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An Experimental Study on Fly Ash Slope

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ABSTRACT

*In India thermal power plants are facing the difficulty in disposal and utilization of Fly ash only some part is utilized for construction works. In present study Fly ash is used for stabilization. Model tests are conducted with different proportion of Fly ash and soil sample. Different percentage of Fly ash is mixed with soil (10%,20%,90%.) by it's dry weight and when Fly ash is mixed with soil OMC decreased and MDD is increased .In the present study the model box of 70cm*50cm*40cm is used .The Plastic scraps and geo grids are used as reinforcement materials. The square footing of 10cm*10cm*0.1cm is placed at 2 cm away from steep slope at two different angles 60° and 45° respectively. The load carrying capacity and settlement is determined and from data load v/s settlement graphs are plotted. From experimental work the factor of safety is determined from Swedish slip circle method and FOS of geo grid of reinforced slope is more i,e. 2.15 and 2.46 for angles 60° and 45° respectively.*

Keywords:- *Fly ash, Slope angles, Plastic scraps, Geo grid, Swedish slip circle method etc.*

INTRODUCTION

In India almost all the thermal power plants facing problem of disposal and utilization of industrial waste. The main industrial waste is FA. In India use of FA is under 25% of complete FA created towards this path in the course of recent years numerous researchers have attempted to change over this loss into valuable structural building development material which is used as substitute with natural soil for the civil engineering constructions mainly in the embankments, road sub base, slopes and other geotechnical fields. it also helps in the control of environment pollutions. it is one of the industrial waste utilized as development material.

FA is a residue generated in the combustion of coal and it is captured in chimneys of coal fired power plants. It is fine, glass powder recovered from gases of coal and these micro sized earth particles comprises of silica, alumina and iron oxide and it contains indistinct and crystalline nature of minerals. It is pozzolanic in nature and contains some lime. By the addition of FA to soil, improves the engineering properties of the soil, example it increase the strength and bearing capacity, to control the swell-shrink characteristics caused by moisture changes, durability and reduces the pavement thickness as well as cost.

For low lying areas, construction of earth embankment, retaining structure in backfilling materials the sufficient amount of soil of required quality is not available easily as filling material that time FA can be used with soil. For construction and also it is used in filling of underground open mines, use in agriculture, waste lands etc. steepened slopes can reduce the cost up to 50% as compared to retaining walls.

The performance of such materials can substantially improve by introducing element such as plastic scraps, geo grid and reinforced soil slope have broad applicability in the construction of highways.

The main objective of the present work is to check the feasibility of using Plastic scraps and geo grid with FA and soil construction of steep slopes, so that a innovative methodology could be adopted for its utilization

OBJECTIVES

The following are the objectives of the present study

1. To analyze slope stability and failure mechanisms of fly ash slope.
2. The main objective is to compare unreinforced and reinforced fly ash slope with respect load carrying capacity.
3. Mitigation of the footing slope settlement.
4. To check the feasibility of using different reinforcement with fly ash.

LITERATURE

Dushyant kumar Bhardwaj (2008) FA is a waste material can be utilized in construction of roads and embankments. The model steep slope FA was constructed with polypropylene stable fiber of 1% by is dry weight was used. The proctor compaction test , UCS and direct shear test are performed with and without fiber reinforcement. The angle of 78.6% slope with 80% compaction effort the centrifugal tests were conducted. Fiber reinforcement increases shear strength and changes is brittle behavior into ductile behavior. In his case by reinforcement there is a reduction in vertical settlement and it fails at higher values of ‘g’ and these slopes sustain higher loads and experimental results are compared with Plaxis software the factor of safety of reinforced slopes are more than the unreinforced slopes.

Kumar and Ilamparuthi (2009) The study was conducted on response of footing on sand slope. Model test were conducted using footing placing a various positions with and without reinforcement materials and comparative study had done with FEM based software plaxis 2D and they conducted that ultimate bearing capacity were improved by the reinforcement materials.

S.Adhana (2011) The model tests are conducted in the laboratory with or without reinforcement and two types of reinforcement were used, circular geo cell strip and polyester geo grid strip. The 60° angle slopes were prepared and footing size of 350mm×100mm were placed on the prepared slope and two dial gauges were placed at top of the footing and other two gauge were placed at the slope and deformation of slope at maximum load was determined. The load vs. deformation graph’s were plotted based on the data reported. The experimental results were compared with numerical results using plaxis 8 software. The FOS of the unreinforced geo cell and geo grid was 0.664, 2.55, 1.88 for experimental and for FEM analysis 0.456, 1.6, 1.69 respectively K.S. Gillet.al (2012) There is inconvenience because of less load-bearing limit of fly ash, when footings lay on the top of the fly ash fill slope, but authors incorporated polymeric reinforcements as horizontal sheets inside the fill which improves the load-bearing capacity of reinforced FA slope. The point of present examination was to discover the efficiency of multi-layer reinforcements in improving the load-bearing capacity when incorporated inside the body of FA embankment. In model slope there was increment in load bearing limit was observed by authors. The outcomes were contrasted and numerical consequences of the finite element utilizing programming

PLAXIS 2D
Tushar Vasant salunkhe (2014) Fly ash is waste material from industry that was used for laboratory model to conduct the test. The plastic recycled polymer is used as reinforcement o check the stability of slope the 68cm× 55cm × 36cm box, 60° angle, footing of 300cm× 360cm was used and compaction was achieved up to 18.6% on dry side of OMC. Load was applied up to failure of slope from experimental results load settlement graphs were plotted. The experiment was compared with numerical analysis through plaxis and stability of without and with plastic recycled polymer slopes are checked.

SUMMARY OF LITERATURE SURVEY

From the literature survey it can be concluded that a significant number of studies have been carried out on the footing located on the FA slope with reinforcement layer using numerical, analytical and experimental procedures, but the very few studies are reported on the footing located on the fly ash slope with different proportion of soil and plastic scraps and geo synthetics using as reinforcement layer and it is the main motivation for present study.

MATERIALS

Fly Ash

FA required for the present work is collected from rain water harvesting layout Barishpur, 5 km away from Bijapur, which is generally grey in colour. Tests are conducted to determine the index properties of the FA.

Soil

The red soil used in the present work is collected from Sangam cross Bagalkot. To study and enhance the properties of soil and to stabilize the slope. The soil used in this study is a murum red in colour, it is classified as inorganic clays soil of low to medium plasticity soil.

Model Test Box

The Size of the test box for the present study is decided on the basis of literature survey. The model test box of length of (l) 70cm, width of (b) 40cm, height of (h) 50cm of steel box is used for the experiment and at the front side of the box a transparent glass sheet is fixed for better view of slope failure.

Lvdt (Linear Variable Displacement Transducer)

LVDT is the instrument used for measuring the displacement in the laboratory. For the present study LVDT is used to measure the settlement of the model footing at the time of application of the load and it measures the displacement with the accuracy up to 0.01mm and maximum displacement up to 40mm.

Model Footing

The square footing is used for the experiment is made up of mild steel, and size of 10cm*10cm and thickness of 0.1cm. A circular groove of 6mm deep is made to hold the metallic ball on one face of the footing center to distribute the load uniformly and to avoid the slipping of plunger.

Plastic Scraps

Plastic scraps required for present work is made from cutting the plastic boxes of required length. The length is 16cm and width is 3cm. the aspect ratio is 5.34

Fig.1:-*Plastic scraps*

Geo Grid

Geogrid is geo synthetic material used for

the reinforcement of soil and it is strong in tension. material is HDPE (High density poly ethylene) . Geogrid used for experiment is having tensile strength of 50KN/m and Square opening of 30mm*30mm.

Fig.2:-*Geo grid*

Table 1:-*Properties of soil*

Properties	**Notation**	**Value**
Soil type	CL	Inorganic clays of low to medium plasticity
Specific gravity	G_s	2.52
Grain Size(mm)	D_{10}	0.23
	D_{30}	0.61
	D_{60}	2.6
Uniformity Coefficient	C_u	11.3
Coefficient of Curvature	C_c	0.62
Liquid limit (%)	W_L	38
Plastic limit	W_p	27.5
Plasticity Index	I_p	10.5
Maximum dry density (KN/m^3)	MDD	18
Optimum moisture content (%)	OMC	16.11
Cohesion (KN/m^2)	C	13
Angle of Friction	Φ	34°

Table 2:-*Properties of fly ash*

Properties	**Notation**	**Value**
Specific gravity	G_s	2.15
Maximum dry density (KN/m^3)	MDD	11.14
Optimum moisture content (%)	OMC	43
Cohesion (KN/m^2)	C	0.03
Angle of Friction	Φ	28°

Table 3:-*OMC & MDD for different proportions.*

PROPORTION	**OMC (%)**	**MDD (KN/m^3)**
100% fly ash	43	11.04
90%F+10%S	39	12.33
80%F+20%S	36	13.55
70%F+30%S	31	14.32
60%F+40%S	27	15.10
50%F+50%S	25	16.02
40%F+60%S	22	16.38
30%F+70%S	20	16.77
20%+80%S	19	16.97
10%+90%S	17	17.55
100% SOIL	14	17.95

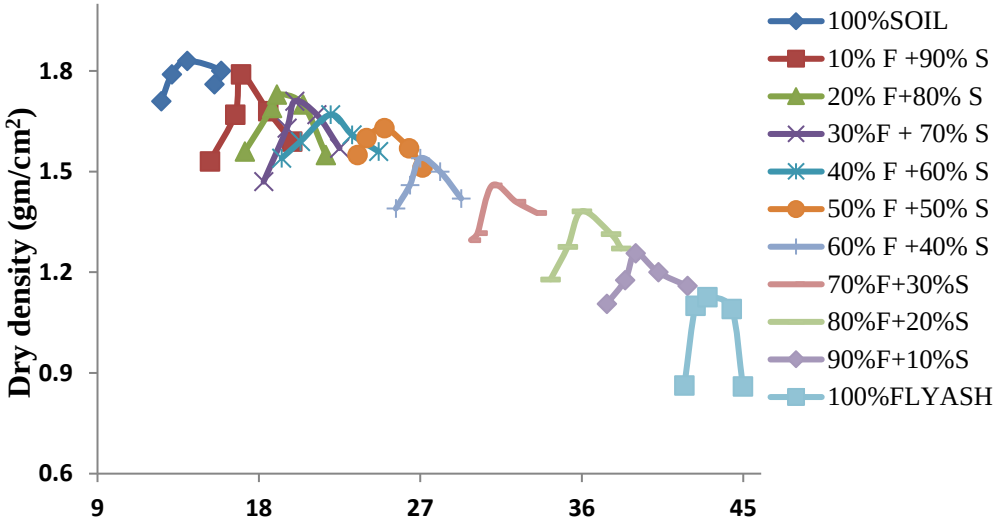


Fig.3:-*Proctor Test for Different Proportions*

Table 4:-*C and φ values for different proportions.*

Proportion	Cohesion(KN/m²)	Angle of friction
100% Fly ash	0.03	28°
90%F+10%S	1.5	29°
80%F+20%S	2.1	29.5°
70%F+30%S	3.9	30°
60%F+40%S	4.8	31°
50%F+50%S	6.7	31.5°
40%F+60%S	7.3	32°
30%F+70%S	8.5	32.5°
20%+80%S	9.6	33°
10%+90%S	10.3	33.5°
100% Soil	11	34°

METHEDOLOGY

Preparation of Slope

The basic index and engineering properties of FA and soil are determined for different proportions are determined and required quantity of FA with 10% and it is incremented by the interval of 10 % till FA proportion reaches 90%, dry weight of soil is mixed with determined amount of OMC. Mixture is spread in the test box in the layer and it is gently leveled. The bed of 5cm is prepared .and slope which is prepared with &without reinforcement at every 10cm height. Compacted bed is cut at 60°and 45° angle slopes. Total height of slopes are of 30cm. The plastic scraps and geo grid as reinforcement materials are placed in the box throughout the slope width. Total 60 trials of model tests are conducted for different compositions of reinforced and unreinforced fly ash and soil.

Fig.4:-*Prepared slope*

Procedure of Experimentation

For conducting the experimental model tests in order to determine the strength and stability of FA slope the following procedure is adopted

1. After the slope preparation of fly ash with soil footing of size 10cm x 10cm 0.1cm is placed 2cm apart from edge of the slope.
2. A little groove at the centre of the footing is made to facilitate the application of load and steel ball is placed above the groove on which proving rests to apply the load vertically.
3. The two LVDT's are placed diagonally on the sides of the footing, instead of dial gauges the LVDT's are used.
4. Two LVDT's are used to measure the settlement at both the side and the average settlement is calculated.
5. The load is applied on the slope with the help of the hydraulic screw jack the load is transferred to the footing is measured with the help of proving ring.
6. For unreinforced slope 20kN and for reinforcement slope 50kN proving ring are used which are pre-calibrated proving rings.
7. In all the tests load is applied until the deformation of slope or indication of crack is observed.
8. For individual experiment the stress Vs settlement graph's are plotted with slope angles of 60^0 and 40^0 .
9. The reinforced slopes with plastic scraps and geogrid as reinforcement and unreinforced slopes for 60^0 and 45^0 slope angles are experimented as per IS: 1888-1982

Fig.5:-*Failure of slope*

SWEDISH SLIP CIRCLE METHOD

Swedish slip circle method used to find out the factor of safety for experimental work .It assumes a circular failure interface. and analyzes stress and strength parameters using circular geometry and statics.

1. Adopted for general type of soil which have combined grains C and Ø soils.
2. For steep slopes and homogenous slopes failure occurs as toe failure and it passes through the toe.
3. In this each slice is assumed to act independently as column of soil.

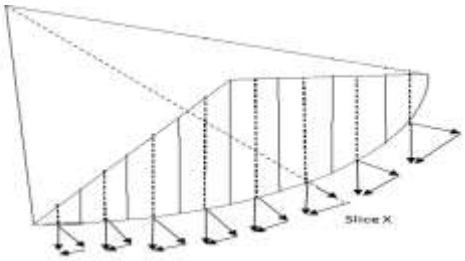
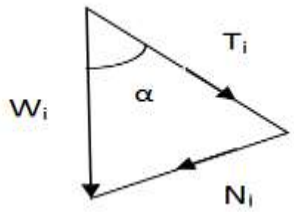


Fig.6:-*Swedish slice circle analysis*



Slice X

The weight W_i of each slice is assumed to act at it's center. if this weight is resolved into normal (N_i) and tangential components(T_i), the normal component N_i will pass through the center of rotation "o" and does not cause any moment.

FOS = M_R

$$F = \frac{M_D}{C\,L + \sum Ni \tan\emptyset}$$

$$\sum Ti$$

CONCLUSION

- Fly-ash is a good backfill material. As addition of percentage of fly ash increases OMC value increases and MDD value decreases.
- Geo grid as reinforcement gives more strength compared to plastic scrap reinforcement.
- For 60° angle slopes in all the proportions 90% S +10% F carry more stress i.e. unreinforced slope 80 KN/m^2, Plastic scrap reinforced slope 136.16 KN/m^2, and geo grid reinforced slope 162.72 KN/m^2.
- For 45° angle slopes in all the proportions 90% S +10% F carry more stress i.e. unreinforced slope 164.16 KN/m^2, Plastic scrap reinforced slope 209.1 KN/m^2, and geo grid reinforced slope 239.11 KN/m^2.
- The 45° angle slopes sustains more load with less settlement compared to 60° angle slope with different proportions of soil & fly ash.
- Plastic Scraps and geo grid is used as a viable alternative to stabilize fly ash slope to make it steeper and stable. Due to its confinement and inclusion property it can take larger stress.
- Factor of safety is determined from Swedish slice circle method and FOS of 60° angle slopes in all the proportions 90% S +10% is more . For unreinforced slope 1.71, Plastic scrap reinforced slope1.92 and geo grid reinforced slope 2.15 are achieved.
- For 45° angle slopes in all the proportions 90% S +10% FOS is more, unreinforced slope 1.59, Plastic scrap reinforced slope 2.26, and geo grid reinforced slope 2.46
- FOS for 60° angle slopes Plastic reinforced slopes are 1.2 times more stable then the unreinforced slopes and geogrid reinforced slopes are 1.5 times more stable then the unreinforced slopes.
- FOS for 45° angle slopes Plastic reinforced slopes are 1.3 times more stable then the unreinforced slopes and geogrid reinforced slopes are 1.45 times more stable then the unreinforced slopes.

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