SOIL IMPROVEMENT USING FLYASH AND GEOFIBER

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ABSTRACT: Coal/lignite based thermal power generation has been the backbone of capacity addition in the country. Indian coal is of low grade having high ash content upto 40% in comparison to imported coals which have ash content of the order of 10-15%. Large quantity of ash is being generated at coal/lignite based power station in the country, which has been one of the sources of pollution of both air and water. In India class F type flyash is generated by thermal power plants. An attempt has been made in this study to utilize the flyash mixed with geofiber in soil stabilization. It is found that the flyash reinforced with geofiber improves the strength of the low bearing soil.

Keywords: flyash, utilazation, geofiber, soil stabilization.

INTRODUCTION

Highly compressible soils are considered to be marginal because they lack the required engineering properties for use in pavement base courses, subbase courses, subgrades, and as a foundation supporting layer under buildings and various structures and for landfilling. Engineers and practitioners are continually looking for methods to improve the properties of fine grained soils. Traditional stabilization techniques require large amounts of additives and specialized skills and equipment to ensure adequate performance (Tutumluer et al., 2004). Recently, geofibers and flyash have been used together to improve highly compressible soils (Mishra, 2014). This technology is nontraditional, and requires minimal installation equipment. For soil stabilization and improvement purposes, geofibers have been used extensively due to their low cost, light weight, and significant contribution to strength gain. The addition of geofiber increases the load bearing capacity of soil; and improves the shear strength.

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Many researchers were carried out for utilizing flyash in soil stabilization. Some of the major works are given below.

Kaniraj and Havangi (1996) had highlighted the result of an experimental study carried out to determine geotechnical characteristics of fly ash and fly ash soil mixtures and there implications on the design of embankments on soft soil and concluded the degree of compaction of fly ash is not sensitive to water content. They added that increase in fly ash content decreases the maximum dry unit weight and increases the OMC of fly ash soil mixtures. They have found that the unconfined compressive strength decrease when fly ash contain in fly ash soil mixture becomes more than 50%. The authors concluded that by increasing fly ash content it is possible to improve the stability of the embankment using even low and medium strength geo-synthetics as reinforcement.

Senadheera (1996) reported that the soil stabilization and cement replacement account for less than 20% utilization of fly ash produced in USA. In this study they have used hydrated fly ash as flexible base materials. The study concluded that hydrated class C fly ash has a potential as a flexible base material provided that the curing process is carefully managed.

Anil (1998) had studied the stabilizations characteristics of clays using Class C fly ash because of having high calcium oxide contain. Stabilization characteristics of clay soils blended with Class C fly ash were evaluated. Because fly ash is a by-product, uniformity of its physical and chemical properties is significant for quality control. It is observed that the fly ash used in this experiment study was having a rapid hydration characteristic. Consequently, higher densities and strengths are achieved when the compaction is performed with little or no delay after the addition of moisture to clay and fly ash blends. Results depict strength gain behavior with curing period for various soil fly ash blends.

Kaniraj and Havanagi (2001) found that fly ash, a waste from thermal power station, use in many countries to build high way embankments, fills, land fill liners, and covers. The MDD and OMC of fly ash or fly ash-soil mixtures are determined by conducting compaction tests. There is a large variation in the MDD and OMC of different fly ashes due to the difference in their characteristics. In this study, data regarding the compaction characteristics and specific gravity (G) of different fly ashes were collected. Correlations have been developed for MDD and OMC for both light and heavy compaction. The correlation for MDD in terms of OMC and G and that between MDD and OMC have been expressed in the form of log-log, exponential, an liner curves the correlation between MDD and G and between OMC and G, that can be used to make a preliminary estimate of the likely range of MDD & OMC if the specific gravity of fly ash is known.

Zang and Cao (2002) conducted an experimental program to study the individual and admixed effects of lime and fly ash on the geotechnical characteristics of expensive soil. Lime and fly ash were added to the expensive soil at 4 to 6% and 40-50% by dry weight of soil, respectively. The specimens were tested for determining chemical composition, grain size distribution, consistency limits, compaction, CBR, free swell and swell capacity. The effect of lime and fly ash addition on a reduction of the swelling potential of an expensive soil texture was reported. It was revealed that changes of expensive soil texture take place when lime and fly ash are mixed with expensive soil. Plastic Limit increases by mixing lime and Liquid Limit decreases by mixing fly ash, which resulted in the decreases of Plasticity Index. As the amount of lime and fly ash is increased, there is an apparent reduction of MDD, free swell. The authors concluded that the expensive soil can be successfully stabilized by lime and fly ash.

Beeghly (2003) studied the use of lime together with fly ash in stabilization of soil subgrade (silt and clayey soils). He reported that lime alone works well to stabilized clay soils put a combination of lime and fly ash is beneficial for soils having low plasticity (higher silt content) soils. Author noticed that both unconfined compressive strength and CBR values of treated stabilized soils with lime and fly ash together are higher than the values with lime alone. He is also concluded that the capillary rise of the stabilized specimens led to a loss of unconfined compressive strength (15-25%).

White (2006) conducted both laboratory and field based study on the use of reclaimed hydrated fly ash in construction of structural layer of highway pavement. The influences of admixtures such as hydrated lime cement, kiln dust were also studied Author concluded that reclaimed hydrated fly ash can be effectively used in construction of pavement base and sub base.

Alam (2008) studied the influence on CBR and Fly ash mixed with lime. Different types of ash residues and large amount of particulate matter and gases are generated by thermal power plants. Fly ash is the most abundant of all the residues and its disposal not only needs enormous land, water and power resources but it also causes serious environmental hazards, In this paper, result of an experimental study have been presented to determine the effect of lime on value of CBR of Fly ash.

Brooks (2009) had tried to upgrade the expansive soil as a construction material using Rice Husk Ash (RHA) and Fly ash, which are waste materials. Remolded expansive clay was blended with RHA and Fly ash and strength tests were conducted. Cost comparison was made for the preparation of the sub base of a highway project with and without admixture stabilization.

Behera and Naik (2009) have studied the ash properties viz. particle size distribution, permeability, slurry flow characteristics, settling characteristics. The SEM of the samples were done to study the characteristics of individual elements as the element having spherical shapes showed maximum pozzolanic character. Visual observations of the SEM images show a distinct spherical nature for the grains for the fly ash samples. The specific gravity attribute to the mineralogical composition i.e. presence of silica content and CaO.

Sharif (2012) had tried fly ash – waste sludge geofiber mix to use it as a fill material to raise low lying areas. To fill this gap, a comprehensive experimental study consisting of California Bearing Ratio (CBR) on compacted fly ash, fly ash – waste sludge and and fly ash –waste sludge –geofiber was carried out. The test result shows that the fly ash alone cannot be used for filling the low lying areas or for replacement of subgrade soil for pavements. On the other hands when fly ash was mixed with waste sludge and reinforced with geofiber the strength was improved to a great extent.

Tripathi (2013) found that the dry density of Fly ash and Soil mix is less than that of virgin soil because Fly ash is light weight material as compared with soil. It was reported that the mix containing 82%BA+10%Soil+8%RBI Grade 81 has good bearing strength characteristics. Addition of small percentage of lime and stabilizer to Fly ash enhances the bearing capacity of ashes.

Experimental Program

An extensive experimental program was carried out to investigate the strength improvement of a compressible soil by adding geofiber and flyash.

3.1 Materials Used: Soil

The soil sample which was collected from Ravindra Nagar (Dhoos) Kushinagar. The engineering property of the soil is given in Table 1.

Table 1 Engineering Properties of Soil

S.No.	Properties	Value
1	Grain size analysis	
	a) Fine gravel size (10mm to 4.75mm)	Nil
	b) Sand size (4.75mm to 75microns)	2.40%
	b) Silt size (75micron to 1 microns)	97.60%
2	Consistency limit	Non –Plastic
3	Maximum Dry Density(MDD)	1.7g/cc
4	Optimum Moisture Content(OMC)	17%
5	California Bearing Ratio(CBR)	1.8%

3.2 FLY ASH

The fly ash used in the study was brought from Tanda Thermal Power Station situated at Ambedkar Nagar in Uttar Pradesh, which was available free of cost. Fly Ash is classified as silt of low compressibility.

The engineering properties and chemical composition of the flyash is given in table 2 and 3 respectively.

Table 2 Engineering Properties of Fly Ash (type Class F)

S.No.	Properties	Fly Ash
1	Grain Size Analysis:	
	a)Fine gravel size particle (10mm to 4.75mm)	Nil
	b)Sand size particle (4.75mm to 75microns)	30.4%
	c)silt and clay size particle (75μm to 1 μm)	69.6%
2	Consistency limit	Non –Plastic
3	Specific Gravity	1.98
4	Maximum Dry Density(MDD)	1.22 g/cc
5	Optimum Moisture Content(OMC)	16.4%
6	Unburnt Carbon	14.56%

Table 3 Composition of materials in Flyash (Source NTPC Tanda)

Material	Composition in %
SiO_2	52.42
Al_2O_3	30.96
Fe_2O_3	5.63
CaO	2.85
B	3.66
Oxides of Na, K and Mg	2.03
Trace Elements (As, Ba, Cd, Cr, Ga, Li, Mn, Pb, Se, Sr, Te, Zn)	0.26
Loss Of Ignition	2.18

3.3 GEOFIBER

The various types of synthetic fiber that may be used for strengthening the soil or fly ash are polypropylene, nylon, plastic, glass asbestos etc. These are preferred over natural fibers because of their higher strength and resistance. Polypropylene fiber are resistant to acidic, alkaline and chemical. These fibers have high tensile strength, resistance to sea water and melting point i.e. 85^0 C. The physical and engineering properties of the fibers are shown in Table 4

Table 4 Physical and Chemical Properties

S.No.	Constituent Properties	Value
1	Molecular formula	$(CH_2 - CH_2)_n$
2	Young's modulus	27.00 GN/m
3	Melting point, (in deg. Celcius)	85.00
4	Tensile strength, N/mm²	127.40
5	Unit weight, kN/m³	9.20

Result and Discussion

	Table 4.1 Variation of OMC%, MDD and CBR% with Fly Ash Content						
S.No.	Denoted	%Fly Ash	%Soil	%Geofiber	OMC %	MDD g/cc	CBR
1	0	100	0	0	16.4	1.22	1.01
2	0	0	100	0	17	1.7	1.8
3	M_1	8	90	2	17.4	1.68	2.0
4	M_2	13	85	2	17.9	1.60	2.7
5	M_3	18	80	2	18.6	1.57	3.1
6	M_4	23	75	2	19.0	1.51	3.6
7	M_5	28	70	2	19.2	1.49	4.1
8	M_6	33	65	2	19.9	1.48	4.8
9*	M_7	38	60	2	20.4	1.46	5.24
10	M_8	43	55	2	21.0	1.41	3.8
11	M_9	48	50	2	21.9	1.39	2.6
12	M_{10}	60	38	2	23.27	1.36	1.12

Different percentage at which Fly Ash was mixed with soil and its OMC and CBR is given in Table 4.1. From the table and graph it is clear that strength of the mixture is maximum when 38% Fly ash and 2% is Geofiber added to the 60 %soil. On the basis of past research (Sharif, 2012) we found that 2% geofiber mixing gives the best result in soil stabilization therefore we mix 2% geofiber in different percentage of soil and flyash.

Study of Scanning Electron Micrograph Imageries

The scanning electron micrograph (SEM) analysis was carried out to study the morphology of the sum of selected samples. The SEM was carried out BSIP, Lucknow.

Fig 1 shows the Scanning electron Micrograph view at 3000X of Soil Compacted on OMC which is 17 %. It is clearly seen from the picture that there is large number of voids and loose packing of soil grains which could be the reason for less strength in structure. Being less in strength makes it unfit for use in many Geotechnical engineering works.

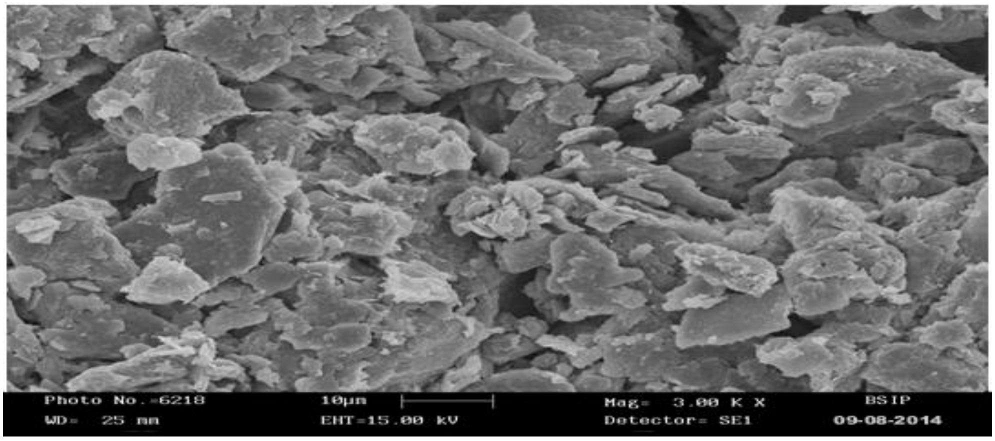

Fig. 4.1: SEM image of Soil AT 3000X magnification

Fig 2 shows the scanning electron micrographs (SEM) for fly ash at various magnifiactions. The micro graphic observation for fly ash indicates presence of spherical particles on the abundance, sub rounded porous grains, irregular agglomerates, opaque spheres and irregular porous grains of unburned carbon.

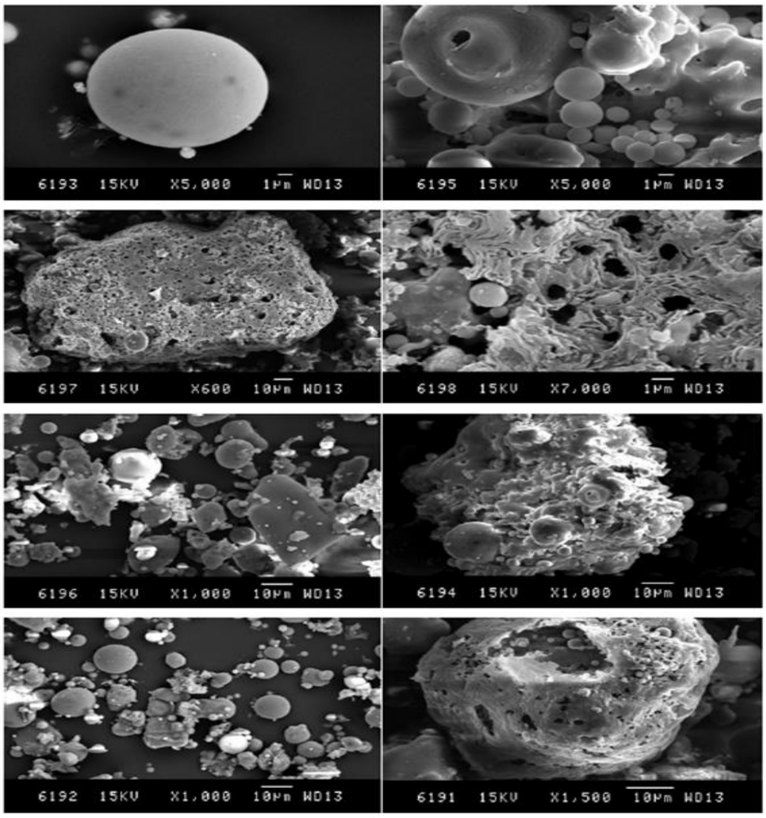

Fig. 2: SEM image of Fly ash at different magnifications (Source NTPC Tanda)

Figure 3 illustrate the SEM- micrograph of 60% soil +38% flyash +2% geofiber, It is clearly seen from the picture that there is less number of voids and tight packing of Fly ash with Soil and Geofiber mix. It could be the reason for high strength which shows the improvement of soil properties.

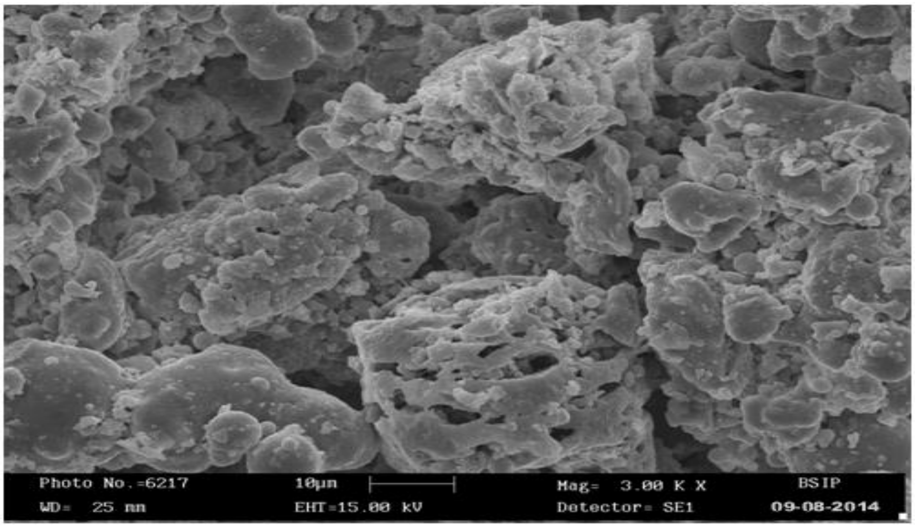

Fig. 3: SEM image of 60% soil +38% flyash +2% geofiber at 3000X magnification

CONCLUSION

The mix containing 38%FA+60%Soil+2%GF has good bearing strength characteristics. In order to achieve good quality structural fills, the MDD values obtained from standard proctor test may be adopted as a benchmark value. The bearing strengths of fly ash were increased to 5.24% on addition of fly ash and geo fiber in the ratios of 38% and 2% respectively.

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