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Influence of Waste Fly Ash on Characteristics of Clayey Soil

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Abstract:
Expansive soils occurring in semi-arid climate regions of the world cause serious problems on civil engineering structures. Such soils swell when given an access to water and get shrink when dry out. Clay soil has also shown the same behavior of expansiveness when water is added into it, which makes the clay unfit as the foundation soil because of possibility of excessive settlement of structures standing on it. Several attempts are being made to control the swell-shrink behavior of these soils. There are many ways to stabilize expansive soil by adding different types of waste materials like cement, lime, geo-polymers, fibers etc., by grouting and mechanical means, but all of these are quite expansive. In this study, Fly ash, by-product of thermal power plant, is used for stabilization of expansive soils. The disposal of Fly Ash is a big problem for environment, so it should be used for good cause. In this research paper, fly ash is added in the clayey soil in the proportion of 5%, 10%, 15%, 20% and 25% by weight of soil and the properties are compared with parent soil. The properties studied are liquid limit, plastic limit, plasticity index, california bearing ratio (CBR) and unconfined compressive strength. With the increase in Fly ash OMC is decreased from 20.75% 17.18% , whereas MDD of the soil has shown an increasing path from 1.614 gm/cc to 1.693 gm/cc. Value of liquid limit is decreased from 26.4to 20.6 and plastic limit of soil is increased from 14.93 to 19.42 whereas plasticity index has shown a decreasing path from 11.77 to 1.17.Un soaked CBR value increases from 2.49% to 12.94% and soaked CBR value increases from 2.08 to 10.78. UCS value of the soil is progressively increased from 0.460 kg/cm^2 to 2.287kg/cm^2.

1. INTRODUCTION

For a long time, we are facing problems like failures of small and big structures. The biggest problem behind this is swelling of soil. This is very unstable soil. Its property varies from hard to soft and dry to wet. It exhibits swelling and shrinkage with different water content. As a result many structures usually face excessive settlement and differential movements, which results in damage to foundation systems and structural elements. . So now our main aim is to improve the properties of swelling soil like Clayey Soil. The purpose was to check the scope of improving bearing capacity value and reduce expansiveness by adding additives like fly ash, lime fly ash, ordinary Portland cement etc. In many countries, coal is the primary fuel in thermal power plant and other industry. The fine residue collected from field is known as fly ash and considered as a waste material. The fly ash is tossed out of either in the dry form or mixed with water and discharged in slurry into locations known as ash ponds. Production of fly ash worldwide is huge and increasing day by day. There are many problems created by Fly ash, they are as follows (a) The dumping of fly ash contaminates ground water which causes various health problems such as cancer, neurological damage etc. due to presence of heavy metal (b) the people who are in exposure to dumping site of fly ash suffer from asthmatic disorder (c) Fly ash can also contaminate surface water and it also contaminates the surface water which is nearby it by erosion. Therefore it is used as admixture for expansive soil like Clayey soil, to stabilize it which is easy, ideal and cheap technique. India at present produces around 120 Million Ton of Ash per annum. Clay soil is defined as soil that is composed of mostly clay particles. Clay is a kind of expansive soil that always creates problem in design and construction of structures. The most common complaint about clay soil is that it has poor drainage. It swells and shrinks. Using expansive soil in construction without improving is not a good option. If we have an expansive soil for construction then we have two options, first one is to replace that soil with another soil or to improve the properties of that soil only. Option of replacing the existing soil is not cost effective, so the option of improving properties of existing soil will be of huge benefit. So, in this research we will study about the stabilization of expansive soil with Fly ash in different proportions, by which we can solve the problem of open dumping of Fly ash.

2. LITERATUE REVIEW

S.Bhuvaneshwari and S.R. Gandhi [1]:A study was carried on the effect of engineering properties of expansive soil through an experimental programme. The present paper describes a study carried out to check the improvements in the properties of expansive soil with Fly Ash added as soil stabilizer in varying percentages. They conducted both lab tests and field tests in order to get optimum values. One of the major difficulties in field application is thorough mixing of the two materials (expansive soil and Fly Ash) in required proportion to form a homogeneous mass. They adopted a method for placing these materials in layers of required thickness and operating a “Disc Harrow” and it is thoroughly explained. Phani Kumar and Sharma (2004)[2]:They both conducted a study that consists of stabilization of expansive soil by adding Fly ash as a waste material to study the various engineering properties of expansive soil. They studied parameters like free swell index (FSI), swell potential, swelling pressure, plasticity, compaction, strength and hydraulic conductivity of expansive soil and compared the results by adding Fly ash in different proportions of Fly ash

taken were from 0 to 20% and they concluded that increase in FLY ASH content reduces plasticity characteristics and the FSI was reduced by about 50% by the addition of 20% Fly Ash. The hydraulic conductivity of expansive soils mixed with Fly Ash decreases with an increase in Fly Ash content, due to the increase in maximum dry unit weight with an increase in Fly Ash content. When the Fly Ash content increases there is a decrease in the optimum moisture content and the maximum dry unit weight increases. Hence the expansive soil is rendered more stable. The untrained shear strength of the expansive soil blended with Fly Ash increases with the increase in the ash content. Mir and Sridharan (2013)**[3]**studied adding, high calcium and low calcium fly ashes in different proportions to a highly expansive black cotton soil. The objective of the study was to study the effect of fly ashes on the physical, compaction, and swelling potential of black cotton soils that were reached from laboratory tests and utilization of waste material without disruptive effect on the environment. The results showed that the liquid limits, compaction characteristics and swelling potential of expansive soil fly ash mixtures are significantly modified and improved. With the addition of fly ash to black cotton soil the maximum dry unit weight of the mixtures decreases with increase in optimum moisture content and it can be attributed to the improvement in gradation of the fly ash. Furthermore, compressibility characteristics of the expansive soil are improved with the addition of fly ash. Chayan Gupta and Dr. Ravi Kumar Sharma (2014) [7]conducted a research on the soil which was already stabilized with Fly ash and in their research they replace soil with different proportions of marble dust from 0% to 20% in the interval of 4%. They studied various engineering properties of soil. CBR value in soaked condition was increased by 200% with the addition of sand, fly ash and marble dust in the above mentioned proportion. Karthik.S, Ashok Kumar.E, Gowtham.P, Gokul.D and Thangaraj.S (2014) [4] conducted soil stabilization using fly ash. The proportions taken were in the manner 3%, 5%, 6% and 9%.Liquid limit shows decreasing manner with increase in amount of fly ash in the soil sample. It decreases by 35% as compared to parent soil. Plastic limit value decreased by 26%.Value of OMC and MDD both showed increasing manner but in an unusual manner. CBR value also shows an undulated path in which they vary. For 3% CBR value decreases but again increases for 5 to 6% replacement and then decreases. Unconfined compressive strength value increases up to 6% replacement then start decreasing. Sabat (2012)**[8]** had studied the effects of polypropylene fiber on engineering properties of expansive soil stabilized by RHA-lime. He added Polypropylene fiber in a varying proportion of 0.5 to 2% with interval of 0.5%. The following properties were determined and they are as follows compaction, UCS, soaked CBR, hydraulic conductivity. The effect of 0, 7 and 28 days of curing were also studied on UCS, soaked CBR and hydraulic conductivity. U Arun kumar and kiran B. Biradar (2014) [11]conducted tests for soft subgrade soil by using quarry dust as stabilizer. They investigate the soil by replacing it with fly ash in proportion of 0 to 50% in increment of 10%.

3. MIX PROPORTION

This study is carried out to keep in mind the best possible utilization of the waste fly ash in soil stabilization by replacing the soil with Fly ash in the proportion of 5%, 10%, 15%, 20% and 25%. Fly Ash is brought from thermal power plant situated at Bathinda , Punjab. The samples were prepared by mixing soil and fly ash in proportions tabulated below:-

Table .1. Mix proportion

Sample No	Soil	Fly Ash
1 A	100%	NIL.
2 B	95%	5%
3 C	90%	10%
4 D	85%	15%
5 E	80%	20%
6 F	75%	25%

4. RESULTS

Table .2. Effect of Fly Ash on OMC

S.No.	Fly Ash %	Optimum Moisture Content (OMC) %
1	0	20.75
2	5	20.31
3	10	19.66
4	15	19.18
5	20	18.50
6	25	17.18

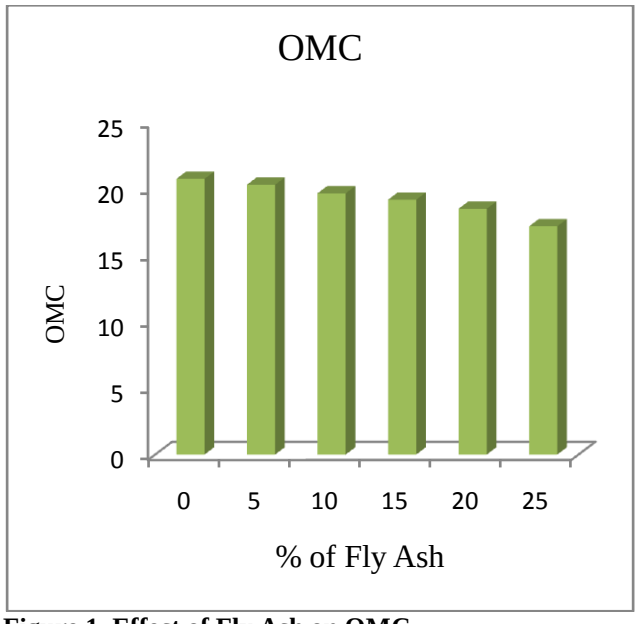

Figure.1. Effect of Fly Ash on OMC

Table .3.Effect of Fly Ash on MDD

S. No.	Fly Ash %	Maximum Dry Density (MDD) gm/cc
1	0	1.614
2	5	1.649
3	10	1.653
4	15	1.678
5	20	1.688
6	25	1.693

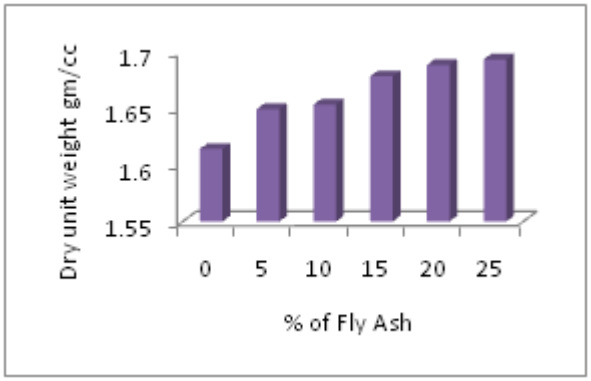

Figure.2. Effect of Fly Ash on MDD

Table. 4. Effect of Fly Ash on Liquid Limit

S. No.	Fly Ash %	Liquid limit
1	0	26.4
2	5	23.8
3	10	22.9
4	15	22
5	20	21.6
6	25	20.6

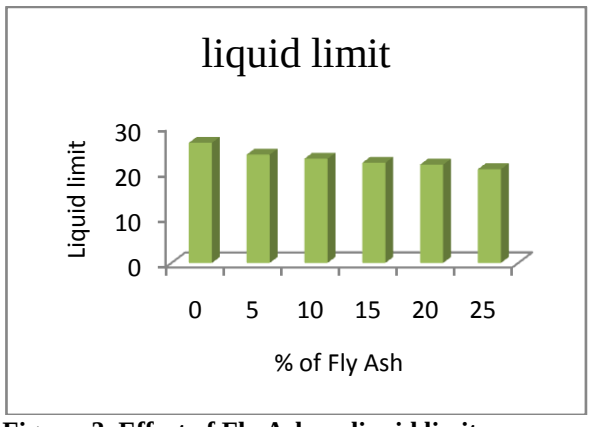

Figure. 3. Effect of Fly Ash on liquid limit

Table.5. Effect of Fly Ash on Plastic Limit

S. No.	Fly Ash %	Plastic limit
1	0	14.63
2	5	15.09
3	10	16.70
4	15	18.91
5	20	19.18
6	25	19.42

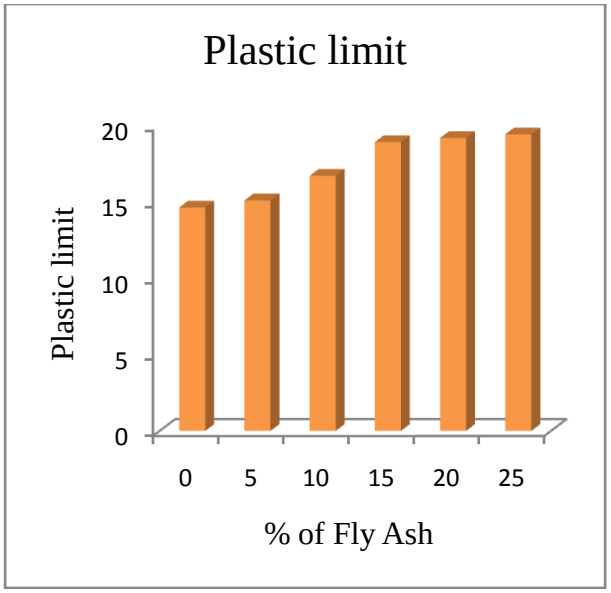

Figure.4. Effect of Fly Ash on plastic limit

Table. 6. Effect of Fly Ash on Plasticity Index

	Fly Ash %	Plasticity index
1	0	11.77
2	5	8.71
3	10	6.2
4	15	3.09
5	20	2.42
6	25	1.17

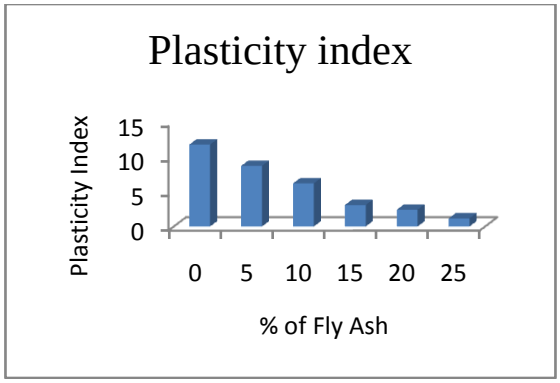

Figure. 5. Effect of Fly Ash on plasticity Index

Table.7. Effect of Fly Ash on CBR (un soaked)

S. No.	Fly Ash %	CBR
1	0	2.49
2	5	5.99
3	10	6.80
4	15	7.75
5	20	9.90
6	25	12.94

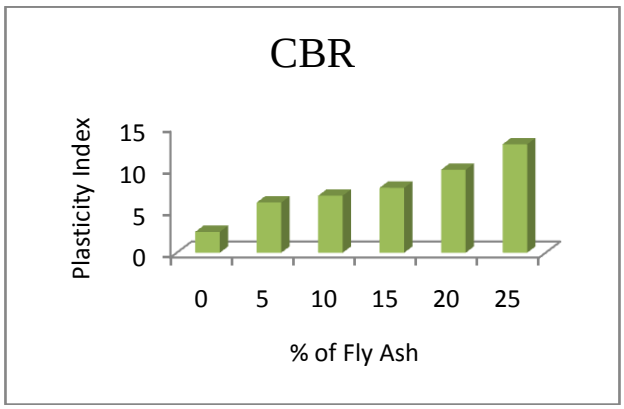

Figure. 6. Effect of Fly Ash on CBR (un soaked)

Table. 8. Effect of Fly Ash on CBR (soaked)

S. No.	Fly Ash %	CBR
1	0	2.08
2	5	5.05
3	10	5.25
4	15	6.67
5	20	8.22
6	25	10.78

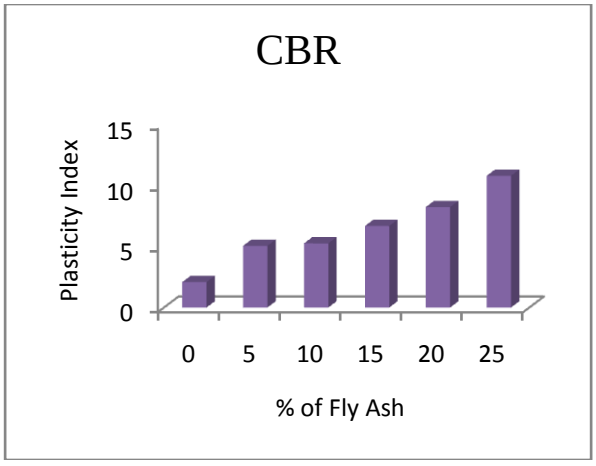

Figure.7. Effect of Fly Ash on CBR (soaked)

Table .9. Effect of Fly Ash on UCS

S. No.	Fly Ash %	Unconfined Compressive strength (Kg/cm^2)
1	0	0.460
2	5	0.601
3	10	0.944
4	15	1.227
5	20	2.287
6	25	2.226

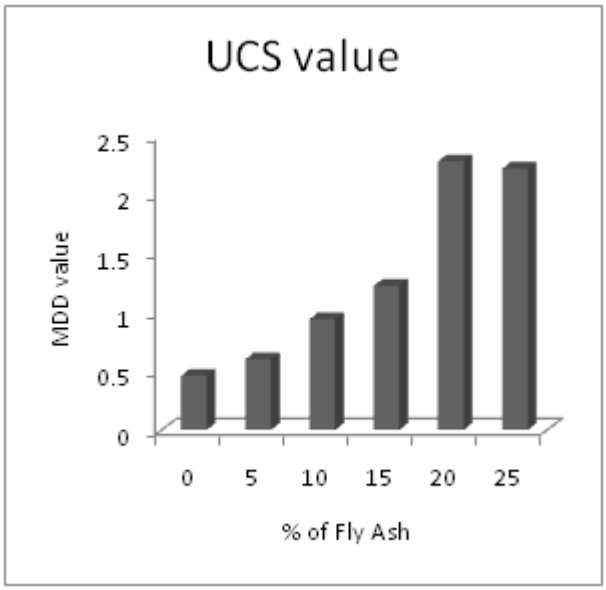

Figure.8. Effect of Fly Ash on UCS

5. CONCLUSIONS

The use of Fly Ash improves the properties of expansive soil. On the basis of research work conducted, following conclusions are drawn:-

♦ OMC of the stabilized soil has decreased from 20.75% of a parent soil to 20.31%, 19.66%, 19.18, 18.50 and 17.18 with partial replacement of soil with Fly Ash as 5%, 10%, 15%, 20% and 25% respectively.
♦ MDD of the stabilized soil has increased from 1.614 gm/cc of a parent soil to 1.649 gm/cc, 1.653 gm/cc, 1.678 gm/cc, 1.688 gm/cc and 1.693 gm/cc with partial replacement of soil with Fly Ash as 5%, 10%, 15%, 20% and 25% respectively.
♦ Liquid limit of the stabilized soil has decreased from 26.4% of a parent soil to 23.8%, 22.9%, 22%, 21.6 and 20.6% with partial replacement of soil with Fly Ash as 5%, 10%, 15%, 20% and 25% respectively.
♦ Plastic limit of the stabilized soil has increased from 14.63% of a parent soil to 15.09%, 16.70%, 18.91%, 19.18% and 19.42% with partial replacement of soil with Fly Ash as 5%, 10%, 15%, 20% and 25% respectively.
♦ Plasticity index of the stabilized soil has decreased from 11.77 of a parent soil to 8.71, 6.2, 3.09, 2.24 and 1.17 with partial replacement of soil with Fly Ash as 5%, 10%, 15%, 20% and 25% respectively.
♦ CBR (un soaked) of the stabilized soil is increased from 2.49% of a parent soil to 5.99%, 6.80, 7.75%, 9.90% and 12.94% with partial replacement of soil with Fly Ash as 5%, 10%, 15%, 20% and 25% respectively.
♦ CBR (soaked) of the stabilized soil is increased from 2.08% of a parent soil to 5.05%, 5.25%, 6.67%, 8.22% and 10.78% with partial replacement of soil with Fly Ash as 5%, 10%, 15%, 20% and 25% respectively.
♦ UCS value of the stabilized soil is increased from 0.460 kg/cm^2 of a parent soil to 0.601 kg/cm^2, 0.944 kg/cm^2, 1.227 kg/cm^2, 2.287 kg/cm^2 and 2.226 kg/cm^2 with partial replacement of soil with Fly Ash as 5%, 10%, 15%, 20% and 25% respectively.

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