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Importance of Bottom Ash in Preventing Soil Failure

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ABSTRACT

This paper mainly focused on strengthened the various geo-technical properties of the cohesive soil in Mugalivakkam, Porur, Chennai area using the different proportions (0, 20, 30, 35, 40, and 50%) of bottom ash. The selected geo-technical properties for this study are Liquid limit (LL), Plastic limit (PL), Optimum Moisture Content (OMC), Maximum Dry Density (MDD) and Unconfined Compressive Strength (UCC), in addition to the above said parameters, the other properties like Swell Index (SI), Swell Potential (SP) and Specific gravity (S) also obtained for this study. The test results showed that relatively good improvement in strength of cohesive soil. Hence, the test result can be used in design of foundation for preventing collapses, settlement of structures and saving thousands of property and life losses in cohesive soil environment.

KEY WORDS: ash, soil, durability, density.

1. INTRODUCTION

The durability and soundness of the structures mainly depend on the soil stratum. Especially, cohesive soil is a problem all over the world for any type of Civil Engineering related works, which lead to many accidental prone especially like Mugalivalkam, Porur, Chennai, Tamil Nadu, where a 11 stored building collapsed due to improper handling of cohesive soil. Cohesive soils are generally dense and tightly bound together by molecular attraction. They are plastic when wet and can be moulded, but become very hard when dry. It has high strength in dry condition. One common disadvantage of cohesive soil is that it is susceptible to water logging where the clay soil will retain water after rainy days and the soil tends to stay wet even when the water is drained out. This leads to foundation settlement, which resulted in building failure. When the soil is exposed to hot condition, cohesive soil will become solid and is hard to break. Structures often settle due to consolidation of saturated clay stratum. Further the consolidation of thick compressible cohesive soil layers is serious and may cause structural damage (uplift pressures can occur in fine grained soils consisting of silts and clays; such soils can cause heaving of foundations and formation of boils) and the cohesive soils are susceptible to freezing and have poor drainage characteristics. Numbers of researches have studied the physical and chemical properties of cohesive soils using various admixtures as a stabilizing agent for strengthening the cohesive soil.

For the construction of a residential building at Mugalivakkam, Porur, Chennai, it was found that the entire area is covered with plastic clay having liquid limit varying from 33 to 50%. The area was being recorded with extensive shrinkage cracks exceeding 10 mm width, which were noticed on the surface. The soil was not suitable in the present form for construction of residential buildings to the following reasons: Poor workability for compaction. The construction schedule was critical and it was necessary to carry out the work during monsoon when optimum moisture content cannot be achieved, High compressibility that leading to settlement, and Inadequate shear strength for required slope stability. Instead of borrowing a suitable soil from a long distance it was proposed to use the locally available plastic clay after stabilization with bottom ash that was available in the power plant. Accordingly, a detailed literature review was carried out on the subject that was followed by laboratory tests and field tests.

This paper described the properties of natural clay, stabilized clay with varying percentage of bottom ash and tests carried out in the field on lateral embankment built with blended soil and bottom ash. The procedure adopted for mixing the soil with bottom ash in the field and the test results have been described.

2. METHODS AND MATERIALS

2.1. Cohesive Soil: The cohesive soil used in the project was collected from an open excavation at 1m depth below the natural ground surface from Mugalivalkam, Porur, Chennai, Tamil Nadu, India. The soil is tested as per the provisions contained in IS 2720-1983. The Geotechnical properties of cohesive soil are given in Table 1. The visual identification of soil was grey in colour and moisture content was found to be 59.2%.

2.2. Bottom Ash: The bottom ash is collected from Energy Resource Power Plant, Electricity Board, Ennore, Chennai, Tamil Nadu. The bottom ash generally contains more than 20% lime (CaO). Bottom ash has pozzalanic activity than other material. Bottom ash is one of the residues generated in combustion of coal and comprises the fine particles that rise with flue gases. Worldwide, more than 65% of bottom ash produced from coal power stations and energy power stations is disposed off in landfills and ash ponds. The general properties of lime are given in Table 2. The soil sample was preserved and tested in the soil mechanics laboratory, Vel Tech High Tech Dr.Rangarajan Dr.Sakunthala Engineering College, Chennai, Tamil Nadu.

Table 1 Geotechnical Properties of Cohesive Soil

Properties	Values
Liquid limit (%)	61.0
Plastic Limit (%)	28.9
Plasticity Index (%)	32.1
Swell Index	86.0
Swell Potential	10.2
OMC (kN/m^3)	01.67
MDD (%)	12.50
Specific gravity	02.56
UCC kPa	33.28

Table 2 Properties of Bottom Ash

Silicon dioxide (SiO_2)	60.09
Aluminium oxide (Al_2O_3)	18.63
Ferric oxide (Fe_2O_3)	-
Calcium oxide (CaO)	-
Magnesium oxide (MgO)	1.10
Sulphur trioxide (SO_3)	1.54
Sodium oxide (Na_2O_3)	0.31
Potassium oxide (K_2O)	0.05
Loss of Ignition (LOI)	2.41

3. RESULTS AND DISCUSSION

In this paper, the properties of cohesive soil were first investigated, and then the cohesive soil was mixed with different percentage of bottom ash separately. The percentage of bottom ash mixed with soil were 0, 20, 30, 35, 40, 50% respectively. The laboratory tests were carried out on Cohesive soil and Bottom ash. The experiments like Liquid limit (LL), Plastic limit (PL), Optimum Moisture Content (OMC), Maximum Dry Density (MDD) and Unconfined Compressive Strength (UCC) were carried out with reference to IS 2720-1983 and other parameters like Swell Index (SI), Swell Potential (SP) and Specific gravity (S) were derived from the experimental results.

3.1. Sieve Analysis: The collected soil sample from the site is undergone sieve analysis for determining the percentage of finer particle, uniform coefficient, coefficient of curvature, particle size determination and also to determine the percentage of sand, silt, clay etc. With these percentages of sand, silt, and clay the grade and nature of soil along with percentage of finer could be determined. By sieve analysis the percentage of clay is obtained to be 73% and hence it is concluded to be cohesive in nature (Fig. 1).

The results obtained from sieve analysis is taken in to consideration at this point of unconfined compressive strength. Since the value of percentage of clay obtained is more than 70% it is opted to confirm as cohesive soil and the experiment is further proceeded with UCS. Fig.2 shows the test result of Unconfined Compression Strength (UCS) of the cohesive soil mixed with different proportions of lime and s. Further, from Fig.2, it was found that UCS increases as the percentage of bottom ash increases.

From Fig.2, the percentage increases in unconfined compression strength for bottom ash combination of 0, 20, 30, 35, 40, 50% with cohesive soil respectively were found to be 0.0023, 0.0026, 0.0029, 0.0034, 0.0025, 0.0020. Different percentages of bottom ash mixed with cohesive soil shows variable increase in unconfined compression strength from which the optimum value of percentage of bottom ash is taken. Hence the optimum increase was obtained to be about $0.0034 N/MM^2$. The optimum value of percentage of admixture obtained from UCS is found to be 35%.

3.2. Plastic Limit: Fig.3 shows the test result of plastic limit of the cohesive soil mixed with Optimized value of bottom ash and soil without bottom ash. From Fig.3, it may be observed that the plastic limit decreases as the percentage bottom ash increases. From Fig.3, the percentage reduction in plastic limit for bottom ash combination of 0% of bottom ash in soil and 35% of bottom ash in soil respectively was found to be 2.59 and 14.80 % (Fig.3).

When compared the results of plastic limit between soil without bottom ash and soil with optimized value of bottom ash, the value of plastic limit decreases to certain extent. The decrease in plastic limit of cohesive soil for 35% of bottom ash and soil without bottom ash is 80%.

3.3. Liquid Limit: Fig.4 shows the test result of liquid limit of the cohesive soil mixed with Optimized value of bottom ash and soil without bottom ash. From Fig.4, it may be observed that the liquid limit decreases as the percentage bottom ash increases. From Fig.4, the percentage reduction in liquid limit for bottom ash combination of 0% of bottom ash in soil and 35% of bottom ash in soil respectively was found to be 1.47 and 15.41 % (Fig.4). When compared the results of liquid limit between soil without bottom ash and soil with optimized value of bottom ash, the value of liquid limit decreases to certain extent. The decrease in liquid limit of cohesive soil for 35% of bottom ash and soil without bottom ash is 89%.

3.4. Plasticity Index: Fig.5 shows the test result of plasticity index of the cohesive soil mixed with Optimized value of bottom ash and soil without bottom ash. From Fig.5, it may be observed that the plastic limit decreases as the percentage bottom ash increases. From Fig.5, the percentage reduction in plasticity index for bottom ash combination of 0% of bottom ash in soil and 35% of bottom ash in soil respectively was found to be 0.467 and 16.57 % (Fig.5). When compared the results of plasticity index between soil without bottom ash and soil with optimized value of bottom ash, the value of plasticity index decreases to certain extent. The decrease in plasticity index of cohesive soil for 35% of bottom ash and soil without bottom ash is 78%.

3.5. Specific Gravity: Fig.6 shows the test result of specific gravity of the cohesive soil mixed with Optimized value of bottom ash and soil without bottom ash. From Fig.6, it may be observed that the specific gravity decreases as the percentage bottom ash increases. From Fig.6, the percentage reduction in specific gravity for bottom ash combination of 0% of bottom ash in soil and 35 % of bottom ash in soil respectively was found to be 2.34 and 13.67 % (Fig.6). When compared the results of specific gravity between soil without bottom ash and soil with optimized value of bottom ash, the value of specific gravity decreases to certain extent. The decrease in specific gravity of cohesive soil for 35% of bottom ash and soil without bottom ash is 78%.

3.6. Swell Index: Fig.7 shows the test result of swell index of the cohesive soil mixed with Optimized value of bottom ash and soil without bottom ash. From Fig.7, it may be observed that the specific gravity decreases as the percentage bottom ash increases. From Fig.7, the percentage reduction in specific gravity for bottom ash combination of 0% of bottom ash in soil and 35% of bottom ash in soil respectively were found to be 0.93 and 13.48 % (Fig.7). When compared the results of specific gravity between soil without bottom ash and soil with optimized value of bottom ash, the value of swell index decreases to certain extent. The decrease in swell index of cohesive soil for 35% of bottom ash and soil without bottom ash is 93%.

3.7. Swell Potential: Fig.8 shows the test result of swell potential of the cohesive soil mixed with Optimized value of bottom ash and soil without bottom ash. From Fig.8, it may be observed that the swell potential decreases as the percentage bottom ash increases. From Fig.8, the percentage reduction in swell potential for bottom ash combination of 0% 0f bottom ash in soil and 35% of bottom ash in soil respectively were found to be 1.17 and 34.57 % (Fig.8). When compared the results of swell potential between soil without bottom ash and soil with optimized value of bottom ash, the value of swell potential decreases to certain extent. The decrease in swell potential of cohesive soil for 35% of bottom ash and soil without bottom ash is 73%.

3.8. Optimum Moisture Content (OPC): Fig.9 shows the test result of optimum moisture content of the cohesive soil mixed with Optimized value of bottom ash and soil without bottom ash. From Fig.9, it may be observed that the optimum moisture content increases as the percentage bottom ash increases. From Fig.9, the percentage increment in OPC for bottom ash combination of 0% 0f bottom ash in soil and 35% of bottom ash in soil respectively were found to be 3.2 and 29.6 % (Fig.9). When compared the results of OPC between soil without bottom ash and soil with optimized value of bottom ash, the value of OPC Increases to certain extent. The increase in OPC of cohesive soil for 35% of bottom ash and soil without bottom ash is 89%.

3.9. Maximum Dry Density: Fig.10 shows the test result of maximum dry density of the cohesive soil mixed with Optimized value of bottom ash and soil without bottom ash. From Fig.10, it may be observed that the maximum dry density increases as the percentage bottom ash increases. From Fig.10, the percentage increment in MDD for bottom ash combination of 0% 0f bottom ash in soil and 35% of bottom ash in soil respectively were found to be 1.19 and 3.83 % (Fig.10). When compared the results of MDD between soil without bottom ash and soil with optimized value of bottom ash, the value of MDD Increases to certain extent. The increase in MDD of cohesive soil for 35% of bottom ash and soil without bottom ash is 69%.

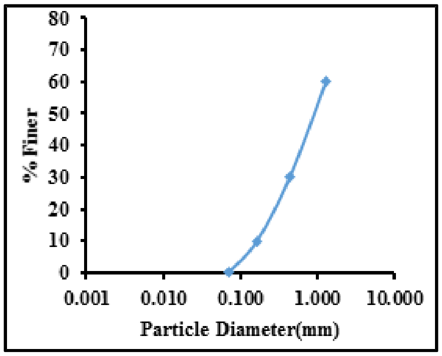

Fig.1 Sieve Analysis Result

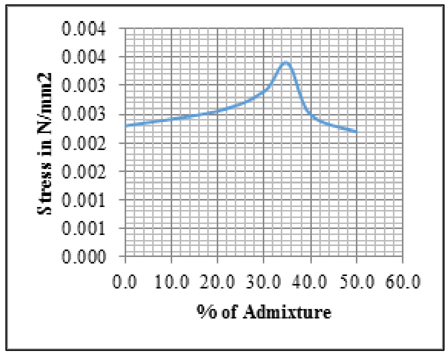

Fig. 2 UCS for the Admixture

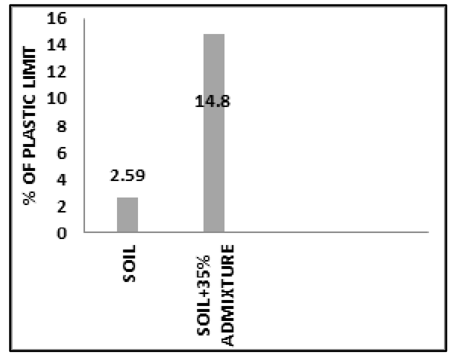

Fig.3 Plastic Limit

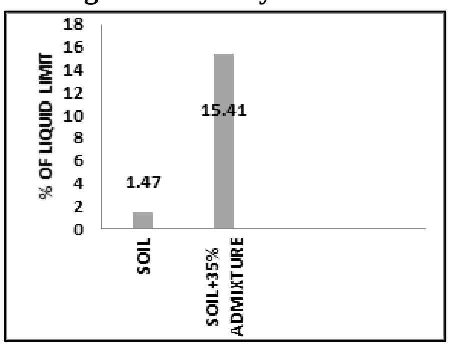

Fig.4 Liquid Limit

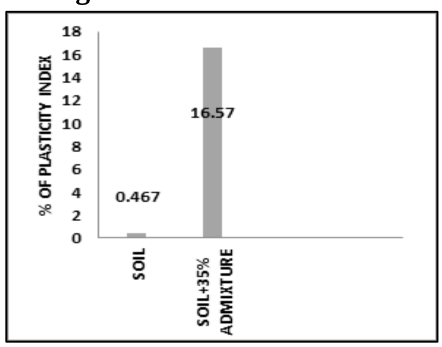

Fig.5 Plasticity Index

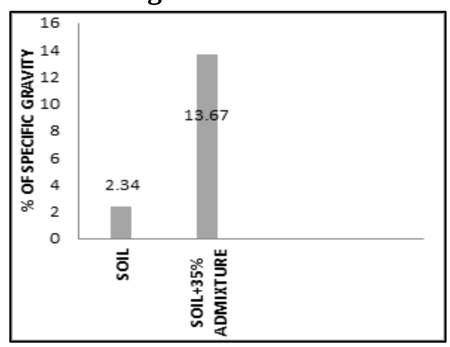

Fig.6 Specific Gravity

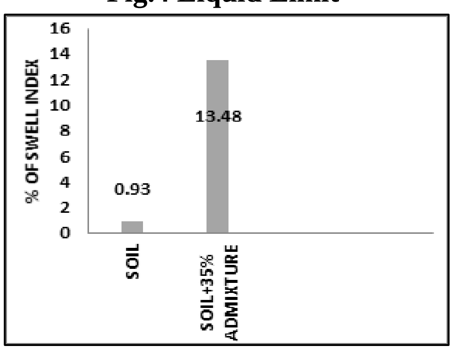

Fig.7 Swell Index

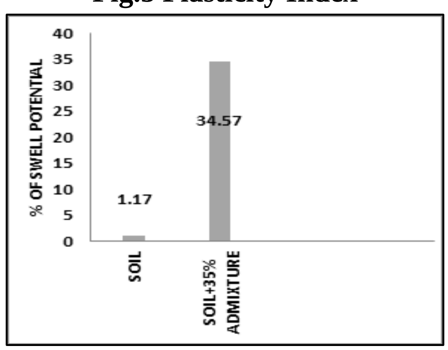

Fig.8 Swell Potential

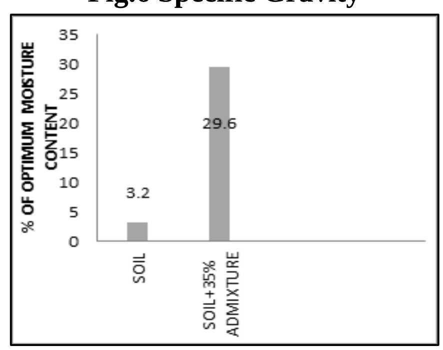

Fig.9.Optimum Moisture Content (OPC)

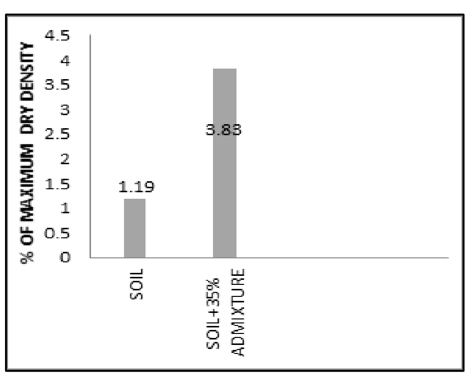

Fig.10 Maximum Dry Density

4. CONCLUSION

The study has been successfully completed to access the geotechnical properties of cohesive soil with bottom ash. The results are summarised below.

a. Bottom ash reduced the liquid limits while the plastic limits were increased.
b. Plasticity indices reduced by adding bottom ash.
c. Swollen potential of cohesive soil got diminished with the addition of admixture.
d. It is well seen that bottom ash admixture showed better results when compared to cohesive soil without admixtures
e. When compared to soil without bottom ash the admixture has improved the strength of soil.

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