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Strength behaviour of soil stabilized with fly ASH and sugarcane bagasse ASH

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Abstract

Enhancement of load carrying capacity and shear strength of soil has been improved by soil stabilization. The largely used soil stabilizing agent is fly ash, the waste from coal-fired power plant, which is produced over 100 trillion each year creating thoughtful dumping as well as ecological complications in India. Sugarcane bagasse ash is a fibrous residue of sugarcane stalk that remains after extraction of sugar, when incinerated gives the ash. The present investigation made to weigh up the efficiency of silty sands blended with sugarcane bagasse ash and fly ash for soil stabilization. CBR and Standard Proctor Test are carried out on samples primed from fly ash admixed soil modified through sugarcane bagasse ash. Samples prepared by means of 2% sugarcane bagasse ash content with fly ash content varying from 0% - 20% along with an increase of 5% by the dry mass of soil. In addition to fly ash the specific gravity and MDD are decreased with increased in OMC.CBR value of unsoaked and soaked sample was maximum with increase of 86% and 55% respectively at 5% FA + 2% SBA.It is noticed in these tests that stabilization of soil using sugarcane bagasse ash along with fly ash improves the strength as well as effective to reduce the negative impact of agricultural plant and coal-fired power plant waste by product on environment.

Keywords: Fly Ash, Sugarcane Bagasse Ash, California Bearing Ratio, Standard Proctor Test.

Introduction

Importance of ground improvement techniques is increasing now a day. At some construction sites, the soil properties may not meet to the necessitate provision; hence it is required to improve the characteristics of soil. Thus in broad sense stabilization is a method employed for modifying the properties of soil to enhance its engineering performance. Soil stabilization may be grouped under two main types i.e. i. modification of soil without adding any stabilizing agent and ii. improving the properties by means of admixtures. Compaction and drainage are categorized under major category, which improves inherent shear strength of soil whereas mechanical stabilization, stabilization with binders such as lime, Cement, fly ash comes under the second type of stabilization. Modern researchers are emphasized more on the effective use of locally available materials from industries and agricultural wastes to enhance the properties of soil for engineering use by minimizing the cost of construction[1].

India, as a developing nation requires more energy to cop up with demand which is produced largely by coal fired power plants. Due to this per year around 150 million of fly ash is generated, from the gases of furnace fired with coal as non-plastic silt causing serious disposal and environmental problem[2]. Fly ash as additive have great influence as it is a industrial by product, thus inexpensive to cement or lime and increases the strength of soil as pointed out by Bose[3]. Fly ash admixed with organic soil and its outcome was the dry density of admixed soil reduced to 15% to 20% due to low specific gravity of fly ash given by Prabhakar[4]. The mixed class-C fly ash and it was distinguished that fly ash stabilization increases unconfined compressive strength[5]. Class-C fly ash mixed soil altered the compaction, physical characteristics of granular as well as cohesive soil[6]. Fly ash also gave greater resilient moduli when mixed with soil at optimum water content. In case of soft organic soils use of class-c fly ash was more relevant than the other binding material like cement or lime, which would be more economical and environment friendly which was investigated by Edil et al[7].

In sugar industry sugar cane straw is produced as major by product during manufacturing of sugar. Bagasse ash is an agricultural by product of sugarcane bagasse incineration to generate electricity and its improper deposit poses a serious environmental problem. The strength and stiffness of soft soil improved by adding this wastes with fibers together with chemical agent[8,9]. The disposal of this by product causing serious environmental problem around sugar factories. To make sugarcane bagasse ash as a useful material several researches are conducted. Sugarcane bagasse ash contains silicon oxide at high percentage with pozzolanic behavior showed by Barasaet al[10]. As pozzolanic material sugarcane bagasse ash also contains oxides of aluminum, silica and calcium sited[11]. In current time, the stabilization of natural soil with sugarcane bagasse ash is an effective means of chemical stabilization was a utmost findings of Mir et al[12]. The benefit from applying baggage ash for soil stabilizations with lime is related to chemical reaction between calcium hydroxide produced by lime with pozzolona that is supplied from bagasse ash, similar to cement reaction with soil was an important findings of Nguyen et al[13].

The objective of this experiment is to utilize the sugarcane bagasse ash and fly ash to enhance the strength of soil, while avoiding the adverse health and environmental problems that can be induced due to the disposal of this material.

Materials and methods

Soil: Soil was collected from the Sadeipalli embankment area near Hirakud dam. The soil was classified as silty sand (SM). The particle size distribution curve of this soil determined based on ASTM C136 and sieved through 4.75mm sieve is shown in Figure-1. Geotechnical properties of soil was calculated before oven drying the soil at temperature of 105 to 110 degree. The properties of the silty sand are summarized in Table-1.

Table-1: Index Properties of Soil.

Properties	Soil
Type of soil	SM
Coefficient of uniformity	3.23
Coefficient of curvature	0.886
Specific gravity	2.321
Liquid limit	33.5%
Plastic limit	28.169%
Plasticity index	5.331
MDD	2.04(gm./cm^3)
OMC	15.36%
CBR(soaked)	2.980%
CBR (unsoaked)	3.660%

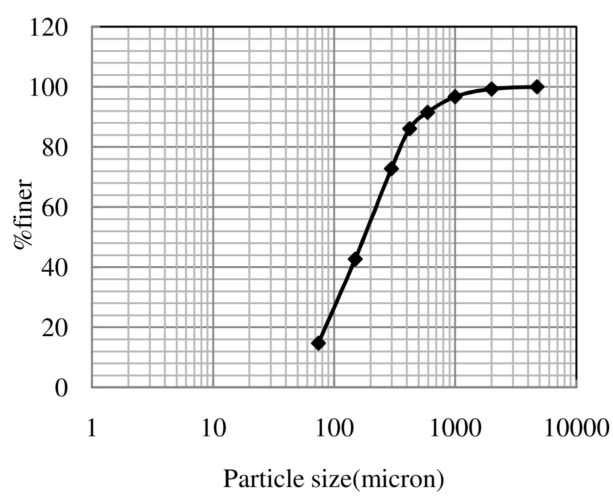

Figure-1: Particle size distribution curve of soil.

Fly Ash (FA): Fly ash was collected from the Hindalco power plant, which is a class-c fly ash. The soil was classified as uniformly graded. The particle size distribution curve of this soil determined based on ASTM C136 and sieved through 4.75mm sieve is shown in Figure-2. Geotechnical properties i.e. specific gravity, limit of soil was calculated before that fly ash was oven dried at temperature of 105 to 110 degree. The geotechnical and chemical properties of the fly ash are summarized below (Table-2).

Table-2: Geotechnical and Chemical Properties of Fly ash.

Properties	Value
Type	Class C
Specific Gravity	2.08
Coefficient of uniformity	3.14
Coefficient of curvature	2.344
Liquid limit & Plastic limit	Non plastic
Silica	60.85%
Alumina	29.14%
Iron Oxide	3.01%
Titanium Oxide	0.68%
Lime	1.88%
Magnesia	0.35%
Potash	0.53%
Soda	0.48%
Sulphate	0.07%
Phosphate	0.68%
Loss on ignition	2.05%

Sugarcane Bagasse Ash (SBA): The sugarcane bagasse ash was collected from nearby sugar mill. The physical properties of bagasse ash depend on size of particles. The particle size distribution curve of sugarcane bagasse ash determined based on ASTM C136 and sieved through 425 μm sieve. Sugarcane bagasse ash was oven dried at temperature of 105 to 110 degree before each experiment. Sugarcane bagasse ash classified as non-plastic material and the specific gravity of SBA found to be 1.315.

Mix Design and Testing Plan: Preparation of samples: The experimental program is conducted in two phase i.e. i. The geotechnical characteristics of Soil sample was studied by conducting Sieve analysis, Plastic Limit and Liquid limit determination. Specific gravity of Soil, FA and SBA was determined. Sieve analysis of FA also done. ii. Soil mixed with FA and SBA samples Engineering properties are determined and compared with soil. Soil and four samples of Soil with varying percentage of fly ash (FA) i.e. from 5% to 20% with increment of 5% admixed to 2 percentage of sugarcane bagasse ash (SBA) content by the dry mass of soil. These fly ash and sugarcane bagasse ash contents were chosen considering the significant effect of fly ash and moderate effect of sugarcane bagasse ash as stabilizing agent on soft soils as concluded by the previous research works.

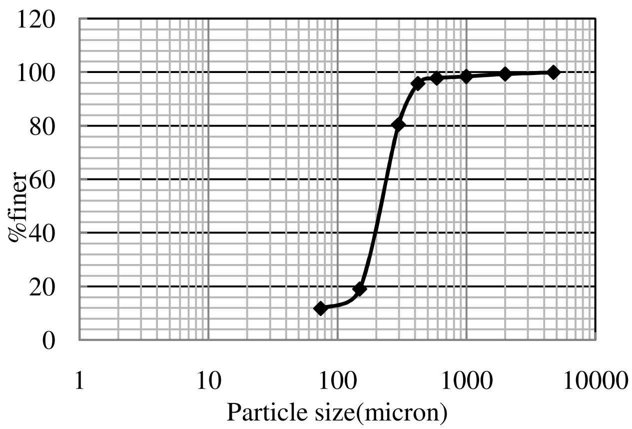

Figure-2: Particle size distribution curve of fly ash.

Compaction Test: To study the compaction characteristics laboratory compaction tests have been carried out on untreated and treated soils as per IS: 2720(part VII) 1965 which recommends mould with a 100mm internal diameter and 127.5mm effective height, whose internal volume is 1000ml.The rammer has mass of 2.6kg with a drop of 310mm.Dry density is plotted against water content to obtain compaction curve from which optimum moisture content and corresponding maximum dry density was determined.

California Bearing Ratio test: As per IS: 2720(Part-XVI)-1987California Bearing ratio test was carried out on untreated and treated soil. Total ten numbers of samples were prepared at individual optimum water content of five number of primary samples. Individual two numbers of sets of treated and untreated soil samples were tested for unsoaked condition and four days of soaking condition.

Results and discussion

Effect on natural properties of soil: The geotechnical properties of soil are summarized in Table-1. The soil at natural state has liquid limit 33.5%, plastic limit 28.169% and plasticity index 5.331. From these parameters, the soil is considered as silty sand (SM) with low plasticity according to ASTM C136. Aggregate weight of treated soil samples were decreased after adding fly ash in an incremental order from 5% to 20% because the particles are hollow and low weight. Thus specific gravity decreased as shown in Figure-3.

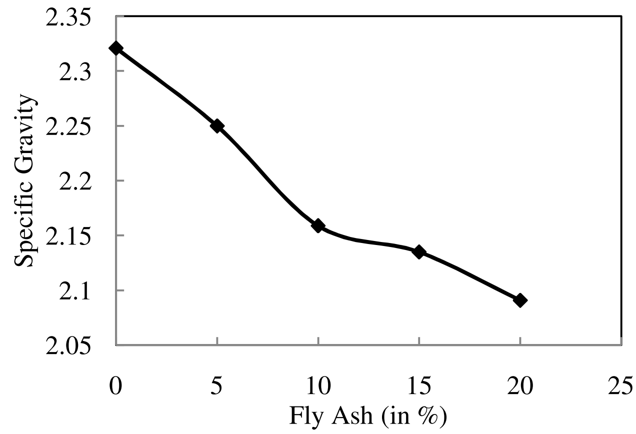

Figure-3: Effect of varying percentage of FA on Specific Gravity of soil.

Compaction Behavior: The Optimum Moisture Content and maximum Dry Density of soil found to be 15.50% and 2.04 respectively. With inclusion of fly ash it is observed that the optimum moisture content increased to 26.62% where as maximum dry density decreased to 1.798 gm/cc. The compaction curve is given from Figure 4-6.

Due to porous property of sugarcane bagasse ash, the soil structure absorbed more water resulted increasing optimum water content. The other cause of omc increase will be cation exchange process between fly ash and soil for which soil voids absorbed more water during compaction. The decrease of the maximum dry unit weight and abrupt change in MDD with the increase of the percentage of fly ash is mainly due to the lower specific gravity of the fly ash and sugarcane bagasse ash compared with soil.

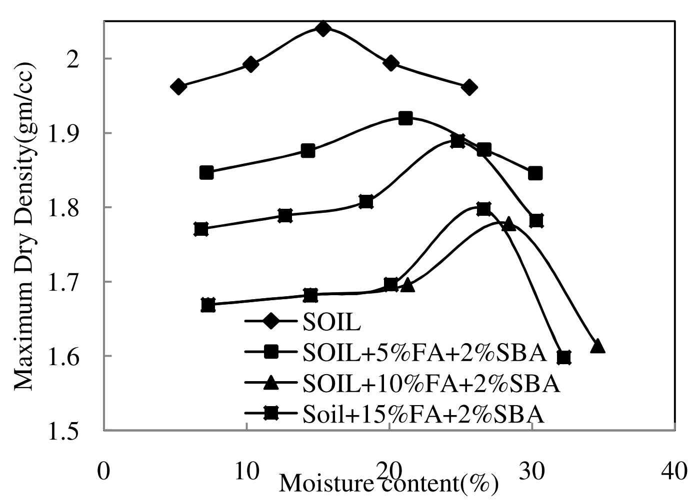

Figure-4: Compaction curve of untreated soil and treated soil with FA and SBA.

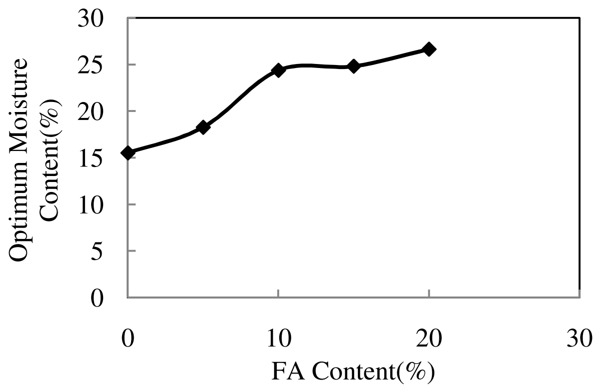

Figure-5: Variation of OMC at varying content of FA.

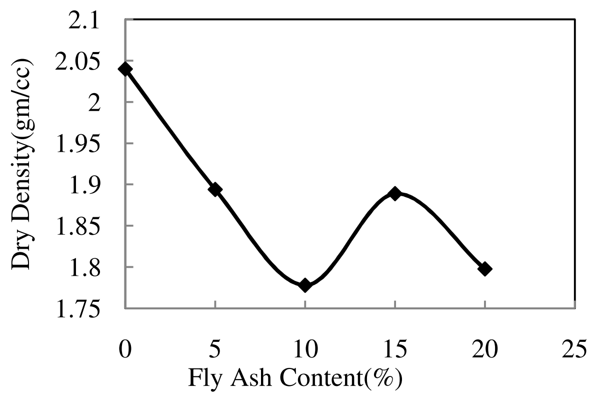

Figure-6: Variation of MDD at varying content of FA.

Calfornia Bearing Ratio: The CBR value gives a rough idea about the shear strength and bearing capacity of soil. The unsoaked and soaked CBR value increased at addition of 5 percentage fly ash plus 2 percentage of sugarcane bagasse ash. The results of soaked and unsoaked CBR test from Table-3 and Figure-7, 8 were indicated that the CBR value was increased by 86% for unsoaked CBR where as 55% increase in soaked CBR for 5% addition of fly ash with soil due to some chemical reaction, then the value was decreased by 55% in unsoaked CBR and 45% decreased in soaked CBR for addition of 10% fly ash with soil. As percentage increase of fly ash keeping percentage of sugarcane bagasse ash constant decreases MDD. This may also be due to grain size effect, specific gravity of both material etc. The increase in CBR value could be attributed to the progressive cementation of soil-fly ash-sugarcane bagasse ash as a result of hydration and the pozzolanic reaction.

Table-3: CBR value of untreated soil and treated soil with FA - SBA.

FA-SBA %	Unsoaked CBR value (%)	soaked CBR value (%)
Untreated Soil	3.460	2.978
Soil+5% Fly ash+ 2% SBA	6.423	4.631
Soil+10% Fly ash + 2% SBA	2.686	2.523

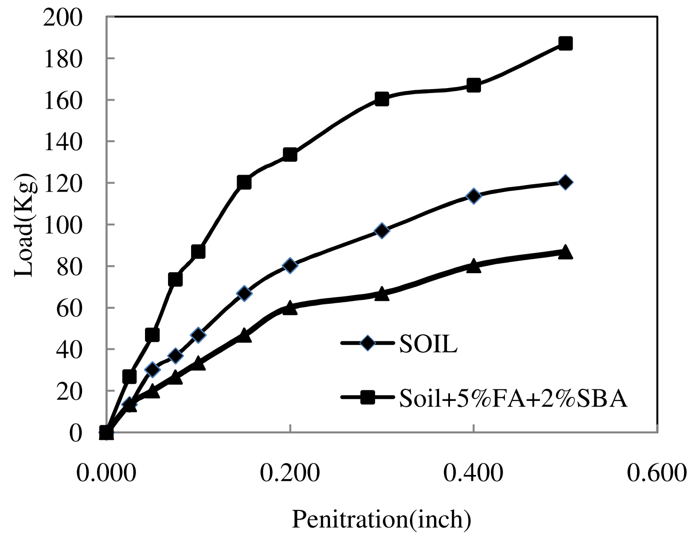

Figure-7: Unsoaked CBR of untreated soil and treated soil with FA-SBA.

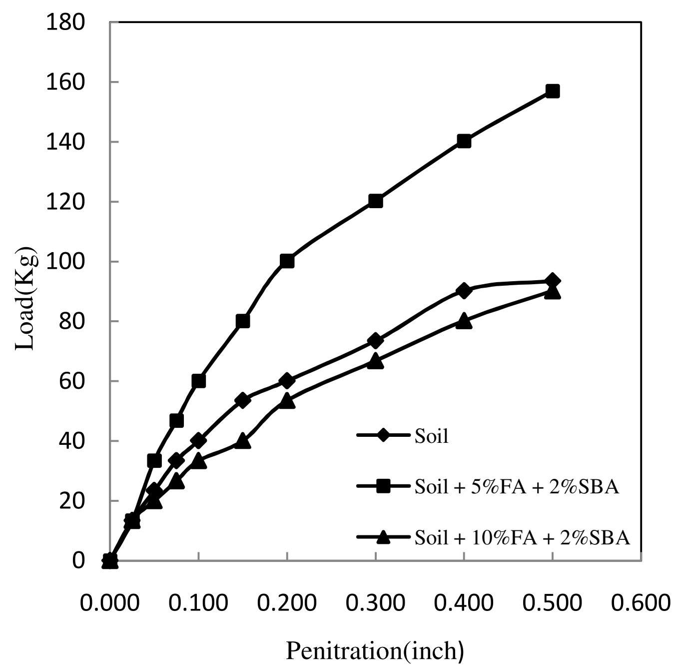

Figure-8: Soaked CBR of untreated soil and treated soil with FA-SBA.

Conclusion

The soil was characterized as silty sand with low plasticity in accordance with ASTM C136. The fly ash was found to be uniformly graded, keeping the quantity of sugarcane bagasse ash constant, on increasing the fly ash content, the specific gravity decreased.

On increasing the fly ash content maintaining the quantity of sugarcane bagasse ash constant, the optimum moisture content increased and the maximum dry density decreased. The additions of these admixtures are akin to increased compactive effort. Hence soil is rendered more stable.

CBR value of unsoaked and soaked sample was maximum with increase of 86% and 55% respectively at 5% FA addition to 2% SBA. However the CBR result indicates that fly ash and sugarcane bagasse ash had the ability to protect the treated soil from adverse effect by increased strength value.

Recycling/utilization of fly ash and sugare cane bagasse ash has the advantage of using industrial waste by-products without harmfully affecting the environment or probable land use with in addition fly ash and sugarcane bagasse ash proved to be effective admixtures for enhancing the engineering behaviour considerably.

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