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A Review: Stabilization of Black Cotton Soil using Flyash

Divya Sen[1], Nupoor Dewangan[2]
[1]Department of Civil Engineering, SSTC, SSGI Bhilai
[1]M.Tech Scholar, Department of Civil Engineering, SSTC, SSGI Bhilai
[2]Assistant professor Department of Civil Engineering, SSTC, SSGI Bhilai

Abstract*: Soil stabilization is very critical for the construction of structures which is widely used in the alignment with pavement design because it improves the engineering and index properties of soil such as strength, volume stability and durability. In the present investigation is to determine the use of fly ash to stabilize the black cotton soil and to check the stability of the soil. In the study concludes that with percentage addition of fly ash improves the strength of stabilized black cotton soil due to the pozzolanic properties of the soil and exhibit relatively well-defined moisture-density relationship.
Keywords: Black Cotton Soil, Fly Ash, OMC, Atterberg Limits, California Bearing Ratio.

I. INTRODUCTION

In developing country like India, due to industrial development there is an surge in a demand for energy which has resulted in construction of considerable development in power plants. This development brought with the problem of safe disposal or beneficial utilization of large quantities of by-product like fly ash every year and there is a need for management of fly ash disposal and utilization. Fly ash is utilized in construction industry. But, the rate of production is greater than consumption. The unused fly ash is disposed into ponds, lagoons, landfills and slag heaps. Coals contains significant quantities of various trace elements, and during combustion of coal as a result of carbon loss as carbon-di-oxide and the trace elements are associated with the surface of the fly ash particles due to evaporation and condensation.

The disposal of fly ash is considered a potential source of contamination due to enrichment and surface association of trace sediments in the ash particles. The toxic elements can contaminate ground water and surface water therefore, effective water management plans are required for fly ash disposal.Two major classes of fly ash are Class C and Class F. These two classes are related to the type of coal burned. Class F fly ash is normally produced by burning anthracite or bituminous coal while Class C fly ash is generally obtained by burning sub bituminous or lignite coal. Therefore, essentially all Class F fly ashes presently available are derived from bituminous coal.

Class F fly ashes with calcium oxide (CaO) content less than 6%, designated as low calcium ashes, are not self-hardening but generally exhibit pozzolanic properties. These ashes contain more than 2% unburned carbon determined by loss on ignition test. In the presence of water, the fly ash particles produced from a bituminous coal react with lime or calcium hydroxide to form cementing compounds similar to those generated on the hydration of Portland cement. Class C fly ashes, containing usually more than 15% CaO and also called high calcium ashes, became available for use in concrete industry only in the last 20 years in the 1970s. Class C fly ashes are not only pozzolanic in nature.

The specific gravity of fly ash is reported to be related to shape, color as well as chemical composition of fly ash particle. It is adopted as an indirect performance parameter for determining the performance of fly ash in soil mixtures. In ASTM C618, for quality control of fly ash, the uniformity of the fly ash is monitored by limiting the variability of the specific gravity and fineness as measured by the amount retained on 45 µm mesh sieve. In general specific gravity of fly ash may vary from 1.3 to 4.8 whereas those of the American ashes have specific gravity between 2.14 and 2.69.

Coal particles with some mineral impurities have specific gravity between 1.3 and 1.6 as the amount of quartz and mullite increases, the specific gravity decreases. The particle density of fly ash is typically 1.5 - 2.5 mg/m3 the lower density associated with a high loss of ignition. There is some variability in the density of particles, with smaller ones having higher densities. This is due to air voids within many of the particles, and between 1% and 5% contains sufficiently large voids that they float on water. The variation in particle density means that sedimentation techniques for determining the particle size distribution are not suitable and more appropriate methods are now used.

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II. LITERATURE REVIEW

Mirsa (1998) in this experiment he used class C fly ash for the stabilization of clay Physical and chemical properties of fly ash and compaction and strength behavior of soils stabilized with Class C fly ash were discussed. Examples were prepared by blending a small proportion of bentonite with kaolinite. Furthermore, fly ash had a rapid hydration characteristic. So, higher densities and strengths were achieved when the compaction is performed with little or no delay. However, delayed compaction produces low densities and strength. It was observed that the stabilization characteristics are related to the soil mineral type and plasticity. The laboratory test showed the use of Class C fly ash for soil stabilization depends on the ash contents, water content, strength developed with time and curing. Concluded that the class C fly ash can be used as a soil improvement.

Cokca (2001) in this study high-calcium and low-calcium class C fly ashes used for stabilization of an expansive soil. Lime, cement and class C fly ash were added to the expansive soil in various percentages. The specimens were tested for grain size distribution, Atterberg limits, and free swell tests and specimens were cured and they were subjected to oedometer free swell tests. Concluded that the expansive soil can be successfully stabilized by class C fly ash. Also, the plasticity index and swelling potential of the samples declined with growing percentage of additive and curing time.

Kumar and Sharma (2004) in this study effectiveness of fly ash in cultivating the engineering properties of expansive soils has shown. In experiments it was shown that the effect of the fly ash on swell index, swelling pressure, plasticity index, compaction, shear strength, and hydraulic conductivity. The results concluded that the plasticity index, hydraulic conductivity and swelling properties of the mix reduced and the dry unit weight and shear strength augmented with an rise in fly ash content. The resistance to penetration of the mixtures increased significantly with an increase in fly ash content for a certain water content.

Nalbantoglu (2004) in this study Cation Exchange Capacity values are used to show the changes in the mineralogy of the fly ash and soils mixtures and explained the reduction in the plasticity and water absorption capacity. CEC values were used to determine the effect of the pozzolanic reaction on the particle size and the swell property of the treated soils. The results of the experiments showed that fly ash is effective in improving the properties of the fly ash and soil mixture by dropping the content of clay size particles, plasticity index and the swelling properties. Concluded that the reduced CEC values directed that fly ash addition changes in the mineralogy of the soils and produced the new minerals. Due to these reactions caused the soils to become more granular and reduced water absorption capacity.

Prabakar et al. (2004) studied the behaviour of soils mixed with fly ash to improve the bearing capacity of the soil. In this study different type of soil and different percentage of fly ash were used and also calculated the cost of fly ash for soil enhancement and also tested soil for the compaction, settlement, CBR, shear strength parameters and swelling characteristics. Concluded that addition of fly ash, condensed the dry density of the soil and unit weight of the soil. The void ratios and porosity changed with increasing percentage content of fly ash in soils. The shear strength capacity of the soil was improved due to the addition of fly ash. The value of cohesion increased by the addition of fly ash. CBR value of soil also enhanced by the addition of fly ash. The outcomes showed that the shear strength and the angle of internal friction of soil admixed with fly ash caused a better strength. The fly ash improved the shear strength, cohesion and bearing capacity. So, this combination can be used as the base materials for the roads, back filling and etc.

Kate (2005) in this study fly ash was used with or without lime for the stabilization of the expansive soil and to increase strength and volume stability of the soil. Laboratory tests were performed, free swell index, swelling pressure and unconfined compressive strength tests had been conducted on expansive soils with mixing bentonite with kaolin clay in different amounts. The outcomes of the experiments showed that the swelling characteristics such as free swell index, maximum swell and swelling pressure reduced with increase in percentage of fly ash. These values are lessened considerably by addition of minor percentage of lime to fly ash. Insignificant changes in Unconfined Compressive Strength values had been observed with increase in percentage of fly ash. These soils that stabilized with fly ash alone did not show noticeable change in immediate strength. However, curing caused a amazing increase in their strengths. As a final result, the soils with low expansion can be stabilized with suitable percentage of fly ash alone. However, for medium to high expansion should be used from slight percentage of lime and fly ash.

Misra et al. (2005) in this study the laboratory tests for stabilization of clayey soils blended with self-cementing class C fly ash and self-cementation of ponded class C fly ash. Performed the uniaxial compressive strength and swelling test. Twelve set of mixtures of clayey soils with the different percentages of kaolinite and montmorillonite, self-cementing fly ash and suitable amount of water were added and cured. For swelling test, the cured samples were flooded and with use of the 1-D oedometer apparatus. Also, UCS and CBR tests were conducted. The outcomes showed that the optimum moisture content deviations due to the addition of fly ash. The samples swiftly gained compressive strength and stiffness within 7 days curing period, and the greatest increase occurred in one day due to the rapid hydration reaction of fly ash. With increasing in montmorillonite content, strength of the samples increased knowingly. By increasing in fly ash content, swelling of stabilized clay condensed. CBR values showed that the ponded class C fly ash can be a good auxiliary as a base course material.

Parsons and Kneebone (2005) enumerated the level of enhancement provided by Class C fly ash and resolute of the mixture weakening with fly ash during the time. A sequence of dynamic cone penetrometer standards were obtained for treated or untreated with fly ash. Pavements aged from zero to nine years. Laboratory tests also presented that fly ash contributed to soil strength and stiffness while plasticity and swell potential were reduced. Use of fly ash alone for stabilization may not be sufficient to improve soil properties to desired levels. In addition, an improved subgrade assisted to the strength of the pavement, and may provide reductions in costs and the thickness of the asphalt section.

Amu et al. (2005) in this study the stabilization of an expansive clay soil is done with the addition of cement and fly ash. The samples were divided to three groups; cement optimal mix, cement plus fly ash optimal mix and unstabilized sample. The three different classes of sample were subjected to MDD, OMC, CBR, Unconfined Compression and Undrained Triaxial test. The results exhibited that the soil sample stabilized with a mixture of cement and fly ash had better performance with consideration to maximum dry densities, optimum moisture content, bearing capacity and shearing resistance tests.

Edil et al. (2006) in this study the effectiveness of self-cementing fly ashes for stabilization of soft fine-grained soils. California bearing ratio and resilient modulus tests were performed on the mixes. Fine grained soils such as inorganic soils, organic soil and fly ashes were used. Two of the fly ashes were high quality Class C ashes. Tests were performed on soils and soil–fly ash mixtures prepared at OMC and other wet of optimum water content. The results exhibited that addition of fly ash significantly, increased the CBR of the inorganic soils. CBR of soil–fly ash mixtures generally improved with fly ash content and reduced with increased compaction water content. Fly ash should be stiffen over time to increase the resistance of the pavement. Organic soil had very less CBR and $MMrr$ values from inorganic soils.

Senol et al. (2006) studied about self-cementing fly ashes without any activators for the stabilization of four types of subgrades. The samples were prepared by mixing fly ash at different percentages at changeable water contents. The laboratory tests such as index properties, compaction, unconfined compressive strength and CBR tests were used. To develop water content–strength relationship, samples were subjected to UCS and CBR tests after seven days curing time. To evaluate the impact of compaction, the samples were compacted two hours far along after mixing with water. The results exhibited that the fly ash increased both the unconfined compressive strength, and the CBR values and can replace with soft subgrade of highways. So, stabilizing the soft subgrade at specified water contents and minimizing compaction delay could maximize the strength of mixtures.

Sezer et al. (2006) presented an investigation into the stabilization of a soft clay subgrade with a very high lime fly ash. The objective of this paper was to use very high lime fly ash in soil stabilization without using any other activator and to investigate some strength characteristics of fly-ash–clay mixtures. Different percentages of the soil was replaced with fly ash. In addition, for different stabilized soil samples with fly ash at optimum water contents, standard proctor test was conducted. The tests lasted for 3 months and the unconfined compressive strength and shear strength parameters, cohesion and internal friction angle, were determined. It was found that, inclusion of fly ash improved the properties of the soil. The maximum dry density decreased and optimum moisture content increased with increasing fly-ash content. In addition, the fly ash increased the unconfined compressive strength and cohesion of the soil.

Phani Kumar and Sharma (2007) studied the effect of fly ash on the volume change of a highly plastic expansive clay and a nonexpansive clay with low plasticity. The effect of fly ash on free swell index, swell potential, and swelling pressure of expansive clays were evaluated. Moreover, Compression index and secondary consolidation characteristics of both clays were also determined. The results showed that Swell potential and swelling pressure, when determined at constant dry unit weight of the mixture, decreased and when determined at constant weight of clay, increased. Compression index and coefficient of secondary consolidation of both the clays decreased by addition fly ash. So, the settlement of structures built on these stabilized clays decreased and consolidation happened in shorter time. Furthermore, maximum dry unit weight increased and optimum moisture content decreased with increasing fly ash content.

Vizcarra et al. (2014) presented the characteristics of municipal solid waste (MSW) incineration ash and evaluates this ash in road pavement layers through the mixture of ash with a clay soil. Chemical, physical, and mechanical tests and the mechanistic-empirical design for a pavement structure were carried out on the pure soil and also in the soil mixture with the addition of different ash content. The results showed that fly ash reduced the expansion of the material, showing an increase in the California bearing ratio (CBR) and resilient modulus value. Furthermore, content and type of ash was important in final results and it showed the efficacy of MSW fly ash for its use in base road pavement layers.

Athanasopoulou (2014) evaluated the improvement in engineering properties of clayey subgrade that was stabilized with lime or fly ash. In this regard, California bearing ratio (CBR) tests were used to evaluate the bearing strength of stabilized soils. The results showed that admixture of lime or fly ash caused an increase in the plasticity limit, while the liquid limit and the plasticity index of the soils have been reduced. However, further increases in the California bearing ratio value obtained when the soil samples were mixed with lime. Also, the swelling reduced with the addition of both additive materials. The increase in optimum moisture content increased CBR value, particularly at high lime or fly ash percentages. Furthermore, the maximum dry density reduced with addition of lime and fly ash.

III.CONCLUSION

The generation of fly ash is more than its utilization. It can be used as an alternative material instead of conventional materials in the construction of geotechnical and infrastructures. If desired results are found in future studies on fly ash in soil stabilization, we could see large reductions in material costs. On the other hands, fly ash is a good material for use in geotechnical applications. The low unit weight of fly ash makes it acceptable for placement in soft soils. Addition of fly ash altered the physical and compaction characteristics of both granular and cohesive soils. Fly ash can create an adequate array of cations than under ionized conditions it can improve flocculation of dispersed clay particles. According to a cation exchange process, the influence of fly ash on expansive soils causes significant reduction of plasticity index, activity, and swell potential. In addition, pozzolanic reaction of it results in formation of cemented combinations with high shear strength and low volume change. The combination of soil and fly ash improves liquid limit, plastic limit, and CBR values to acceptable limits. Fly ash increases strength and decreases shrinkage strains of expansive soils. It can be concluded that fly ash treatment method can be used to stabilize expansive soils.

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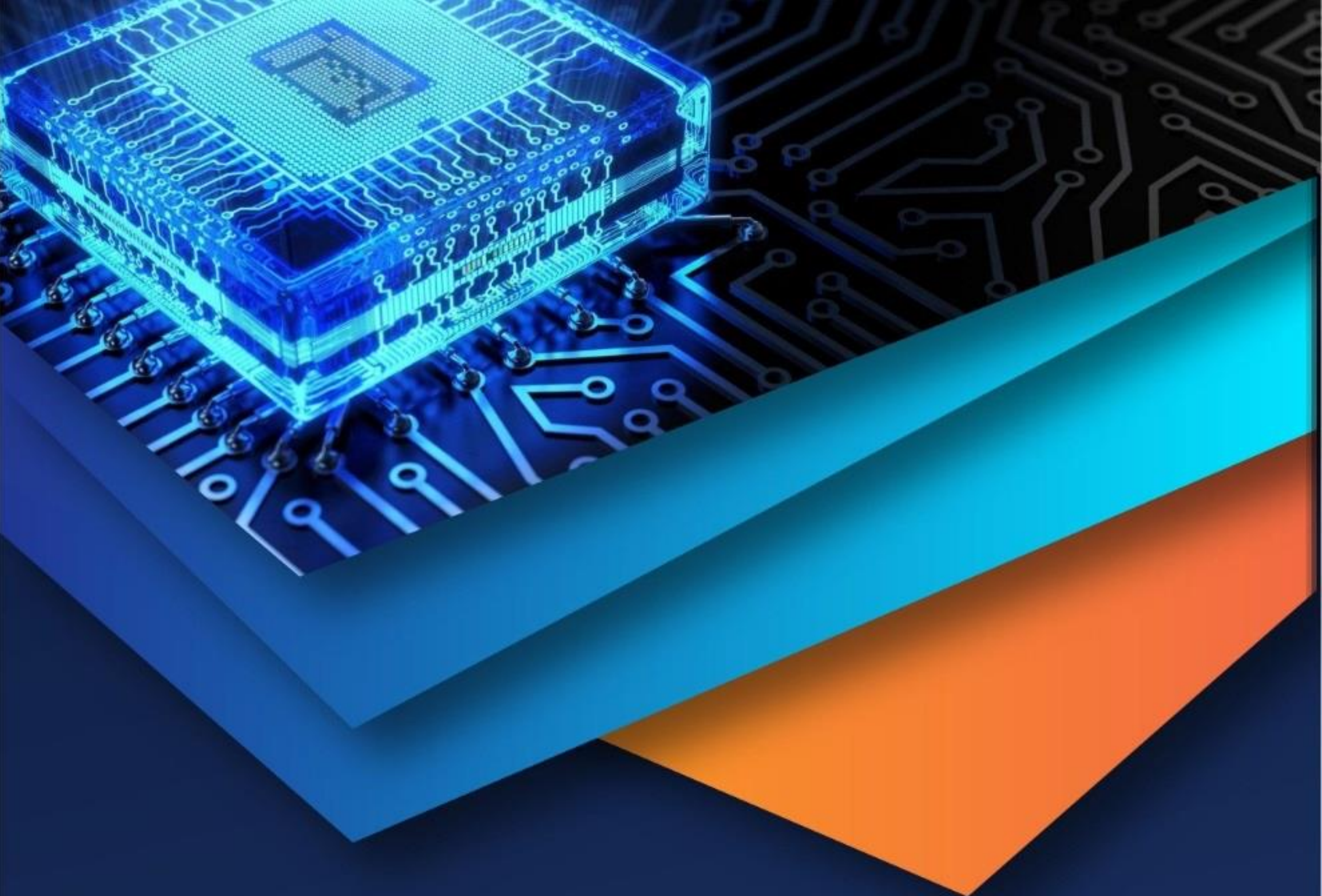

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