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Study on the behavior of soft soil reinforced with rice husk ash

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Abstract: Soil stabilization has become a major issue in Construction engineering and the researches regarding the effectiveness of using industrial wastes are rapidly increasing. This industrial waste when exposed to the opening causes environmental hazards along with depositional problems. Keeping this in view agricultural waste materials like Rice husk ash (RHA) are now used as admixture to stabilize soil which save the construction cost considerably. This study demonstrates the effects of rice husk ash (RHA) and the mixture of rice husk ash (RHA) and cement on the geotechnical properties of soil. The addition of rice husk ash (RHA) and cement were found to improve the engineering properties of the construction site soil in stabilized forms specifically compaction characteristics, shear strength characteristics, compressive strength and California bearing ratio (CBR). Optimum moisture content, shear strength, CBR value increases with the addition of mixture of RHA and cement and maximum dry density decreases. Unconfined compressive strength has great influence with the addition of RHA and mixture of RHA and cement.

Keywords: RHA, Compaction Characteristics, Shear Strength, CBR, UC Strength.

Introduction:

Soft soil is that type of soil which has large amount of liquid and small strenght and it can be defined as silty clay or soft clay soil. Its just capable of carrying the overburden weight of the soil but additional load will result in relatively large deformation. High water content, high compressibility and low workability of these soils often caused difficulties in the civil engineering construction projects (Das, B. M. 2002**).** On the other hand plastic soil is very prone to shear failure due to the constant load over time and considered poor material for foundations (Liu, et.al. 2008**).** To overcome from such problem improvement in the properties of soil is needed and it is done by the technique known as stabilization.

Stabilization incorporates the various methods employed for modifying the properties of a soil to improve its engineering performance, where the main objective is to increase the strength or stability of soil and to reduce the construction cost by making the best use of locally available materials. Soils with low-bearing capacity can be strengthen economically for building purposes through the process of “soil stabilization” using different types of stabilizers like cement, lime, natural oils, plant juices, animal dung, and crushed anthills. For a given country, an understanding of local conditions is of paramount importance in the application of principles of soil stabilization (Ali, et al. 1992). The soil found in a place may differ in imperative aspects from soils tested in others. Soil type and climatic conditions affect the characteristics of stabilized soil materials as well as technical method and procedures like at higher temperature the rate of curing proceed rapidly and drop of rain may affect the compaction and strength of stabilized soil. Cement and lime are the two main materials used for stabilizing soils. These materials have rapidly increased in price due to the sharp increase in the cost of energy since 1970s (Neville, 2000).

Replacing cement in soil stabilization with a secondary material like RHA will reduce the overall environmental impact of the stabilization process as well as save construction cost (B. Suneel Kumar, 2014**).** Agricultural waste like Rice husk obtained from rice milling and annually about 108 tons of rice husks are generated in the world (Alhassan, 2008).

RHA which is generated from the burning of Rice husk is considered as waste material and usually dumped backside of the kitchen of the village people in Bangladesh. RHA can be used as a cost- effective additive particularly in regions having high production capacity like Bangladesh. RHA categorized as pozzolanic material with about 67 - 70% silica and about 4.9% and 0.95%, Alumina and iron oxides, respectively (Oyetola and Abdullahi, 2006). The silica content in RHA depends on the burning temperature. An arrangement has been designed by (Grytan Sarkar *et al*, 2012) to produce RHA containing 93% silica which is the key factor for improving the properties of soil.

Materials and Methods:

Specification of Soil- Soil sample was collected from the backside of the administration building, Khulna University Engineering & Technology, Khulna, Bangladesh. It was collected from the depth of 5 ft. The collected soil was soft and it was harden by heating. Then the soils were screened through the sieve of 4.75 mm before preparing the specimen for testing. Standard tests were conducted to determine the physical properties of the soil and the results are given in Table 1.

***Table 1**: Physical Properties of original Soil.*

Serial No.	Test Conducted	Result
1	Specific gravity	2.46
2	Liquid Limit	41.5
3	Plastic Limit	15.72
4	Plasticity Index	25.78
5	Shrinkage limit	18.5
6	USCS classification	CH

Specification of RHA- For preparation RHA, a brick fence around the rice husk. Rice husk was placed on the floor and brick fence prepared by this project. There was also a roof above husk. The height of brick fence was not high and as a result of this there was provision if sufficient aeration rice husk. Rice husk was then burned and RHA was collected. RHA was then sieved with #200 sieves and by this way RHA was prepared.

Preparation of testing samples- The collected soils, ash contents and cement contents were oven dried at 105ºC overnight to remove moisture and repress microbial activity. Then the oven dried samples were mixed thoroughly by hand in a large tray in a dry state as per shown in Table2.

***Table 2:** Combination scheme of soil samples*

Sample ID	Soil (gm)	Admixture (%)	RHA and Cement	
			RHA (gm)	Cement (gm)
R1	2000	2.5	50	--
R2	2000	5	100	--
R3	2000	7.5	150	--
R4	2000	12.5	250	--
RC1	2000	2.5	20	30
RC2	2000	5	40	60
RC3	2000	7.5	60	90
RC4	2000	12.5	100	150

RESULTS AND DISCUSSION

Compaction Characteristics:

The variation of optimum moisture content of RHA treated and mixture of RHA and cement treated soil are shown in figure 1. Optimum moisture content increases with the increases of RHA content. This results because the RHA and cement are finer than the soil. The more fines the more surface area, so more water is required to provide well lubrication. The increase of water content was also attributed by the pozzolanic reaction of RHA and cement with the soil. The optimum moisture content of RHA treated soil is larger than the RHA and cement treated soil.

The variation of maximum dry density of RHA and RHA and cement treated soil in figure 2 shows that the maximum dry density of soil decreases with the increases of RHA content and the mixture of RHA and cement content. The reduction of dry density is a result of flocculation and agglomeration of fine grained soil particles, which occupies larger space leading to a corresponding drop in maximum dry density. It is also result of initial coating of soils by RHA and cement to form larger aggregate, which consequently occupy larger spaces.

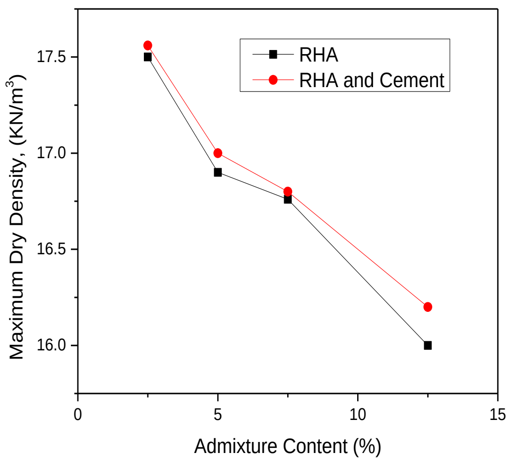

***Figure 1:** Variation of optimum moisture content with RHA and mixture of RHA and cement.*

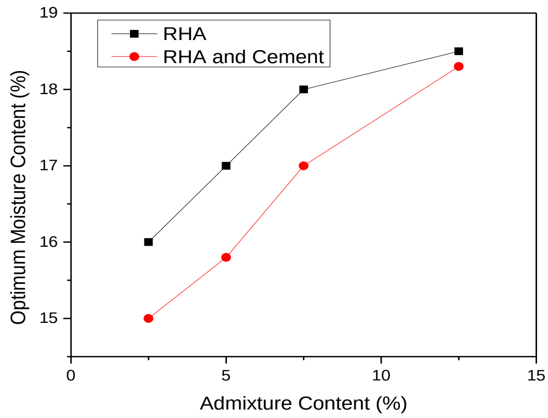

***Figure 2:** Variation maximum dry density with RHA and mixture of RHA and cement*

Shear strength parameters:

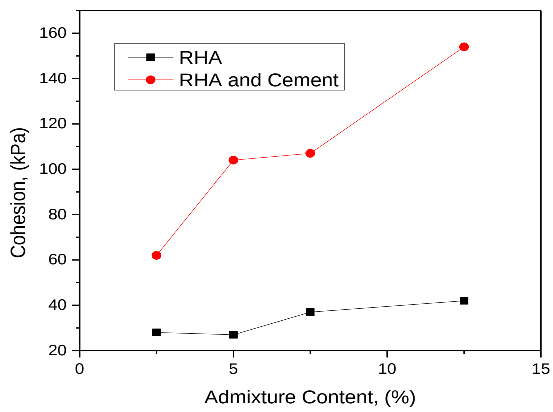

***Figure 3(a)**: Variation of Cohesion with respect to RHA and the mixture of RHA and cement for 3 days soaking*

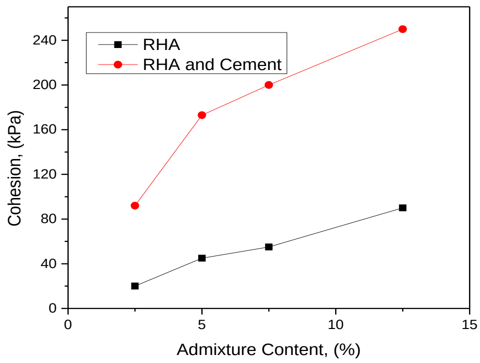

***Figure 3(b)**: Variation of Cohesion with respect to RHA and the mixture of RHA and cement for 7 days soaking*

The Mohr-Coulomb shear strength parameters of RHA and the mixture of RHA and cement (for 3 and 7 days soaking) are shown in figure 3(a) and figure 3(b). The cohesion(C) is slightly increases with the addition of RHA. On the other hand the cohesion is greatly increases with respect the mixture of RHA and cement treated soil. For 5% and 7.5% the cohesion is almost same but when the addition was 12.5% than the cohesion is increased greatly. The bond between soil particles and RHA and cement are caused the increase of cohesion of soil

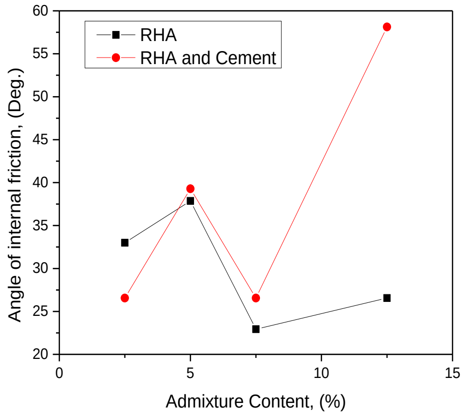

***Figure 4(a)**: Variation of angle of internal friction (φ) with respect to RHA and mixture of RHA and cement for 3 days soaking.*

In figure 4(a) shows that the angle of internal friction is increases with the addition up to 5% of RHA and mixture of RHA and cement. When it is 7.5% then angle of internal friction decreases and further internal friction is increases with the addition of 12.5% admixture. It is also shows internal friction is greater in RHA and cement admixture than only RHA addition in 3 days soaking of samples. On the other hand figure 4(b) shows that the angle of internal friction for 7 days of soaking is almost same with the addition of RHA and mixture of RHA and cement up to 5 % admixture. When the RHA and mixture of RHA and cement addition is increases the result shows great influence of internal friction. The addition of 7.5% and 12.5% mixture of RHA and cement shows the internal friction is greatly increases while decreases greatly with the addition of RHA in the same amount. The improvement of angle of internal friction (φ) implies that the silica content in RHA and cement act as a binder which agglomerate the particles into a larger one and the changes its normal characteristics.

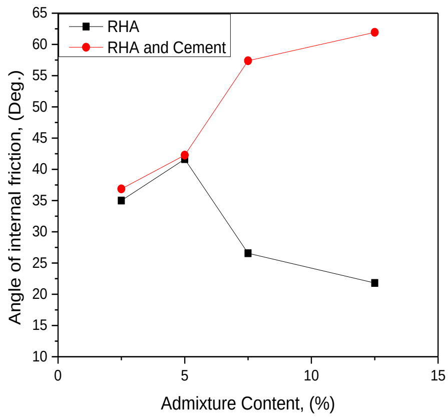

***Figure 4(b):** Variation of angle of internal friction (φ) with respect to RHA and mixture of RHA and cement for 7 days soaking.*

Unconfined compressive strength

The test result of unconfined compressive strength is shown in Figure 5(a) and figure 5(b) for RHA treated soil and RHA with Cement treated soil respectively. This figure illustrates the stress-strain behavior under vertical load. Initially the stress is gradually increases with the increase of strain. After attaining the peak stress, it remains almost constant with the increase of strain for all the combination. Approximately all the specimen shows shear failure after observing the failure plane of specimens.

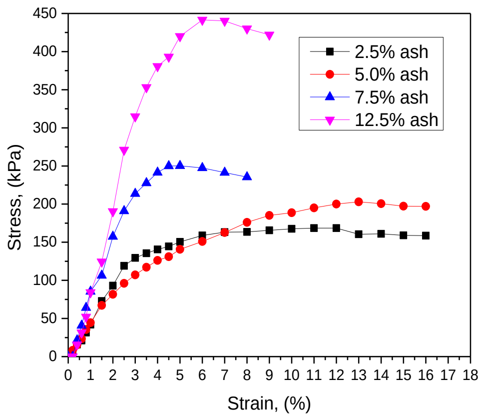

***Figure 5(a)**: Variation of Stress with respect to strain with Different percentage RHA*

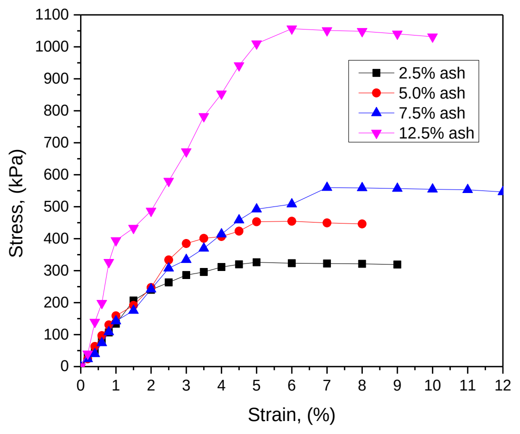

Figure 5(b)*: Variation of Stress with respect to strain with Different percentage RHA and Cement*

The following figure 6(a) and figure 6(b) illustrate the variation of unconfined compressive strength of RHA and mixture of RHA and cement treated soil for 3 days as well as 7 days of soaking under vertical load.

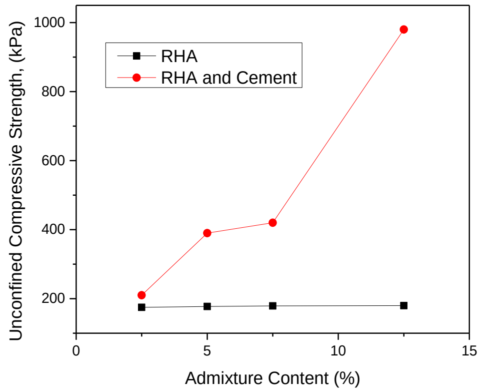

Figure 6(a)*: Variation of Unconfined compressive strength with respect to RHA and mixture of RHA and cement for 3 days of soaking.*

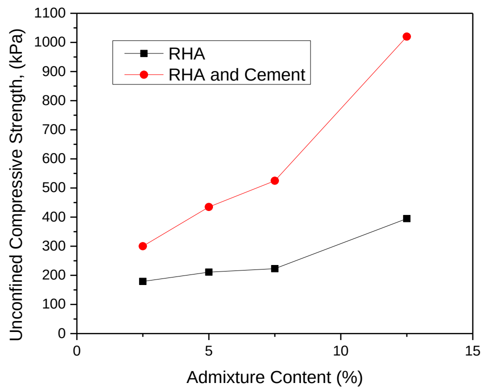

Figure 6(b)*: Variation of Unconfined compressive strength with respect to RHA and mixture of RHA and cement for 7 days of soaking.*

For 3 days of soaking the unconfined compressive strength is almost similar for RHA treated soil. Mixture of RHA and cement treated soil shows great increase of unconfined compressive strength with the addition of mixture. When 12.5% admixture is added unconfined compressive strength is greatly increase than that in 7.5% admixture. The optimum value of unconfined compressive strength is 970 kPa for addition of 12.5% admixture. For the soaking of 7 days, RHA treated soil exhibit small increase of unconfined compressive strength while mixture of RHA and cement shows great increase of strength. Comparatively mixture of RHA and cement treated soil exhibit great result with respect to RHA treated soil. It is also visible that unconfined compressive strength has influence with respect to soaking of sample. When soaking is increase than compressive strength. The reason for the improvement of soil is due to the pozzolanic reactions of cement with soil. This results in agglomeration in large particles and causes the increase in compressive strength**.**

California bearing ratio (CBR):

The table shows the variation of California Bearing Ratio (CBR) with respect to RHA and mixture of RHA and cement. It represents the CBR value is decreases with the increase of RHA and CBR value is greatly increases with the addition of mixture of RHA and cement. Addition of RHA and cement agglomerate the soil particles and make a hard bonding with cement, RHA and soil. So the CBR value is greatly increased. On the other hand RHA shows lower value of CBR because the RHA make weaker the soil than RHA and Cement mixture. For Roads & Highway Department in Bangladesh, CBR value for sub grade is less or equal 5%, which we can get using only 2.5% admixture of RHA and cement for soft soil. On the other hand CBR value for sub base, base can be get using admixture.

Table 3*: Results of CBR value with various admixtures*

Admixture name	Admixture (%)	**California bearing ratio**
RHA	2.5	4.3
	12.5	3.63
RHA (40%) & Cement (60%)	2.5	5.65
	12.5	42.03

Conclusion:

The following conclusions based on the test results in this study are made.

- The optimum moisture content increases with the addition of RHA as well as the mixture of RHA and cement. Optimum moisture content of RHA treated soil is larger than mixture of RHA and cement treated soil.
- The maximum dry density is gradually decreases with the addition of RHA and mixture of RHA and cement. Decreasing of dry density indicates

that it need low compactive energy than the natural soil to attain its maximum dry density, as a result the cost of compaction will be economical..

- Unconfined compressive strength increases with the increase of RHA and cement as well as the addition of RHA. Addition of RHA lesser the amount of cement to achieve a given strength compared to RHA cement stabilized soil.
- CBR value increases with the addition of mixture of RHA and cement and decreases with the addition of RHA.
- 2.5% mixture of RHA and cement with soil may use for subgrade soil for the design of pavement.
- For the economical consideration, stabilization of soil by the mixture of RHA and cement is a convenient way.

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