International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 32, Issue 01) and (Publishing Month: July 2016)
(An Indexed, Referred and Impact Factor Journal)
ISSN: 2319-6564
www.ijesonline.com

EFFECT AND APPLICATION OF FLY ASH ALONG WITH COIR FIBER ON STABILIZATION OF SILTY SAND

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ABSTRACT: One of the fundamental limitations faced by the geo-technical engineers is the development of any framework over a weak or delicate soil as the soil goes through differential settlements; helpless shear strength and high compressibility. Different procedures have been adjusted to work on the bearing capacity of soil like soil adjustment, reception of support and so on For the most part, admixing strategy in soil has a successful ground improvement due to its simple versatility. Fly debris created in the burning of subbituminous coals shows self – solidifying attributes and can be utilized in a wide scope of adjustment application. Along these lines, this paper reports the consequences of the lab concentrate on performed on silty sand admixed with fly debris and built up with coir strands and exhibits that discrete and haphazardly conveyed coir filaments are valuable in working on the bearing limit of soil. The silty sand has been viewed as utilizing diverse level of fly ash going from 4 to 22% by weight of soil and the impact of restoring period is additionally thought of. Coir strands are added going from 0.25 – 5% and having distinctive perspective proportion (l/d=40, 80, 120, 160) to examine the overall strength acquire as far as unconfined pressure. This concentrate additionally helps the compelling utilization of fly ash and coir fiber, proposing a financially savvy technique for further developing the soil properties.

KEYWORDS: Stabilization, Fly debris, Coir Fiber, Unconfined Compression

Introduction

A complete network of road system in developing countries like India is not easy due to limited finances available to build roads. The reduction of available land resources and the increased cost associated with the use of high quality materials have led to the need for local soils to be used in geotechnical construction. However, poor engineering properties of these soils pose difficulties for construction projects and need to be stabilized to improve their properties. The stabilization of soil for use in subgrade for pavement is an economic substitute of costly paving materials. Improvement of certain desired properties like bearing capacity, shear strength (c and ϕ) and permeability characteristics of soil can be undertaken by a variety of ground improvement techniques such as the use of prefabricated vertical drains (Abuel-Naga et al, 2006; Chu et al, 2006) or soil stabilization. Several additives, which may be utilized for ground modification such as cement, lime and mineral additives such as fly ash, silica fume, and rice husk have been used under various contexts. On the other hand, extensive studies have been carried out on the stabilization of soft soils using various additives mentioned above (Al rawas and Goosen, 2006). There are many techniques for soil stabilization, either mechanical or chemical, but all of them require skilled manpower and equipment to ensure adequate performance.

Chemical stabilization by cement or lime is a proven technique for improving the performance (strength and stabilization) of soil

However, these chemical additives usually result in a high stiffness and brittle behavior (Wang et. al., 2003). The findings from the previous studies reported in the literature showed that the addition of such additives reduced the plasticity index (Parsons and Kneebone, 2005; Nalbantoglu, 2004; Basha et al., 2003). In terms of compaction, several researchers (Senol et al., 2006; Sezer et al., 2006; Prabakar et al., 2004; Muntohar and Hantoro, 2000) observed that soils treated with cementing additives showed an increase in optimum moisture content and a decrease in maximum dry density. Furthermore, the studies indicate that the strength (shear and compressive) of soft soils can be improved by adding the cementing additives mentioned above. On the other hand, cementing additives react with the lime more effectively than alone. The efficiency of lime stabilization may be greatly increased. Some investigators (Goswami and Singh, 2005; Muntohar and Hantoro, 2000; Bagherpour and Choobbasti, 2003) found that the workability and the strength behavior of soft soils were greatly improved after combined treatment. Several research studies were undertaken to better understand the durability of lime and/or fly ash stabilized clayey soils (Rao et al., 2001; Shihata et al., 2001; Guney et al., 2007; Khattab et al., 2008).

The concept of reinforcing soil with natural fiber materials originated in ancient times. However, randomly distributed fiber reinforced soils have recently attracted increasing attention in geotechnical engineering. In comparison with conventional geosynthetics (strips, geotextile, geogrid, etc.), there are some advantages in using randomly distributed fiber as reinforcement. First, the discrete fibers are simply added and mixed randomly with soil, in much the same way as cement, lime, or other additives.

Second, randomly distributed fibers limit potential planes of weakness that can develop parallel to oriented reinforcement. Therefore, it has become a focus of interest in recent years. Randomly distributed fiber, when used as insertion in highway subgrades, can produce a high performance in the stabilization of weak roads. Many investigators (Raymond, 2002; Tang et al., 2007) have used various types of fibers under different test conditions. The most important findings of the research work is that the use of certain fiber, such as synthetic and natural, in road construction can significantly increase pavement resistance to rutting, as compared to the resistance of non-stabilized pavement over a weak subgrade.

A number of triaxial tests, unconfined compression tests, CBR tests, direct shear tests on the subject have been conducted by several investigators in the last few decades (Sivakumar Babu et al., 2008; Yetimoglu et al., 2005; Michalowski and Cˇerma´ k, 2003; Prabakar and Sridhar, 2002; Kaniraj and Gayathri, 2003). All these previous studies have shown that the addition of fiber-reinforcement caused significant improvement in the strength and decreased the stiffness of the soil. More importantly, fiber reinforced soil exhibits greater toughness and ductility and smaller loss of post-peak strength, as compared to soil alone. Therefore, the discrete fiber can be considered as a good earth reinforcement material, which causes significant modification and improvement in the engineering properties of soil.

The objective of the study is to find out the effective percentage of fly ash and coir fiber which are used to stabilize a particular soil sample (Taken from paddy field at Chitoor, Palakkad District). The study also evaluates the cementing property of fly ash that causes the improvement of UCC strength, at different curing stages.

MATERIALS

Silty Sand

The soil collected from the paddy field at chitoor, Palakkad District is used for the investigation. Sieve Analysis are conducted on the soil sample as per IS: 2720 (Part4)- 1985. Water content – dry density relationship for the sample is found out using heavy compaction (IS: 2720 (Part 5)-1983). As per Indian Standard soil classification system the sample soil is classified as Silty sand (SM). The Physical properties of soil sample are shown in Table 1.

Table 1: Physical Properties of Silty Sand

Property name	Value
Optimum Moisture Content OMC	10%
Maximum Dry density (MDD) (g/cc)	2.03
Specific Gravity of soil solids G	2.51
Average grain size D_{50} (mm)	0.18
Sand	70%
Silt	19%
Clay	11%
Classification as per Indian Standard	SM
Typical soil Classification	Silty Sand

Fly ash

Fly ash is a non-crystalline pozzolanic and slightly cementitious material. The physical properties of fly ash used in the study are given in Table 2 and the chemical properties of fly ash in Table 3. The fly ash was collected from thermal power station at Trichy.

Table 2: Physical Properties of Fly ash

Sl. No.	Property	Description
1.	Appearance	Fine grey
2.	Form	Powder
3.	Colour	Grey
4.	Density (g/cc)	0.80-0.85

Source: Tests conducted by Pierce Leslie Surveyors and Accessors Ltd.

Table 3: Chemical Properties of Fly ash

Sl.No.	Tests	Protocol	Unit	Result
1.	Loss on ignition	ASTM C 114	%	0.18
2.	Sulphur Trioxide (SO_3)	ASTM C 114	%	0.30
3.	Retention by weight sieving method on 45µm mesh	ASTM C 430	%	23.44
4.	Moisture content	ASTM C 311-05	%	0.12
5.	Silica (SiO_2)	ASTM C 114	%	64.64
6.	Alumina (Al_2O_3)	ASTM C 114	%	28.12
7.	Ferric Oxide (Fe_2O_3)	ASTM C 114	%	2.62
8.	Magnesium Oxide (MgO)	ASTM C 114	%	0.18
9.	Soluble Phosphate (P_2O_5)	ASTM C 114	mg/kg	36.5
10.	Sodium Oxide (Na_2O)	ASTM C 114	%	0.22
11.	Chloride (Cl)	ASTM C 114	%	0.05
12.	Calcium Oxide (CaO)	ASTM C 114	%	2.14
13.	Potassium Oxide (K_2O)	ASTM C 114	%	0.08
14.	Titanium Dioxide (TiO_2)	ASTM C 114	%	0.88
15.	Manganese Dioxide (MnO_2)	ASTM C 114	mg/kg	Traces
16.	Reactive CaO	BS EN 197-1	%	0.98
17.	Reactive SiO_2	BS EN 197-1	%	28.84

Source: Tests conducted by Pierce Leslie Surveyors and Accessors Ltd.

Coir fiber

The Coir fiber is collected locally available source. The average diameter of the coir fiber is calculated by making a bunch of coir fibers having known number of coir fibers whose diameter is measured using screw gauge. From this method the average diameter of a single coir fiber is found to be 0.25 mm.

METHODS

Five different soil specimens were prepared by blending of clay and adding 0%, 5%, 10%, 15% and 20% Fly Ash by weight of soil in dry conditions. The samples were mixed with proper care to get homogeneous mix.

The unconfined compressive strength of different samples containing different percentage of fly ash is found out. From which optimum fly ash percentage is determined. Coir fibers having different aspect ratios (l/d = 40, 80, 120 and 160) were added to the sample having optimum fly ash content and variation of UCC strength is evaluated. From this test results the optimum fiber content in each aspect ratio is determined.

Compaction test

Standard proctor tests were performed to find out the optimum moisture content (OMC) and the maximum dry unit weight (γ_{max}) with varying fly ash contents. Fig. 1 shows the variation of percentage moisture content with percentage fly ash content. From the figure it is clear that as percentage of fly ash increases the optimum moisture content increases. At the same time, Fig. 2 gives the inference that, there is decrease in dry density with increase in fly ash content.

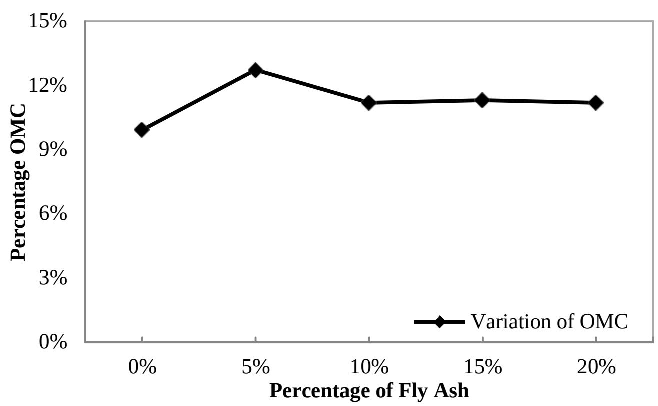

Fig. 1. Variation of OMC with Percentage fly ash

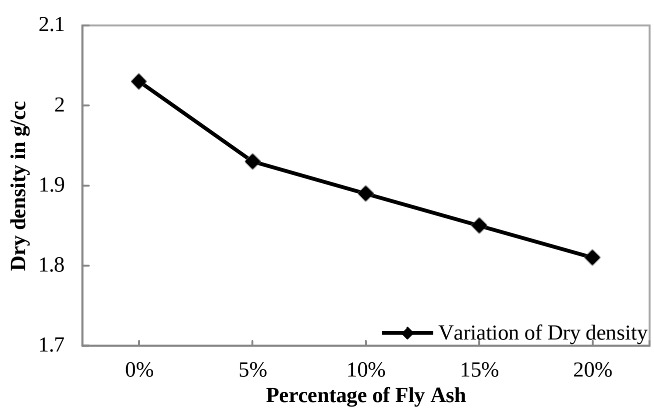

Fig. 2. Variation of dry density with percentage of fly ash

Unconfined Compression test

UCC tests are conducted in various specimens having an L/d ratio 2 (Length of Specimen is 74 mm and diameter is 37 mm). Load applied is measured using a proving ring and deformation is measured using dial guages. Load is applied at a constant strain rate of 1.25 mm per min. The optimum percentage of fly ash to be mixed with the silty sand has been determined on the basis of maximum UCC strength. Weight fractions of fly ash of 5%, 10%, 15%, and 20% were used to mix with silty sand at their corresponding OMC and MDD. The proportion of 15% fly ash and 85% silty sand yielded the

For different percentages of coir fiber 0.5%, 1.0%, 1.5%, 2.0%, 3%, 4% and 5% by weight of dry soil were used in the present study to carry out UCC tests. Results of the tests were used to calculate the optimum fiber proportion in soil based on the maximum UCC values. The UCC value continuously increases as compared to pure soil case. Coir fiber addition up to 4% (by dry weight of soil mass) having l/d ratio of 80 appeared as optimum and is thus recommended for reinforcement. (Fig. 3 shows the details of variation of UCC with percentage of fiber for silty sand mixed with fly ash.)

Result and Analysis

Variation of UCC with the addition of Fly ash in soil

As the percentage of fly ash increases the UCC strength also increases. When the presence of fly ash percentage increases beyond a limit, i.e. above 15%, the UCC strength is decreased. It may be caused due to the increase in void ratio and porosity due to the flocculation of fly ash particles. From the test results the optimum fiber content is selected as 15%. Fig. 3 includes the test results of variation of UCC for different percentage of fly ash without curing.

Effect of Curing on fly ash mixed samples

Cementing property of fly ash due to the presence of high percentage of silica and alumina will depend on the curing period of the sample. Fig. 3 shows the variation of UCC strength for different percentage of fly ash having different curing period. From the results it is clearly seen that when the curing period increases, the UCC strength also increases. It is also seen that with increase in percentage of fly ash the UCC strength also increases due to the cementing property of fly ash.

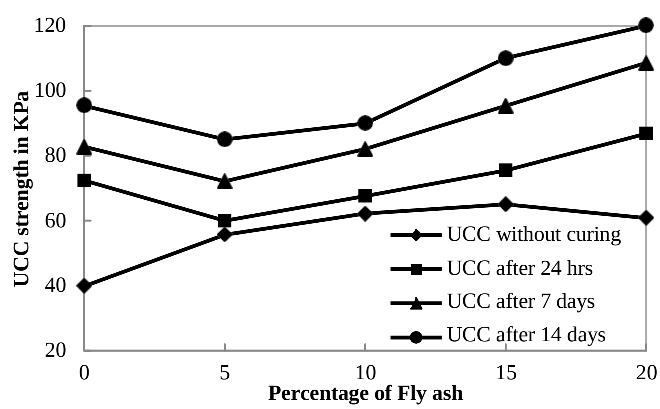

Fig. 3. Variation of UCC strength with percentage of fly ash having different curing period

maximum UCC value (q_u). Hence, the same percentage has been adopted for further studies.

Effect of Coir fiber in Soil sample

The increase of UCC strength due to addition of coir fiber depends on the length and quantity of fiber. From the test results it is clear that coir fiber having the different aspect ratio have different optimum quantities. Coir fibers upto this optimum percentage acts as an effective reinforcing medium to the soil. But, when the percentage of coir fiber increases beyond the optimum percentage, they starts to accumulate together within the sample. As a result the coir fiber slips each other, which in turn result in the decrease of UCC strength. The variation of UCC strength with different percentage of coir fiber having different aspect ratio is shown in Fig. 5.

The optimum percentage for different aspect ratios of coir fibers is obtained from Fig. 5. The optimum fiber percentage for coir fiber having aspect ratio of 40 is 3%, for l/d = 80 it is 4%. For l/d = 120 the optimum value is 2% and is same for l/d = 160 also.

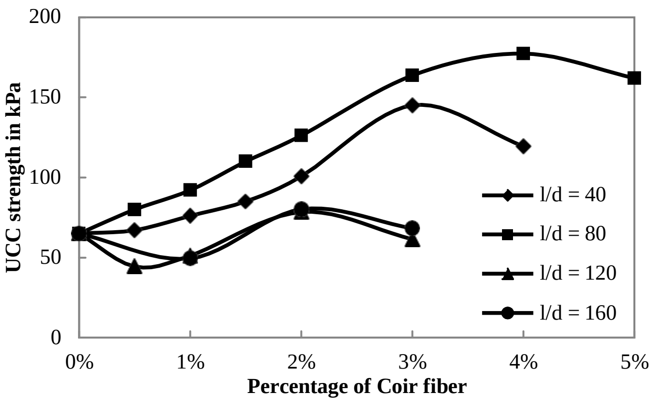

Fig. 4. Variation of UCC strength with percentage of coir fibers having different aspect ratios

CONCLUSIONS

The investigation is conducted to assess the effective percentage of fly ash and coir fiber which are used to stabilize the soil. The following conclusions can be drawn from the investigation.

1. Inclusion of fly ash decreases the maximum dry density values of the soil.
2. Increase in fly ash content results a hike in Optimum moisture content.
3. The optimum value of fly ash mix was found to be approximately 15%. The variation of unconfined compressive strength (UCS) with percentage of fly ash mix reveals that UCS increases up to 15% of fly ash mix by 53% and then it decreases for sample without curing.
4. Coir fiber increases the UCS value in soils. The present study suggests that 4% of coir fiber with l/d = 80 and 3% of coir fiber with l/d = 40, appeared to be optimum. The improvement in UCS is 170% and 120% with respect to soil sample having 15% fly ash. There is no improvement in strength for 3cm and 4cm length coir fibers.
5. The curing time has improved the strength in UCS. After 24hrs, 7 days, 14 days there is an improvement in UCS by 20%, 31% and 26% respectively.
6. It seems to be one of many acceptable answers for handling the fly ash waste problem. Utilization of fly ash in this way will have a positive influence on the environment and the economy since large amounts can be consumed in the soil improvement applications.

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