Behaviour of cement treated kaolin clay mixed with fiber and rice husk ash

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Abstract - *A series of tests were conducted to study the combined effect of polypropylene fiber, cement and rice husk ash on kaolin clay. Cement and rice husk ash were added to clayey soil at ranges of 0–6% and 0–20%, respectively. Fiber content was varied as 0, 0.5, 1, 1.5, and 2%. To understand the impact of these additives on clay different tests like; compaction tests, unconfined compression tests (UCS), split tensile strength tests (STS) and California bearing ratio tests (CBR). In addition SEM (scanning electron microscopy) were carried out on certain samples in order to study the surface morphological characteristics, particle size and hydraulic compounds, which were formed. CBR tests sample were soaked for 4 days. Based on the favourable results obtained, it can be concluded that the expansive soil can be successfully stabilized by the combined action of fibers, cement, and rice husk ash.*

Keywords: *Rice Husk Ash; OMC; MDD; Cement; Stabilization*

INTRODUCTION

Weak or soft soils are undesirable in case of structure which transfer high load to the ground like multi-storey buildings, embankments with heavy traffic etc. These soils are susceptible to large settlements due to its poor shear strength and high compressibility. Different ground improvement techniques like densification techniques, reinforcement techniques and stabilization techniques are available options for improvement of the properties of weak soil.
Among these technique addition of different materials like cement, fiber, and wastes like; fly ash, rice husk ash etc. is one of the popular technique among the engineers.

Rice husks are produced during the operation of paddy, which varies from 20% (Mehta, 1986) to 23% (Della et al., 2002) by weight of the paddy. The rice husk is a waste material used in the boiler for processing paddy. This process generates ash about 20% of its weight as ash (Mehta, 1986). The ash produced is known as rice husk ash. Its properties depends upon the the burning process (Nair et al., 2006). Rice husk ash is utilized as pozzolanic material (ASTM C 168, ASTM 1997) due to its high amorphous silica content (Mehta, 1986). Production of paddy in India is about 100 million tonnes, which can produce more than 4 million tonnes of RHA (Ramakrishna and Kumar, 2008). Most of the studies are done on clay mixed with rice husk and cement or with fiber alone. The objectives of this paper are to study the effects of fiber inclusions on the cement treated clay mixed with rice husk.

Scope of present study

The geotechnical characteristics of cement treated kaolin clay mixed with fiber and rice husk ash were investigated. Cement was added to clayey soil at 0–6% and rice husk ash was added to the clayey soil at 0–20% by dry weight of sample. Test specimens were subjected to compaction tests and California bearing ratio (CBR) tests. Samples were tested with 0, 0.5, 1.0, 1.5, and 2% polypropylene fibres (3, 6, 12 mm lengths). This paper presents the details and results of the experimental study and the conclusions from the study.

EXPERIMENTAL INVESTIGATION

MATERIAL

SOIL

Kaolin clay was used in this study which was obtained from the locally available market. Properties of soil is presented in Table 1.

Table 1. Properties of Clay

PROPERTIES	VALUES
Specific gravity (G)	2.65
Liquid limit (%)	43.3
Plastic limit (%)	19.5
Plasticity index (I_p)	23.8
Optimum moisture content (%)	16.5
Maximum dry density	1.75gm/cc

RICE HUSK ASH

Rice husk ash used in this study was obtained from the locally available market. Its physical properties are shown in the Table 2.

Table 2. Physical properties of Rice Husk Ash

Physical composition	
Specific gravity	1.98
Optimum moisture content (OMC)	60 %
MDD (g/cc)	0.879

FIBERS

Polypropylene fibers were used in this study. Fibers used in the experiment were purchased from the Nina Concrete Systems Pvt. Ltd. The length of the polypropylene fibres used in present study is varied as 3, 6 mm and 12 mm. Fibers are of fibrillated type. Properties of the fiber used in this study are presented in Table 4.

Table.4. Physical and mechanical properties of fibers

Property	Value
Specific gravity	0.9-0.91
Cut length (L)	3 mm, 6 mm, 12mm
Diameter (D)	0.02 mm
Aspect Ratio (L/D)	150, 300, 600
Water Absorption (24 hours duration)	0.3%
Solubility in water	Below 0.1%

EXPERIMENTAL DETAILS

Planning of Experiments

A series of tests were conducted on the cement treated Kaolin clay mixed with various percentages of rice husk ash and fiber. The tests performed include modified proctor compaction test and California bearing ratio tests. Six different combination of the mix were used in this study. Details of the combination are presented in Table 6.

Table 5 Detail of combination

$W=W_R+Ws+W_C+W_f$	Variation of W_R (% by total dry weight)	Variation of W_S (% by total dry weight)	Variation of W_c (% by total dry weight)	Variation of W_f (% by total dry weight)
Combination 1	0	100, 98, 96, 94	0, 2 ,4, 6	0
Combination 2	0, 5, 10, 15, 20	100, 95, 90, 85, 80	0	0
Combination 3	0, 5, 10, 15, 20	100, 95, 90, 85, 80	2	0
Combination 4	0, 5, 10, 15, 20	100, 95, 90, 85, 80	4	0
Combination 5	0, 5, 10, 15, 20	100, 95, 90, 85, 80	6	0
Combination 6	10	100, 95, 90, 85, 80	6	0.5, 1, 1.5, 2

RESULTS AND DISCUSSION

Influence of rice husk ash, cement, and randomly distributed` fibers on the geotechnical characteristics of clayey soil was investigated by conducting modified proctor compaction tests and California bearing ratio tests. Results obtained from these tests are presented in the following sections.

Compaction Test

The tests were performed as per ASTM D698 (2000) specifications for modified Proctor compaction tests. Modified proctor compaction test were carried out on the rice husk ash-soil-cement-fiber mixture proportions.. The compaction tests were performed for various combinations of rice husk ash-soil-cement-fiber mixtures as detailed in Table 5. Fig 5 and Fig 6 shows the variation of maximum dry density and optimum moisture content for different proportions of rice husk ash-soil-cement mixtures. From the results, it is observed that with increase in cement content, the maximum dry density of soil-cement mixes decreased and optimum moisture content increased. The fall in density is due to quick reaction of cement with the soil and brings changes in Base Exchange aggregation and flocculation, resulting in increased void ratio of the mix leading to a decrease in the density of the mix. The increase in optimum moisture content is probably on account of additional water held within the flocs resulting from flocculation due to cement reaction.

With the addition of rice husk ash, there is further decrease in maximum dry density and increase in optimum moisture content. The presence of rice husk ash having a relatively low specific gravity may be the cause for this reduced dry density (Ali et al. 1992; Jha and Gill 2006; Alhassan 2008).

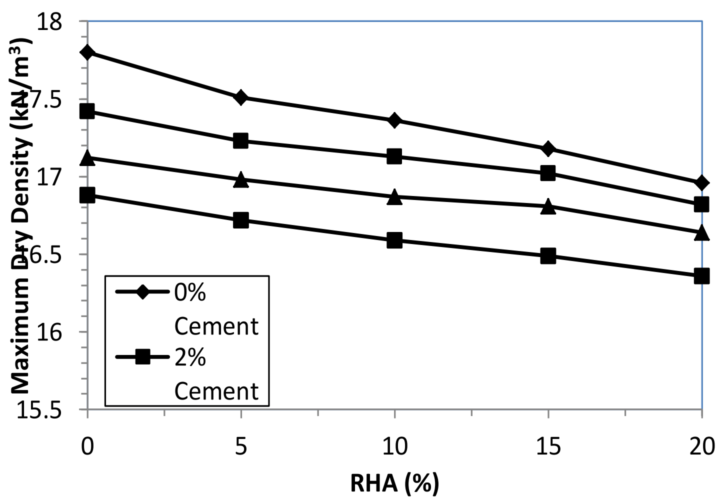

Fig.5. Dry density versus RHA (%) with different % of cement

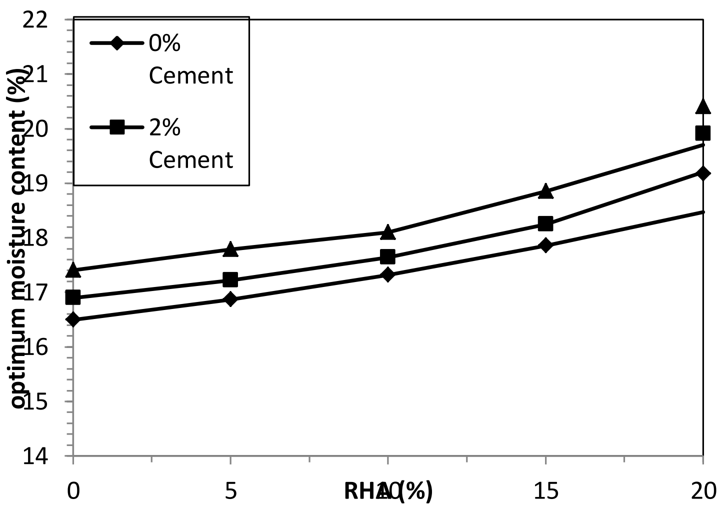

Fig.6. Optimum moisture content (%) versus RHA (%) at different (%) of cement

California bearing ratio

The CBR value of the subgrade is an important factor for the designing pavement thickness composition. The CBR value is commonly used to evaluate the quality of road materials. Fig. 19 shows the 3-day CBR values for un-stabilized and stabilized soil mixtures. The un-stabilized soil had the smallest CBR value at 2.5%, when subjected to 3 days of water immersion. The Cement/RHA mixture enhanced the bearing of soil in which the soaked CBR increased from 2% to 30% with the addition of 10% RHA and 6% cement. The reason for the CBR improvement was because of the cementing pozzolanic reaction between the soil and Cement/RHA material (Brooks 2009). The chemical hydration during the reaction, regarded as the primary reaction, formed additional cementitious material that bound particles together and enhanced the strength of the soil.

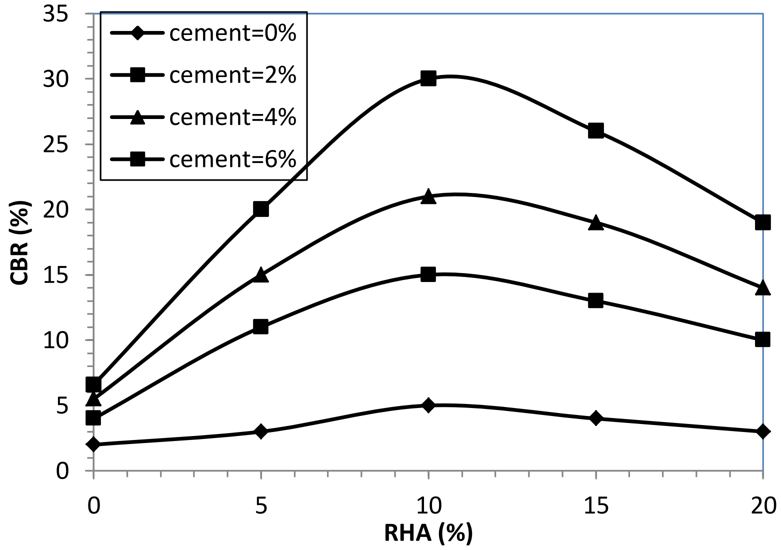

Fig.19. Variation of California bearing ratio with rice husk ash content.

Based on the previous discussion, the fiber reinforced specimens were tested for 10% RHA and 6% cement in the RHA-clay-cement-fiber mixtures. Polypropylene fiber of length 3 mm, 6 mm and 12 mm were mixed in different proportions of 0.5, 1, 1.5 and 2%. Specimens prepared for rice husk ash-soil-cement-fiber mixtures (as per Combination 6 shown in Table 5) were tested for each fiber length after 3 days of soaking. The results of CBR are presented in Fig. 20. The curves show that the addition of 1.5% of 12 mm fibers increases CBR value by approximately 74% as compared to that of same mixture without fibers. The CBR values increased with an increase in the amount of fiber up to 1.5%, and thereafter the CBR decreased slightly with the further addition of fibers (Fig. 20).

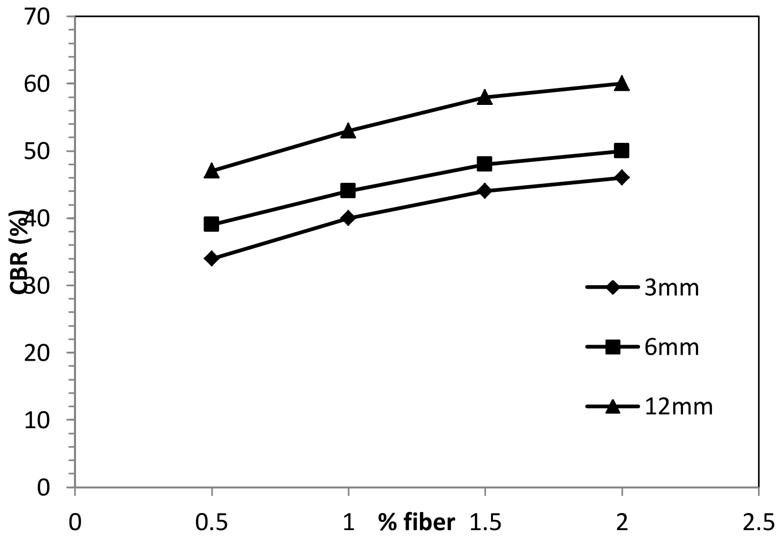

Fig. 20: Variation of California bearing ratio with % fiber.

CONCLUSION

In this study different tests like modified proctor compaction tests and California bearing ratio tests were done to evaluate the behaviour of the fibre reinforced and cement stabilized soil mixed with Rice husk ash. The major conclusions drawn are presented below.

- The MDD of cement-stabilized soil–rice husk ash mix slightly decreases with the increase in cement content and OMC increases with increase in the cement content.
- With increase in the RHA content MDD is decreasing, while OMC is increasing. MDD is increasing because of the decrease in the specific gravity of the mix and OMC is increasing because of the higher water absorption of rice husk ash.
- The results of compaction tests showed that limited quantity of polypropylene fibers (0.5–1.5%) had no significant effect on maximum dry density and optimum moisture content of rice husk ash-soil-cement-fiber mixtures
- CBR value of the mix increases with increase in the content of the cement to a certain limit of fiber content (FC = 1.5%) known as optimum content, after which further improvement in the CBR is not significant.
- There has been a remarkable improvement of the CBR value with the admixture of rice husk ash and cement. The CBR value was 6-fold the initial one with the addition of rice husk ash at a content of 10% by weight.

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