Research Article

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Behaviour of Square Footing on Reinforced Fly Ash Slope

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Abstract:
Thermal power plant or similar plants in India which use pulverized coal as a fuel, generates million of fly ash every year as a waste. The disposal of waste material is great problem. Fly ash can be used as backfill material for low lying area, construction of backfill material on slope and in retaining structure, foundation basematerial, sub-base material for pavement and construction of earth embankment. To use waste fly ash in the construction of slopes and highway embankment the laboratory model tests were conducted with and without reinforcement in fly ash to check the strength and stability of fly ash slope. In this study fly ash was used as a filling material and geogrid is used as reinforcement to improve the bearing capacity of slope. The footing is rest at various position on steep slope of 60° and bearing capacity is checked. From the experimental study, load and settlement were measured. It has been observed from test results that load carrying capacity of fly ash slope reinforced with geogrid is more than that of unreinforced slope.

Keywords: backfill material, bearing capacity, fly ash, reinforced, steep slope

1. INTRODUCTION
In developing country like India, there is tremendous increase in population, tourism and scarcity of plain land, therefore development in hilly and nearby region is important. Construction of foundation on slope is different from the plain ground. Hence, it is necessary to distinguish between the behavior of shallow foundation on slope and on plain ground. There are many situations where foundations need to be located either on the top of a slope or on the surface of slope itself, for examples foundation of a bridge abutment, tower footings for electrical transmission lines, the small to medium rise buildings at slope, slallows foundations are frequently used in hilly regions, etc. When footing is constructed on sloping ground, the bearing capacity of the footing may be reduced depending on location of footing on slope.

2. LITERATURE REVIEW
The study of effect on bearing capacity by provision of shallow foundation on slope is observed in various literature. Several experimental, analytical and numerical analyses were performed on shallow foundation placed on crest as well as at certain setback distance from crest of the slope by various author.

Kumar and Ilamparuthi (2009) [1] had conducted study on response of footing on sand slopes. A numerical study was carried out using Plaxis FEM code and compared with the model test results. They had done a comparative study on performance of a strip footing on a reinforced slope with the unreinforced slope. They concluded that ultimate bearing capacity of the unreinforced Slope is improved by reinforcing the slope.

Alamshahi and Hataf (2009) [2] had conducted study on bearing capacity of strip footings on sand slopes reinforced with geogrid and grid-anchor. The test where conducted by varying parameters such as geogrid type, number of geogrid layers. They concluded that geogrid anchor are more effective than geogrid. The optimum number of reinforce is 2.

Choudhary et al. (2009) [3] conducted laboratory investigation of bearing capacity behaviour of strip footing on reinforced flyash slope. The results of the investigation indicate that both the pressure–settlement behaviour and the ultimate bearing capacity of footing resting on the top of a flyash slope can be enhanced by the presence of reinforcing layers. However the efficiency of flyash geogrid system increases with the increasing number of geogrid layers and edge distance of footing from the slope.

Gill et al. (2011) [4] conducted numerical study of footing on single layer reinforced soil. Two different soil; sand and silty soil were considered. Ultimate load carrying capacity can be improved by using reinforcement. The optimum depth of location of the single geogrid layer for silty soil is a depth of 0.75 to 1 times the footing width and for sand it is 0.5B.

Zhan and Liu (2012) [5] conducted study on undrained bearing capacity of Footings on Slopes. They study bearing capacity behaviour of strip footings on purely vertical loading on bearing capacity for footings adjacent to slopes, by using the finite element analysis method. They concluded that bearing capacity factor decrease with increase in slope angle.

3. METHODOLOGY
The experimental set up was required for conducting the model test in the laboratory on flyash slopes to check its stability. In this study an attempt had been made for proper utilization of fly ash as fill material in slopes.

3.1 Material
- Fly ash

For the model tests, dry and clean fly ash as shown in Fig. 1 was used. The fly ash was collected from Ratan India Power Limited, Nandgaon Peth, Amravati, Maharashtra.

FIGURE 1: FLY ASH
The geotechnical and engineering properties of fly ash such as specific gravity, density of flyash, dry density and optimum moisture content were determined by conducting various lab test. The values of these properties are given in table I.

Table I Properties of Fly ash

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Properties</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific gravity</td>
<td>2.22</td>
</tr>
<tr>
<td>2</td>
<td>Max dry density</td>
<td>13.62 kN/m³</td>
</tr>
<tr>
<td>3</td>
<td>Optimum moisture content</td>
<td>25%</td>
</tr>
<tr>
<td>4</td>
<td>Cohesion</td>
<td>20 kN/m²</td>
</tr>
<tr>
<td>5</td>
<td>Angle of friction</td>
<td>15°</td>
</tr>
</tbody>
</table>

Geogrid

The use of geogrid improves the bearing capacity and settlement performance of shallow foundations has proven to be a cost-effective foundation system. A reinforced soil foundation (RSF) consists of two layers of a geogrid reinforcement placed below a square footing to create a composite material with improved performance. Biaxial geogrid as shown in Fig 2. was use for experimental study.

Table II : Property of Geogrid

<table>
<thead>
<tr>
<th>Property</th>
<th>Test method</th>
<th>TGB-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate Tensile Strength (kN/m)</td>
<td>MD</td>
<td>30</td>
</tr>
<tr>
<td>Elongation at break (%)</td>
<td>CD</td>
<td>30</td>
</tr>
<tr>
<td>Tensile Strength at 2% strain (kN/m²)</td>
<td>MD</td>
<td>7</td>
</tr>
<tr>
<td>Tensile Strength at 5% strain (kN/m²)</td>
<td>CD</td>
<td>6.5</td>
</tr>
<tr>
<td>Aperture Size (mm)</td>
<td>MD</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CD</td>
<td>26</td>
</tr>
</tbody>
</table>

3.2 Preparation of Slope

The required quantity of dry fly ash was mixed with a predetermined amount of water corresponding to the optimum moisture content (OMC). The well mixed fly ash was then spread in the tank in layers and compacted. Uniform compaction of each layer should be achieved. Initially, a few trial foundation beds were made for standardization of compaction and checking of unit weight. In order to verify the uniformity of test bed, undisturbed samples were collected from different locations of the test bed in order to determine the in-situ unit weight and the values were found to be almost same (coefficient of variability within 1.5%). To ensure uniform moisture distribution throughout the test, compacted fly ash bed was left for 24 h for moisture equilibration and the top surface was kept covered with wet gunny bags in order to prevent the moisture loss if any. After 24 h; the compacted fly ash bed was cut to desired slope with the help of a sharp edged trowel. In case of reinforced fly ash slope, the reinforcements were placed at the desired depth within the fill and the compaction was continued in a similar manner until the desired height was reached. At any given position, the location of the reinforcement was such that it extended up to the face of the slope.

3.3 Model Test Procedure

For the experimental investigation, the model slope stability tests were conducted on fly ash to evaluate the strength and stability of fly ash. The test tank was made of 4 mm thick mild steel having internal dimension 900 mm X 500 mm in plan and 650 mm high. The experimental set up is shown in fig.3.

FIGURE 2: GEOGRID

FIGURE 3: EXPERIMENTAL SET-UP

After preparation of fly ash slope, the model footing of size 100 mm x 100 mm and 10 mm thick was placed on the slope. Two dial gauges were then placed on the sides of footing. Footing had a little groove at the center to facilitate the application of load. The footing was provided with the two flanges on two sides of footings to measure the settlement of footing under the action of load with the help of dial gauges. The load was applied on the footing with the help of screw jack. The load transferred to the footing was measured with the help of proving ring. Footing settlement were measured through two dial gauges. The footing settlement was reported as the average value of the reading taken at two different points. In all the test, load was applied until the failure indicated by crack and deformation of slope. The geometry of test configuration is shown in fig. 4.
Where,
\( H \) = Total Height  
\( B \) = Width of footing  
\( h \) = Height of Slope  
\( D_e \) = Edge Distance  
\( P \) = Load  
\( S \) = spacing of reinforcement  
\( L_r \) = Length of reinforcement  
\( D_e/B \) ratio = Edge distance/ width of footing

The various parameter studied in experimental work are mentioned in table III. Height of slope, angle of slope, width of footing, spacing of reinforcement and length of reinforcement are kept constant. Edge distance is varying

TABLE III : Parameter Studied

<table>
<thead>
<tr>
<th>Type of footing</th>
<th>Constant Parameter</th>
<th>Varying Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unreinforced</td>
<td>( H=600 ) mm, ( B=100 ) mm, ( h=500 ) mm, ( s=25 ) mm, ( L_r=5B )</td>
<td>( D_e/B=0.0, 0.5, 1.0, 1.5 ), ( d/H = 0.2, 0.4, 0.6 )</td>
</tr>
<tr>
<td>Reinforced</td>
<td>( H=600 ) mm, ( B=100 ) mm, ( h=500 ) mm, ( s=25 ) mm, ( L_r=5B )</td>
<td>( D_e/B=0.0, 0.5, 1.0, 1.5 ), ( N = 2, 3, 4 )</td>
</tr>
</tbody>
</table>

4. EXPERIMENTAL RESULTS

The test was conducted at various \( D_e/B \) ratio for unreinforced and reinforced case. The result of various \( D_e/B \) ratio for unreinforced and reinforced case are shown in fig.5. From which it is observed that bearing capacity of reinforced case more as compare to unreinforced case. Bearing capacity increase with increase in \( D_e/B \) ratio. The bearing capacity is minimum at crest of slope.

As the test were conducted at various edge distance on flyash slope, similar test were carried out on sloping surface of slope. The square footing was placed at various location on the sloping surface. \( d/H=0.2, 0.4, 0.6 \). From the test result it is observed that as \( d/H \) ratio increases the bearing capacity decreases.

5. CONCLUSIONS

The following conclusion are drawn from the work:

- Bearing capacity of footing on slope is less than bearing capacity of footing when placed on top of slope.
- As \( D_e/B \) ratio increases the bearing capacity increases. However there is significant increase in bearing capacity upto \( D_e/B=1.0 \)
- Insertion of geogrid layer increase the bearing capacity of flyash slope. As number of geogrid layer increases the bearing capacity increases. There is significant increase in bearing capacity upto three layer of reinforcement

REFERENCES


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