TRIAXIAL BEHAVIOUR OF JUTE REINFORCED FLY ASH

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ABSTRACT: Fly Ash is a by-product from thermal power plants. In India 184.14 million tons of fly ash was generated in the year 2014 to 2015 out of which only 55.69% was utilised. Disposal of Industrial waste is one of the major problems. This problem can be solved by utilizing fly ash in bulk quantities in geotechnical applications such as backfill in reinforced walls and slopes. Studies by several researchers have suggested fly ash is a good construction material. India is leading producer of jute in world. Jute geotextile is used in many geotechnical applications. Researchers have discussed its potential to be used as reinforcing material. However, its use as reinforcing material is limited. In this study, an attempt is made to investigate the shear strength parameters of fly ash reinforced with jute geotextile so that they can be used in geotechnical works. A series of unconsolidated undrained triaxial tests have been performed of unreinforced and reinforced fly ash samples by varying the spacing and number of reinforcement layer. Stress-strain behaviour and shear strength characteristics were determined for each test. It was found that inclusion of jute geotextile reinforcement increased the shear performance of fly ash. Also, the increase in number of reinforcement layer increases the shear strength characteristics of fly ash.

Keywords: Fly ash, Jute, Shear strength

1 Introduction

Fly ash is a by-product formed in the thermal power plants due to burning of pulverized coal. In India 184.14 million tons of fly ash was generated in the year 2014 to 2015 out of which only 55.69% was utilised. Several researchers have explored its potential to be used as engineering material. Studies have also been conducted to understand its feasibility in geotechnical applications (Martin et. al., 1990; Pandian, 2004; Ghosh et al., 2005; Kim et. al., 2005; White, 2006; Ghosh and Subbarao, 2007; Kim and Prezzi, 2008; Bhardwaj and Mandal, 2008; Lal and Mandal, 2013; Lal and Mandal, 2014). From the past research, it is evident that fly ash acts as a good material for geotechnical applications. Since disposal of industrial wastes is one of the important problems, it is important to carry out research so that effective and effective utilization can be made in geotechnical engineering.

Jute geotextile is made up of naturally occurring jute fibres. India is leading producer of jute. The production of jute was 1944000.00 tonnes in India in 2013 (FAOSTAT). The use of jute in geotechnical engineering is limited as it has mostly found its use as separator, erosion control etc. Ranganathan (1994) have discussed the potential of using jute geotextile as reinforcing material. Few studies have utilized jute as a reinforcing material (Ghosh et al., 2005; Saride et al., 2014; Bera et al, 2009). However its utilization as a reinforcing material is limited.

Even though research has been done on fly ash reinforced with different types of material, the studies discussing triaxial behavior of fly ash reinforced with jute geotextile are scant. Thus, this study attempts to understand the triaxial behavior of fly ash reinforced with jute geotextile so that it can be utilized for various geotechnical projects. Unconsolidated undrained triaxial tests were performed on a series of jute geotextile reinforced fly ash samples by varying the amount of reinforcing layers of jute geotextile reinforcement and spacing between the reinforcing layers. The effect of jute geotextile reinforcement on deviator stress, shear strength parameters and failure pattern were determined.

2 Materials used

2.1 Fly Ash

Fly ash used for experiment was collected from Dahanu Thermal Power Station, Palghar (District), Maharashtra (state), India. The fly ash has been classified as ML as per the Unified Soil Classification System which is silt of low compressibility. Table 1 shows the geotechnical properties of fly ash. Figure 1 shows the fly ash used for the experiments.

Table 1. Properties of Fly Ash

<table>
<thead>
<tr>
<th>Properties</th>
<th>Values</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity, G</td>
<td>2.1</td>
<td>IS: 2720–1980 Part III</td>
</tr>
<tr>
<td>Liquid Limit (%)</td>
<td>29</td>
<td>IS: 2720 Part V</td>
</tr>
<tr>
<td>Plastic Limit (%)</td>
<td>NP</td>
<td>ASTMD 698</td>
</tr>
<tr>
<td>Maximum dry density (kN/m³)</td>
<td>12.3</td>
<td>IS: 2720-1977 Part IV</td>
</tr>
<tr>
<td>Optimum moisture content (%)</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Fine sand size (%)</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Silt size (%)</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Clay size (%)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>D₁₀ (mm)</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>D₅₀ (mm)</td>
<td>0.016</td>
<td></td>
</tr>
<tr>
<td>D₉₀ (mm)</td>
<td>0.065</td>
<td></td>
</tr>
<tr>
<td>Uniformity coefficient, c_u</td>
<td>7.2</td>
<td></td>
</tr>
<tr>
<td>Coefficient of curvature, c_f</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1 Fly Ash

2.2 Jute Geotextile

Woven jute geotextile was used as reinforcement in the experiments. It was procured from the local market of Ghatkopar, Mumbai, Maharashtra. The properties of woven jute geotextile have been listed in Table 2. Figure 2 shows the jute geotextile used for the experiments.

Table 2 Properties of Jute Geotextile

<table>
<thead>
<tr>
<th>Properties</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass per unit area (g/m²)</td>
<td>212</td>
</tr>
<tr>
<td>Tensile Strength (kN/m²)</td>
<td>6.33</td>
</tr>
<tr>
<td>Elongation at break (%)</td>
<td>7.33</td>
</tr>
</tbody>
</table>
3 Experimental program

Unconsolidated undrained triaxial tests were performed on jute geotextile reinforced fly ash samples at confining stresses of 50 kPa - 150 kPa. The diameter, d of the sample was 75 mm, and the height, h of the sample was 150 mm. All the samples were made at the maximum dry density and a moisture content of 12%. The samples were prepared at dry of optimum to understand the behavior of relatively dry fly ash which can be used to construct geotechnical structures such as retaining wall. The moisture content was chosen according to the findings of Lal and Mandal (2012). Different samples were reinforced by varying the number of reinforcing layer and the spacing between the layers. Figure 3 shows experimental plan of the triaxial tests. The triaxial setup used for testing is shown in Figure 4.

4 Results and Discussions

4.1 Effect of Jute Geotextile Reinforcement on Failure Plane

Figure 5 shows the triaxial sample after the failure. It was observed that failure of unreinforced samples was accompanied by formation of shear plane. However, no such clear shear plane was observed on reinforced samples due to the interference of jute geotextile with the shear plane. The reinforced samples showed some bulging on failure. However the bulging of the sample reduces as the number of reinforcing layers increases.

4.2 Effect of Jute Geotextile Reinforcement on Deviator Stress

Figure 6, 7 and 8 shows the deviator stress vs. axial strain curve for fly ash by varying the number of reinforcing layer at confining pressure of 50 kPa, 100 kPa and 150 kPa respectively. It is evident from the figures that increase in the number of reinforcing layers causes increase in the peak deviator stress.
4.3 Effect of Jute Geotextile Reinforcement on Shear Strength Parameters

The Mohr’s circles were drawn for all the samples to determine the failure envelope. Figure 9-12 shows Mohr’s circle for all the samples. It was observed that with the increase in confining stresses, shear strength increases.

The modified failure envelopes were drawn on t-s plot for all the specimens to determine the shear strength parameters of unreinforced and jute reinforced fly ash.

Where,

\[ t = \frac{\sigma_1 - \sigma_3}{2} \quad \text{and} \quad s = \frac{\sigma_1 + \sigma_3}{2} \]

The shear strength parameters observed are cohesion of unreinforced fly ash \((c)\), adhesion between the fly ash and jute geotextile reinforcement \((c_a)\), angle of internal friction of unreinforced fly ash \((\phi)\) and friction angle of jute geotextile reinforced fly ash \((\phi_r)\). It was observed that shear strength parameters increases with increase in the number of layers.

Figure 13 shows t-s curve for jute geotextile reinforced fly ash samples. Spacing between the reinforcing layers and the number of layers of jute geotextile affected the deviator stress and shear strength parameters.
Fig. 13 t-s plot for jute reinforced fly ash by varying the number of layers

With increase in the spacing between the layers and decrease in the number of layers of jute geotextile, it was observed that there was a decrease in deviator stresses. Unlike standard UU test the samples exhibited higher value of $\phi$ or $\phi_i$ because the samples were not saturated. Also there was an increase in the shear strength parameters with decrease in spacing with increase in number of layers. Similar results were observed by Lal and Mandal (2013). The increase in shear strength is due to the interference of geotextile with the potential shearing plane and redistribution of the stresses. Table 3 summarizes the effect of reinforcement in the shear strength parameters.

Table 3 Shear Strength Parameters of Jute Reinforced Fly Ash

<table>
<thead>
<tr>
<th>Number of Layers of reinforcement</th>
<th>Spacing h</th>
<th>$\phi$ or $\phi_i$ (°)</th>
<th>$%$ increase in $\phi$</th>
<th>$c$ or $c^*$ (kPa)</th>
<th>$%$ increase in $c^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>unreinforced</td>
<td>0</td>
<td>29.66</td>
<td>0</td>
<td>24.54</td>
<td>0</td>
</tr>
<tr>
<td>1 layer</td>
<td>$h/2$</td>
<td>35.73</td>
<td>20.46</td>
<td>27.01</td>
<td>10.06</td>
</tr>
<tr>
<td>2 layer</td>
<td>$h/3$</td>
<td>38.71</td>
<td>30.51</td>
<td>29.03</td>
<td>18.30</td>
</tr>
<tr>
<td>3 layer</td>
<td>$h/4$</td>
<td>41.37</td>
<td>39.48</td>
<td>35.66</td>
<td>45.31</td>
</tr>
</tbody>
</table>

5 Conclusion

Unconsolidated undrained triaxial test was performed on a series specimen of jute geotextile reinforced fly ash. The parameters varied are number of layers of jute geotextile reinforcement and the spacing of reinforcement. Following conclusion can be drawn from the observation and analysis of the test results:

1. As the number of layers of reinforcement increases there was as evident increase in the deviator stresses of the specimen. Similar trend was also observed for shear strength parameters.
2. For the same confining pressure, increase in the number of jute geotextile reinforcing layers increases the deviator stress of the specimen.
3. The shear strength parameters of fly ash reinforced with jute geotextile increases with the increase in the number of layers of reinforcement.
4. Increase in the spacing between the layers of jute reinforcement layers cause reduction in the deviator stress and shear strength parameters.
5. Fly ash reinforced with jute geotextile act as a good geotechnical engineering material and can be applied in many geotechnical engineering applications such as reinforced earth retaining wall and reinforced embankment.

Reference


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