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Experimental Study of Change in Plasticity of Black Soil with addition of Bottom Ash

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Abstract –*Continuous rise in population has led to an increase in land demand for construction of roads, buildings and other civil engineering works, as a result of which, the land available for construction has been decreasing day by day. This results in the need to construct over land with weak soil of low bearing capacity. However, weak soil cannot hold any structure and will lead to its failure. The scarcity of suited land for the construction guided the researchers to develop new technique to enhance the bearing capacity of unsuited or weak soil. Therefore, in order to overcome this problem of construction on weak soil, the soil needs to be stabilized before construction, to increase its load bearing capacity and for effective load distribution of a structure. As it is known, Black soil is a weak soil. In this paper, Black Soil has been stabilized using Bottom Ash. Experimental studies have been carried out to understand the change in the plastic properties of Black Soil with addition of Bottom Ash, to make it suitable for construction of roads, buildings and other civil engineering structures.*

Key Words: Black Soil, Bottom Ash, Stabilization

1. INTRODUCTION

Soil plays a very important role in the design and construction of any structure. The structure is in direct contact with soil and, the stability of the entire structure depends on the properties of the soil. The soil acts a load bearing medium for the structure. With continuous rise in population and reduction of available land suited for construction, the structures now have to be constructed on weak soil with low bearing capacity. However, if soft soil base is used for construction, it results in differential settlement of structure over time, due to continuous compaction and consolidation of soil. This may cause catastrophic damage of the structure. In order to avoid such problems in weak soil, stabilization of soil should be considered to enhance the plastic properties and load bearing ability of the soil.

1.1 Black Soil

Black soil is a major grey-black deposit found in Central India. It covers about 70-80% of the Deccan Plateau. It is suitable for growing cotton, rice, wheat, tobacco, sugarcane, jowar and various citrus fruits. However, this type of soil has been found to be troublesome for civil engineers. It's high swelling and shrinking properties, when exposed to moisture, causes difficulty in construction of roads, buildings and other structures. High compressibility, low bearing capacity and low shear strength of this type of soil makes it unsuitable for construction purposes.[1]

In order to make this soil suitable for construction, experimental studies have been carried out to determine the change in the Atterberg's Limits of this type of soil with addition of Bottom Ash as a stabilizer. Black Soil from Thane, Maharashtra was used to carry out the tests. Changes in the consistency limits, and the optimum moisture content of Black soil were studied. Black soil was mixed with 0%, 10%, 20%, 30%, 40%and 50% Bottom Ash by weight of total mix to determine the change in plastic properties.

1.2 Bottom Ash

Bottom Ash is a by-product obtained during combustion of coal. It is present at the bottom and along the side walls of the coal furnaces. It is glassy in its appearance and greyish in colour. Furthermore, bottom ash is granular and coarse in nature and comprises about 10% of the total waste. Disposal of Bottom Ash is a major problem as it contains heavy metals. The use of Bottom Ash for stabilization of Black Soil is an effective way to dispose-off this waste product.

2. DESCRIPTION OF PROBLEM

The main objective of this paper is to study the effect on the Atterberg's Limits of Black Soil when Bottom Ash is added to it, as a stabilizer.

Water content greatly affects the consistency of soil. Dry soil exists in four distinct states starting from solid state to semi-solid state, to plastic state followed by liquid state. The water contents at the boundary of each of these states

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of soil are known as Atterberg's limits or Consistency limits.

These limits are further categorized into three types, namely, Shrinkage Limit (solid to semi-solid state), Plastic Limit (semi-solid to plastic state) and Liquid Limit (plastic to liquid state).[5]

In this paper, consistency limit tests for Plastic Limit & Liquid Limit are carried out on soil sample at different concentrations of Bottom Ash. Details of test samples are tabulated below in Table 1.

Furthermore, the numerical difference between Plastic Limit (PL) and Liquid Limit (LL) is known as Plasticity Index (PI). It is defined as the percentage moisture content in which a soil remains in a plastic state, while passing from semi-solid state to liquid state.

PI = LL – PL (%)

Table -1: Sample Nomenclature

S. No.	Sample Number	Soil in % by Weight	Bottom Ash in % by Weight
1	Sample Number 1	100	0
2	Sample Number 2	90	10
3	Sample Number 3	80	20
4	Sample Number 4	70	30
5	Sample Number 5	60	40
6	Sample Number 6	50	50

3. LABORATORY TESTING

The tests for consistency limits that were performed in the lab were conforming to IS 2720 (1985) Methods of Test for Soil, Part V guidelines.

To obtain the liquid limit of soil after performing the test using Casagrande's apparatus confirming to IS 9259 (1979), a flow curve is plotted between water content on the arithmetical scale and number of drops on the logarithmic scale.[7] The moisture content confirming to 25 drops as read from the curve is reported as liquid limit of the soil.

For tests carried out for each of the soil samples of black soil, the flow curves obtained are shown in Charts-1 to 6.

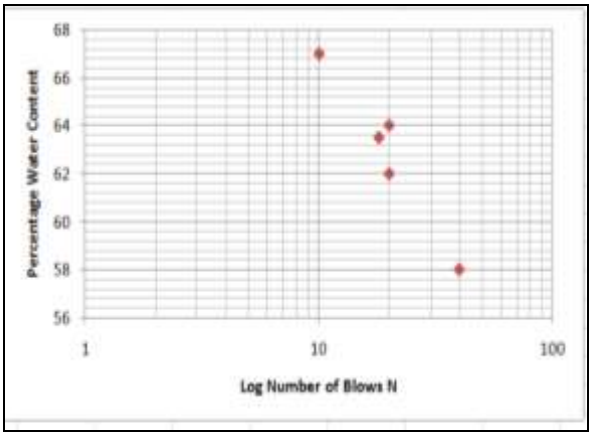

Chart -1: Flow Curve for Sample 1

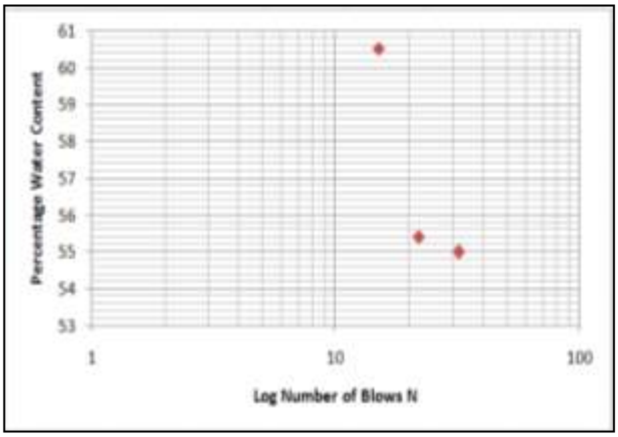

Chart -2: Flow Curve for Sample 2

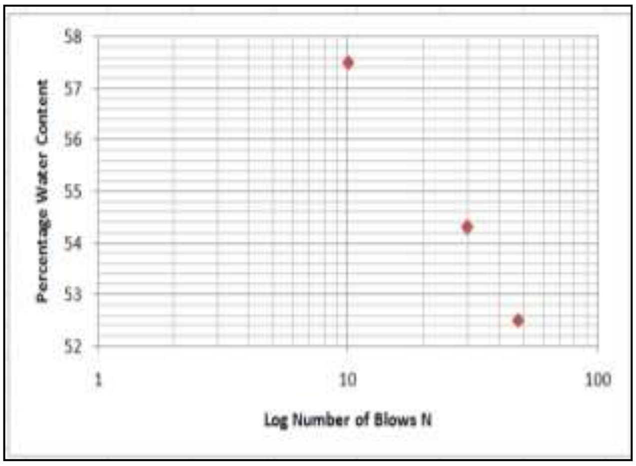

Chart -3: Flow Curve for Sample 3

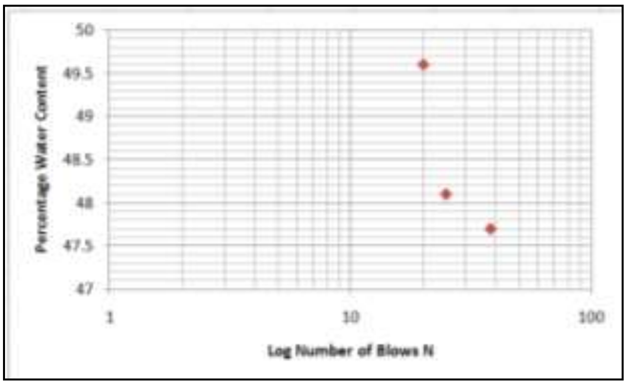

Chart -4: Flow Curve for Sample 4

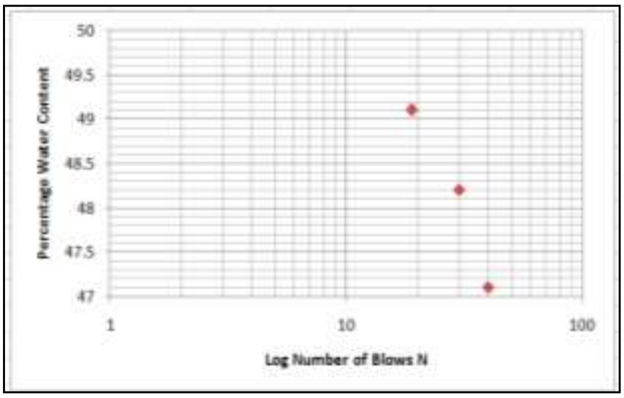

Chart -5: Flow Curve for Sample 5

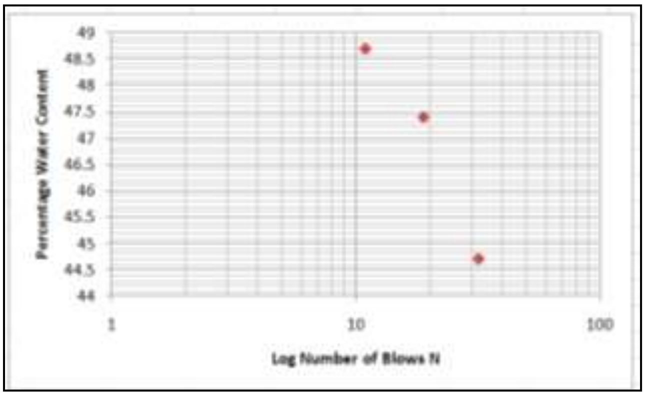

Chart -6: Flow Curve for Sample 6

4. RESULTS & DISCUSSIONS

The values of liquid limit obtained from each graph are read and tabulated in Table-2 below, along with the values of plastic limit of each soil sample.

As per IS 2720 (1985), plastic limit is defined as the water content at which the soil just begins to crumble when rolled into threads of 3mm diameter.[6] The values of plasticity index are also calculated using the relationship discussed earlier.

Table -2: Variation of LL, PL & PI with Bottom Ash

Bottom Ash (%)	0	10	20	30	40	50
Liquid Limit (%)	61.70	55.40	54.80	48.10	48.65	45.50
Plastic Limit (%)	35.18	31.20	28.47	23.96	26.84	24.11
Plasticity Index (%)	26.52	24.20	26.33	24.14	21.81	21.39

Furthermore, to understand the effect of Bottom Ash on liquid limit, plastic limit and plasticity index of black soil, graphs have been plotted, as shown in Charts-7 & 8.

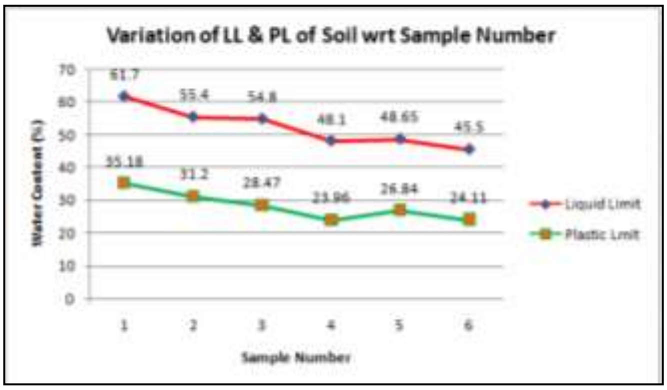

Chart -7: Variation of LL & PL with Sample Number

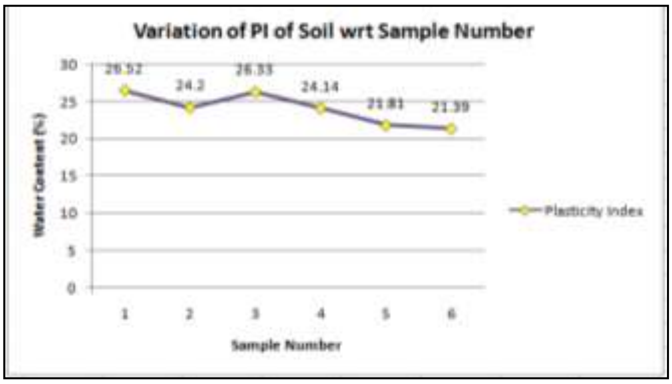

Chart -8: Variation of PI with Bottom Ash

5. CONCLUSIONS

Liquid Limit and Plastic Limit of Black Soil varies with the addition of Bottom Ash. The following conclusions have been made, based on the readings obtained by tests carried out in the laboratory and the graphs plotted and shown.

a) As the content of Bottom Ash is increased in the soil from 0% to 30%, liquid limit decreases rapidly. However, as the Bottom Ash content is increased from 30% to 40%, there is a gradual increase in the value of liquid limit of black soil. This is followed by a nose-diving plunge as the content of Bottom Ash is increased from 40% to 50%.

b) A similar relationship is observed in case of plastic limit of soil. The plastic limit decreases significantly as the Bottom Ash content in Black Soil is gradually increased from 0% to 30%. On further increase in the Bottom Ash content from 30% to 40%, the plastic limit takes a positive leap and then again dips down to a comparatively lower value when Bottom Ash content is 50%.

c) It can be clearly seen that the presence of Bottom Ash in Black Soil affects the plasticity of the soil.

d) It may therefore be reported that Bottom Ash has good potential to be used as a stabilizer in geotechnical engineering.

6. SCOPE FOR FURTHER STUDY

Based on the results obtained and conclusions made, the scope for further study in this field can be read as follows:

a) The effect of Bottom Ash on Black Soil can be studied with respect to other index properties of soil (compaction, moisture content, MDD etc.).

b) The effect of Bottom Ash as a stabilizer can be studied and compared on different types of soil.

c) Further research can be carried out to study the soil stabilization effect of other kinds of industrial waste.

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