2012 International Conference on Environment Science and Engieering
IPCBEE vol.32(2012) © (2012)IACSIT Press, Singapoore

Silica and Calcium effect on Geo-Technical Properties of Expansive soil Extracted from Rice Husk Ash and Lime

S.M.PRASANNA KUMAR+

Principal, Rungta college of Engineering and Technology, Bhilai, Pin – 490 024 Chhattisgarh, India

Abstract. Study brings out the effect of siliceous compound available in amorphous form in burnt Rice Husk ash, when different doses are mixed with expansive black cotton soil, having two extreme end Geotechnical properties, for soil stabilization purpose. Rice Husk ash containing cementitious material called pozzolan, interact with soils to attain stabilized status. Use of Rice Husk ash for soil stabilization attributes to the chemical composition and physical characteristics of ash, which favour pozzolanic reactions. The major chemical compounds present in Rice Husk ash contribute active role in chemical reactions with constituents of soil is Silica Si^- ions. Calcium is another additive to form binding compounds along with soil to reach stabilized stage. Lime is added at different doses to supplement calcium Ca^+ to form binding compounds along with Silica. The optimum binder combination varies with type of soil and binder pozzolanic reactivity. The pozzolanic reactivity assessed on the rate at which the strength imparting phases are produced due to chemical reactions between soil ingredients and binder. In this work Geotechnical engineering properties of Black cotton soil is stabilized using Rice Husk ash along with calcium (Lime) at different doses. Addition of calcium component through Lime to soil is used to exploit chemical compounds formation along with the contribution of siliceous Rice Husk ash. The Geotechnical engineering properties like Liquid limit, Plastic limit, volume stabilization, Compressive strength, Compaction character, CBR values of soil have been studied in this work. On addition of Rice Husk ash the diffused double layer thickness of mixture increases and hence water holding capacity of soil mixtures increases. Specific gravity decreases on addition of ash. On addition of Rice Husk ash the gradation of mixture is adversely affected which leads in reduction of dry density. Rice Husk ash can be used as a good stabilizer along with lime. Cement imparts little strength to soil after stabilization of soil with RHA and lime. The liquid limit raised from 55 to 80% and plastic limit changed from 38 to 60% when ash content in the soil is 40%. This is because of addition of rice husk ash increases the development of diffused double layer thickness. Since rice husk ash is highly non-plastic, it was found difficult to role threads of mixture to find plastic limit of sample. Addition of rice husk ash to soil reduces the specific gravity continuously. This would be the reason for reduction in specific gravity of soil and rice husk ash mixtures. For every addition of ash (10% every time) the maximum dry density goes on decreasing. The maximum dry density from 13.56 kN/ m^3 reduces to 9.56 kN/ m^3. Moisture content of the mixtures continuously increases for addition of rice husk ash. Optimum water content increases from 34% to61%. The decrease in maximum dry density is due to domination of reduced specific gravity of ash. Further the soil gradation has adversely affected the dry density at higher content of rice husk ash in the mixture. Addition of rice husk ash along with 3% lime shows steep increment in unconfined compressive strength for 20% ash for curing period of 14 days. Further curing of samples has not shown much marginal improvement in strength. Samples cured upto 14 days have shown continuous increment and strength increased from 310 KPa to 567 KPa for 20% addition of ash and 3% of lime. It is interesting to note that samples cured upto 28 days for addition of 10% RHA and 3% lime have reached strength equal to 30% ash with 3% lime cured upto 14 days combination. Hence it reveals that less ash is sufficient to gain strength for more period of curing compared to more ash for less curing time.

Keywords: Rice Husk Ash, Lime, Pozzolanic Reactivity, Stabilization, Black Cotton Soil, pozzolana, Geotechnical Properties, calcium Ca^+ and Silica Si^- ions, Compressive strength,

1. Introduction

+ Prasanna_vec@yahoo.co.in

In most Asian countries and particularly in India, large quantity of Rice Husk Ash is available. Rice husk ash contains high reactive silica. If incorporated with lime, rice husk ash can develop cementitious products. This amorphous silica is highly reactive particularly when it is grounded.

An attempt has been made in this work to improve physical and strength properties of soils. Rice husk ash, which contains only reactive silica, requires addition of lime to produce pozzolanic compounds.

The variations in physical and strength properties of soils with addition of RHA alone and with lime are studied. RHA addition is considered up to about 40% as in most cases the initial gain in strength with Fly ashes was only up to 40%.

2. Effect of Rha on Physical Properties of Soils.

2.1. Effect of RHA on Specific Gravity of B C Soil

The specific gravity of B C soil alone is 2.37. On addition of RHA to B C soil, specific gravity of mixture decreases linearly. The reduction of specific gravity is because of lower specific gravity of RHA. Linear decrease in specific gravity indicate that no mineralogical alterations have occurred with RHA alone. At 40% addition the specific gravity of mixture reduces to 2.25.

2.2. Effect of RHA on Liquid Limit and Plastic Limit of B C Soil

B C soil alone has a liquid limit of 55% and plastic limit of 38 %. On addition of RHA both liquid limit and plastic limit of RHA and B C soil mixtures gradually increases. This is because of high water holding capacity of RHA. At 40% addition of RHA the liquid limit of mixture increases to 80 %. The plastic limit of mixture at 40% addition of RHA increases to 60 %. However, the plasticity index of soil remains unaffected.

3. Effect of Rha on Compaction Behaviour of Soil

Compaction parameters of soil assume great importance in controlling the strength of stabilised soils. Hence the effect of addition of RHA on the compaction behaviour of soil has been studied.

3.1. Effect of RHA on Compaction Behaviour of B C Soil

The addition of RHA up to 40% to BC soil has shown decrease in maximum dry density from 13.65 kN/m3 to 9.56-kN/m3. The decrease is continuous. The percentage of decrease in maximum dry density is found to be 29.9% for 40% addition of RHA and dry density of BC soil is found to be 9.56 kN/m3 for 40% addition of RHA. Similarly the optimum moisture content of the soil increases with the addition of RHA. Fig 1 shows the compaction curves of soil with different percentages of RHA. The decrease in the maximum dry density is due to increase in the water holding capacity and lower specific gravity of the mixture on addition of RHA.

4. Effect of Rha on Unconfined Compressive Strength of Soil

4.1. Effect of RHA on Strength of B C Soil

Rice husk ash has high amount of reactive silica, which is a very good pozzolanic material. It develops high strength only with lime in presence of water. Thus B C soil whose strength is about 310 kPa improves the strength marginally with RHA. 28 days strength of soil increases with increasing amount of RHA. Fig 2 shows the variation in strength of B C soil with RHA and 5% lime.

4.2. Effect of RHA and 3% Lime on Strength of B C Soil

To improve the strength of Soil and RHA mixture, addition of lime is considered. Lime is added in the range of 3 to 5%. Reactive silica reacts with lime to produce cementitious material and binds soil particles together to increase strength. Samples mixed with 40% RHA and 3% lime, cured upto 7 days have shown increment in strength reaching 599 kPa. The increase in strength is high when 20% of RHA is added when samples cured upto 14 days showing strength 608 kPa. Further addition of

RHA has not added much to the strength. Fig 3 show the variation in strength of B C soil with RHA and 5% lime.

4.3. Effect of RHA And 5% Lime on Strength of B C Soil

When B C soil treated with RHA and 5% lime, the increase in strength is observed to be slightly higher than 3% lime samples. The increase in strength of samples with 20% RHA and 5% lime, cured upto 14 days has reached 578 kPa. Similar to that of 3% lime samples, the enhancement of strength is increasing upto curing period of 14 days and further curing has not shown much improvement. At 10% addition of RHA and 5% lime, the strength of 28 days cured samples have reached 602 kPa, which is two folds of strength of B C soil alone. Fig 4 shows the variation in strength of B C soil with RHA and 5% lime. Comparison of the strength of soil RHA mixture with 3% and 5% of lime shows that increasing lime beyond 3% is not beneficial.

5. Effect of Curing on Strength of Soil

The reaction between reactive silica available in RHA and calcium available in lime takes time to increase binding strength among particles in presence of water. The effect of curing time on strength has been observed for both soils.

5.1. Effect of Curing on Strength of B C Soil and RHA Mixtures

The samples of BC soil and RHA mixtures cured upto 28 days, have reached 698 kPa. The variation in strength does not continuously increase. It is observed, very high in rate of increment, upto 14 days of curing. Further, even though strength increases, but rate of increment is not as high as in the beginning of curing period upto 14 days. Fig 5 shows the variation of strength of B C soil upon curing.

5.2. Effect of Curing on Strength of BC Soil, RHA and 3% Lime Mixtures

The samples cured with 3% lime, have shown high rate of increment in strength for lesser curing period. When samples cured upto 7 days, have shown very high rate of increment of strength. The increment in strength for 7 days cured samples with 30% RHA is 190% compared to its original strength. After 28 days curing, the increase in strength is 210%. The rate of increment for 7 days curing is 172% for 20% RHA addition, which reaches 196% for 28 days curing period.

5.3. Effect of Curing on Strength of BC Soil, RHA and 5% Lime Mixtures

The samples treated with 5% lime have shown increase in strength for lesser period. When samples treated with 30% RHA and 5% lime cured upto 7 days, have shown increment in strength reaching 195% compared to its original strength. After 28 days curing, the improvement in strength has reached 206%. The increase in strength of samples with 20% RHA and 5% lime is 174% for 7 days cured samples, which reaches 197% after 28 days curing period. Fig 6 shows the variation of strength of B C soil, RHA and 5% lime mixtures upon curing.

6. Summary

Addition of RHA decreases the specific gravity of mixtures due to low specific gravity of RHA.

Addition of RHA increases liquid limit and plastic limit of soil due to higher water holding capacity of RHA along with lower specific gravity.

Addition of RHA lowers maximum dry density and increases optimum moisture content.

Addition of RHA alone does not improve the strength of soils due to presence of only reactive silica with out lime content in RHA.

While addition of lime along with RHA considerably improves the strength of BC soil, the improvement in Red earth is marginal. This may be due to lower lime reactivity of Red earth.

Even for BC soil, addition of lime beyond 3% along with RHA is not beneficial.

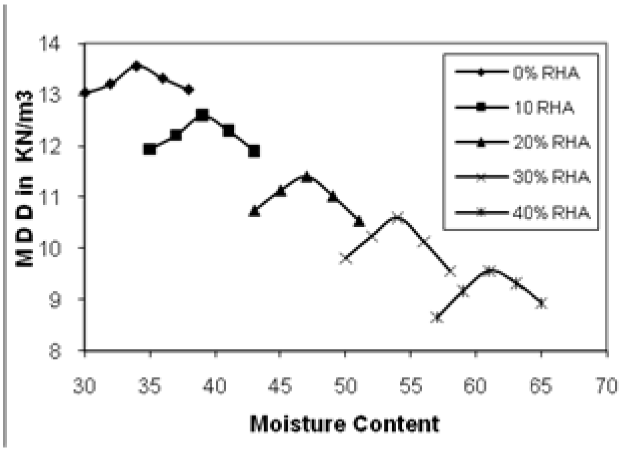

Fig 1 : Compaction curves of B C soil and RHA mixtures

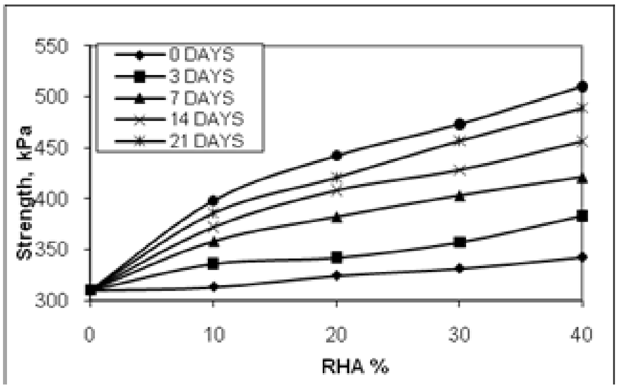

Fig 2: Variation of strength of B C soil on addition of RHA

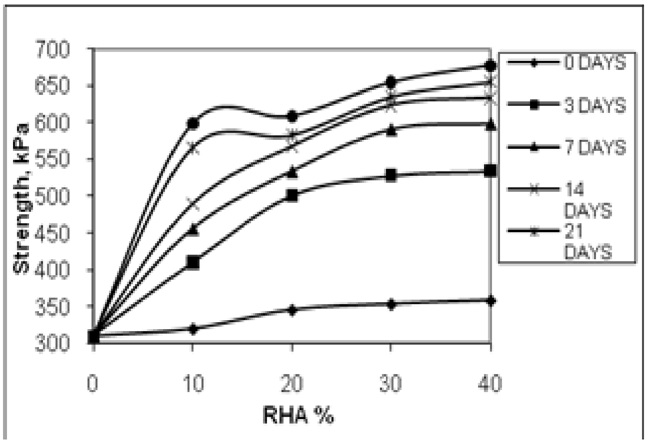

Fig 3: Variation of strength of B C soil on addition of RHA and 3% lime

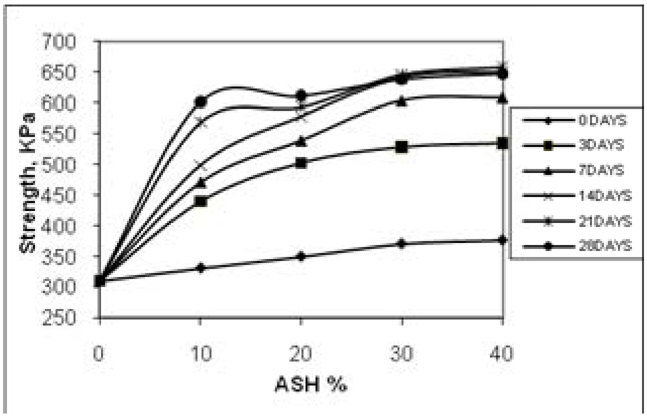

Fig 4: Variation of strength of B C soil on addition of RHA and 5% lime

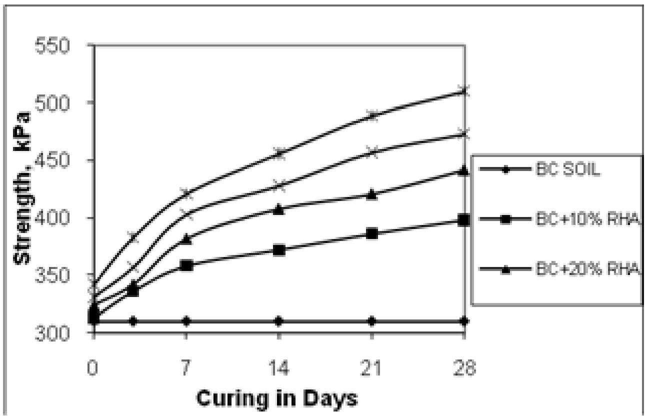

Fig 5: Variation in strength of B C soil upon curing

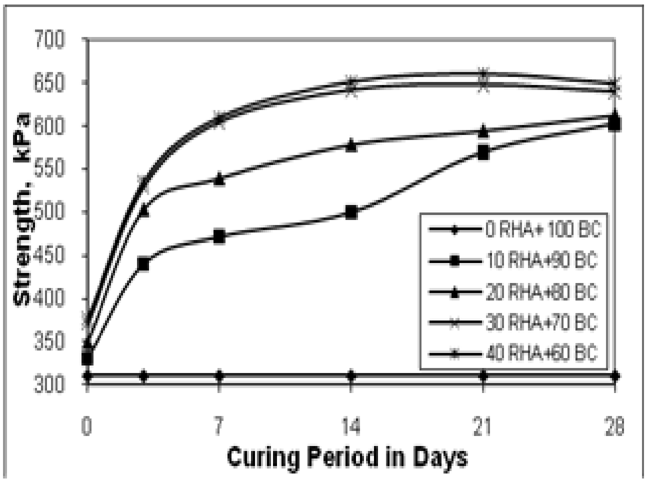

Fig 6: Variation in strength of B C soil, RHA and 5% lime upon curing

7. References

[1] Sivapullaiah P.V., Prasanth J. P., Sridharan A & Narayana B. V (1998) "Reactive Silica & strength of fly ashes", Geotechnical & Geological Engineering, 16, 239-250.

[2] Sivapullaiah P.V., Prasanth J. P & Sridharan A (1995) "Optimization of lime content of fly ash", ASTM Jl. Of Testing & Evaluation, 23, 222-227.

[3] Uppal H. L. and Dhawan P. K. (1968) "A Resume on the use of fly ash in soil stabilization", Road Research Papers, 95, 1-12.

[4] Sridharan A., Sivapullaiah P.V & Prasanth J. P (1997) "Effect of fly ash on unconfined strength of black cotton soil", Ground improvement, 1, 169-175.