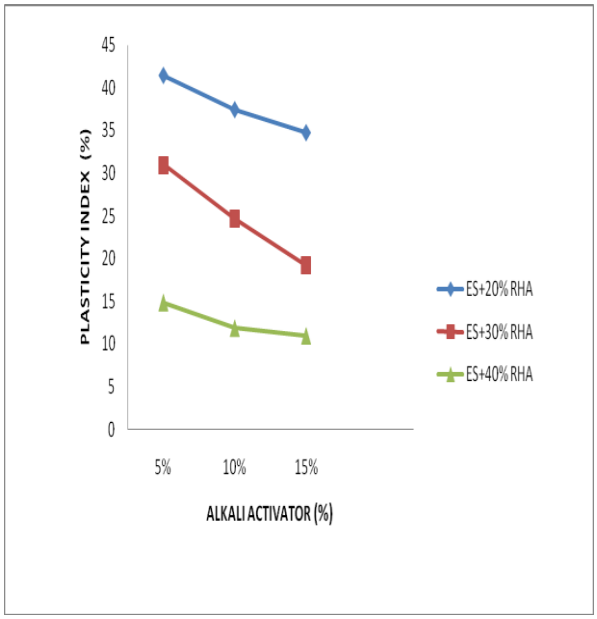
it can be noticed that the percentage of LL slightly decreases with the increase in the percentage of Alkali activator at a composition of ES with 20%RHA and decreases abruptly for



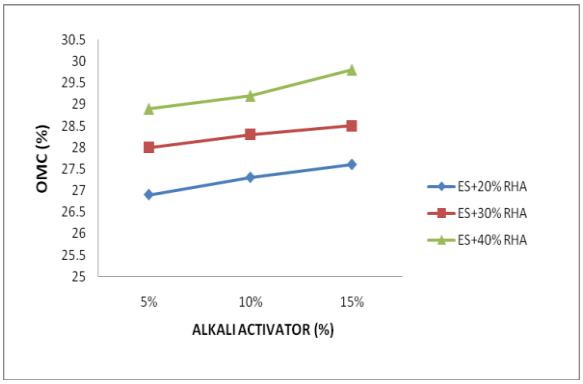
the composition of ES with 30%RHA and 10%of alkali solution

Effect of Additives on PI:

it can be noticed that the percentage of PI gradually decreases with the increase in the percentage of Alkali activator at any composition of ES & RHA (20, 30, 40%).

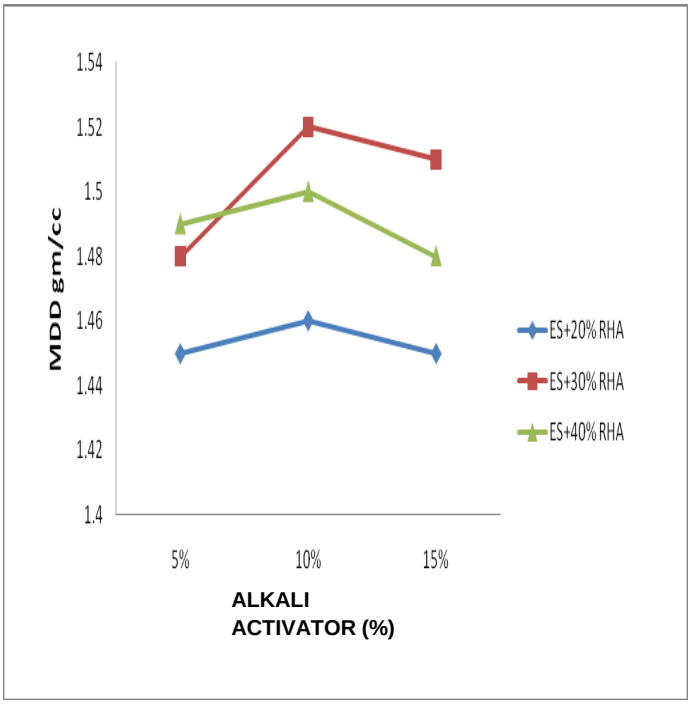


Effect of Additives on OMC:



increases as percentage of alkali activator increases with ES with RHA of percentages (5, 10, and 15%). This is due to the fact that the rice husk particles are hollow and they require more water for their absorption and lubrication. Hence as the percentage of Alkali activator increases, with the increase in OMC.

Effect of Additives on MDD



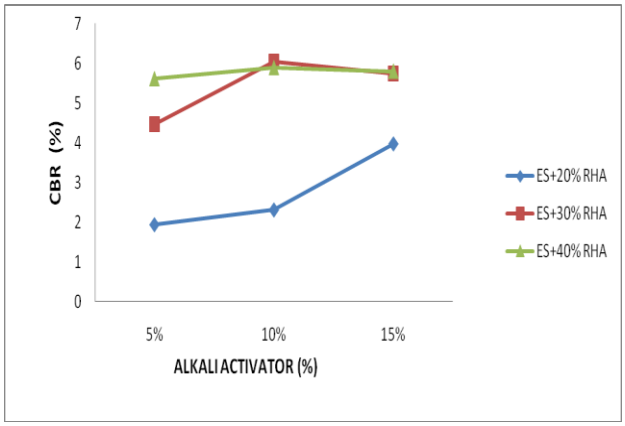
the compacted soils at optimum rice husk ash content will result in reduction in the MDD compared to the MDD of only soil. This is due to the fact that soil volume is replaced by the low-density rice husk ash.

In addition to this is due to the fact that more volume of soil is replaced by Nylon fibre in addition to the fly ash (both the materials have low densities). Hence the MDD values are greatly reduced by increase in % of waste material in the composite mix

UCS, CBR (S) results of Soil with Rice husk Ash of 20, 30 and 40%and alkali activators of5%, 10%, 15% soil sample mixtures

Mix proportion	**UCS (kPa)**	**CBR (S)%**
Untreated Expansive soil	104.0	1.7
ES+RHA (20%) +S (5%)	116.0	1.9
ES+RHA (20%) +S (10%)	128.0	2.3
ES+RHA (20%) +S (15%)	139.0	4.0
ES+RHA (30%) +S (5%)	150.0	4.5
ES+RHA (30%) +S (10%)	181.0	6.1
ES+RHA (30%) +S (15%)	172.0	5.7
ES+RHA (40%) +S (5%)	168.0	5.6
ES+RHA (40%) +S (10%)	173.0	5.9
ES+RHA (40%) +S (15%)	163.0	5.8

Effect of Additives on CBR:



Significant increase in CBR is recorded in stabilized expansive clay with addition of 30% rice husk ash, beyond this percentage the increase in CBR is marginal. The increase in the strength with addition of 30% rice husk ash and 10% Alkali activator solution may be attributed to the formation of silicate gel.Hence, we observed the optimum results of CBR values attained at the strength of soil+30%RHA+10%Alkali by weight of total solids

LABORATORY TEST RESULTS ON STABILIZATION WITH ES+RHA (30%) +S (10%) SOIL MIXTURE AND FIBER DOSAGE:

it is observed that the 1% fibre provides tensile strength to the mix. Beyond this 1 % of Nylon fibre the development of strength is insignificant. As the fiber dosage increases gradually with the soil sample ES+RHA (30%) +S (10%)attains max MDD AT 1% of fiber dosage. As the maximum CBR value is at 30% sodium alkali activated rice husk ash content at 1 % of Nylon fibre, hence at the initial stage the randomly distributed fibre maintains

LABORATORY TEST RESULTS ON STABILIZATION WITH ES+RHA (30%) +S (10%) SOIL MIXTURE AND FIBER DOSAGE AND CURING PERIODS

S	% Of fiber Added	OMC (%)	MDD (%)	UCS (Kpa)	CBR (%)
1	0	28.3	1.52	181	6.05
2	0.5	28.2	1.53	228	6.4
3	1	28.3	1.54	252	7.32
4	1.5	28.5	1.53	239	7.08

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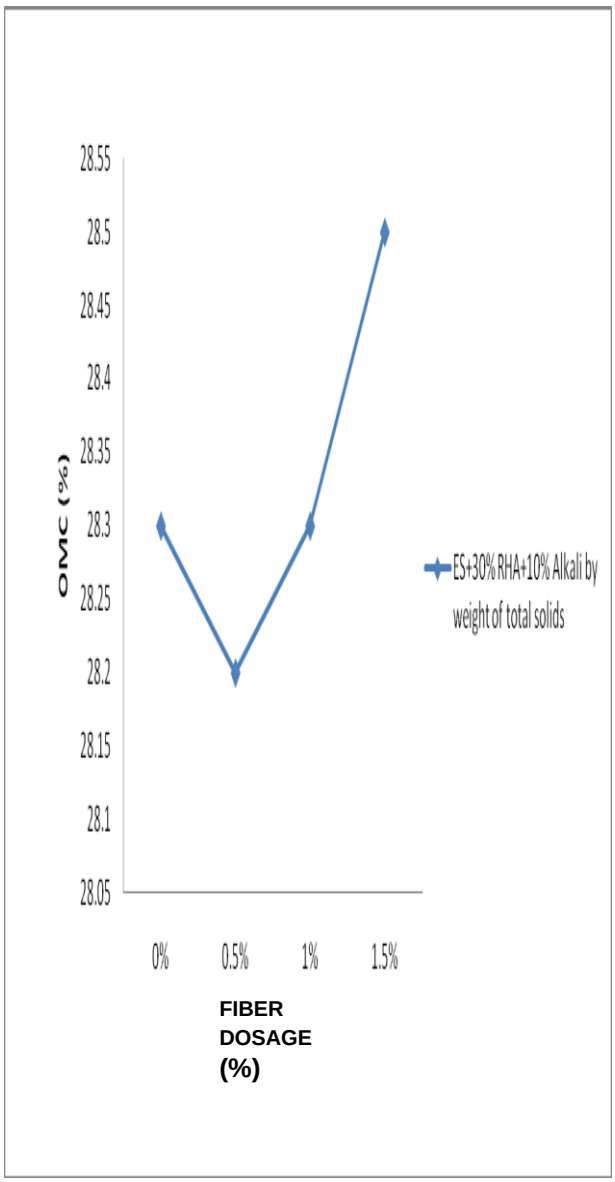
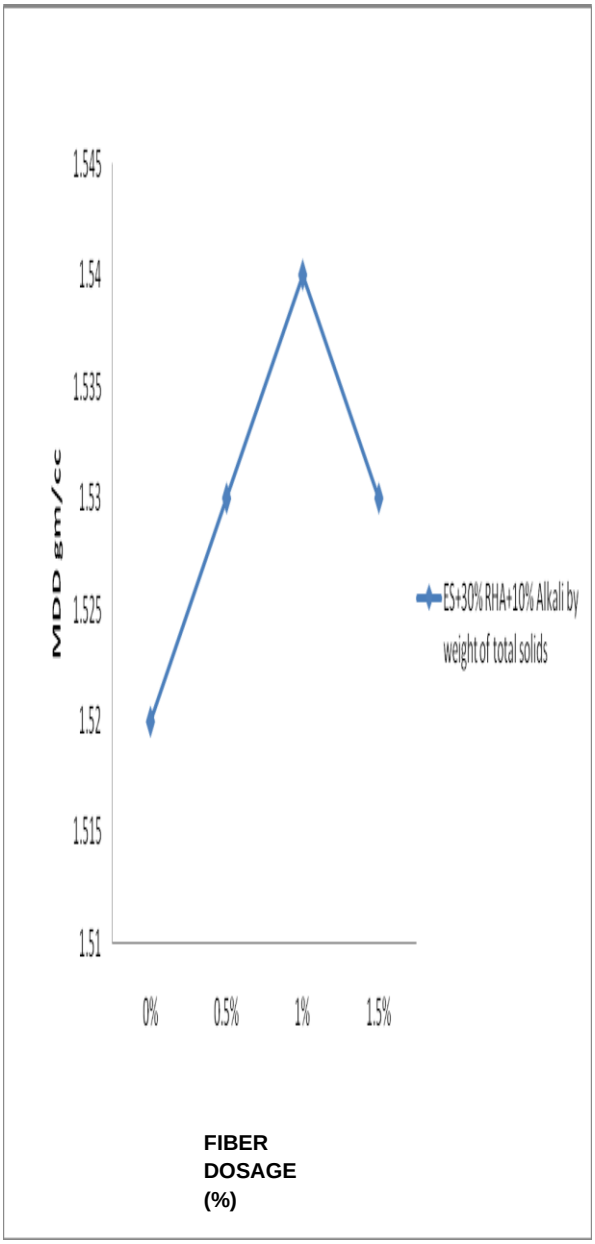
Effect of Fiber dosage on OMC Values of Expansive Soil Mixtures



Effect of Fiber dosage on MDD Values of Expansive Soil Mixtures



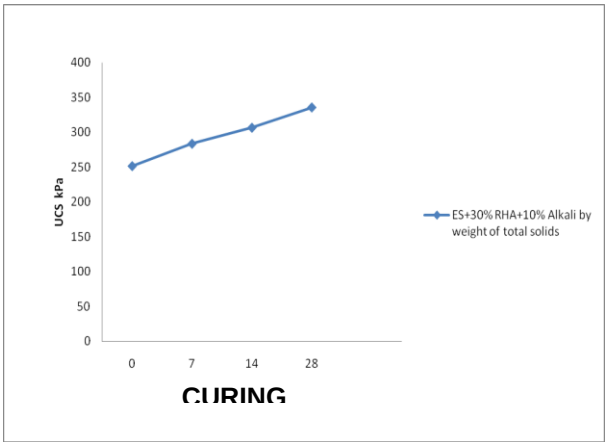
LABORATORY TEST RESULTS ON STABILIZATION WITH ES+RHA (30%) +S (10%) SOIL MIXTURE AND FIBER DOSAGE AND CURING PERIODS:

S	Curing in days	UCS (KPa)	CBR (%)
1	0	252	7.32
2	7	284	7.56
3	14	307	8.05
4	28	336	8.1

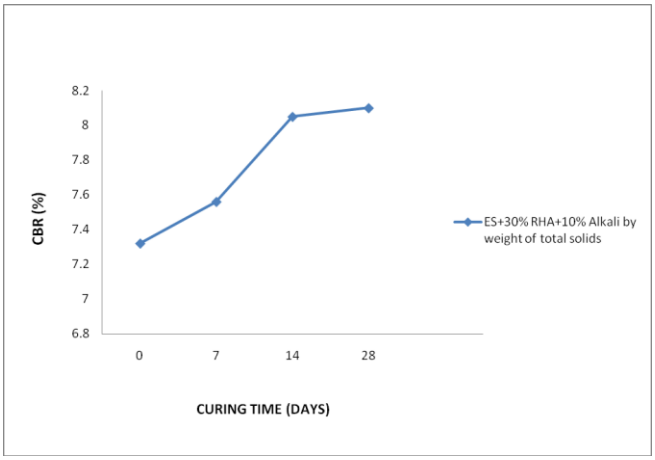
UCS & CBR results of ES+RHA (30%) +S (10%) mix with 1%fiber sample curing in 7,14,28 days.

UCS & CBR results of ES+RHA (30%) +S (10%) mix with 1%fiber sample curing in 7,14,28 days.

It is observed that as the maximum CBR value is at 1.0% fibre dosage is optimum. Hence curing has been done for 7, 14, 28 days. The results are shown in the graphs below



UCS results of ES+ RHA (30%) +S (10%) +1% fiber dosage soil sample curing in 0, 7, 14 & 28 days.



CBR results of ES+ RHA (30%) +S (10%) +1% fiber dosage soil sample curing in 0, 7, 14 & 28 days

The variation of strength obtained for 20, 30 and 40% fly ash content and containing 10% fluid by weight of dry mass (activator) mixed soil samples, after 7,14 and 28 days curing periods is shown in Table 5.4. The variations are also shown in Figures 5.11, 5.12, 5.13&5.14 shows the gain in strength of all mixes after 7,14and 28 days respectively . From the tables and graphs it is evident that the 7 days strength is more in case of untreated soil sample. while the 14 and 28 days strength is more in case of mix ES with ARHA and 1%of nylon fiber respectively. The least 7, 14and 28 days strength is exhibited by mix ES+RHA (30%) +S (10%).

The maximum strength of ARHA with RDF on treated soil sample increases with increasing in curing period, the strength also increases.

CONCLUSION:

1) Optimum Moisture Content (OMC) increased by increase in percentage of Alkali Activator Rice Husk Ash (ARHA). It is due to the volume of soil is replaced by Rice Husk Ash with Alkali activator. As the percentage of ARHA increases the Maximum dry density (MDD) values of soil decreases. It is due to the volume of soil replaced by the low density of sodium alkali activated Rice Husk Ash.

2) The UCS value of the stabilized expansive soil found to vary with percentage of Rice Husk Ash (RHA) and alkali solution; and maximum UCS value was obtained with 30% RHA and 10% alkali solution.

3) The addition of ARHA is improving the CBR values for all mix proportions, but there is an abrupt increase in CBR at 30% rice husk ash with 10%alkali activated total solids sample.

4) From the studies it is concluded that 1% randomly distributed fiber is optimum percentage. the unconfined compressive strength, California bearing ratio soil is found to vary with concentration of chemical in the activated rice husk ash and curing period.

- The UCS value of the 30% RHA + 10% of Alkali by weight of total solids with 1% of nylon Fiber gives the maximum value of 252 KPa.
- The CBR value of the 30% RHA + 10% of Alkali by weight of total solids with 1% of nylon fiber gives the maximum value of 7.32%.It gives 5.64% more strength than the untreated soil sample.

5) The unconfined compressive strength soil is solvable found to vary with concentration of chemical in the activated rice husk ash with 1% of nylon fiber and curing period

- Maximum 7 day strength attained by activated sample is 284 kPa.
- Maximum 14 day strength attained by activated sample is 307 kPa.
- Maximum 28 day strength attained by activated sample is 336 kpa.

SCOPE FOR FUTURE STUDY

- Efforts should be made to reduce the cost of operation, by searching other natural alkaline materials.
- Field application of this method, by using suitable technology.
- Application of ARHA for stabilization of other low strength high compressible clay.
- Advance cyclic tri-axial tests and some other tests may be conducted for the further improvement of the expansive soils.

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BIOGRAPHIES

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