Experimental Investigation on Clay Soil Stabilization using Lime and Rice Husk Ash

Iyappan.G.R
Assistant Professor
Department of Civil Engineering
Valliammai Engineering College SRM Nagar, Chennai 603203

Geetha.G
Assistant Professor
Department of Civil Engineering
Valliammai Engineering College SRM Nagar, Chennai 603203

Divya.S.K
Assistant Professor
Department of Civil Engineering
Valliammai Engineering College SRM Nagar, Chennai 603203

Abstract

Clay soil provides poor working platform due to its plasticity characteristics and thus leading to construction delays. Excessive settlement of foundations, uplift of structures, Formation of cracks in the superstructure, failure of structural elements is the effects produced by clay soil. The adverse effects of the clay soil are improved by decreasing its shrinking, swelling and plasticity characteristics. Clay soil with high swelling and shrinking characteristics is thoroughly mixed with various percentages of lime, rice husk ash and also with lime – rice husk ash. In this research work mainly consider the reducing plasticity and improving the shear strength of clay in treated and untreated samples. Initially the untreated clay (without admixtures) sample were collected in nearer to our campus. Treated samples are made up of chemical admixtures in various proportion like 4%, 6%, 8% of lime and 5%, 10%, 15% rice husk ash and combination of 8%L+5%R, 8%L+10%R, 8%L+15%R. Twenty days after treatment, the shrinking-swelling characteristics of the clay are compared by determining the liquid limit, plastic limit, shrinkage limit, differential free swell index and unconfined compressive strength. Finally, it is concluded comparatively with treated and untreated samples due to reducing the plasticity characteristics and improving the shear strength of clay are found through the experimental analysis.

Keywords: treated, untreated samples, rice husk ash, lime, shear strength, compressive strength

I. INTRODUCTION

The soil stabilization includes both physical stabilization [such as dynamic compaction] and chemical stabilization [such as mixing with cement, fly ash, lime, and lime by-Products, etc.] (Materials & Tests Division, Geotechnical Cal Section, Indiana, 2002). Chemical stabilization involves mixing chemical additives (binding agents) with natural soils to remove moisture and improve strength properties of the soil (sub-grade). Generally, the role of the stabilizing (binding) agent in the treatment process is either reinforcing of the bounds between the particles or filling of the pore spaces. Most of these chemical stabilizing agents are not available in Egypt except cement and lime which are well-known. The chemical stabilizing agents are relatively expensive compared with other methods of stabilization, so that the soil stabilization technique is an open-field of research with the potential for its use in the near future. There are two types of chemical stabilization depending to the depth of the problematic soil and the type of geotechnical application surface or deep stabilization. The traditional surface stabilization begins by excavating and breaking up the clods of the soil followed by the addition of stabilizing agent (additive). Soil and additives are mixed together with known amounts of water and compacted. Depths of the order of 150 to 250 mm can be strengthened by this surface method. The depth of the stabilized and strengthened zone may be increased up to one meter by using heavy equipment with appropriate modification. These methods are used extensively to stabilized bases and sub-bases of highways and airfield pavements.

Additives refer to manufactured commercial products that, when added to the soil and thoroughly mixed, will improve the quality of the soil. Examples of additives include Portland cement, lime, fly ash, bitumen, and any combination of the cement, lime, and fly ash materials (Tensar Technical Note, TTN, BR10, 1998). Chemical (Additive) soil stabilization is achieved by the addition of proper percentages of cement, lime, fly ash, bitumen, or combinations of these materials to the soil. The selection of the type and the determination of the percentage of the additive to be used are dependent upon the soil classification and the degree of improvement in soil quality desired. In general, smaller amounts of additives are required when it is simply desired to modify soil properties such as gradation, workability, and plasticity. When it is desired to improve the strength and durability significantly, larger quantities of additive are used. After the additive has been mixed with soil, spreading and compaction are achieved by conventional. Soil modification refers to the chemical stabilization process that results in improvements of some properties of the soil for improved constructability, but does not provide the designer with a significant increase in soil strength and durability.
II. METHODOLOGY

- Study of soil characteristics
- Sample collection
- Sample testing
- Stabilization of weak sample
- Recommendation

III. LITERATURE REVIEW

- The objective of this study is to review the stabilization of soil using sustainable methods.
- These methods consist of stabilization with soil replacement, chemical additives, moisture control, rewetting, surcharge loading, compaction control and thermal methods.
- It is concluded that all the methods due to ineffectiveness and expensiveness.
- Based on study is concluded that the Portland cement, scrap tire, lime and fly ash and are less expensive and effective to soil stabilization.

- The present study made an attempt to enhance the geotechnical properties of a soil replaced with industrial wastes having pozzolanic value like rice husk ash (RHA) and fly ash (FA).
- Soil is replaced with RHA in 2%, 4% and 6% to dry weight of soil. It is observed that soil replaced with 4% RHA is the optimum for the soil used in this study from geotechnical point of view.
- To know the influence of fly ash, soil is further replaced with 4% FA along with 4% RHA. It is found that results of soil replacement by both RHA and FA proved to be soil modification and not the improvement.
- Hence, concluded that a cost-effective accelerator like lime is used for further replacing the above soil. The optimum lime content is found to be 8%.

- In India, the soil mostly present is Clay, in which the construction of sub grade is problematic.
- Keeping this in view stabilization of weak soil insitu may be done with suitable admixtures to save the construction cost considerably.

The present investigation has therefore been carried out with agricultural waste materials like Rice Husk Ash (RHA) which has mixed with soil to study improvement of weak sub grade in terms of compaction and strength characteristics

A. Critical Comments on Literature Review:
- Based on the above literature studies, we concluded that stabilization of clay soil can be done by adding lime and rice husk ash.
- It is the most effective and economical among all the additives.

IV. EXPERIMENTAL INVESTIGATION

A. Material Used:

1) Clay

The below properties of untreated clay samples were taken from based on the laboratory works.

<table>
<thead>
<tr>
<th>Particular</th>
<th>Physical properties of clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>2.08</td>
</tr>
<tr>
<td>Water absorption %</td>
<td>18.3</td>
</tr>
<tr>
<td>Fine material</td>
<td>5.9</td>
</tr>
<tr>
<td>Fineness modulus</td>
<td>3.07</td>
</tr>
<tr>
<td>Los angles</td>
<td>-</td>
</tr>
<tr>
<td>Practical size distribution in (mm)</td>
<td></td>
</tr>
<tr>
<td>19mm</td>
<td>-</td>
</tr>
<tr>
<td>12.5mm</td>
<td>-</td>
</tr>
<tr>
<td>9.5mm</td>
<td>-</td>
</tr>
<tr>
<td>4.75mm</td>
<td>100</td>
</tr>
<tr>
<td>2.36mm</td>
<td>80.5</td>
</tr>
</tbody>
</table>
Experimental Investigation on Clay Soil Stabilization using Lime and Rice Husk Ash

1.18mm | 51.2
600µm | 31.3
300 µm | 20.3
150 µm | 9.7

| Silicon dioxide / silica (SiO₂) | : 60.34-72.6 |
| Aluminum oxide/alumina (Al₂O₃) | : 4.67-6.5 |
| Calcium oxide | : 1.75-3 |
| Magnesium oxide | : 5.98-7.3 |
| Sodium oxide | : 8.56-9.1 |
| Manganese | : 0.127-0.26 |

Fig. 1: untreated clay sample

B. Test Results on Untreated Samples:
The tested samples were taken has prescribed in the standard laboratory procedures in various testing. In untreated samples involve testing and results are concluded below. In the each laboratory tests are conducted in at least minimum a 3 trial bases.

1) Specific gravity test

<table>
<thead>
<tr>
<th>trial</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity value</td>
<td>2.56</td>
<td>2.53</td>
<td>2.55</td>
</tr>
</tbody>
</table>

2) Plastic limit test

<table>
<thead>
<tr>
<th>trial</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water content in %</td>
<td>18</td>
<td>20</td>
<td>22</td>
</tr>
</tbody>
</table>

Plasticity Index (Ip) = Wl - Wp = 10
Toughness Index = (Ip / If) = 0.875

3) Liquid limit test

<table>
<thead>
<tr>
<th>trial</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water content in %</td>
<td>30</td>
<td>32</td>
<td>34</td>
</tr>
</tbody>
</table>

Flow Index, If = (W₁ - W₂) log₂ N₂/N₁

Flow Index, If = 24

4) Shrinkage limit

Shrinkage Limit, W₅ = W - (V - Vd)γw × 100

Shrinkage Index, Iₛ = W₅ - Wₐ

Shrinkage Ratio, SR = Wₐ / Vₒγw

Shrinkage limit, W₅ (%): 5.11
Shrinkage ratio (Wₐ/Vₒγw): 2.75
Shrinkage index, Iₛ: 28.5

C. Test Results on Treated Samples

In this laboratory test the various percentage of mix proportion add like 4%, 6%, 8% of lime and 5%, 10%, 15% rice husk ash and combination of 8%L+5%R, 8%L+10%R, 8%L+15%R. after 20 days as per code provision the treated samples are conducted a prescribed various tests and results are found to be tabulated and graphically.

1) Geotechnical Properties of Treated Samples

The test results for clay soil treated with different percentages of additives are presented in the table.

<table>
<thead>
<tr>
<th>Mixes</th>
<th>Code</th>
<th>LL%</th>
<th>PL%</th>
<th>SL%</th>
<th>PI</th>
<th>Free swell%</th>
<th>UCC kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated clay</td>
<td>S</td>
<td>58</td>
<td>20.57</td>
<td>5.4</td>
<td>37.43</td>
<td>47.83</td>
<td>106</td>
</tr>
<tr>
<td>Clay+5% RHA</td>
<td>R1</td>
<td>43.77</td>
<td>29.32</td>
<td>8.13</td>
<td>14.45</td>
<td>30</td>
<td>174</td>
</tr>
<tr>
<td>Clay+10% RHA</td>
<td>R2</td>
<td>54</td>
<td>37.87</td>
<td>36.66</td>
<td>16.13</td>
<td>20</td>
<td>164.55</td>
</tr>
<tr>
<td>Material</td>
<td>R3</td>
<td>56</td>
<td>NS</td>
<td>56</td>
<td>10.53</td>
<td>176.48</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>----</td>
<td>----</td>
<td>-----</td>
<td>----</td>
<td>-------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>Clay+15% RHA</td>
<td>R3</td>
<td>56</td>
<td>NS</td>
<td>56</td>
<td>10.53</td>
<td>176.48</td>
<td></td>
</tr>
<tr>
<td>Clay+4% Lime</td>
<td>L1</td>
<td>40</td>
<td>26.23</td>
<td>9.55</td>
<td>13.70</td>
<td>25</td>
<td>369.91</td>
</tr>
<tr>
<td>Clay+6% Lime</td>
<td>L2</td>
<td>39.1</td>
<td>30.10</td>
<td>14.29</td>
<td>9.00</td>
<td>18</td>
<td>439.47</td>
</tr>
<tr>
<td>Clay+8% Lime</td>
<td>L3</td>
<td>36.21</td>
<td>29.05</td>
<td>22.87</td>
<td>7.16</td>
<td>7</td>
<td>144.78</td>
</tr>
<tr>
<td>Clay+5% RHA+8% Lime</td>
<td>LR1</td>
<td>38.72</td>
<td>28.71</td>
<td>10.01</td>
<td>7</td>
<td>198.23</td>
<td></td>
</tr>
<tr>
<td>Clay+10% RHA+8% Lime</td>
<td>LR2</td>
<td>45.65</td>
<td>37.47</td>
<td>NS</td>
<td>8.18</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>Clay+15% RHA+8% Lime</td>
<td>LR3</td>
<td>50.48</td>
<td>43.28</td>
<td>NS</td>
<td>7.20</td>
<td>16</td>
<td>-</td>
</tr>
</tbody>
</table>

Fig. 2: SHRINKAGE LIMIT
Fig. 3: PLASTIC LIMIT
Fig. 4: UNCONFINED COMPRESSION TEST
Fig. 5: LIQUID LIMIT
Fig. 6: FREE SWELL
2) **Liquid Limit**

From the chart (i), it can be observed that Liquid limit of clay treated with different percentage of additives decreases. Substantial reduction in liquid limit values occurs for clay treated with different percentage of lime.

**SAMPLES CODE**
- **S** - Untreated clay
- **R1** - Clay +5% RHA
- **R2** - Clay +10% RHA
- **R3** - Clay +15% RHA
- **L1** - Clay +4% Lime
- **L2** - Clay +6% Lime
- **R3** - Clay +8% Lime
- **LR1** - Clay +5% RHA +8% Lime
- **LR2** - Clay +10% RHA +8% Lime
- **LR3** - Clay +15% RHA +8% Lime

3) **Plastic Limit**

From the chart (ii), it can be observed that Plastic limit for clay treated with various percentages of additives decreases. Substantial decrease in plastic limit value occurs for clay treated with different percentage of lime alone and for clay treated with 8% lime + different % of RHA.

4) **Plasticity Index**

From the chart (iii) it can be observed that plasticity index for clay treated with various percentages of additives decreases. Substantial decrease in plasticity index value occurs for clay treated with different percentage of lime alone and for clay treated with 8% lime + different % of RHA. This indicates that the plasticity characteristics of the clay are greatly reduced.
5) Differential Free Swell

![Fig. 10: Chart (iv)](chart-iv)

From the chart (iv) it can be observed that free swell index values of clay after treatment with different percentage of additives are greatly reduced. This indicates reduction in the swelling - shrinking property of the clay.

6) Unconfined Compressive Strength

![Fig. 11: Chart (v)](chart-v)

In chart (v) we can observe substantial increase in the value of unconfined compressive strength for clay treated with 4% and 6% lime alone. However there is also a considerable increase in the value of UCC for clay treated with 8% lime + 5% RHA. For clay treated with 8% lime + 10% & 15% RHA, cylindrical intact samples could not be obtained for conducting the UCC test since the compacted sample spongy in nature.

V. APPLICATION

In agricultural based country like India where rice husks are abundant and considered as waste materials, utilization of RHA in the construction of roads, airfields, and other geotechnical works is intensely attractive. This would generally lead to low construction costs, help alleviate disposal costs and environmental impact and conserve high - grade construction materials for higher priority uses.

The results obtained during this investigation as discussed in the previous sections showed encouraging signs for the use of RHA in soil improvement schemes. The results showed that although the RHA used in the study was obtained from an uncontrolled burning, it could still be effective in improving the properties of the expansive soil. Hence, it implies that the necessary technology required for controlled burning can be omitted reducing the cost of utilizing RHA for soil improvement.

VI. CONCLUSION

- The study has been successfully conducted to assess the improved geotechnical properties of expansive clay treated with RHA and lime. RHA and lime altered the texture and properties of clay soil through pozzolanic reaction.
- Lime and RHA reduces the value of liquid limit and increases the value of plastic limit. Hence the plasticity index is reduced. Also the free swell index values are reduced with the addition of lime and RHA. This indicates the reduction the swelling - shrinking and plasticity properties of the clay.
- Clay treated with 6% lime shows considerable decrease in plasticity index about 81% and free swell index about 30%. Also it shows appreciable increase in shear strength from 65 kN/m² to 439.47 kN/m². Hence the optimum percentage of lime for improving the property of clay is 6%.
- Clay treated with 5% RHA has considerable decrease in plasticity index about 48% and decrease in free swell index about 18% when compared to other proportions of RHA and also it has gained an appreciable shear strength from 65 kN/m² to 174 kN/m². Hence it taken as optimum proportions.
- Clay treated with 8% lime + 5% RHA has considerable decrease in plasticity index about 58% free swell index about 41%. Also it has greater shear strength value of 198.23 kN/m² compared to other proportions.
- Therefore RHA can be effectively used in the stabilization of clay along with lime.
REFERENCES


[2] Engineers (India), Volume 87, November 28, 2006


