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Research Article

Influence of Fly Ash to Improve the Shear Strength of Commercial and Natural Soil

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Abstract

Industrial waste materials are utilized to improve the problematic soils which are cost efficient and eco friendly method. The present paper evaluated the influence of fly ash on the commercial and natural soil to improve its geotechnical properties. In this experiment, Atterberg's limit, maximum dry density (MDD), optimum moisture content (OMC) of the samples with various fly ash proportions (at 10%, 20%, 30% and 40%) was analyzed. The main objective of this study is to investigate the improvement of shear strength on soils were evaluated using unconfined compression strength (UCC) test. The test results showed a significant change in the geotechnical properties of samples with fly ash. The UCC values improved by using fly ash from 108 kPa to 171 kPa for natural soil. The commercial soil obtained the optimum strength about 228 kPa at 10% of fly ash on the soil.

Keywords: *Waste utilization, Fly ash, Expansive soil, Shear strength, UCC test.*

1. Introduction

Fly ash is a by product from burning the coal in thermal power generating plants. SiO_2, Al_2O_3, Fe_2O_3 and CaO are the main chemical constituents present in fly ash. Fly ash can be classified into two class according ASTM C-618 namely class F and class C based on the amount of calcium, silica, alumina, and iron oxides presents in the ash. Class F fly ash is normally produced by burning anthracite or bituminous coal while Class C fly ash is generally obtained by burning sub bituminous or lignite coal. In India, every year 112 million tons of fly ash is produced, from that only 38 % were utilized. As per the estimates, fly ash generation is expected to increase to about 225 million tons by 2017 *(*V.Kumar *et al*, 2005). The fly ash used for gainful purpose in construction material such as brick/blocks manufacturing, cement, concrete product, soil stabilizer, etc about 5-10% (A.Boominathan and S.Hari, 1999).

Expansive soils are known as shrink-swell soils which is highly plastic material which contains clay minerals such as Montmorillonite, Illite group which attracts and absorbs water that poses several challenges for civil engineers. They are natural hazard which can cause extensive damage to structure if not adequately treated. Soil stabilization is the process of controlling the potential of soils for a change in volume and improves the engineering properties such as strength of soils. In this experiment, fly ash is used as the admixture for soil stabilization. Utilization of fly ash also has the advantage of reusing an industrial waste by-product without adversely affecting the environment or potential land use (Murat Mollamahmutoglu *et al*, 2009). Various investigations were carried out to analyze the effect of fly ash on expansive soils. Several work has been done in this area by Mahesh & Satish, 2013, Gyanen *et al*, 2013, Bidula, 2012, Hasan, 2012, Saeid 2012, Ramadas *et al*, 2011, Robert, 2009, Kate, 2005, Bhuvaneshwari, *et al*. 2005, Pandian, 2004, Nalbantoglu, 2004, Cokca, 2001

2. Materials Used

2.1 Soil Samples

Table.1 Geotechnical properties of soils

Properties	Commercial soil (CS)	Natural soil (NS)
Specific gravity (Gs)	2.31	2.63
Liquid Limit (%)	53.6	208.7
Plastic Limit (%)	24.4	59.1
Plasticity Index (%)	29.2	149.6
MDD (kN/m^3)	16.37	13.15
OMC (%)	19	26.2
Soil Classification	CH	CH

Natural soil (NS) was collected from Madakatipattu, Puducherry region. The soil was excavated from of 1.0 – 2.0 m depths from the ground level. The obtained soil was air dried and soil passing through 425 µ IS sieve was used.

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Commercial soil (CS) namely Bentonite was used in this experiment. The geotechnical properties of the soil samples used in this experiment were analyzed and classified based on Indian Standard are given in Table 1.

2.2Fly Ash

Fly ash was collected and their chemical constituents were analyzed using X-ray Fluorescence (XRF) method and the results are shown in Table. 2

Table.2 Chemical Constituent of fly ash

S.No	Chemical Constituent	Results (%)
1	SiO_2	57.3
2	Al_2O_3	23.8
3	Fe_2O_3	6.1
4	CaO	11.7
5	MgO	0.47
6	SO3	0.9
7	Loss of Ignition	1.8

3. Tests Conducted

In this study, fly ash is mixed with commercial and natural soil in different proportions which are 10%, 20%, 30%, 40% respectively to determine of influence of fly ash on geotechnical properties. The following tests were conducted on the soils mixed with different proportion of fly ash. The liquid limit and plastic limit were conducted as per IS: 2720 (Part V) – 1985. The Specific gravity were conducted as per IS: 2720 (Part III) – 1980. Proctor compaction test were conducted to determine Maximum dry density (MDD) and Optimum moisture content (OMC) as per IS: 2720 (Part VII) - 1965. Unconfined compressive strength (UCC) test were conducted as per IS: 2720 (Part X) – 1991. The effect of fly ash on the geotechnical properties of soils were analyzed and shown in Table. 3

Table.3 Effect of fly ash on Natural soil (NS) and Commercial soil (CS)

Properties	Type of Soil	0% fly ash	10% fly ash	20% fly ash	30% fly ash	40% fly ash
Liquid Limit (%)	NS	53.6	49.6	45.1	40.4	38.8
	CS	208	145	138	107	98.5
Plastic Limit (%)	NS	24.4	23.8	22.6	21	20.6
	CS	59.1	51.3	47.4	43.9	39.5
Plasticity Index (%)	NS	29.2	25.8	22.5	17.8	18.2
	CS	149.6	94	90.9	63.1	59
Maximum dry density (kN/m^3)	NS	16.3	16.5	16.7	16.9	16.8
	CS	13.1	13.9	15.7	15.6	15.6
Optimum moisture content (%)	NS	19	18.6	18.3	17.7	17.1
	CS	26.2	28.4	26.2	24.1	24.9
Unconfined Compressive Strength (kPa)	NS	108	145	161	166	171
	CS	154	228	218	189	157

4. Results and Discussion

4.1 Influence of fly ash on Atterberg's Limits

The natural soil and commercial soil were mixed with different proportion of fly ash and the test has been conducted in the laboratory. Figure 1 and 2 shows the experimental result of liquid limit and plastic limit of natural and commercial soils. From these figures, it is observed that as percentage of fly ash increase there is decrease in liquid limit and plastic limit values for natural and commercial soils.

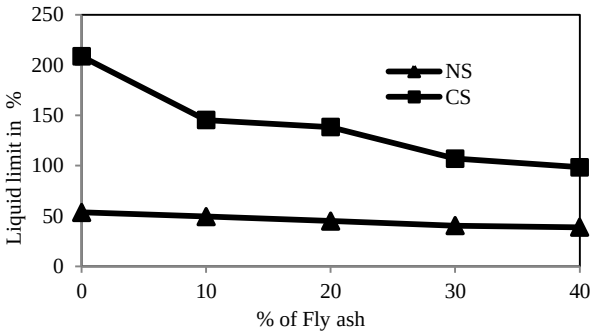

Fig.1 Influence of fly ash on Liquid Limit

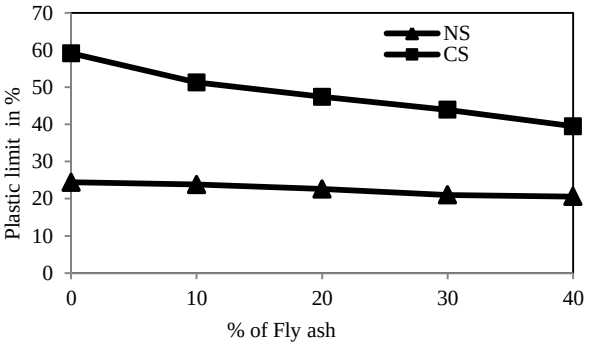

Fig.2 Influence of fly ash on Plastic Limit

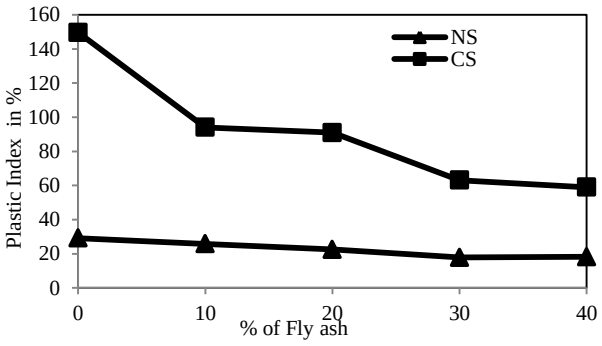

Fig.3 Influence of fly ash on Plastic Index

The liquid limit values decreased from 53.6% to 38.8% and 208.7% to 98.5% for natural and commercial soil respectively. There will be marginal reduction for plastic limit values on natural and commercial soil with the addition of fly ash were shown in the Figure 2. The Plasticity index is reduced for commercial soil and natural soil with the addition of fly ash is shown in the Figure 3.

4.2 Influence of fly ash on MDD and OMC

The compaction characteristics namely OMC and MDD for the soil samples mixed with fly ash are shown in Figure 4 and 5. The test result shows that the OMC values were decreasing gradually about 19% to 17.17% for natural soil with increased proportion of fly ash. For commercial soil, the OMC values increase from 26.2% to 28.2% at 10% of fly ash were shown in Figure 4. Addition of fly ash above 10 % shows the OMC values were decrease from 28.2% to 24.9%.

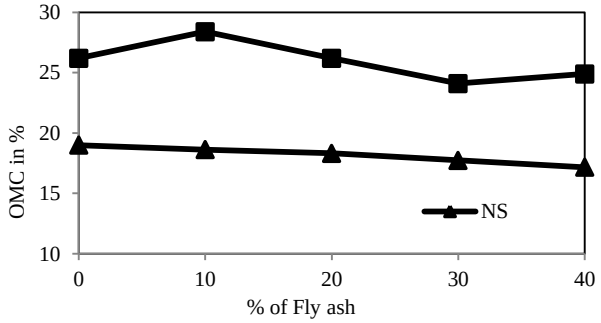

Fig.4 Influence of fly ash on OMC

The experimental results of MDD were shown in Figure 5 and it is observed that as percentage of fly ash increase, maximum dry density values were increased from 16.37(kN/m^3) to 16.81(kN/m^3) for natural soil. In the case of commercial soil there will be rapid increase in MDD values at 20 % of fly ash from 13.15(kN/m^3) to 13.65(kN/m^3) and marginal reduction in MDD values after 20 % of fly ash.

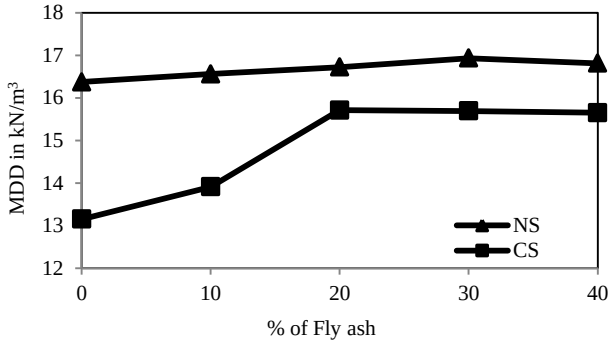

Fig.5 Influence of fly ash on MDD

4.3 Influence of fly ash on Shear strength

The samples were compacted to their maximum dry density at the optimum moisture content and subjecting them to unconfined compressibility strength test. Figure 6 shows the variation of shear strength on commercial and natural soil with different proportion of fly ash. The results indicated that the value increased from 154 kPa to 224 kPa with increasing the amount of fly ash added in soil mixtures to10% fly ash, then decreases for the commercial soil. For the natural soil, the UCC values increased with the addition of fly ash. At 10% of fly ash, values were increased from 108 kPa to 145 kPa. The increment of fly ash above 10 % will have marginal improvement of 171 kPa from 145 kPa for natural soil.

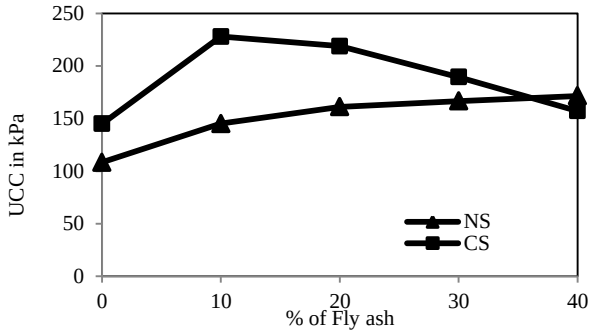

Fig.6 Influence of fly ash on UCC

Conclusion

From the above investigation it is clear that influence of fly ash to improve the geotechnical properties of natural and commercial soils. Based on this test a few conclusions are the following:

1. The addition of fly ash to soils decreases the liquid limit. The reductions of liquid limit values were optimum at 10% of fly ash on commercial soil and 30% of fly ash on natural soil. The soil classification of natural soil moves to CI from CH which implies degree of expansion is reduce to intermediate from high level of expansion .
2. Addition of fly ash shown good decrement on plasticity index about 60% and 40% from commercial and natural raw soils.
3. MDD values were increased with the maximum of 13% at 20 % of fly ash for commercial soil and marginal reduction for natural soil on MDD.
4. 9.6% and 5% of OMC values were decreased with the addition of fly ash on commercial and natural soils.
5. UCC values increases on adding of fly-ash up to 10% to have the greatest value of 228 kPa of commercial soil which has 48% of increment in strength and 34% increment of UCC value for natural soil.

Thus the result indicates the influence of fly ash at 10% to the soil improves the shear strength

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