IMPROVEMENT OF CALIFORNIA BEARING RATIO OF LATERITE SOIL USING RICE HUSK ASH

Arup Bhattacharjee¹, Bandana Borgohain²

ABSTRACT

Disposal of different waste material produced from various industries is a major concern to the society. The wastes pose environmental problems to the surrounding of disposal area. The utilization of industrial wastes in road construction has been of great interest. Rice husk is a waste material abundant in rice producing countries like India, Indonesia, Thailand etc. It is sometimes burnt for parboiling paddy in rice mills. The partially burnt rice husk will contribute to environmental pollution. All rice husk ash (RHA) commonly composed of silica, lime, alumina, iron oxide, magnesia. The main component of the rice husk ash is silica, which is the element that governs the reactivity of the ash. Lateritic soils are reddish colour weathered pathogenic surface deposit occurred in tropical and sub-tropical regions of the world. They are rich in iron and aluminium and developed by long lasting weathering of underlying parent rock. The lateritic soil contains lot of clay minerals that its strength and stability cannot be guaranteed under load especially in presence of moisture. In this paper, the improvement of California bearing ratio (CBR) of lateritic soil in addition to rice husk ash is studied. The rice husk ashes are added in different percentage by weight to the lateritic soil at optimum water content of lateritic soil. The soil rice husk ash mixtures are tested after curing period of one, seven, fourteen and twenty eight days of mixing to observe the effect of chemical reaction on mixture. The optimum moisture contents of soil increases with increase in percentage of rice husk ash present in the soil-RHA mixture. The increase in optimum moisture content is due to replacement of alumina by silica present in the rice husk ash. The maximum dry density of soil rice husk mixture decreases and optimum moisture content increases. The decrease in maximum dry density can be attributed to the replacement of soil by rice husk ash which has relatively low specific gravity of 2.25 compared to that of soil which is 2.69. More increase in optimum moisture content is observed for longer curing period. The CBR increases with increase in rice husk ash content in soil. This may be due to replacement of alumina by silica present in the rice husk ash. More CBR is observed for sample after 28 days of curing. The longer curing period after mixing the rice husk ash with laterite soil increase the optimum moisture content and CBR values of soil, resulting in more development of strength with

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passage of time. This study signifies uses of rice husk ash mixed lateritic soil as light weight backfill material for retaining wall for flyovers, overpass etc. with more CBR value than lateritic soil.

Keywords: CBR improvement, rice husk ash, lateritic soil, ground improvement
ABSTRACT: Rice husk is a waste material abundant in rice producing countries like India, Indonesia, Thailand etc. The main component of the rice husk ash is silica, which is the element that governs the reactivity of the ash. The lateritic soil contains lot of clay minerals that its strength and stability cannot be guaranteed under load especially in presence of moisture. In this paper, the improvement of California bearing ratio (CBR) of lateritic soil in addition to rice husk ash is studied. The rice husk ashes are added in different percentage by weight to the lateritic soil at optimum water content of lateritic soil. The soil rice husk ash mixtures are tested after curing period of one, seven, fourteen and twenty eight days of mixing to observe the effect of chemical reaction on mixture. The optimum moisture contents and CBR of soil increases with increase in percentage of rice husk ash present in the soil-RHA mixture. The longer curing period after mixing the rice husk ash with laterite soil increase the optimum moisture content and CBR values of soil.

INTRODUCTION

Necessity of ground stabilisation is increasing as availability of ground is decreasing day by day. It is hard to find a ground with suitable bearing capacity naturally. Hence artificial means are adopted to get a suitable bearing capacity of soil. On the other side, regular production of industrial wastes like rice husk is becoming threat to the environment as disposal of such waste is a problem. To solve these problems, various experimental studies are carried out. Now a days, utilization of industrial wastes in ground stabilisation or soil improvement has been of great interest. Further, various experimental studies are carried out using rice husk and rice husk ash (RHA) which is produced by burning rice husk, as stabiliser. Due to its low cost, it has a promising perspective in sustainable construction. Recent studies conclude that in combination with lime, its effect in soil improvement can be equal to cement treatment but its production process consumes much less energy. The RHA contains some amount of organic content. Its effect on behavior of soil with passage of time is not observed by researchers. The objective of this paper is to study the effect, suitability of RHA as a stabilizer on lateritic soil when mixed alone with virgin soil. Specifically, the effect of RHA on CBR of lateritic soil which is generally of low CBR is studied in this paper. Effect of RHA on compaction of lateritic soil is also observed here. The time dependent effect of lateritic soil mixed with RHA on maximum dry density and CBR is also studied.

Composition of rice husk ash (RHA)

All RHA commonly composed of silica, lime, alumina, iron oxide, magnesia. The main component of the rice husk ash is silica, which is the element that governs the reactivity of the ash. A delicate burning process is required to eliminate the organic components in the rice husk but keep the silica to be amorphous so that a highly reactive rice husk ash can be obtained. A too high temperature would transform amorphous silica to crystalline silica, which would reduce the reactivity. The suggested burning process in literature is 2 hours at 500°C. However, due to the exothermic property of the burning rice husk it is difficult to control the exact burning temperature,
hence there is still a possibility that the carbon and the crystallized silica are present and hinder the activity of the rice husk ash[8]. Based on the silica state and the carbon content, the rice husk ash is classified in three types:
C-RHA which is collected from an quick and open-air burning and contains a large amount of carbon; Cr-RHA which is collected from slow burning at above 600°C and contains a large amount of crystallized silica; and A-RHA which is collected from the suggested burning process which is 500°C in 2 hours and is considered to be the most active.
The activity of these three types of rice husk ash and their effect in soil improvement were tested. As expected, the higher reactivity of the A-RHA compared with the Cr-RHA confirmed the capability of these burning conditions. Surprisingly, the C-RHA appeared to be the most reactive and its effect to the soil was also the most positive despite of the large carbon content and the detected crystalline silica. The high reactivity of the C-RHA derives that there is a hierarchy of the solubility depending on the burning duration so that although all the three types of ash were mainly amorphous, the C-RHA is the most soluble. From the experiments, the role of the carbon was seen in only the term of quantity as it reduce the proportion of the silica, but might it have any support to the reactivity of the material in those experiments then it needs more investigation. The results of the treated soil showed that the rice husk ash need the lime to be activated, but then it helped to enlarge the positive effect of the lime. The immediate effect of the additives to the plasticity of the soil were seen to be the results of the lime only, but the long-term effect of the strength and the compression of the soil were seen to be the results of the combination between rice husk ash and lime. Different types of RHA are mentioned in Table 1 and Figure 1.

Table 1: Types of RHA [8]

<table>
<thead>
<tr>
<th>Type</th>
<th>Colour</th>
<th>Reactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-RHA</td>
<td>Black</td>
<td>Highly active</td>
</tr>
<tr>
<td>A-RHA</td>
<td>Grey</td>
<td>Averagely active due to high amount of carbon</td>
</tr>
<tr>
<td>Cr-RHA</td>
<td>pink</td>
<td>Averagely active due to crystallized of silica</td>
</tr>
</tbody>
</table>

Fig 1: A-RHA, C-RHA, Cr-RHA [8]

Lateritic Soil
Lateritic soil has been used as a base material in this study. Lateritic soils are reddish colour weathered pathogenic surface deposit occurred in tropical and sub-tropical regions of the world. They are rich in iron and aluminium and developed by long lasting weathering of underlying parent rock. The lateritic soil contains lot of clay minerals that its strength and stability cannot be guaranteed under load especially in presence of moisture. It has been replaced partially with RHA by weight. For this study, the soil is collected from shallow depth, from a hilly area of Guwahati city. In Figure 2, the soil is shown.

Fig 2: Lateritic soil collected from Guwahati

Physical properties of the soil are shown below in Table 2. The soil is clay with intermediate plasticity (CI).
Table 2: Properties of laterite soil

<table>
<thead>
<tr>
<th>Properties</th>
<th>values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>2.65</td>
</tr>
<tr>
<td>Liquid limit (%)</td>
<td>46</td>
</tr>
<tr>
<td>Plastic limit (%)</td>
<td>33</td>
</tr>
<tr>
<td>Plasticity index (%)</td>
<td>13</td>
</tr>
<tr>
<td>Maximum dry density (g/cm³)</td>
<td>1.65</td>
</tr>
<tr>
<td>Optimum moisture content (%)</td>
<td>21</td>
</tr>
<tr>
<td>Un-soaked CBR(%)</td>
<td>3.9</td>
</tr>
<tr>
<td>Soaked CBR(%)</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Rice Husk Ash
Rice husk is an industrial waste material, easily available in India. For this study, rice husk is collected from a local rice mill near Jorhat, which is un-conditionally burnt. Based on burning process rice husk ash (RHA) may be classified as C-RHA [8]. The RHA, used in this study, is shown in Figure 3. The chemical composition of RHA is determined in the laboratory and listed in Table 3.

Fig 3: Rice Husk Ash used

RESULTS AND DISCUSSION
The effects of addition of RHA to the lateritic soil are discussed in this study. The compaction test and CBR test of the lateritic soil and soil mixed with different percentage of RHA are performed. For compaction test, soil-RHA mix samples with 5%, 10%, 15%, 20%, 25% and 30% RHA are prepared. The optimum moisture content (OMC) and maximum dry density (MDD) of each sample is determined. To observe the effect of RHA, further each sample is cured at OMC of lateritic soil and tested at 7, 14, and 28 days. For CBR, soil is mixed with 3%, 5%, 10%, 15% and 20% RHA, at OMC of soil+ RHA mix. The soil+RHA mix is prepared at OMC of soil RHA mix and kept for a curing period of 7, 14, and 28 days. Both soaked and un-soaked CBR is performed on soil+RHA samples after curing period of 7, 14, and 28 days. The results obtained from the experimental study are discussed here. Results of Compaction test and CBR test are presented separately.

Compaction Test
Compaction tests are performed in the laboratory as per IS code [9] on soil-RHA mix samples with 5%, 10%, 15%, 20%, 25% and 30% RHA and results are shown in Figure 4 and Figure 5. The OMC increases from 21.5% for soil + 5% RHA to 32% for soil+30% RHA. The MDD decreases from 1.62 g/cm³ for soil+5% RHA to 1.20 g/cm³ for soil+30%RHA. The percentage of decrease in dry density is 25% for 30% addition of RHA. The increase in OMC is due to replace of alumina in lateritic soil by silica of RHA. The presence of higher lighter material in soil+30% RHA causes more decrease of MDD. The soil+ RHA samples are cured for 7 days, 14 days and 28 days at OMC of lateritic soil. The OMC increases from 21.5% at instant of sample preparation to 24% after 28 days of sample preparation for soil+5% RHA mix. Similarly MDD decreases from 1.62 g/cm³ at instant of sample preparation to 1.54 g/cm³ after 28 days of sample preparation for soil+5% RHA mix. The changes in OMC and MDD are due to more replacement of alumina by silica with passage of time.
CBR Test
CBR test is performed in laboratory as per IS code [10] on soil-RHA mix samples with 3%, 5%, 10%, 15% and 20% RHA. Figure 6 and Figure 7 are showing improvement of un-soaked CBR of lateritic soil with varying RHA content at the instant of sample preparation (0 days) and after 28 days of sample preparation. The figure shows more variation of load with increase in percentage of RHA in soil at instant of sample preparation. The variation of load for soil with increase in percentage of RHA in soil is lesser after 28 days of curing period.

The variation of un-soaked and soaked CBR for soil-RHA mix samples with 5%, 10%, 15%, 20%, 25% and 30% RHA are shown in Figure 8 and Figure 9. The un-soaked and soaked CBR for lateritic soil is 3.9% and 3.4% respectively. The un-soaked and soaked CBR for soil+5% RHA are 6.6% and 5.9% respectively. An increase 40% and 25% in un-soaked and soaked CBR is observed for addition of 5% of RHA to lateritic soil. The un-soaked and soaked CBR increases from 6.6% and 5.9% for soil+5% RHA to 8.3% and 7.4% for soil+30% RHA respectively. The CBR values increases with increase in percentage of RHA in lateritic soil. The figures also show effect of curing period of soil-RHA mix on CBR. The un-soaked CBRs at time of sample preparation and after 28 days of curing period at OMC are 6.6% and 14.6% for soil+ 5% RHA respectively. Similar trend of increase in CBR with passage of time is observed for other soil-RHA mix. The increase in CBR of soil-RHA mix with time is due to more replacement of alumina by silica present in RHA.
Rice husk ash is a waste material with great potential as is a source of active silica. From the results obtained from the experimental study, the following conclusions can be made:

1. The OMC of soil-RHA mix increases with increase in percentage of RHA. The MDD of soil-RHA mix decrease with increase in percentage of RHA in mix.
2. The OMC of soil increases with passage of time for soil-RHA mix. Similarly MDD of soil decreases with time of curing period for soil-RHA mix.
3. Both the soaked and un-soaked CBR improves considerably, after adding RHA to the soil. The CBR increased as the percentage of RHA by weight of soil increases in the soil-RHA mix.
4. The curing period is a governing parameter as the CBR increases with increasing curing period.
5. Adding of RHA alone to the soil gives substantial increase in CBR values of laterite clay. So, it can be concluded that RHA is a good stabilizer and can be used alone as a stabiliser widely as it is easily available, thus reducing the problem of disposal.

REFERENCES


