IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X,
PP 06-11
www.iosrjournals.org

Effect of Fly Ash on Stabilization of Silty Soil

Poonam D Patil, Yogesh N. Bafna, P. P. Patil

Abstract: *Soil stabilization is the process of increasing strength and bearing capacity of soils either by mechanical or chemical methods. Stabilization also eliminates or decreases settlements, hydraulic conductivity and swell and shrinkage potential.The mechanical method of stabilization involves the change of gradation of the soil and densifying the soil by mechanical methods such as rollers. Chemical stabilization involves altering the properties by adding cement, lime or any other cementations material.In this study an attempt has made to investigate the usefulness of Fly Ash to stabilize silty soils.From the analysis of the results of this study, it appears that fly ash is not an effective stabilizer to stabilize silty soils. This may be due to the fact that both silt particles and fly-ash particles have approximately same size. This might result in poor gradation that is deficient in particle interlocking in silt-fly ash mixtures. Another important property required for effective stabilization is plasticity. Unlike lime, fly ash is a low or non-plastic material and is not effective in binding the soil particles together.*

I. Introduction

To improve the engineering properties of soil, one of the ground improvement techniques is soil stabilization.It includes physical, chemical, or biological methods, or may be their combination; Stabilization of soil is a very complicated process, as it depends upon many external factors. For example stabilization of a slope of cut or fill against erosion is a vastly different procedure than from stabilizing a loose soil deposit against heavy load without deformation. Efficient soil stabilization can be achieved only when the nature of the soil and the engineering goals are exactly identified. The main objective of soil stabilization is to improve the engineering properties of the soil mass. Some specific objectives are as follows,

a) to reduce or prevent detrimental settlements,
b) to increase the strength of soil,
c) to ensure the stability of slope
d) To increase the bearing capacity of pavement sub-grades,
e) To decrease hydraulic conductivity,
f) To avoid causes of an undesirable volume changes, for example, by frostaction, swelling, and shrinkage of fine-grained soils may be controlled

II. Literature Review

The process of stabilization includes many of the following techniques:

a) Densification of soil by compaction, pre-compression, drainage, vibration or a combination of some of these procedures.
b) Mixing soils with chemicals or grouting or using geo-fabrics to develop more stable bases.
c) Replacing of undesirable soil with a controlled fill.

Some available methods of soil stabilization are,

1. Mechanical Stabilization:

This method consists of two procedures for altering the soilproperties, namely, the rearranging the soil particles, modification of soil structure and the improving of the soil gradation. Particle rearrangement is accomplished by blending different soils, and modification of soil structure is achieved by densification by compaction.

2. Dewatering

Dewatering is also a mechanical method that involves in the removal of or reduction in unwanted excess ground -water.

3. Preloading

In preloading methods, foundation soils are surcharged with a temporary overload to increase the strength and decrease expected settlements.

4. Cement Stabilization

Stabilization of soils by using cement is a chemical method in which soil, depending on its type is treated with some percentage of Portland cement. Mixtures of soil and cement are commonly called as *soil-cement*.The strength of soil-cement increases with aging. Well compacted soil-cements have high shearing strength and bearing capacity and low compressibility, shrinkage and permeability.

5. Lime stabilization

Lime increases the plasticity index of low plastic soils and decreases the plasticity index of high plastic soils. Almost all types of soils can bestabilized using lime. However lime is more effective than cement in stabilizing clayey soils.

6. Polymer Stabilization

Natural polymeric materials such as resins and synthetic polymeric materials such as polyvinyl alcohol (PVA) have been used as soil stabilizers. These polymers waterproof fine-grained soils and impart strength and decrease permeability.

7. Using Geosynthics

Geosynthetics are used to stabilize and reinforce soil masses. Stabilization of soil using geofabrics is widely applicable for erosion control on soil slopes exposed to flowing water. Geosynthetics are also employed to construct of airports and highway pavements over soft ground.

8. Using vacuum Preloading

This method involves in applying vacuum pressure and to expel the pore water. Vacuum preloading method is performed to increase bearing capacity before construction and to reduce settlements after construction.

9. Using Electro osmosis and electro kinetics

Electro osmosis consists in making the pore water to flow from positive to negative electrodes (anode and cathode). Cathode is usually placed in a well that collects water flowing towards cathode and can be pumped out by conventional methods. Electro kinetics method is a combined process involving electro osmosis and chemical grouting. Silty and clayey soils have low hydraulic conductivity and in those soils this method is more effective.

10. Soil columnar method

Load carrying capacity of soft soils such as silt and clay can be improved by making a bore hole using augers and removing part of it and filling the hole by a mixture lime or cement with sand and water and compact. This process results in the formation ofan in-situ pile. This method increases bearing capacity and reduces settlement of soft soil. Added advantage can be achieved by adding 10 to 12 percentage of fly ash.

11. Using Fly ash

Stabilization soils by using fly ash and mixture of lime or cement and fly ash is gaining more importance in recent times since it has widespread availability. This method is inexpensive and takes less time than other stabilization methods. Fly ash may be mixed with soil during excavation right in the field.

Soil with high percentage of silt is very unstable because of its low strength, low bearing capacity and higher frost susceptibility The main aim of this research work is to carry out the experiments to ascertain the feasibility of use of fly ash for soil stabilization. This paper addresses the issues pertaining to the change in engineering properties of the Silty soil containing fly ash.

Experimental Work:

Trials were conducted to check the effect of fly ash on non-cohesive soil i.e. silts or siltysoil So the objective of this research is to determine the suitability of fly ash as a stabilizer to stabilize non cohesive fine soil i.e. silty soils.

III. Materials

1. Soil:

The soil used for this study is a predominantly silty soil and was collected from Dhule. Based on the test results, as per the Unified Soil Classification System (USCS) the soil falls into group SM—"Sandy Silt". And as per the Indian soil classification systems (IS: 1498-1971) the soil falls into group ML – Inorganic silt or silty sand of low plasticity. The test results are summarized in Table 1

Table 1 Identification and Physical Properties of Soil Used

1.Specific gravity			2.62
2.Consistency Limits and Indices			
a)Liquid Limit			24.5
b)Plastic Limit			21.0
c)Plasticity Index			3.5
3.	Grain size distribution		
	a)	Percent sand	28.04
	b)	Percent silt size	70.96
	c)	Percent clay size	Almost equal to 0
	d)	USCS Classification	SM—Sandy Silt
	e)	ISCS Classification	ML- Inorganic Silt
4.	Compaction characteristics		
	a) Standard Proctor Compaction test		OMC = 15.9 %,
			MDD= 1.64 g/cc
	b) Modified Proctor Compaction test		OMC = 14.4 %,
			MDD = 1.75 g/cc

2. Fly ash as Soil Stabilizer:

This fly ash was obtained from Deep Nagar Thermal power plant", Bhusawal, Maharashtra, India. The physical and chemical properties of this fly ash are obtained from supplier.

Table 2 Physical Properties of Fly Ash

Colour	Dark grey
Specific gravity	2.65
Grain size distribution :	
Sand fraction (%)	Nil
Silt size fraction (%)	87.00
Clay size fraction (%)	13.00
Atterberg's limits:	
Liquid Limit (%)	39.30
Plastic Limit (%)	NP

Table 3 "Chemical Compositions of Fly ash

Constituent	**Percentage Range of Fly ash (%)**	
Silica (SiO_2)	49	– 67
Alumina (Al_2O_3)	16	– 29
Iron Oxide (Fe_2O_3)	4 – 10	
Calcium Oxide (CaO)	1	– 4
Magnesium Oxide (MgO)	0.2 – 2	
Sulphur (SO_3)	0.1 – 2	
Loss of Ignition	0.5 – 3	

Testing Program

Oven dried soil was mixed with different proportions of fly ash and geotechnical properties of these mixtures were determined. The properties determined were: specific gravity, plasticity characteristics, compaction characteristics and unconfined compression strengths corresponding to water contents of OMC-2%, OMC, and OMC+2%.

Table 4: Utilized Indian standards to carried out tests are

Tests	Related IS
Water content (oven dry method)	IS : 2720 (Part 2) - 1973
Specific Gravity (Density Bottle)	IS : 2720 (Part 3/Set 1) - 1980
Grain size Analysis (Hydrometer)	IS : 2720 (Part 4) - 1985
Atterberg's Limits	
1. Liquid Limit	IS : 2720 (Part 5)– 1985
2. Plastic Limit	IS : 2720(Part 5)- 1985
Compactness and Density	
1.Light Compaction	IS : 2720(Part 7)– 1980
2.Heavy Compaction	IS : 2720(Part 8)- 1983
Unconfined Compressive Strength	IS : 2720(Part 10) - 1973.

IV. Results And Discussion

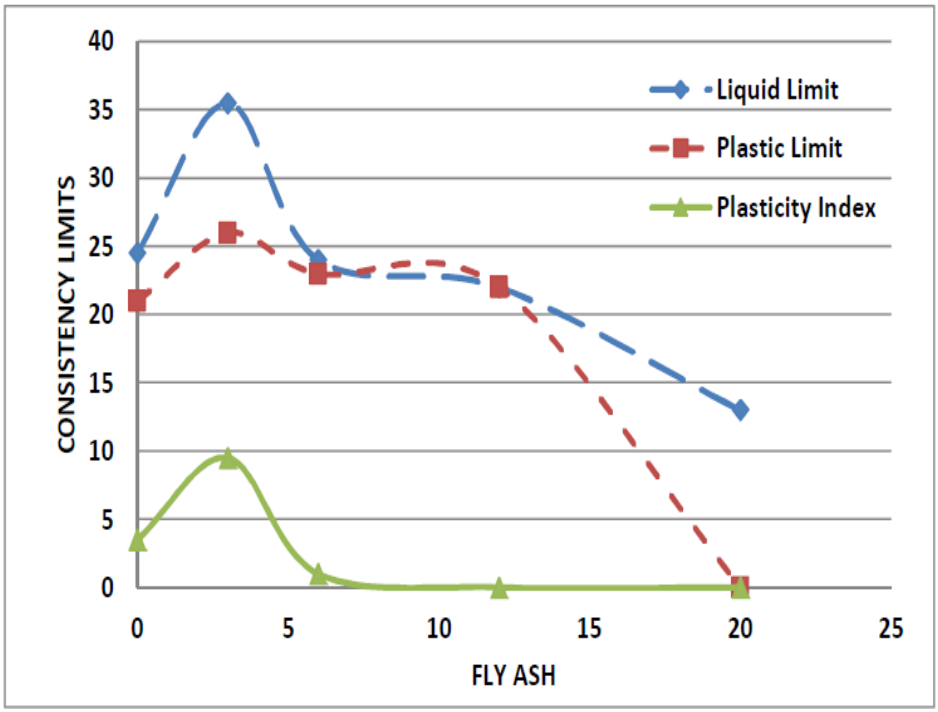
1. Specific Gravity Values for Soil and Fly Ash (FA) Mixes

The results presented in this table indicate that there is very small variation in specific gravity of the soil - fly ash mixes. This may be due to the fact that the specific gravity of fly ash is also close to that of silt used in this study

Soil+0%FA	Soil+3%FA	Soil+6%FA	Soil+12%FA	Soil+20%FA
2.62	2.62	2.62	2.63	2.63

2. Plasticity Characteristics:

Graph 1 shows effect on soil and fly ash mixes. Observing the trends in the graph, addition of 3 % of fly ash increases plasticity characteristics of silty soil by 1.7 times compare to plain silty soil. However decrease in plasticity is seen for fly ash content more than 3% to silty soil. Umesh T.S (2011) also found a similar behaviour during his study on silty soil treated with fly ash.



Graph 1: Variations of Liquid Limit and Plasticity Indices with Increasing Values of Fly Ash.

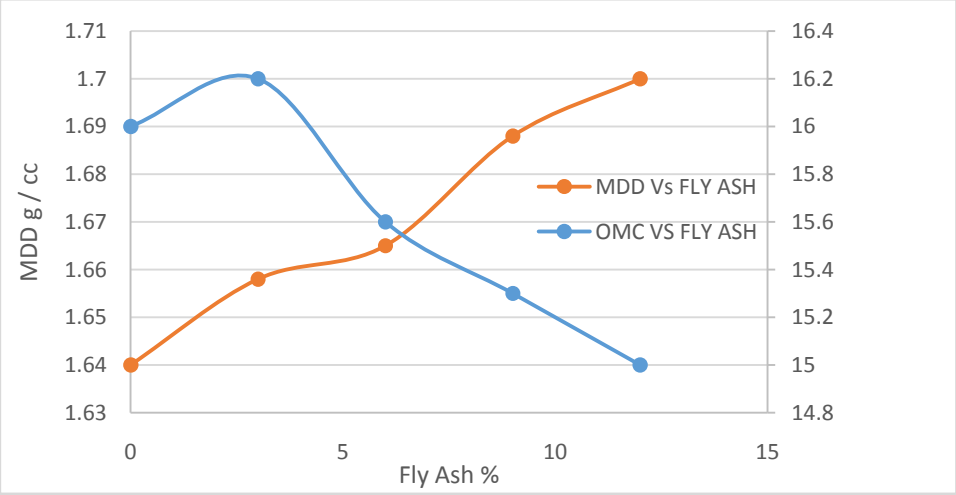
3. Compaction : (Graph 2)

It is observed that decrease in moisture content and increase in dry density of 20% fly ash mix soil is 1 % and 0.6g/cc compare to soil having ash 0%.

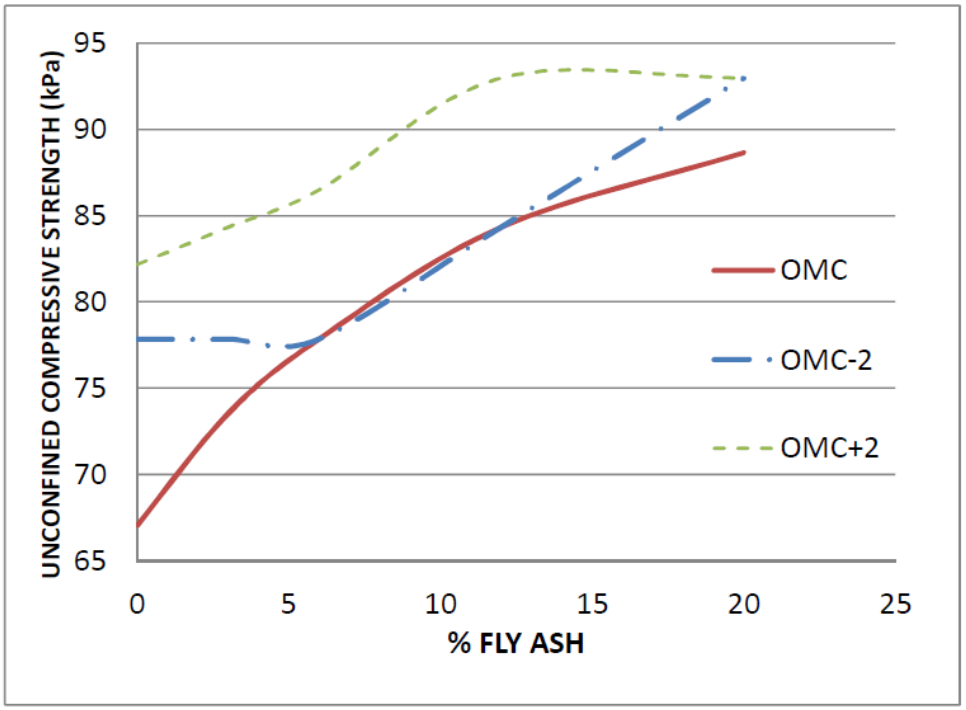
4. Unconfined Compression Test : (Graph 3)

Unconfined compression tests were carried out on proportion mix of soil and fly ash for three different moisture contents at OMC-2%, OMC and OMC+2%, to determine the unconfined compressive strength (Cu) and the stress-strain modulus (Es).

For specimens tested with water contents of OMC+2%, there is a steep increase in unconfined compressive strength at 3% fly ash content. Thereafter the strength increased with a decreasing rate. Specimens prepared at water contents equalto OMC showed a steady increase in unconfined compressive strength with increasing fly ash content. Specimens prepared and tested at water contents of OMC-2% also showed a similar tendency.



Graph 2: Variation of MDD and OMC w.r.t. percentage of fly ash



Graph 3: Variation of Unconfined Strength with Increasing Fly Ash

V. Conclusions

From this experimental work the following conclusions are drawn:

1. Addition of fly ash to the silt has shown no significant change in specific gravity values of the mixtures.
2. Addition of a small percentage of fly ash (about 3%) increases plasticity characteristics of silty soil. However increasing ash content tends to decrease plasticity properties. Higher percentage of ash content shows reduction in plasticity of soil. This is undesirable since higher percentage of fly ash failed to render the silty soil binding properties.
3. From the results of Standard Proctor Compaction Test, it was observed that there is an increase in maximum dry density with the increasing ash content. Optimum Moisture Contents (OMC) decreases with the increasing ash content.
4. However specimens prepared has water contents with OMC and OMC -2% seems to be stiffer when compared to that of specimens prepared at OMC+2%.
5. From this experimental work it may be concluded that fly ash is not very effective stabilizer to stabilize in ease of silty soil. This may be due to the following reasons –

1. Both silt and ash have similar grain sizes and specific gravity.
2. Both materials are either non-plastic or low plastic.
3. Similar grain size distribution failed to impart friction.
4. Its low plastic nature failed to cement the particles together.

References

[1]. American Society for Testing and Materials (2007). Annual Book of ASTM Standards, Sec. 4, Vol. 04.08, West Conshohocken, Pa.
[2]. Bowles J.E (1996) "Foundation Analysis and Design", The McGraw – Hill Companies, Inc. New York.
[3]. CIDA(2005), "Fly Ash Status Summary Report in India", A report prepared by Canadian International Development Agency (CIDA) under HVFAC project, Copyright Confederation of Indian Industry – 2005.
[4]. Das, Braja M. (2005) "Fundamentals of Geotechnical Engineering". 2-nd ed. Bill Stenquist.
[5]. Das, Braja M. "Soil Mechanics Laboratory Manual". New York: Oxford UP, 2009.
[6]. Punmia B. C.(1998), "Soil Mechanics and Foundations", Laxmi Publications (P) Ltd.
[7]. Vittal and Mathur (2008), "Fly Ash Usage for Road Construction- A Decade of success" Journal – CE & CR, February – 2008, pp-22-26.
[8]. Virendra Kumar (2004), "Compaction and Permeability Study of Pond Ash amended with Locally Available Soil and Hardening Agent", Journal of Institution of Engineers (India), IE(I) Journal, CV, Volume-85, May – 2004, pp-31-35.
[9]. Website According to American Coal Association (AACA) - http://www.coalashfacts.org/