STABILIZATION OF SOILS BY FLY ASH

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Abstarct: Fly ash is an important industrial by-product that comes from the combustion of coal, for the production of electrical energy. It is the residual remains after the combustion of coal which is made up of very fine particles. Fly ash mix can be used for stabilizing of soil having poor compressive strength for construction. After it has been added the reactions that take place between fly ash and water gives rise to cementitious products which bonds the soil particles together. From research, it has been found that stabilization with fly ash, improves the natural and mechanical characteristics of soils (plasticity, compressive strength and particle size distribution). In the present paper soil is stabilized with different quantities of fly ash for the creation of good strength bearing soil. This paper presents the results of laboratory experiments of fly-ash soil stabilization. Tests were conducted on soil and fly ash samples form electric power plant. Effects of fly ash on physical and mechanical properties of soil (Atterberg limits, moisture-density relationship, shear strength, CBR) were evaluated. Test mixtures were prepared at optimum water content from standard Proctor compaction test. Results of the project indicate that fly ash can effectively improve some engineering properties of soil.
Key Words: Fly ash, shear strength, CBR

I.INTRODUCTION

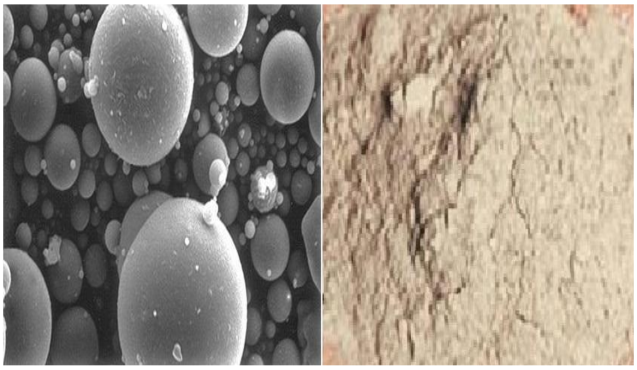
The term ‘Soil’ has different meanings in different scientific fields. It has originated from theLatin word “Solum”. To an agricultural scientist, it means ‘‘the loose material on the earth’scrust consisting of disintegrated rock with an admixture of organic matter, which supportsplant life’’. To a geologist, it means the disintegrated rock material which has not been transportedfrom the place of origin. But, to a civil engineer, the term ‘soil’ means the looseunconsolidated inorganic material on the earth’s crust produced by the disintegration of rocks,overlying hard rock with or without organic matter. Foundations of all structures have to beplaced on or in such soil, which is the primary reason for our interest as civil engineers in its engineering behavior.

II.FLY ASH

Coal fly ash, a burnt residue of pulverized coal is hazardous and its disposal is a problem. The power requirement of the country is rapidly increasing with increase in growth of the industrial sectors. India depends on thermal power as its main source (around 65% of power produced is thermal power); as a result the quantity of ash produced shall also increase. Indian coal on an average has 30% to 40% ash and this is one of the prime factors which shall lead to increased ash production and hence ash utilization problems for the country.

III.COMPOSITION OF FLY ASH

Fly ash is the by-product of coal combustion collected by the mechanical or electrostatic precipitator (ESP) before the flue gases reach the chimneys of thermal power stations in very large volumes. All fly ash contain significant amounts of silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), iron oxide (Fe_2O_3), calcium oxide (CaO), and magnesium oxide (MgO) however, the actual composition varies from plant to plant depending on the coal burned and the type of burner employed. Fly ash also contains trace elements such as mercury, arsenic[24], antimony[25], chromium, selenium[26], lead, cadmium, nickel, and zinc.



IV.SOIL STABILIZATION

Soil stabilization is the alteration of soil properties to improve the engineering performance of soils. Modification of soil properties is intended to enhance subgrade stability and accelerate construction. Typically, the properties altered are density, moisture content, plasticity and strength. Stabilization can increase the shear strength of a soil, thus improving the load bearing capacity of a soil to support pavements and foundations. Soil stabilization a general term for any physical, chemical, biological, or combined method of changing a natural soil to meet an engineering purpose. Improvements include increasing the weight bearing capabilities and performance of in-situ subsoils, sands etc.
“Soil Stabilization or Rammed Earth” has been used for thousands of years as a basic building material. Soil stabilization from the “Ancient Pyramids to the Great Wall of China”, soil has provided structural solutions that were principally based on the binding properties of soils.Throughout Latin America soil stabilization of sorts was achieved with clay-based soil blocks (rammed earth blocks or earthen blocks) were known as the Adobe Block. In our rapidly changing and developing world we have needed to find alternatives for soil stabilization. Unlike Portland cement, soil cement with low tensile strength, asphalt, tree resin, ionic stabilizers, soil with fly ash others,waste materials in order to strengthen.
Types Of Equipment Required For Stabilizing Soils:Equipment may include a distributor truck for

spreading ash, a roto-reclaimer for blending ash into the soil, pad foot roller, a drum roller and a water truck. Equipment for the stabilization processes include: chemical additive spreaders, soil mixers (reclaimers), portable pneumatic storage containers, water trucks, deep lift compactors, motor graders.

V.STABILIZATION OF SOIL USING FLY ASH

Emerging trend of using waste material in soil stabilizing or soil strengthening is being operational all over the world in present days. The main reason behind this trend is the excessive production of waste like fly ash, plastics, rice husk ash which is hazards to the environment. Using some of these waste materials in construction practice will reduce the problem in a great extent.

In India we have different types of soils. Soils with low qualities are a worldwide problem that poses several challenges for civil engineers. Various methods are adapted to improve the engineering characteristics of these soils. The problematic soils are either removed and replaced by good and better quality material or treated using additive. This project deals with the improvement of properties of soils in local areas by adding fly ash in proportions. In this study, soil was stabilized using fly ash (obtained from thermal power plant). Soils were stabilized with various proportion of fly ash i.e. at 0,10,20 25% . Fly ash possess no plasticity. Plasticity index of soil fly ash mixes decreases with increase in fly ash content. Thus addition of fly ash makes soil less plastic and increases its workability by colloidal reaction and changing its grain size. The CBR values of soils are obtained by mixing fly ash to the soil in different proportions. With analysis it is found that the fly ash has a good potential to be used as an additive for improving the engineering properties of soils.

Class C fly ash, with its self-cementing properties,is typically useful for soil stabilization. It is used to stabilize soil for various types of construction. High calcium fly ash (Class C) acts as a good source of calcium hydroxide which "self-activates", reacting with silica and alumina in the fly ash and soil to form a cementitious hydration product. In addition, C_3A in fly ash (Class C) can react with sulfates to gain strength relatively quickly. However,Class F ash with an additional activator (cement,cement kiln dust, lime and lime kiln dust) can beused successfully to modify soil properties, as well as for numerous geotechnical applicationscommonly found on commercialconstruction projects.The self-cementitious behavior of fly ash isdetermined by “Characterizing flyash for use in Soil Stabilization”.

Very self-cementing>3,400 kPa

Moderately self-cementing 700 – 3,400 kPa

Mix Design Considerations:

Prior to stabilization, the cementitious properties of fly ash should be characterized followingASTM D 5239-04[62]. But, it should be noted that ASTM D 5239-04 does not evaluate theinteraction between fly ash and soil or aggregate which must to be verified separately based onmix design procedures.

For self-cementing fly ash, one of the primary design considerations is the rate at which fly ashhydrates upon exposure to water. Hydration reactions can start immediately on exposure to waterand hence the time delay in mixing and compaction of the specimens needs to be accounted forand included in laboratory mix designs. As hydration progresses, soil particles are bonded ina loose state and a portion of the compaction energy used in densification[63] is lost in breakingbonds in the mix. Maximum dry density achieved for a given compaction energy thereforedecreases with increase in compaction delay. In addition, compaction delay can cause asignificant reduction in compressive strength. This is most likely due to the inability to maximizethe impact of cemetitious and/or pozzolanic product development at lower densities. In otherwords, if a soil mass is under-compacted, the cemetitious/pozzolanic product does not have thesame opportunity to develop “bonds” among soil particles (or agglomerates of particles) as theywould if the soil mass were compacted to within a reasonable range of target density. This effectis much more likely to be significant in class C fly ash mixtures due to the faster rate of reaction.An additional design consideration when selecting the optimal fly ash content is to determine theoptimum moisture content at which maximum strength gain is achieved. Optimum moisturecontent for strength gain may typically be 1–8 percent below optimum moisture content neededto attain maximum dry density. This value may vary with soil type and the mineralogy of ashparticles.

Expriments:

- Atterberg Limit Test
- Permeability Test
- Proctor Compaction Test
- Direct shear Test
- CBR Test

VI.RESULTS

Atterberg Limit Test

Sl.no	Soil type	Liquid limit	Plastic limit	Plasticity index
1	Soil alone	24.5	21.39	3.11
2	Soil +10% fly ash	22.5	19.05	3.45
3	Soil+20% fly ash	21.5	18.64	2.86

Optimum moisture contentand Dry density

Sl.no	Soil+ fly ash	Optimum Moisture Content (%)	Max Dry density (g/cc)
1	Soil	12	1.57
2	Soil+10% fly ash	8	1.73
3	Soil+20% fly ash	12	1.66

Shear strength=cohesion+normal stress*tan(angle of shear resisitance)

Shear strength of normal soil

Test	Normal stress (kg/cm$^{2)}$	Shear stress at failure (Kpa)	Shear stress (kg/cm^2)
Direct shear 1	0.5	39.6	0.396
Direct shear 2	1	64.8	0.648
Direct shear 3	1.5	100.7	1.007

Angle of shear resistance =34^O Cohesion =0.1 kg/cm^2

Shear strength of soil+10% fly ash

Test	Normal stress (kg/cm^2)	Shear stress at failure (Kpa)	Shear stress (kg/cm^2)
Direct shear 1	0.5	80.5	0.805
Direct shear 2	1	115.2	1.15
Direct shear 3	1.5	155.6	1.556

Angle of shear resistance =42^{O}Cohesion =0.45 kg/cm^2

Shear strength of soil+20% fly ash

Test	Normal stress (kg/cm^2)	Shear stress at failure (Kpa)	Shear stress (kg/cm^2)
Direct shear 1	0.5	112	1.12
Direct shear 2	1	165	1.65
Direct shear 3	1.5	215	2.15

Angle of shear resistance =55^O Cohesion =0.55 kg/cm^2

Cbr Values

CBR value for normal soil = 7.37 %

CBR value for soil+10% of fly ash =10.94 %

CBR value for soil+20% of fly ash = 12.408 %

The CBR value of soil is 7.37%. With the addition of fly ash at different percentages the CBR values have increased.The results indicate that as fly ash amount in the mixture is increased, the CBR values also increase.

VII.CONCLUSION

Based on the experiments the following conclusions have been drawn,The addition of 20% fly ash improved the index properties and shear strength.The soil under study is not appropriate for paving and foundation due to its plasticity. Nevertheless, the Atterberg limits of the mixture of fly ash with the soil, has improved. A reduction of the liquid limit and plasticity index up to 15% and 9% respectively (case of 20 % ash).Fly ash can be mixed with water to stabilize granular materials with few fines ash particles, producing a hard, cement-like mass. Its role in the stabilization process is to act as a pozzolan and/or as a filler product to reduce air voids.The soil became more resistant to additional water infiltration, provides additional support for traffic, creates a more stable work platform and reduces dusting from construction traffic.The increase of the optimum moisture content contributed to an increase of the stabilized soil's capability .The results, that agree with of other researchers will provide a stable soil, suitable for construction of new, financially viable and durable pavements.Class C, Class F fly ash has been used in road construction in other regions. The current study shows that even Class N fly ash could be used in road construction, when it used with cement.The use of stabilized soil in this way has the dual benefits of removal of harmful materials from the environment and at the same time the usage of cheap construction material.

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