SOIL STABILIZATION USING POZZOLONIC MATERIALS

Ketan Bajaj, UG Student, University of Petroleum & Energy Studies, Dehradun, 16ketan1990@gmail.com
Yash Shrivastava UG Student, University of Petroleum & Energy Studies, Dehradun, vs208681@gmail.com
Vikas Pratap Singh, Assistant Professor, Thapar University, Patiala, vps.vikas@gmail.com

ABSTRACT: Every year millions of tonnes of pozzolonic material is produced all over India and is characterized as hazardous material. It is better to use such pozzolonic materials in variety of ways, including roadbeds, construction fill or cement admixture. The objective of the present study is to upgrade the properties of weaker clayey soil with pozzolonic materials such as fly ash, rice husk ash and foundry sand. The above pozzolonic materials are used in different replacement percentages (e.g. 10%, 30%, 50%, and 70%) with clayey soil. For the various mixes, stress-strain behaviour, compaction properties and CBR values are obtained from laboratory tests and results are compared. Further, a cost comparison is proposed for the preparation of the sub-base of a highway project with and without the pozzolonic materials as soil stabilizer. The results of the study will be of immense benefits in various geotechnical constructions.

INTRODUCTION
Soil stabilization has been widely recommended for developing countries for the geotechnical construction. Many stabilizing, additives and conditioners agents have been developed to improve the physical and engineering behaviour of soil. The effectiveness of such agents relies on the formation of cementing bonds between the particles in the soil system. The most common cementing stabilizing agents are pozzolonic materials such as fly ash, foundry sand (FS) and rice husk ash. Rice husk, fly ash and foundry sand are the major by-products obtained from the food crop of paddy, nuclear power plants and iron and steel industries. Thousands of tonnes of pozzolonic material is disposed of either by dumping it in an open heap or on the roadside. The ash and sand being very light is easily carried by wind and water in its dry state. It is difficult to coagulate and thus contributes to air and water pollution. Cumulative generation of ash requires a large space for disposal. Utilization of pozzolonic by exploiting its inherent properties is the only way to solve the environmental and disposal problem of the ash. A number of researchers studied the physical and chemical properties of pozzolonic material.

Brooks [1] recommended that Rice Husk Ash (RHA) content of 12% and a fly ash (FA) content of 25% suitable for strengthening the expansive sub-grade soil. A fly ash content of 15% is suggested for blending into RHA for forming a swell reduction layer. Okafor [2] recommended that increase in RHA content, reduced plasticity and increased volume stability as well as the strength of the soil. Emilliani et.al [3] and McLaren and DiGioia [4] investigated standard Proctor Maximum Dry Densities (MDD) varied between 11.6 and 18.4 kN/m³ and the Optimum Water Contents (OMC) ranged from 12 to 34% for class F fly ash. National Cooperative Highway Research Report (NCHRP) [5], Washington DC report Foundry Sand Facts civil engineering states that foundry sand can be used for ground improvement and many other civil engineering fields.

This research aims at studying the stress strain behaviour of the RHA, FA and FS, and it is observed that 30%, 50% and 70% respectively replacement of clay with fly ash improves the unconfined compressive strength of the clayey soil. However, a further replacement by pozzolonic content of decreases its strength. This is because of the chemical reactions that occur when pozzolonic material is mixed with clay contributes pozzolanic reactions, cation exchange, carbonation and cementation [6]. These result in agglomeration in large size particles. Similarly, CBR value improved with the replacement of 10%, 30% and 30% of RHA, FA and FS with clayey soil. The reason for increment in CBR may be because of the gradual formation of cementitious compounds in the soil by the reaction between the pozzolonic material and some amounts of CaOH present in the soil. The decrease in CBR above certain amount of pozzolonic material may be due to extra pozzolonic material that could not be mobilized for the reaction which consequently occupies spaces within the sample. This reduced the bond in the soil-pozzolonic mixture.

EXPERIMENTAL INVESTIGATION

Materials used
The material used in the research is the Class C Fly Ash, locally available Rice Husk Ash and Foundry sand having chemical and physical properties [7, 8] as shown in tables 1 and 2 respectively.

Table 1 Chemical property of pozzolonic materials

<table>
<thead>
<tr>
<th>Constitue</th>
<th>RHA (%)</th>
<th>FA (%)</th>
<th>FS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al₂O₃</td>
<td>4.90</td>
<td>26.8</td>
<td>18.5</td>
</tr>
<tr>
<td>SiO₂</td>
<td>67.3</td>
<td>55.3</td>
<td>76.5</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.95</td>
<td>13.6</td>
<td>0.85</td>
</tr>
<tr>
<td>CaO</td>
<td>1.36</td>
<td>2.98</td>
<td>3.65</td>
</tr>
<tr>
<td>MgO</td>
<td>1.81</td>
<td>1.24</td>
<td>0.50</td>
</tr>
<tr>
<td>Loss on Ignition</td>
<td>17.7</td>
<td>13.3</td>
<td>8.73</td>
</tr>
</tbody>
</table>
It has been found that the specific gravity of FS is more than the both pozzolonic materials. But the OMC of the FS is less because of having heavier particles. The shear strength of the RHA is more as compared to others.

**Table 2 Physical properties of pozzolonic materials**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>RHA</th>
<th>FS</th>
<th>FA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td></td>
<td>1.95</td>
<td>2.7</td>
<td>2.36</td>
</tr>
<tr>
<td>MDD (g/cc)</td>
<td></td>
<td>1.15</td>
<td>1.62</td>
<td>1.23</td>
</tr>
<tr>
<td>OMC (%)</td>
<td></td>
<td>31.8</td>
<td>9.5</td>
<td>31.2</td>
</tr>
<tr>
<td>Angle of internal friction (°)</td>
<td></td>
<td>38</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>Unsoaked CBR (%)</td>
<td></td>
<td>8.75</td>
<td>7.05</td>
<td>9.25</td>
</tr>
<tr>
<td>Soaked CBR (%)</td>
<td></td>
<td>8.15</td>
<td>6.89</td>
<td>8.82</td>
</tr>
</tbody>
</table>

The coefficient of uniformity is more for FA as compared to RHA and FS and it seems that clayey soil which is used in the research is of CL type and fig. 1 describes the particle size distribution of pozzolonic material.

**RESULTS AND DISCUSSIONS**

**Compaction properties**

It can be seen that the MDD of the clayey soil decreases with replacement with RHA very rapidly as compared to FA whereas MDD of Clayey soil increases in FS. After 50% replacement with FA, OMC of clayey decreases as shown in figs. 2 and 3.

**Permeability**

The permeability of clayey soil goes on increases in case of FA up to 50% whereas in case of RHS it extended up to 70% but the permeability goes on decreasing for FS after the replacement of 30% as shown in fig. 4.

**Stress-strain response**

With the increase in FA content in the clayey soil the unconsolidated compressive strength (UCS) goes on increase up to replacement with 50% after that it reduces it is due to the weakening the bond between FA. But in case of RHA it increases only up to 30% replacement whereas UCS increases from 300 KPa to 800 KPa in case of FS as shown in fig. 5, 6 and 7.

**CBR value**

The CBR value widely increases with the increase in FA content as compared to RHA and FS. The thickness of subgrade decreases with increase in pozzolonic material.
Soil Stabilization using Pozzolonic Materials

Strength of the soil with penetration in all the cases first decreases up to 50% replacement and then increases due to compaction of soil particles and reduction in voids ratio but after certain limit the bond between Pozzolonic material and clayey soil decreases and which decreases the CBR value as shown in figs. 8, 9, and 10.

COST COMPARISON

It has seemed that replacement of 50% of FA with clayey soil is proved to be beneficial but in case of FS and RHA its 30% and 30% respectively. So let us consider for 'X' m² area which is to be compacted. (shown in table 3)
This is to be computed that for a small scale work RHA and FS can be used for soil improvement but for a large scale work FA is recommended.

**CONCLUSIONS**

1. With the replacement up to 50% of clayey soil with fly ash the Unconfined Compressive Strength increases from 200kPa to 700kPa with further increase in fly ash content UCS decreases down to 20%.
2. The Unconfined Compressive Strength of clayey soil increases up to 30% replacement of Rice Husk Ash with every extend in its percentage, declines the UCS to 15.65%.
3. In case of Foundry Sand, Unconfined Compressive Strength increases from 200kPa to 800kPa with the replacement from 10% to 70%.
4. In all the cases of pozzolonic material like fly ash and rice husk ash strength with respect to penetration first decreases and then increases.
5. The strength of clayey soil increases with the increase in the replacement of foundry sand.
6. The permeability of clayey soil goes on increasing with the replacement of fly ash up to 50% whereas in case of rice husk ash it extended up to 70% but the permeability goes on decreasing for foundry sand beyond the replacement of 30%.
7. Maximum Dry Density of the clayey soil decreases with replacement with rice husk ash very rapidly as compared to fly ash whereas MDD of Clayey soil increases in foundry sand.
8. After 50% replacement with fly ash, Optimum Moisture Content of clayey decreases whereas for foundry sand replacement it decreases with increase in its percentage.
9. There is 23% reduction in cost with the replacement of clayey sand with fly ash.

**REFERENCES**

2. Fidelis, O.O. (2009), *Physical and geotechnical properties of RHA*, Department of Civil and Environmental Engineering, West Virginia University, Morgantown.