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A Study on Stabilization of Expansive Soil using Alkali activated Flyash

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ABSTRACT:*The objective ofthis bestudy was to evaluate the result of Fly Ashderived from combustion of sub-bituminous coal atelectrical power plants in the stabilization of soft pleasant-grained purple soils. California bearing ratio (CBR) andother force property checks were conducted on the soil.The soil is in the range of plasticity, with plasticityindices ranging between 25 and 30. The Checks had beenconducted on soils and soil–Fly Ash mixturesall set at a greater water content material of 9%.Additionof Fly Ash resulted in considerable increases within theCBR of the soil. For water contents, 9% wet ofsuperior, CBRs of the soils are located in variouspercentages such that 3,5,6and 9.We will locatemost fulfilling CBR value of the soil is 6%.Increment ofCBR value is used to shrink the thickness of thepavement. And increasing the bearing ability of the soil.From the investigation theproperties of expansive are improved to increase innumber of days of curing with fly ash.*

KEYWORDS-Expansive soils, California bearing ratio,peculiar material

I. INTRODUCTION

Expansive soils also known as swelling soilsor shrink-swell soils are the terms applied tothose soils, which have a tendency to swelland shrink with the variation in moisturecontent. As a result of which significantdistress in the soil occurs, causing severedamage to the overlying structure. Duringmonsoon‟s, these soils imbibe water, swell,become soft and their capacity to bear wateris reduced, while in drier seasons, these soilsshrinks and become harder due toevaporation of water. These types of soilsare generally found in arid and semiaridregions of the world and are considered as apotential natural hazard, which, if not treatedwell can cause extensive damages to notonly to the structures built upon them butalso can cause loss of human life. Soilscontaining the clay mineralsmontomorillonite generally exhibit theseproperties. The annual cost of damage to thecivil engineering structures caused by thesesoils are estimated to be ₤ 150 million in theU.K., $ 1,000 million in the U.S. and manybillions of dollars worldwide.

II. RELATED WORKS

Stabilization is one of the methods of treating the expansive soils to make them fit forconstruction. Variety of stabilizers may be divided into three groups (Petry 2002): (a)traditional stabilizers (lime, cement etc.), (b) by-product stabilizers (fly ash, quarry dust,phosphor-gypsum, slag etc.) and (c) non-traditional stabilizers (sulfonated oils, potassiumcompounds, polymer, enzymes, ammonium chlorides etc.).Stabilization ofexpansive soil is one way of utilization of these byproducts. Some of the research workconducted by earlier researchers in the above has been described below.

Stabilization using fly ash:

Sharma et al. (1992) studied stabilization of expansive soil using a mixture of fly ash,gypsum and blast furnace slag. They found that fly ash, gypsum and blast furnace slag in theproportion of 6: 12: 18 decreased the swelling pressure of the soil from 248 kN/m2 to 17kN/m2 and increased the unconfined compressive strength by 300%.

Srivastava et al. (1997) studied the change in micro structure and fabric of expansive soil dueto addition of fly ash and lime sludge from SEM photograph and found changes in microstructure and fabric when 16% fly ash and 16% lime sludge were added to expansive soil.

Srivastava et al. (1999) have also described the results of experiments carried out to study theconsolidation and swelling behavior of expansive soil stabilized with lime sludge and flyash and the best stabilizing effect was obtained with 16% of fly ash and 16% of lime sludge.

Wagh (2006) used fly ash, rock flour and lime separately and also in combination, in differentproportion to stabilize black cotton soil from Nagpur Plateau, India. Addition of either rock-flour orfly ash or both together to black cotton soil, improve the CBR to some extent and angle of shearingresistance increased with reduced cohesion. However, in addition to rock-flour and fly ash whenlime is mixed to black cotton soil CBR value increases considerably with the increase in both cohesionand frictional resistance.

Phani Kumar and Sharma (2007) studied the effect of fly ash on swelling of a highly plasticexpansive clay and compressibility of another non-expansive high plasticity clay. The swellpotential and swelling pressure, when determined by constant dry unit weight of the sample(mixture), decreased by nearly 50% and compression index and coefficient of secondaryconsolidation of both the clays decreased by 40% at 20% fly ash content.

Kumar et al. (2007) studied the effects of polyester fiber inclusions and lime stabilization onthe Geotechnical characteristics of fly ash-expansive soil mixtures. Lime and fly ash wereadded to an expansive soil at ranges of 1–10% and 1–20%, respectively. The samples with the optimum proportion of fly ash and lime content (15% fly ash and 8% lime) based oncompaction, unconfined compression and split tensile strength, were added in 0, 0.5, 1.0,1.5, and 2% plain and crimped polyester fibers by weight. The MDD of soil-fly ash-limemixes decreased with increase in fly ash and lime content. The polyester fibers (0.5–2.0%)had no significant effect on MDD and OMC of fly ash-soil-lime-fiber mixtures. However, theunconfined compressive strength and split tensile strength increased with addition of fibers.

Stabilization using quarry dust:

The quarry dust/ crusher dust obtained during the crushing of stone to obtain aggregates causes a health hazard in the vicinity and many times considered as an aggregate waste.Gupta et al. (2002) made a study on the stabilization of black cotton soil using crusher dust a wasteproduct from Bundelkhand region, India and optimal % of crusher dust(quarry dust) found to be40%. There was a decrease in liquid limit (54.10% to 24.2%), swelling pressure (103.6 kN/m^2 to 9.4kN/m^2) and increases in the shrinkage limit(12.05% to 18.7%), CBR value (1.91 % to 8.06%), UCSvalue (28.1 $kN/m^2$to 30.2 kN/m^2) with 40% replacement of expansive soil with crusher dust.

Stalin et al. (2004) made an investigation regarding control of swelling potential of expansiveclays using quarry dust and marble powder and observed that LL and swelling pressuredecreased with increase in quarry dust or marble powder content.

Gulsah (2004) investigated the swelling potential of synthetically prepared expansive soil(kaolinite and bentonite mixture), using aggregate waste (quarry dust), rock powder and lime.Aggregate waste and rock powder were added to the soil at 0 to 25% by weight with limevarying from 0 to 9% by combined weight. There was a reduction in the swelling potential andthe reduction was increased with increasing percent stabilizers and days of curing.

Jain and Jain (2006) studied the effect of addition of stone dust and nylon fiber to Blackcotton soil and found that mixing of stone dust by 20% with 3% randomly distributed nylonfibers decreased the swelling pressure by about 48%. The ultimate bearing capacity increasedand settlement decreased by inclusion of fiber to stone dust stabilized expansive soil.

Stabilization using rice husk ash:

Rice husks are the shells produced during dehusking operation of paddy, which varies from20% (Mehta 1986) to 23% (Della et al. 2002) by weight of the paddy. The rice husk isconsidered as a waste material and is being generally disposed of by dumping or burning inthe boiler for processing paddy. The burning of rice husk generates about 20% of its weightas ash (Mehta 1986). The silica is the main constituent of rice husk ash (RHA) and the quality(% of amorphous and unburnt carbon) depend upon the burning process (Nair et al. 2006).

The RHA is defined as a pozzolanic material (ASTM C 168 ASTM 1997) due to its highamorphous silica content (Mehta 1986).Rajan and Subramanyam (1982) had studied regarding shear strength and consolidationcharacteristics of expansive soil stabilized with RHA and lime and observed that RHAcontributes to the development of strength as a pozzolanic material when used as a secondaryadditive along with lime and cement. Under soaked conditions, the soil stabilized with ricehusk ash had lower strength. The RHA, lime combination also decreased the compressionindex of stabilized soil.

Bhasin et al. (1988) did a laboratory study on the stabilization of Black cotton soil as apavement material using RHA, bagasse ash, fly ash, lime sludge and black sulphite liquorwith and without lime. The bagasse ash and black sulphite liquor are found to be not effectiveas a stabilizing agent. The addition of lime sludge alone to the black cotton soil improves theCBR values marginally but reduces the UCS values. Lime sludge in combination with limeimproves the strength parameters of black cotton soil sufficiently for its use as a sub-basematerial. The rice-husk ash causes greater improvement than that caused by fly ash andbagasse ash due to the presence of a higher % of reactive silica in the rice-husk ash in comparison to fly ash and bagasse ash. In conjunction to lime both rice husk ash and fly ash improves theproperties of black cotton soil sufficiently meriting its use as a sub-base material.

Muntohar and Hantoro (2000) used rice husk ash and lime for stabilization of expansive soilby blending them together. The RHA used were 7.5%, 10% and 12.5% and lime as 2%, 4%,6%, 8%, 10% and 12% as replacement of expansive soil. Their PI (plasticity index) decreasedfrom 41.25% to 0.96% and swell potential decreased from 19.23% to insignificant with 12-12.5% of RHA-lime mixture. There was also increase in CBR value (3 % to 16%), internalfriction angle (5 0 to 240) and cohesion (54.32 kN/m2 to 157.19 kN/m2), thereby increasedbearing capacity to 4131 kN/m^2 from 391.12 kN/m^2

Chandrasekhar et al. (2001) presented the results of laboratory and field investigationscarried out to understand the characteristics of black cotton soil with stabilizing agents likecalcium chloride and sodium silicate in comparison with conventional RHA-limestabilization. The RHA-lime stabilization resulted in maximum improvement and strengthcompared to all other treatment. Calcium chloride treated road stretch showed maximumreduction in ground, heave compared to lime, sodium silicate and RHA stabilized stretches, butthe maximum reduction in shrinkage is observed in lime treated stretch, when additives are usedindividually. When additives are used in combination, Calcium chloride – sodium silicate treatedstretched showed maximum reduction in heave compared to RHA– lime and calcium chlorideRHA stabilized stretches whereas highest reduction in shrinkage is observed in RHA- limestabilized stretch.

Ramakrishna and Pradeep Kumar (2006) had studied the combined effect of rice husk ash(RHA) and cement on engineering properties of black cotton soil. RHA up to 15% in stepsof 5% and cement up to 12% in steps of 4% were added. RHA and cement reduced theplasticity of the expansive soil. The dry density of soil increased marginally with the increase in the OMC after 4% cement addition. MDD of soil decreased and OMC increased with the increase inthe proportion of RHA- cement mixes. The UCS of Black cotton soil increased linearly withcement content up to 8% and at 12%, strength rate reduced. The soaked CBR of the soil was foundto be increased with cement and RHA addition. Similar trends to that of UCS were observed withthe increase in CBR rate. At 8% cement content, the CBR value of soil was 48.57% and withthe combination of RHA at 5%, 10% and 15%, the values were 54.68%, 60.56% and 56.62%,respectively.

Sharma et al.(2008) had studied the engineering behavior of a remolded expansive clayblended with lime, calcium chloride and Rice-husk ash . The amount of RHA, lime andcalcium chloride were varied from 0 to 16%, 0 to 5% and 0 to 2% respectively by dry weightof soil . The effect of additives on UCS & CBR was found. The stress–strain behavior ofexpansive clay improved upon the addition of up to 5% lime or 1% calcium chloride. Amaximum improvement in failure stress of 225 &

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328% was observed at 4% lime & 1%calcium chloride. A RHA content of 12% was found to be the optimum with regard to bothUCS & CBR in the presence of either lime or calcium chloride. An optimum content of 4% inthe case of lime and 1% in the case of calcium chloride was observed even in clay – RHAmixes.

Stabilization using Copper Slag (CS):

Copper slag is produced as a by product of metallurgical operations in reverberatory furnaces. It istotally inert material and its physical properties are similar to natural sand.

Al-Rawas et al. (2002) made an investigation regarding the effectiveness of using cement bypass dust, copper slag , granulated blast furnace slag, and slag-cement in reducing theswelling potential and plasticity of expansive soils from Al-Khod (a town located inNorthern Oman). The soil was mixed with the stabilizers at 3, 6 and 9 % of the dry weight of the soil. The treated samples were subjected to liquid limit, plastic limit, swell percent and swellpressure tests. The study showed that copper slag caused a significant increase in the swellingpotential of the treated samples. The study further indicated that cation exchange capacity and theamount of sodium and calcium cations are good indicators of the effectiveness of chemicalstabilizers used in soil stabilization.

Saravan et al. (2005) stabilized the expansive soil using 0%, 10%, 20%, 30%, 40%, 50%,60%, 70% and 80% of the dry weight of copper slag. The MDD increased, OMC decreased withincrease in CS content and free swell index decreased by 60% corresponding to soil + 70%CS. However, the soaked CBR improved only after addition of 2% of cement and theexpansive soil found to be suitable as a sub-grade material by utilizing 50% copper slagwaste along with 2% cement.

III. THE APPROACH

In the present investigation, expansive blackcotton soil was procured from a site havingcoordinates as N 21° 12‟ 34.03” and S 79°09‟ 29.09”, Khairi, Kanli road, Nagpur,Maharashtra. The black cotton soil wascollected by the method of disturbed samplingafter removing the top soil at 500 mm depthand transported in sacks to the laboratory.

Fig.1 Photographic image showing the test setup ofUCS

The least amount of the sample was sealed in a polythene bag for determining its naturalmoisture content. The soil was air dried,pulverized and sieved with 4.75 mm Indianas required for laboratory test.

IV. EXPERIMENTAL SETUP

This paper presents the results ofthe stabilization of the expansive black cotton soil,with fly ash.The increase in strength criteria isascertained by conducting unconfinedcompression test on samples, at 3, 7 and 28days curing. The samples, cast were of 50mm diameter and 100 mm height, therebyensuring L/D ratio as 2. These samples contain fly ash in 20, 30 and 40% byweight of dry mass and water to the total solid ratio has varied from 15, 20 and 25%. All thesamples were covered with cling film, after casting and are kept in the air tight containerfor 48 hours. After 48 h, the samples wereremoved from the moulds and wrapped incling film and left at ambient temperatureand humidity conditions (50–60 % RH and32-35º C). Immediately before testing, at theages of 3, 7 and 28 days, the samples weretrimmed to 100 mm long and tested forunconfined compressive strength (UCS) onan Aimil hydraulic testing machine atconstant strain rate of 1.2 mm/min. Everysingle result obtained was the average of 3tested samples.

V. CONCLUSION

Based on the acquired results and conversationthereof succeeding conclusions can be made.Lowering the viscosity of the groutmixtures to similar values to that of cementgrout can have a negative effect on finalstrength, since it demands an increase in theactivator/ash ratio. Consequently, it isrecommended that a compromise is madebetween an optimum viscosity level and thelowest activator/ash ratio possible, wheneverthe viscosity is a key issue for a particularapplication.Alkali-activated fly ash can be usedeffectively as a chemical stabiliser forstabilizing expansive soils.

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Bio-data:

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