

Effect of Flyash on Low Bearing Capacity Soils

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Abstract— Infrastructure projects such as highways, railways, water reservoirs, reclamation etc. requires earth material in very large quantity. In urban areas, borrow earth is not easily available which has to be Hauled from a long distance. Quite often, large areas are covered with highly plastic and expansive Soil, which is not suitable for such purpose. For this purpose the application of such expansive soil after Stabilization with additives such as sand, silt, lime, and fly ash is used. As fly ash is freely available, for Projects in the vicinity of a Thermal Power Plants, it can be used for stabilization of soils. In this project the Percentage of fly ash is varied from 5 to 30 percent. The study from the laboratory test it concludes that with percentage addition of fly ash improves the strength of stabilized clay soil. The compressive strength of soil is increased by addition of fly ash content up to 1.600kpa. i.e., when the fly ash is increased (10 to 30) % the strength of soil mix improved by 11%.The maximum shear stress of soil is improved by the addition of fly ash at 1.044KN/m² (i.e., a 15% increase in shear stress)

Keywords: Fly ash, Compressive strength, Shear Strength

I. INTRODUCTION

Soil can be used as a load bearing material or construction material. When used for these purposes soil should possess engineering properties to meet the requirements such as high strength, low settlement etc. In many situations the soil present in the field may be a problematic one such as expansive soil. Expansive soils undergo volumetric changes due to changes in water content. The swelling characteristics of these soils depend on various factors such as the initial water content and suction. However shrinkage occurs on evaporation of water in dry seasons. This dual problem of swelling and shrinkage causes damage to many lightly loaded structures. In order to proceed with construction under engineering conditions, some techniques are needed to improve such properties of the soil. Soil Stabilization of expansive soils with various additives is one of the techniques to mitigate the problems possessed by expansive soils (Sharma 2007). Chemical stabilization of expansive soils involves additives such as cement, lime, bitumen, calcium chloride, fly ash etc (Osinubi 2006). Soil stabilization has been used in the buildings of roads & air-craft runways, earth dams and embankments in erosion control (Osinubi 2006).

II. LITERATURE REVIEW

Kaniraj et al (1994) conducted an experimental investigation on the geotechnical characteristics of fly ash and fly ash soil mixtures. The test carried out includes grain size analysis, compaction test, direct shear test, unconfined compression test, drained shear test, consolidation test and CBR test. The results they arrived from the tests include, increase of fly-ash content decreases the maximum dry density and increases the optimum moisture content of fly-ash soil mixtures. When the fly ash content in fly ash soil mixtures becomes more than 50% there is a considerable decrease in

UCC strength. Use of fly ash improves the stability of the soil because of the reduction in the self-weight. Erdal (2001) conducted a study on expansive soil stabilized with cement, lime, two types of class C fly ashes with low and high calcium contents. The percentage of lime and cement added to the expansive soil varies from 0-8% whereas 0-25% of fly ash was used for stabilization. He conducted odometer free swell tests and consistency limits tests. Specimens stabilized with fly ash were cured for 7 days and 28 days after which they were subjected to odometer free swell tests. The prepared sample A composed of 85% kaolinite, 15% of bentonite and 10% of water. 23 samples were prepared by adding lime, cement, low and high calcium fly ash to a sample A with different percentages. Free swell tests were conducted under the condition of no curing, 7 days curing, and 28 days curing. The liquid limit values of expansive soil decreased with an increasing amount of stabilizers. Addition of the stabilizers decreased the plasticity index of the sample. The swelling potential of sample A is reduced by all the stabilizers. High calcium fly ash addition of at 25% reduced the swelling potential by 65%. Adding 25% low calcium fly ash caused the highest reduction in the swelling potential 68%. Pandian (2004) characterized fly ash with reference to geotechnical applications, he conducted an experimental program to study the physical, chemical, compaction and strength behaviour among various Indian fly ashes collected from Raichur, Korba, Vijayawada, Badarpur, Ramagundam, and Neyveli by the detailed investigations, carried out on fly ashes the results shows that fly ash has good potential for use in geotechnical applications due to its low specific gravity, freely draining nature, ease of compaction, insensitiveness to change in moisture content and good frictional properties. It can be gainfully exploited in construction of embankments, roads, reclamation of low lying areas, fill behind retaining structures etc. it can also be used in reinforced concrete structures since the alkaline nature will not corrode the steel.

Sunil Arora Ahmet (2005) conducted experiments to investigate the use of class F fly-ash amended soil, cement or soil lime as base layers in highways. Class F fly-ash cannot be used alone in soil stabilization application as it is not self-cementing. An activator such as cement or lime must be added to produce cementitious products often called as pozzolan stabilization mixtures. The developed mixture must possess adequate strength and durability, should be easily compacted and should be environment friendly. Roadways have a high potential for large volume of fly-ash stabilized soils. The experiments that were performed on soil fly-ash mixtures prepared with cement and lime as activators were unconfined compression test, California bearing ratio test and resilient modulus test. Finally base thickness were calculated using lab based strength of a mixture, highly dependent on curing period, compactive energy, cement content, water content at compaction. Freeze thaw cycles do not have any determined effect on cement treated mixtures. Phanikumar et al (2007) has

studied the volume change behaviour of fly ash stabilized clays. They used two different types of clays both are highly plastic in nature but one is expansive in nature and the other one is non-expansive. The added fly ash ranged from 0-20%. Here the effects of fly ash content on free swell index swell potential and swelling pressure of expansive clays were studied. Compression index and secondary consolidation characteristics of both expansive and non-expansive clays were also studied. It was found that, when swell potential and swell pressure determined at dry unit weight of the sample both are decreased by nearly 50% at 20% of fly ash and when determined at constant weight of clay it is increased by nearly 60% at 20% of fly ash content. It was also found that compression index and coefficient of secondary consolidation of both the clays decreased by 40% at 20% of fly ash content.

III. MATERIALS

A. Soil

Locally available expansive soil is used for the experimental investigation. Soil sample was collected from the local area at a depth of 0.5m to 1.0m. Sample was collected at krishnapuram, Vellore district.

TABLE I. PROPERTIES OF SOIL

Properties	Values
Liquid Limit	25%
Plastic Limit	19.58%
Shrinkage Limit	12.73%
Flow Index	18.59%

Figure 1 Shows the Particle size distribution of clay soil used in the present study

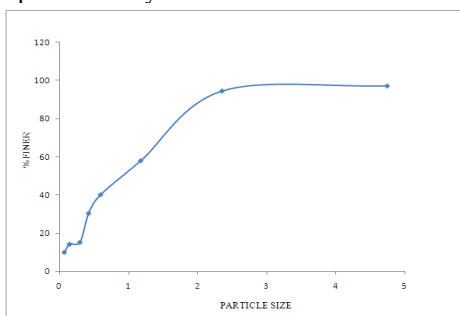


Figure 1. Particle size Distribution

B. Fly Ash

Fly ash collected from Prema Casting Limited, Ambattur Industrial Estate was used in present study. The Physical and chemical properties of flyash are listed in Table 2 and Table 3.

TABLE II. PHYSICAL PROPERTIES OF PREMA CASTING LTD. FLY ASH

Physical properties	
Fineness (m ² /kg)	252
Specific gravity	2.09

TABLE III. CHEMICAL PROPERTIES OF FLYASH

Chemical properties	Chemical Properties	
	Fly ash F	
	% by mass	ASTM C618 class-F
SiO ₂	63.6	-
CaO	1.57	<10
Al ₂ O ₃	28.2	-
Fe ₂ O ₃	2.99	-
MgO	0.54	5(max)
Na ₂ O	0.05	-
K ₂ O	0.003	-
SO ₃	0.26	-
MnO	0.03	-
Loss on ignition	0.85	
Soluble residue	-	
Al ₂ O ₃ /Fe ₂ O ₃	-	
SiO ₂ +Al ₂ O ₃ +Fe ₂ O ₃	94.78	70(min)

IV. EXPERIMENTAL PROGRAMME

The various engineering tests were performed by varying the percentage of flyash from 5% to 30% . as per the IS Procedures.

V. RESULTS AND DISCUSSIONS

Atterberg limits for various percentage of flyash

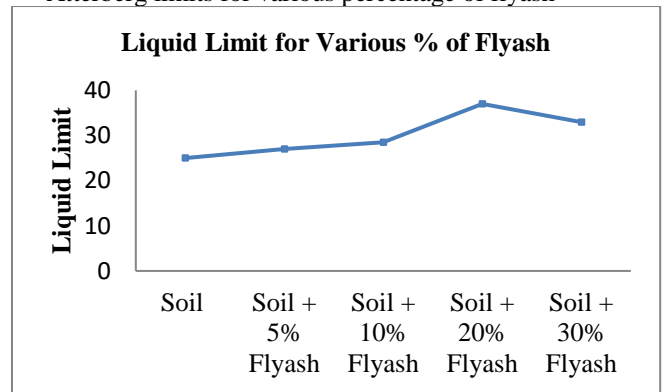


Figure 2. Liquid Limit for Various % of Flyash

From figure 2 it is clear that for flyash from 5% to 20% the liquid limit increases and hence there of decreases. Therefore increase of flyash to certain limit only is used for studies.

Standard Proctor Test

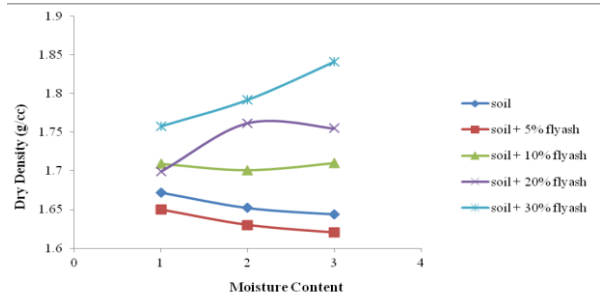


Figure 3. Comparison of dry density of soil with various proportion of fly ash

From the proctor compaction result shown in fig 3 the maximum dry density should be occur at 70% of soil and 30% of fly ash and the value should be range between 1.758 g/cc.

The minimum dry density should be occur at 95% of soil and 5% of fly ash and the values are vary between 1.60 g/cc to 1.65 g/cc. These values are measured at the Optimum moisture content such as 6% to 10% .Dry density should be depends on specific gravity of soil and fly ash. While the specific gravity of fly ash should be decrease it increases the dry density of fly ash. The decreasing of specific gravity of fly ash is proved at above mentioned specific gravity analysis. Therefore the mixture of soil and fly ash at lower specific gravity increases the dry density at optimum moisture content.

A. Unconfined Compression Test

Unconfined compression tests were performed for soil mixed with various percentages of fly ashes (5%, 10%, 20% and 30%).

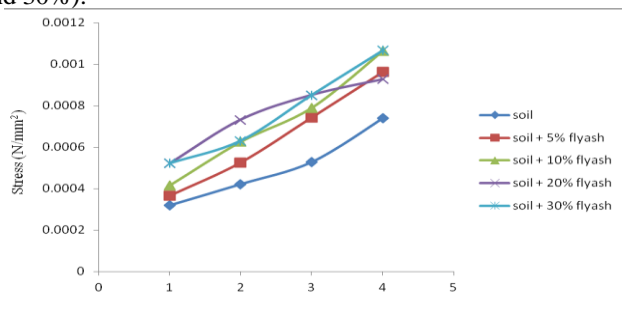


Figure 4. Comparison of Unconfined Compressive Strength of Soil with various proportion of fly ash

The stress- strain characteristics curve of the soil-fly ash mix shown in fig 4. The maximum compressive strength of soil should be occurred at 70% of soil and 30% of fly ash mix and 90% of soil and 10% of fly ash mix the values are range between 1.066 kpa to 1.600kpa. The minimum compressive strength of soil (without fly ash) is 0.740kpa and for considering the fly ash the minimum compressive strength of soil should be 0.9625kpa. From the above results the compressive strength of soil should be increased and it should be well stabilized.

Direct Shear Test

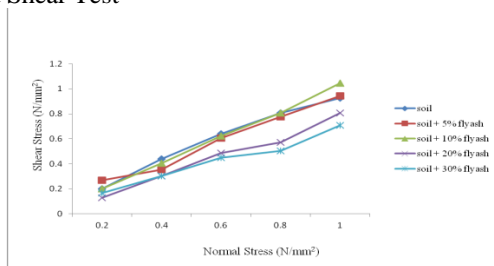


Figure 5. Comparison of shear strength of soil with various proportion of fly ash

Direct shear test is carried out by soil sample and sample plus fly ash content (5%, 10%, 15%, 20%, and 30%) and the results are mentioned fig 5. The maximum shear stress occurred at soil +10% fly ash the value is 1.044KN/m² and the angle of internal friction and cohesion values are 42° and 0.04N/mm² respectively. These are measured from graph values. Further addition of fly ash (5%, 15%, 20%, and 30%) the shear stress is constantly increased or decreased corresponding angle of

internal friction and cohesion values are varied at 36° to 42° and 0.04 to 0.1N/mm². From the above results the fly ash is very suitable for controlled the shear of normal soil and improve the stabilisation property of soil.

VI. SUMMARY AND CONCLUSION

The engineering properties of expansive clay are not suitable for construction purposes. Conventional soil improvement techniques are generally expensive involving large quantities of costly material. A large quantity of fly ash has been produced every year. The important conclusions arrived from the current study are presented below.

The specific gravity of soil is reduced by increasing of fly ash content such as 70% of soil with 30% of fly ash specific gravity is reduced to 1.572 for room temperature and 1.509 for standard temperature. Dry sieve analysis of soil gives the various percentages of soil particles present in sample and it shows the grade of soil such as well graded soil. The liquid limit, plastic limit and shrinkage limit of soil with the addition of fly ash shows the better improvement of stabilized property of soil. The maximum dry density increased with increasing fly ash content. The maximum dry density should be occur at 70% of soil and 30% of fly ash and the value should be range between 1.758 g/cc. The minimum dry density should be occur at 95% of soil and 5% of fly ash and the values are vary between 1.60 g/cc to 1.65 g/cc. The optimum moisture content increased with increasing fly ash content. The compressive strength of soil is increased by addition of fly ash content up to 1.600kpa. i.e., when the fly ash is increased (10 – 30) % the strength of soil mix improved by 11%. The maximum shear stress of soil is improved by the addition of fly ash at 1.044KN/m² (i.e., a 15% increase in shear stress). The soil properties are well improved and it's suitable for various purposes. It should be done by freely available fly ash.

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