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Numerical analysis of multilayer reinforced pond ash slope

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Abstract
In the present study, numerical analysis is carried out in which pond ash is been employed as a fill substance in the embankment slope. The main rationale of the current exploration is to scrutinize leading parameters which are accountable for the recital of a typical strip foundation on a pond ash slope with endosure of multiple layers of fortification (geo-grid and geo-jute), and to recommend an appropriate configuration of geo-grid and geo-jute placement. The geo-grid and geo-jute reinforcement used is SGi 040 and DW TWILL respectively. Numerical analysis was conducted using software program PLAXIS 2D to calculate the bearing capacity using different reinforcements. The comparisons are made using two non dimensional parameters i.e. settlement ratio and bearing capacity ratio. The number of multiple layers used are 2, 3, 4 and embedment ratios used for modeling are 0.25, 0.5, 0.75 and 1.0 with D_e/B as 1, 2.3. From the obtained results it is scrutinized that the bearing capacity is increased with increasing number of reinforced layers and De/B ratio. With increasing z/B ratio, bearing capacity is seen to decrease significantly. The ultimate bearing capacity comes out to be maximum when N=4. The percentage increase in the bearing capacity while using geo-grid as compared to geo-jute is about 18% approximately.

Keywords: pond ash, geo-jute, bearing capacity, plaxis

1. Introduction

Coarser than fly ash, with grain sizes spanning from fine sand to fine gravel. Coal ash is a flammable black or brownish black4. Pond ash: This particular ash is made from collective sedimentary rock frequently occurring in coal beds or coal seams of the coal mines. This coal is then transported to thermal plants through railways over long distances. In thermal plants coal is burnt which gives coal ash as a waste substance. Due to burning, high temperature turns the coal minerals into coal powder mainly comprising of aluminum silicate.

Components of coal ash:

1) Iolite with overlying marine rocks
2) Clay minerals make up 60-80% of the entire mineral matter of the coal
3) Detritus or antigenic minerals
4) Environment kaolinite influences type of clay mineral. Coal ash is further categorized as:
   i) Fly ash: Fly ash is the most common and frequently used coal ash and it is generated in huge quantities. It is coarser than the standard fly ash. It is categorized as fly ash because it is transferred to the inflammable chamber through the means of exhausted gases.
   ii) Boiler slag: Boiler slag is formed when ash in liquid state is called with water. It is coarser than the standard fly ash. Boiler slag is generally a black granular matter with numerous engineering applications.
   iii) Bottom ash: Bottom ash is a coarse, granular, inflammable mixing of two types of ashes i.e. bottom ash and boiler slag. The two ashes are muddled up with water to produce slurry, which is later transported to ash ponds by pumping. In ash pond heavier particles settles down and spare water comes on the top which is then poured out. This dumped ash at the base is called pond ash.

When pulverized coal is burnt to produce heat, the residue includes 80% fly ash and 20% bottom ash.

A geo-synthetic is a planar product fabricated by using polypropylene elements that are being used in various geo-technical operations. The geo-synthetics that are routinely used in the transportation industry are geo-textiles, geo- grids, geo-membranes, erosion control blankets and mats, geo-synthetics clay liners, geo-composite drainage substances and geo-nets. Those concerned with the analysis, design, installation, and performance of geo- synthetics employed in transportation facilities focus on specifications, design methodologies, construction techniques, long term performance, and economics. The principal functions performed by geo-synthetics are filtration, drainage, severance, reinforcement, provision of a fluid barrier and environmental protection.

Derivative that does not rises up along with exhaust gases□

Geo-Grids: Geo-grids are geo-synthetic substances that and is collected from the base of furnaces. Bottom ash is have a small opening grid-like look. The main function for geo-grids is the reinforcement of soil.

Geo-Textile: Geo-textiles prepared from the natural fibers, e.g., jute geo-textiles, show high permeability and at the same time are environment friendly and mostly show quite low strength in tension. These are not endorsed as geo- synthetics due to which their application in geotechnical engineering is quite limited. The most common uses of jute which has been explored by the mankind are casing, sacking, carpeting and crafting purposes. The use of jute has been replaced by fibers of synthetic nature. Nowadays jute is used in blankets, furnishings, yarns, paper and products made by knitting machines and geo-textiles usually recognized as geo-jute.

1.1 Scope of Work

The main purpose of investigating is to scale the efficiency of single geo-synthetic sheets and also multiple sheets of geo-synthetics, at a pre-determined longitudinal spacing, in improving stability of pond ash slope when incorporated within the embankment. Apart from studying the effect of the load bearing potential and also immovability of such slopes, the effect of other variables like slope crest distance from loading, embedment-ratio (z/B) of geo-grid sheets were also studied for un-reinforced and reinforced cases. Comparison between the two reinforcements used i.e. geo-grid and geo-jute is done by using two non- dimensional parameters (BCR and settlement ratio).

1.2 Objectives of Study

This study revolves around the importance of addition of geo-synthetics and geo-textiles reinforcement in the pond ash slopes. With the inclusion of reinforcement sheets. The load-bearing capacity is enhanced. The numerical investigation is done for different cases of geo-grid reinforcement and geo-jute reinforcement. In present investigation numerical analysis will be carried out using mercantile software PLAXIS 2D to calculate load for number of geo-grid layers at a particular settlement.

Variable parameters are:

5) Embedment ratio
6) Number of reinforcement layers
7) Edge distance to footing width ratio
    - To compute the load-bearing capacity of different geometries with geo-grid layers.
    - To compute the load-bearing capacity of different geometries with geo-jute layers.
    - To investigate the impact of settlement ratio on bearing capacity ratio (BCR).
    - To formulate the relationship between the two different reinforcements used.

1.3 Methodology

Basically PLAXIS has four phases in which the analysis can be done and the output can be obtained in the form of load settlement curves and plots showing total as well as horizontal and vertical displacement, effective stresses, total stresses and the various stress point concentration etc.

The steps are:

- Geometry modeling
- Mesh generation
- Calculation
- Output

The model will be tested for different test condition such as:

- Effect of the embedment ratio
- Impact of different number of reinforcement sheets
- Impact of edge distance to footing width ratio

The output will be used to compute the bearing capacity of different cases investigated. Graphs of comparisons will be made to see the trend of bearing capacity ratio and settlement characteristics.

2. Present Work

This section depicts the geometry of model used and various data inputs in Plaxis 2D software.

Table 1: Parameters of Test Program

S. No.	Test Category	Invariable Parameters	Variabl E Paramet ERS
1.	Unreinforced slope	B=300mm β=45º	D_e/B = 1,2,3
2.	Reinforced slope (N=2)	B=300mm β=45º z/B=0.25,0.50	D_e/B= 1,2,3
3.	Reinforced slope (N=2)	B=300mm β=45º z/B= 0.50,0.75	D_e /B= 1,2,3
4.	Reinforced slope (N=2)	B=300mm β=45º z/B= 0.75,1.0	D_e/B= 1,2,3
5.	Reinforced slope (N=3)	B=300mm β=45º z/B= 0.25,0.50,0.75	D_e/B= 1,2,3
6.	Reinforced slope (N=3)	B=300mm =45º z/B= 0.50,0.75,1.0	D_e/B= 1,2,3
7.	Reinforced slope (N=4)	B=300mm β=45º z/B= 0.25,0.50,0.75,1.0	D_e/B= 1,2,3

Table 2: Properties of Geo-grid (Sgi-040)

Geo-grid Specification	Value
Machine direction properties: Lone Rib Tensile trength	43.4 kN/m

Table 3: Properties of geo-jute (DW TWILL)

Property	Value
Tensile strength (MD) (kN/m)	32.8

Table 4: Properties of pond ash used in analytical study

Name	Units	Value
TYPE	-	Drained
MODEL	-	Mohr-Coulomb
Γunsat	kN/m³	10.49
Γsat	kN/m³	14.05
E_{ref}	kN/m²	8000
M	-	0.380
Gref	kN/m²	2900
E_{oed}	kN/m²	

Cref	kN/m²	14
ϕ	°	34.5
Ψ	°	0
Rinter.	-	0.55
Interface	-	Neutral

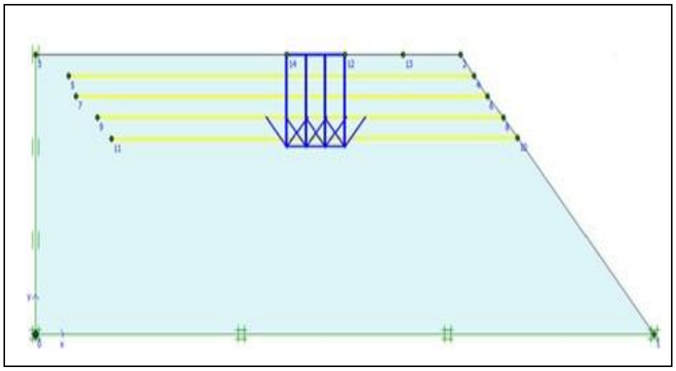

Fig 1: Plot of typical geometry model

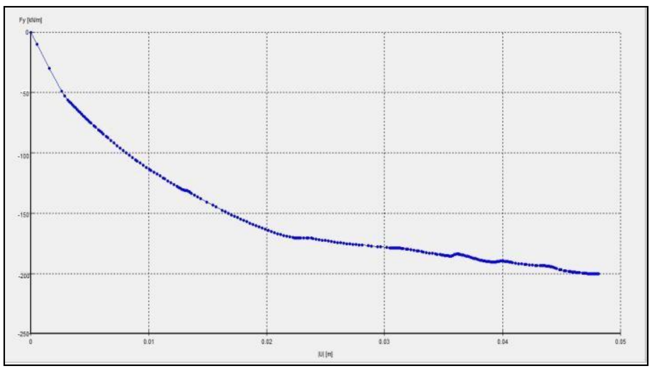

Fig 2: Pressure Settlement curve

3. Results

3.1 Comparison of Ultimate Bearing Capacity between Geo-grid and Geo-jute Reinforcement

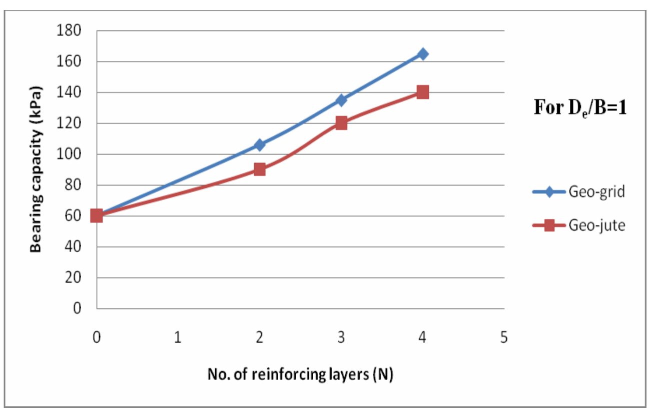

Fig 3: N vs. Bearing capacity for De/B=1

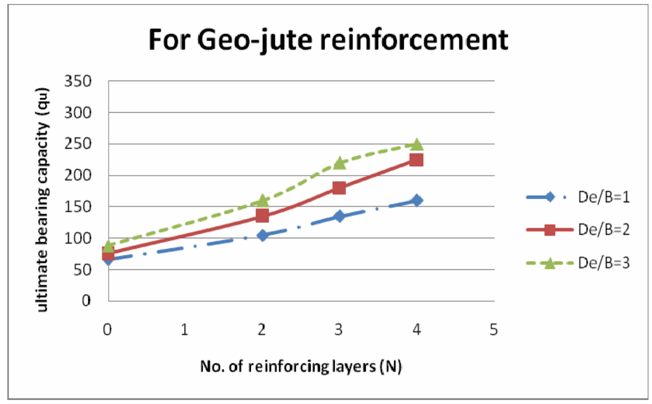

Fig 4: Ultimate Bearing Capacity vs. N for geo-grid

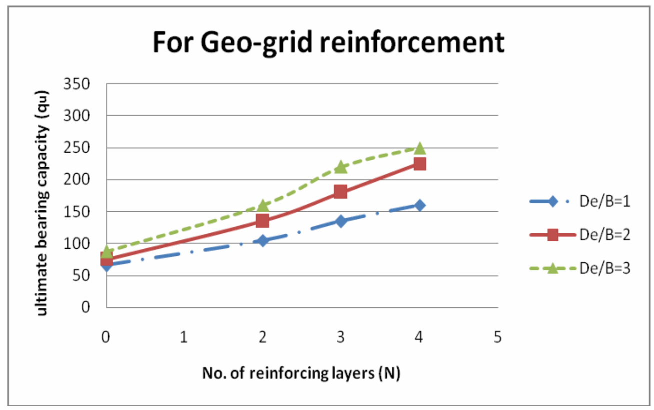

Fig 5: Ultimate Bearing Capacity vs. n for geo-jute

4. Conclusion and scope

4.1 Conclusions

1. The load carrying capacity of the rigid footing resting on the pond ash slope is quite low but with the inclusion of geo-grid and geo-jute layers, there is seen a considerable increase in the load carrying capacity and stability.
2. It is observed that with the increase in the number of geo-grid and geo-jute layers, the bearing capacity also increases. But only till 4 layers. After that the increase is negligible.
3. With the increasing distance of footing from the slope edge, the bearing capacity also increases significantly and is optimized for De/B=3. For the same footing, the settlement ratio deceases with increasing number of reinforcement layers.
4. With the increase in z/B ratio of geo-grid layers, there is a

certain decrease in bearing capacity ratio as observed in the results.

5. The increase in the value of bearing capacities while using geo-grid as compared to geo-jute is reported to be 18% (approx.).
6. Geo-jute is also a good substitute for geo-grid considering the cost factor and environmental criteria. Sometimes, there is need to stabilize soil for a limited period then we can use geo-jute.

4.2 Future Scope

1. Different more tests by using other variables like changing embedment ratio (z/B) and slope angle (β) can be conducted on this software
2. Different combinations of geo-grid and geo-jute can be scrutinized.
3. Number of reinforcement layers can be increased; also the length and angle of reinforcement can be varied.
4. Factor of safety using different software like Oasys can be used.
5. The tests can be conducted for different types of footings (prototype conditions) without generating any laboratory model as it is more convenient to check.
6. The pond ash can also is checked for pile foundations with the use of reinforcement layers.

5. References

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