

A Review on Fly Ash Slope Stability

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Abstract: Fly ash is a by product of coal based thermal power plant and its disposal causes several environment and ecological problems. Proper utilization of fly ash is major concern in India. Fly ash can be used as backfill material for low lying area. The laboratory model tests can be conducted with and without reinforcement in fly ash to check strength and stability of fly ash slope. Fly ash is used as filling material and plastic scraps and different geo-synthetics are used as reinforcement materials. The square and different footings are rest at various position on steep slope of different angles. From experimental works load carrying capacity, settlement and deformations of fly ash slopes are determined and from the data, load –settlement curves have been reported. It is concluded that load carrying capacity is high in case of reinforced fly ash slopes to unreinforced fly ash slopes and numerical analysis is carried using PLAXIS 2D software.

Key Words: Fly ash, slope stability, Plastic scraps, Geo synthetic, Steep slope, PLAXIS 2D.

1. INTRODUCTION

Most of the thermal power plants in India are facing difficulty for disposal and utilization of fly ash. The effective uses of the industrial wastes which are used as a substitute for natural soil in the construction not only solve the problems of disposal and environmental pollution but also help to preserve the natural soil. One of the industrial wastes used as a construction material is the fly ash.

In India utilization of Fly ash is less than 25% of the total fly ash produced. In this direction over the past few years many researchers have attempted to convert this waste into useful civil engineering construction material. Hence, the proper utilization fly ash is major concerned in India. It may be used in embankment. Steepened slopes can reduce the cost up to 50 % as compared to retaining walls. Fly ash can be utilized as a fill material in many civil engineering applications, mainly in the construction of roads and embankments. Fly ash provides an economical and suitable alternative to good earth for construction of embankments. The performance of such materials can substantially improved by introducing reinforcing element such as geo grid. Reinforced soil slopes have broad applicability in the construction of highways.

The objective of the study is to check the feasibility of using Plastic recycled polymers with fly ash in construction of steep slopes so that a innovative methodology could be

adopted for its utilization. The experimental analysis and validation using finite element method for the methodology

2. LITRATURE REVIEW

The study of effect on stability of slope observed in various literatures. Several experimental, analytical and numerical analyses were performed with different reinforcement materials and Geo-synthetic materials of the slope stability and bearing capacity by various author.

1]S.Adhana.et.al(2011):The model tests were conducted in the laboratory without and with reinforcement in fly ash steep slopes on soft foundation to check the stability of steep slope. In this two types of reinforcement were used: (a) Three dimensional circular Geo cell strip made from waste plastic bottles and (b) polyester geo grid strip, with test box of 70*50*40cm were used. From the experiments, load and settlement have measured. From these data, load -settlement curves have reported. It has been observed from test results that load carrying capacity of geo-cell is more than that of geo grid strip. The deformation of geo cell is slightly more than that of geo grid strip. Using PLAXIS 2D the failure pattern, deformations and factor of safety are reported based on analytical program. The results from experimental data and analytical program compared and reported.[5]

2] K.S. Gillet.al(2012) : There is difficulty due to poor load-bearing capacity of fly ash, when footings rest on the top of the fly ash fill slope; but inclusion of polymeric reinforcements as horizontal sheets within the fill may be advantageous in improving the load-bearing capacity of reinforced fly ash slope. The aim of present investigation is to find out the efficacy of multi layer reinforcements in improving the load-bearing capacity when incorporated within the body of fly ash embankment. In model slope there is increase in load bearing capacity was observed in the laboratory. The experimental results were compared with the numerical findings obtained from the finite element analysis using software PLAXIS 2D [6]

3. Tushar vasant salunkhe et.al(2014):The model tests were conducted in laboratory without and with Plastic Recycled Polymer (PRP) in fly ash steep slopes on soft

foundation soil (fly ash) to check the stability of slope. In this experiment fly ash was used as a slope filling material and Plastic Recycled Polymers made from waste plastic products (lower grade plastic products). From the experimental investigation, load and settlement were measured. From these data, load-settlement curves have been reported. It has been observed from test results that load carrying capacity of fly ash mixture with plastic recycled polymers slope is more than that of fly ash slope. The deformation of Plastic Recycled Polymers slope is slightly more than that of fly ash slope. The experimental results were validated with a Finite Element Software (PLAXIS 2Dversion). The failure pattern, deformation sand factor of safety are reported based on analytical program (Bishop's simplified method) and Finite Element Method (FEM). The results from experimental data and analytical programme are compared .[7]

4] Tarun Kumar Rajak(2016): In this shear strength parameters of the soil stabilized with fly ash. The soil has been mixed with 10%, 20%, 30% and 40% fly ash by dry weight for conducting compaction test and direct shear test. The experimental results indicate that the dry density and cohesion value of soil decreases where as the angle of internal friction increases with increase in the percentage of fly ash. The analysis is done by using FLAC slope software. Parametric study has been done to calculate the factor of safety by considering different slope height at constant slope angle. The addition of fly ash enhances the strength and provides resistance to slope instability. It has been found from the analysis that the factor of safety increases with increase in percentage of fly ash at a particular height. 30% fly ash is obtained as optimum amount as stabilizer for a slope of certain height [9]

5] Dr. A.I.Dhatrak et.al(2016): The laboratory model tests were conducted with and without reinforcement in fly ash to check the strength and stability of fly ash slope. Geo grid is used as reinforcement to improve the bearing capacity of slope. The square 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. For optimum configuration the same test were conducted on circular footing .From test results it is observed that the load carrying capacity of fly ash slope reinforced with geogrid is more than that of unreinforced slope.[10]

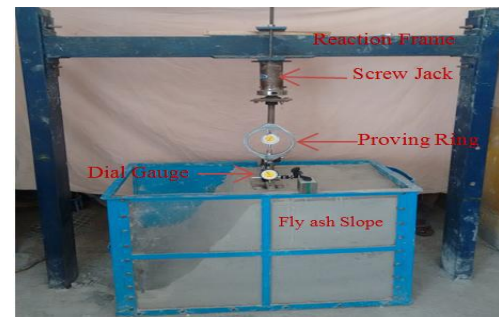


Fig 1: Experimental Set Up

6] Karthik.S(2016): Soil is a peculiar material. Some waste materials such Fly Ash, rice husk ash, pond ash may use to make the soil to be stable. Addition of such materials will increase the physical as well as chemical properties of the soil. Some expecting properties to be improved are CBR value, shear strength, liquidity index, plasticity index, unconfined compressive strength and bearing capacity etc. The objective of this study was to evaluate the effect of Fly Ash derived from combustion of sub-bituminous coal at electric power plants in stabilization of soft fine-grained red soils. California bearing ratio (CBR) and other strength property tests were conducted on soil. The soil is in range of plasticity, with plasticity indices ranging between 25 and 30. Tests were conducted on soils and soil-Fly Ash mixtures prepared at optimum water content of 9% .Addition of Fly Ash resulted in appreciable increases in the CBR of the soil. For water contents 9% wet of optimum, CBRs of the soils are found in varying percentage such that 3,5,6and 9.We will found optimum CBR value of the soil is 6%.Increment of CBR value is used to reduce the thickness of the pavement and increasing the bearing capacity of soil.[11]

Summary Of The Literature Survey

It is concluded from the literature review that a significant number of studies have been carried out on the footing located on the fly ash 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

III. Case Study

Jindal Power Open Cast Coal Mine is almost flat with small undulations from surface. The lithological section comprises about 3-4 m unconsolidated loose soil/alluvium. Below the top soil there is weathered shale/sandstone up to 6-8 m depth. The weathered shale and sandstone are comparatively loose in nature and can be excavated without

blasting. Below weathered zone (which varies from 3 – 10 m), the rock is hard, compact and massive in nature and can be excavated only after blasting. Thus the average depth of the excavation of these excavations, which can be removed, is about 16 m. In the sub-block IV/2 & IV/3 only lower groups of Gondwana sediments have been deposited. and almost uniform throughout the block. JPL admixture with OB, design of dump geometry, filed application and field monitoring for more than three years for the first time in India.

Jindal Power Limited, Tamnar has already have captive thermal power plants of 1000 MW and generating fly ash, a solid coal combustion residue form due to the burning of coal, of nearly 16000 tons per day. Therefore, quantity of fly ash generated requires large area for its dumping. In last two decades it was realized that fly ash is no more a waste.



Fig 2: Decks with Fly ash as admixture in overburden material after compaction

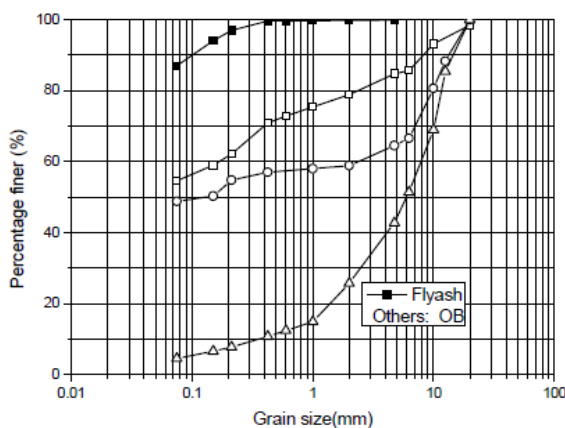


Fig3: Grain size distribution of typical overburden (OB) and fly ash

Sample type	Cohesion (kN/m ²)	Angle of internal friction(Φ), Degree
Overburden	41.8	28.5
Fly ash + OB	89.6	22.9
Soil	78.2	20.5

Table1: Shear parameters for the overburden, soil and Mixture of fly ash and OB

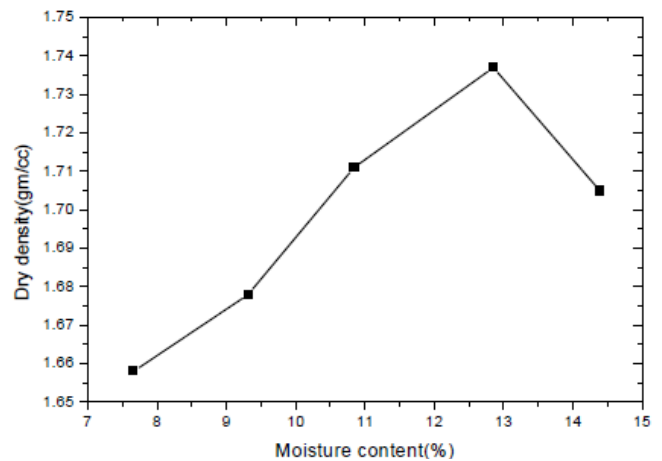


Fig 4: Compaction characteristics of mixture of overburden and fly ash (25%)

Slope stability Analysis of JPL Mines

The stability of dumped slope is analyzed by PLAXIS software, Version 9 using the geotechnical parameters. Finite element program for geotechnical applications in which Mohr- Columb models are used to simulate the behavior of dump material. Its implementation consists of three stages, known as input stage, calculation stage and post processing (curves) stage. Input stage contains model design, assigning the material parameters, boundary conditions, loading and meshing. In the present analysis 15-node triangular element is considered for meshing which contains 12 stress points. In the calculation stage, analysis type is chosen such as Plastic, dynamic, consolidation and phi-c reduction. The assigned loads are activated in this stage and analyzed. In the post processing stage, curves are plotted between various calculated parameters such as load Vs displacement. In PLAXIS *Phi-c reduction* method is used to compute factor of safety (FOS) for dump slope stability. The total multiplier ΣMsf is used to define the value of the dump material strength parameters at a given stage in the analysis.

$$\Sigma Msf = \frac{\tan\phi}{\tan\phi_r} = \frac{c}{c_r} \quad (1)$$

The safety factor is then defined as the value of ΣM_{sf} at failure, provided that at failure more or less constant value is obtained for a number of successive load steps. Different trials were made with overburden and mixture of overburden and fly ash with overall slope angle of 27. The compaction control may be periodically checked for proper compaction of overburden and fly ash mixture. Slope stability of the overburden dump after mixing of fly ash, it was observed that on the application of 25% fly ash mixture safety factor has increased to 1.78, which was only 1.32 with 8% fly ash mixture with overburden.

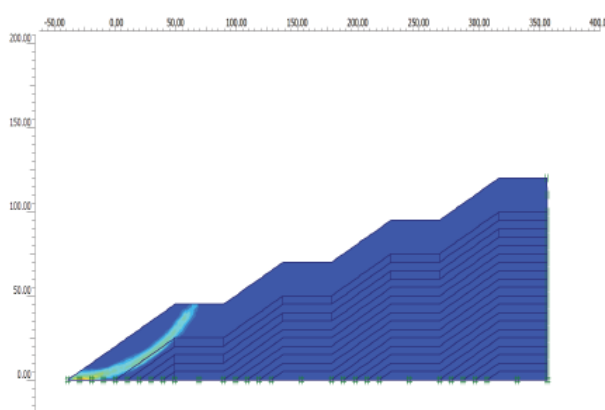


Fig 5: Failure surface with factor of safety 1.75 as per PLAXIS analysis

Fig.7. A view of the plantation over the admixture of OB and Fly ash at Jindal Power Limited, Tamnar

• Conclusion Of The Case Study

Field measurements conducted using total station monitoring system in a typical coal mine for the first experimental trial in India with admixture for fly ash and Overburden material indicated stability of dumps over one year period and also unwrapped the scope of new areas of application of research introducing wireless sensor Networks for evaluation of slope stability. Dump with alternative layer of overburden and overburden mixed with fly ash (only 25%) are found to be stable with safety factor more than 1.2 for total height of the dump. Displacement pattern of the monitoring stations during one-year period indicated no significant displacement in the Overburden dumps with fly ash ensuring stability of the dump near majority of the stations. Wireless Network system along with Time Domain Reflectometry (TDR) is also recommended, and attempts are being made for online and real-time monitoring of stability of slope in other opencast mines as sponsored by the Ministry of Mines, Government of India.[12]

• Transitioning from state of the art to state of the practice

Fly ash is waste material, it can be used as back filling material. Using fly ash model slope the stability and settlement can be checked using unreinforcement and reinforcements as plastic scraps and geo synthetic materials and experimental values are compared with PLAXIS 2D software.

4. CONCLUSIONS

Based on study the conclusions are made

- Fly ash can be used successfully as an embankment fill material.
- Fly ash will solve the problem of its disposal leading to a better utilization of the product which does not decompose with time.
- Bearing capacity of square footing on Fly ash slope is more than circular footing on slope.
- The MDD of the sample decreases whereas OMC increases with increase in the percentage of fly ash. It may be due to the lower density and lower specific gravity of fly ash

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