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Stability Of Embankment On Fly Ash Stabilized Soil Bed -A Case Study

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ABSTRACT

Improvement in broad sense refers to alteration of any property of a soil to improve its engineering performance. This may be a permanent measure to improve the completed facility or a temporary process to allow the construction of a facility. The technique involved in the attainment of the required improvement facilities is referred to as Geotechnical processes. When it involves usage of large quantities of soil for filling, it is always wise and economical to use locally available soils. The usage has two fold advantages, i) reduces cost of project, ii) saves time of construction. These soils under special circumstances need improvement in their engineering behavior. Soil reinforcement, stabilization etc. are few notable techniques described in literature. This paper presents a case study carried out to improve engineering performance of clayey sand of lateritic origin stabilized using fly ash. It is observed that the performance of fly ash in stabilizing soil is considerable in increasing engineering properties. The performance is studied in lab and modeled using slope/w software.

Key words: Stabilization, ground improvement, engineering properties, optimum content of fly ash, stability.

I.INTRODUCTION

1.1 Origin and usage of Fly ash:

Fly ash is a waste material of coal burning in thermal power stations. Several million tons of fly ash is being produced globally every day and its disposal presents a serious problem to coal based power plants. Only a small portion of the amount produced is utilized and the majority is dumped on land.

About 75% of India's energy supply is coal based and shall be so for the next few decades. There are about 82 utility thermal power stations, in addition to several captive power plants, using bituminous coal (with ash content > 30 %) to produce approximately 85 million tone of fly ash per annum. The fly ash produced as a result of burning of Indian coal has tremendous potential to be utilized for different applications. Rough estimates of utilization are around 15% (2005) of the total generated as against 3-5% (1994).

II. USAGE OF FLY ASH AND ITS INFLUENCE ON PROPERTIES OF SOIL

Many researchers have carried out work to understand the influence of fly ash on engineering properties of soils. The fly ash shows important pozzolanic properties which depend upon many factors including quality of coal, degree of pulverization of coal, proportion of free lime and unburnt carbon in the fly ash. Pozzolanic property of a fly ash is directly proportional to the amount of free lime and indirectly proportional to the amount of unburnt

carbon in the fly ash (Bheegly, 2003). The fly ash is widely used in various applications namely stabilization, mixed to sub grade in pavements etc. Fly ash in combination with lime has proved effective in controlling the heave of expansive soils (Phani Kumar, 2004, Scott et al.), reduction of swell potential and plasticity (Parsons et al. 2005), reduces plastic limit of lateritic soil and increases workability with lime Goswami (2005), Sahu(2001), improves strength properties of fissured clay by grouting(Akbulut et al., 2003).

The fly ash soil mixtures have proved effective in pavements and improving soil strength. Life of pavements from deterioration effect can be increased by treating pavement materials with fly ash (Parsons et al. 2005). Fly ash influences curing and compactive effort ((Sunil Arora 2005), CBR values of all types of sub grade (Sahu 2001, Pandian et al., 2001). Compaction behavior of fly ash was similar to cohesion less sands or sandy gravels (Sridharan et al.2001).

Fly ash has proved efficient in improving strength of soil. Up on blending strength is increased with reduction in cohesion and increase in Phi (Al-rawas et al. 2004, Nilo Cesar Consoli, 2001). Unconfined compression strength increases with fly ash (Akbulut et al., 2003, Khaled Sobhan, 2003, Nilo Cesar Consoli, 2001, Bert D. Trzebiatowski et al.).Fly ash a waste product of coal based power plants can be used in combination to another waste product "Plastic" as reinforcement in enhancing strength of stabilized soils (Khaled Sobhan, 2003). In the form of vertical columns fly ash proved its efficacy by accelerating rate of consolidation and settlement of clay layer than with sand columns (A.Porbaha 2001). It is found that fly ash significantly reduces the plasticity index of the organic soil, whereas the liquid and plastic limits increase. The dry density of the fly ash-soil mixture increases significantly, while the water requirement reduces due to the addition of fly ash.(Bayasakhi deb et al. 2017). As the % of FA increases, reduction in maximum dry density and higher optimum moisture content were observed (Siavash Mahvash et al. 2017).

III. EXPERIMENTAL STUDY

In experimental program studies are carried out on the fly-ash & soil mixtures. The soil under study is collected from a depth of 30 to 60cm from village Raavivalasa located 30 KM west of Rajam town. The fly ash used was a waste product of Rayagada paper mill, Rayagada, Orissa. The fly-ash sample was collected from ash pond at a depth of 1 meter from the surface of the pond. Tests are carried out on soil blended with fly ash at 0, 5, 10, 15, 20, 25, 30%. Index properties of clayey sand & fly ash and engineering properties namely, O.M.C, M.D.D and Unconfined compressive strength of blended soil at different fractions were determined. Embankment of height 5m and side slope 1;2 is modeled using slope/w considering the properties of stabilized soil as ground. The stability is computed for un-stabilized and stabilized ground and later compared.

IV. PRESENTATION OF RESULTS AND DISCUSSIONS

The results obtained from the experimental program were tabulated in Table 4.1 to 4.3. It is observed from Table 4.1 that the soil is predominantly rich in percentage of sand and clay. Results of tests conducted on fly ash are shown in table 4.2 indicates that the soil was predominantly rich in silt content and with fraction of clay. Fly ash was observed to be non plastic.

Table 4.1 Index properties of Clayey sand

Parameters	Values
Natural moisture content (%)	6
Specific gravity	2.667
Liquid limit	41.2
Plastic limit	16.82
Plastic index	24.38
Gravel (%)	0%
Sand (%)	43.91
Silt (%)	20.54
Clay (%)	35.54
Optimum moisture content (%)	20.6
Maximum Dry density (gm/cc)	1.72
Unconfined compressive strength (KPa)	22
Classification	SC

Table 4.2 Properties of Fly ash.

Parameters	*Values*
Specific gravity	*2.14*
Liquid limit	*none*
Plastic limit	*Non plastic*
Plasticity index	*Non plastic*
Sand (%)	*0*
Silt (%)	*62.67*
Clay (%)	*37.33*
Classification	*Non plastic silt*

Table 4.3 Variation of OMC, MDD and UCS with fly ash

% FLY ASH	*OMC (%)*	*MDD (gm/cc)*	*UCS (kPa)*
0	*20.6*	*1.72*	*22*
5	*16.4*	*1.83*	*54*
10	*16.2*	*1.85*	*66*
15	*17.2*	*1.78*	*58*
20	*19.6*	*1.73*	*50*
25	*19.2*	*1.65*	*42*
30	*21*	*1.62*	*35*

4.1 Variation of Optimum Moisture content with Fly ash:

From the fig 4.1 it was observed that the optimum moisture content was reduced initially with increase in fly ash content up to 10% and increases with increase in fly ash thereafter. Due to filling up of voids in clayey sand by fines void volume reduced causing reduction of OMC. With increase of fly ash content beyond 10% the densification effect taken place by using lubricating mechanism of water added. Hence an increase in optimum moisture content was observed. Fly ash was effective in reducing optimum moisture content of sandy clay soil from 20.6% to 6.2% by increasing fly ash from 0to 10%.

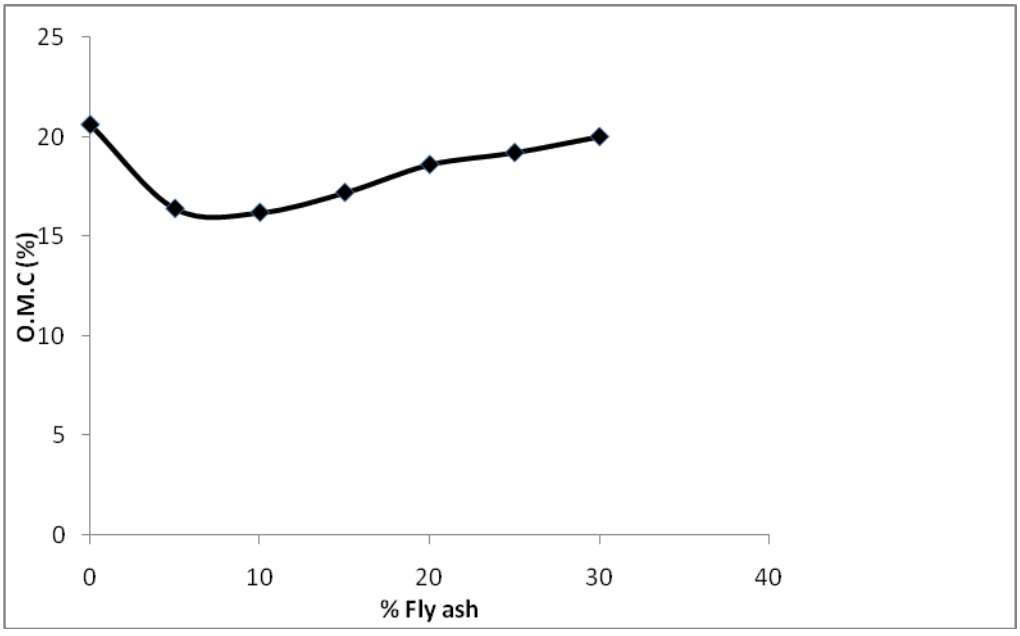

Fig. 4.1 Variation of Optimum Moisture content with Fly ash

4.2 Variation of Maximum Dry Density with Fly ash Content:

From the fig.4.2 it was observed that fly ash content has an effect on dry density which increased by increasing fly ash content. However this increasing trend was up to 10% addition only. Beyond which, increasing fly ash content showed a drastic influence on maximum dry density with a clear reduction in maximum density. Due to

conversion of uniformly graded soil in to well graded soil up on addition of fly ash is effective up to 10% only. There after decreasing trend is observed due to increase of silt content.

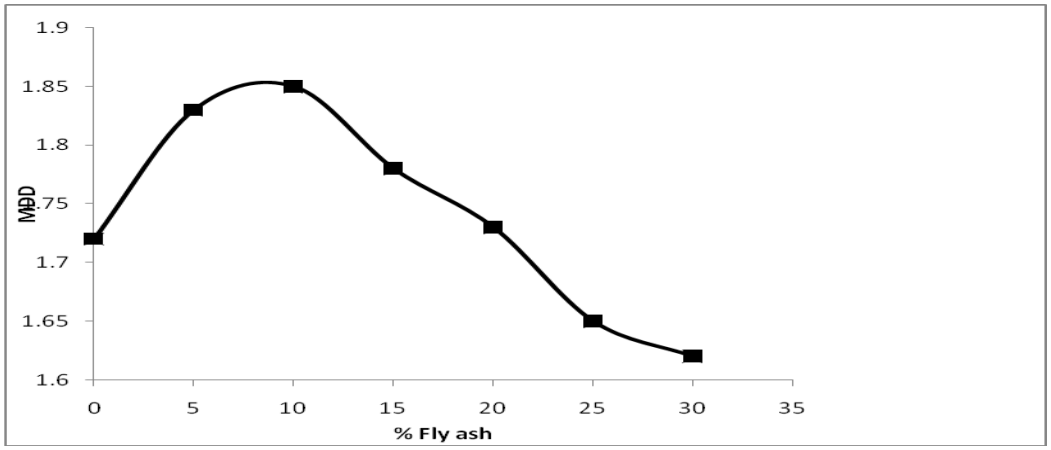

Fig. 4.2 Variation of Maximum dry density with Fly ash

There is an increase in dry density from 1.72gm/cc to a maximum of 1.85 gm/cc at 10%.

4.3 Variation of Unconfined compressive strength with fly ash:

From the fig. 4.3 it was observed that the strength of soil was increasing with increasing fly ash content from 22kPa at 0% to a maximum value of 66 kPa at 10% fly ash content. There after decreasing trend is observed with fly ash. The increase in strength is due to increase of density and decrease is due to formation of poorly graded soil again with addition of fly ash coupled with pore water pressure. As from the Fig. 4.1 an increase of OMC after 10% has influenced pore water pressures to develop. However fly ash has proved effective in increasing strengths upon its addition to sandy clay up to 10%.

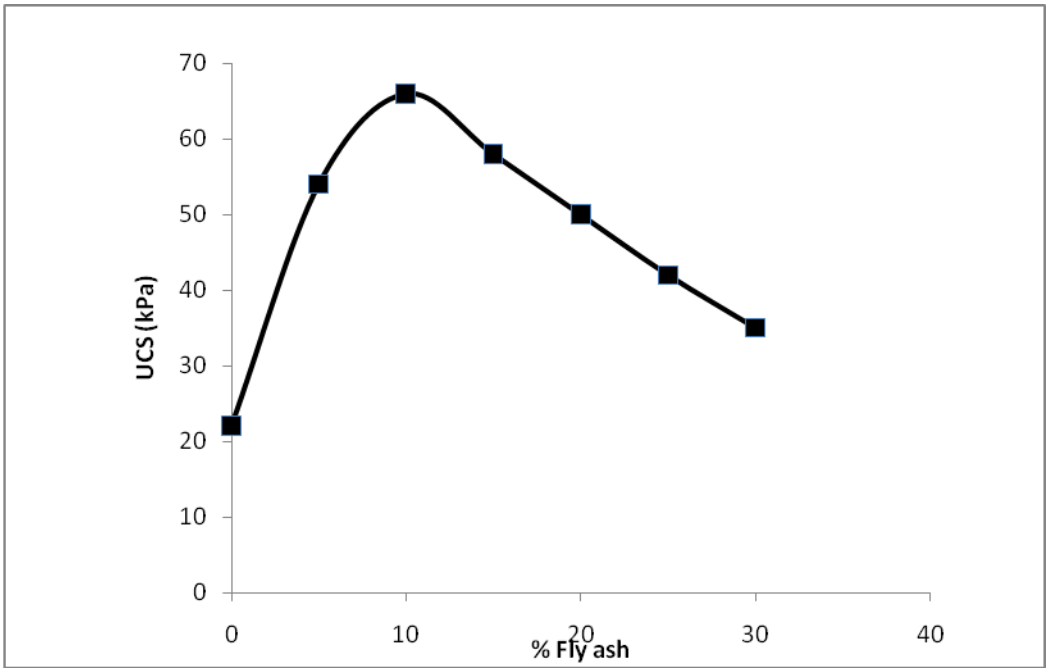

Fig. 4.3 Variation of Unconfined compressive strength with Fly ash

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4.4 Stability of slope constructed on stabilized beds:

The stability of slope for an embankment on these soils is analyzed using slope/w. The Fs on unstabilized ground (**c_u = 11 kPa)** is 0.76 and that on stabilized ground (**c_u = 32 kPa)** is 1.983. Hence the stability is more pronounced.

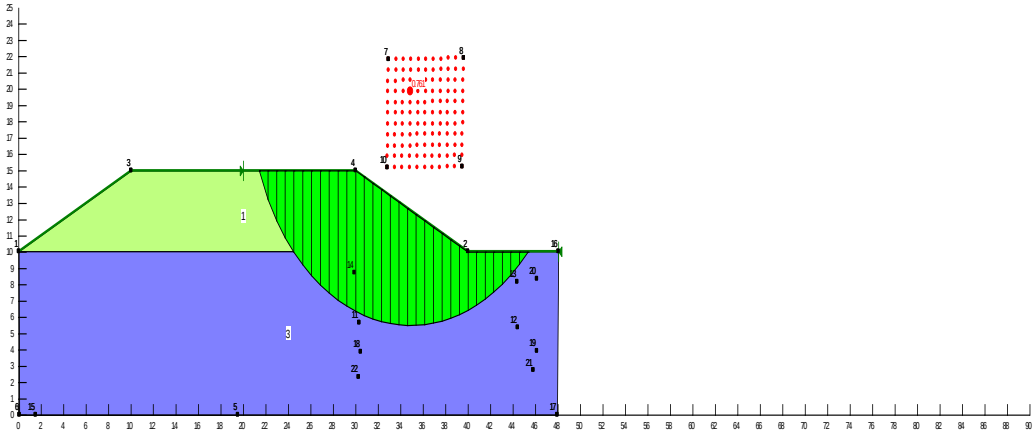

Fig. 4.4 Slope stablity on unstabilized bed (c_u = 11 kPa Fs=0.7)

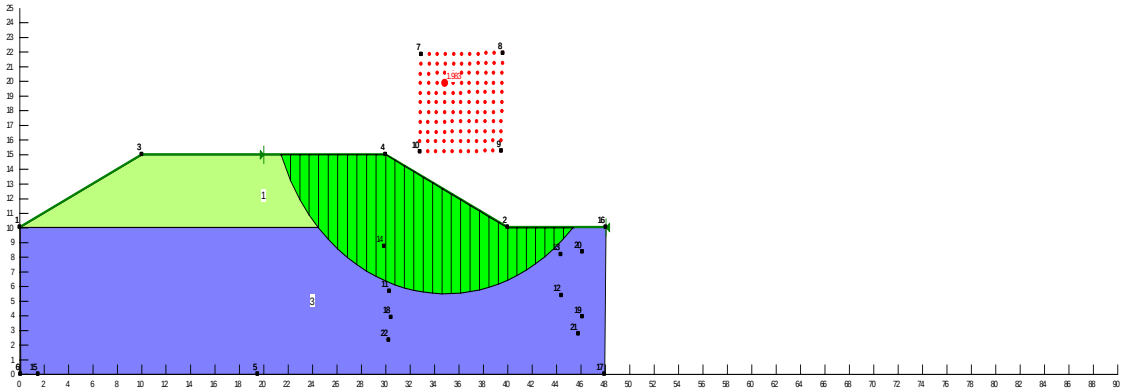

Fig. 4.4 Slope stablity on stabilized bed (c_u = 32 kPa, Fs=1.98)

V.CONCLUSIONS

From the tests conducted on clayey sand and fly ash mixture for variation of optimum moisture content, maximum density and strength the following conclusions are drawn

- The fly ash was effective in reducing optimum moisture content with increasing fly ash content up to 10%.
- Fly ash was effective in increasing in dry density up to 10%.
- Fly ash was effective on increasing compressive strength of sandy clay soil up to 10% addition.

- The slope stability of embankments constructed on stabilized beds can enhance Fs by 1.5 times which will add stability.
- The present work highlights the proper utilization of natural hazard in ground improvement applications with three fold advantage in consumption of hazard, improvement of weak soils and optimization of fly ash content.

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