International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 03 | Mar 2022 www.irjet.net p-ISSN: 2395-0072

OPTIMIZATION OF FLY ASH PERCENTAGE USED TO IMPROVE THE PROPERTIES OF BLACK COTTON SOIL

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Abstract - *In this world, various types of soils are present and found. Based on the particle size distribution and consistency limit soil may be classified into two parts :(I) cohesive soil (II) cohesionless soil or non-cohesive soil. The engineering properties of Soil are the most important factor in any type of structure construction. The most critical problem faced by the civil engineers is construction on expansive soil (black cotton soil). 51.8 million Hector land of India is covered by Black cotton soil. This expansive soil can prove to be a substantial hazard to engineering construction due to its ability to swell or shrink with seasonal changes in moisture content. On the other hand, millions of tons of waste material are produced by thermal power industries known as fly Ash. Nowadays a major problem is "How to utilize the industrial waste product." This research deals with how to improve the geotechnical characteristics (liquid limit, plastic limit, plasticity index, MDD, and OMC) of Expansive soil by adding a different percentage of Fly Ash (0%, 10%, 20% & 30%).*

Key Words: **Fly Ash, Expansive soil, Atterberg's Limit, OMC, MDD,**

1. INTRODUCTION

Extensive soil also called Black cotton soil is substantially planted in Maharashtra, Madhya Pradesh, Gujarat, and Andhra Pradesh in India. Black cotton soils are also planted in a swash vale of Tapi, Krishna, Godavari, and Narmada. Also, these types of soils are formed due to the riding of igneous jewels and the cooling of lava after a stormy eruption. This soil is containing lime, iron, magnesia, and alumina in advanced amounts but lacks phosphorus, nitrogen, and organic matter. Extensive soil tends to swell and shrink with the variation in humidity content. As a result of this significant torture in the soil occurs, causing severe damage to the overlying structure. During the thunderstorm season this soil absorbs lots of water, swell, come soft and their capacity to bear water is reduced, while in drier seasons, these soils shrink and come harder due to evaporation of water. These types of soils are generally planted in thirsty and semi-arid regions of the world and they beget expansive damages not only to the structures but also can beget loss of mortal life. Soils containing the complexion minerals montmorillonite generally parade these parcels. Due to that reason stabilization of expansive soil could be a must. During this present paper material from a thermal station referred to as Fly ash was accustomed to improving geotechnical properties of Black cotton soil rather than ordinary Portland cement (OPC). Fly ash could be a fine waste matter from thermal power plants, which is extracted from the flue gases of a coal-fired furnace. These thermal power plants use coal to produce electricity and after the coal is burnt, whatever mineral residue is left is called Fly ash. This Fly ash is collected from the Electrostatic precipitator (ESPs) of the plants.

In this research paper, the black cotton soil is stabilized by Fly ash and engineering properties are studied. For studying the engineering properties of black cotton soil, the Fly ash is mixed with 0% to 30% by weight of black cotton soil.

2. MATERIAL

Expansive soil

Expansive soil used for this study was collected from Kadana District, Mahisagar, Gujarat from a depth of 1m to 1.5m below the ground surface with the help of excavation. The soil was air-dried, pulverized, and sieved with 4.75 mm Indian standard as required for laboratory tests.

Fly Ash

Fly ash used for this research was collected from the thermal power plant, Gandhinagar. Class F fly ash was used as binder material. A total of three mix ratios from 10% to 30% by weight of Fly ash was replaced with natural soil.

3. EXPERIMENTAL INVESTIGATION

Atterberg's Limit

In Atterberg's limit test, the raw black cotton soil Atterberg's limits are determined separately and the tests are conducted for a mixed specimen of the black cotton soil with different percentages of fly ash. The result of Atterberg's limit is shown in Table 1.

The liquid limit and plastic limits are 40.31% and 18.78% determined respectively for black cotton soil. It's observed that the liquid limit and plastic limit are decreased with the amount of fly ash increases. The plasticity index of black cotton soil was found to be 21.52%. When the amount of fly ash increases, the plasticity index varied.
From Table 1, the value of the liquid limit was decreased and the plastic limit was increased with the amount of fly ash increased. When 20% fly ash is added to black cotton soil value of the liquid limit, plastic limit, and plasticity index is 30%, 20.74%, and 9.26% respectively.

Standard proctor test (SPT)

The objective of the test is to find out the maximum dry density (MDD) and optimum moisture content (OMC) of black cotton soil with a varied percentage of fly ash. The results of the standard proctor test are shown in table 2.

From Table 2, it is observed that the maximum dry density of soil is 1.543gm/cc determined. the value of maximum dry density was increased and optimum moisture content was decreased with the amount of fly ash increased. When the 20% fly ash is added in raw soil maximum dry density and optimum moisture content were obtained 1.559gm/cc and 18.60% respectively. The graphical representation of the standard proctor test is shown in fig 2.

Free swell index

From fig 3, it has been observed that with increasing the percentage of fly ash in raw soil, the percentage of the free swell index decreased. The percentage of the free swell index decreased from 33.33 % to 24.93% when 30% of fly ash is added to the soil.

California bearing ratio test (CBR)

From fig 4, it has been observed that when the percentage of fly ash increased the value of CBR also increased. The value of CBR varied from 0.63% to 1.53% at 2.5mm of penetration and 0.60% to 1.50% at 5mm of penetration. The maximum CBR value was obtained at 20% fly ash and at 30% of fly ash, the value of CBR was decreased.

Test specimen	Liquid limit (%)	Plastic limit (%)	Plasticity index (%)
BCS	40.31	18.78	21.52
BCS + 10% FA	36.00	20.00	16.00
BCS + 20% FA	30.00	20.74	9.26
BCS + 30% FA	37.90	23.83	14.07

TABLE- 1: Atterberg's limit for different specimen

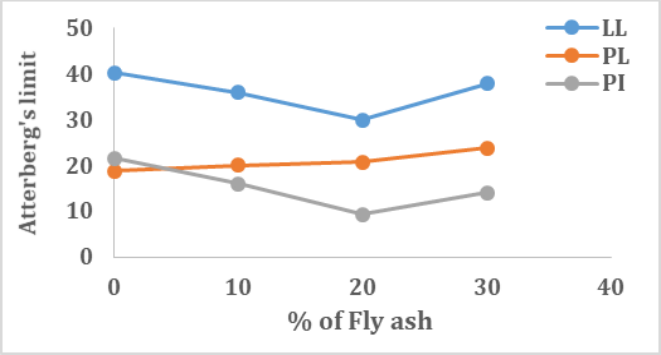

FIG-1: Atterberg's limit of BCS with fly ash specimen

Test specimen	MDD (gm/cc)	OMC (%)
Black Cotton Soil (BCS)	1.543	24..6
BCS + 10% FA	1.557	22.8
BCS + 20% FA	1.559	18.6
BCS + 30% FA	1.540	23.0

TABLE- 2: SPT for different specimen

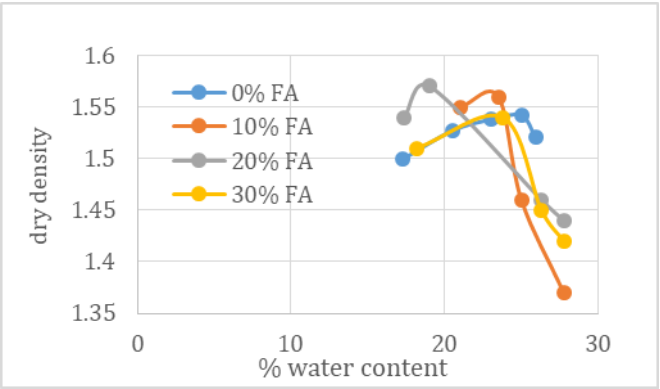

FIG-2: SPT of BCS with different % of fly ash specimen

Test specimen	Free swell index (%)	Degree of expansiveness
(BCS)	33.33	High
BCS + 10% FA	28.55	moderate
BCS + 20% FA	26.92	Moderate
BCS + 30% FA	24.93	Moderate

TABLE- 3: diff. free swell index for different specimen

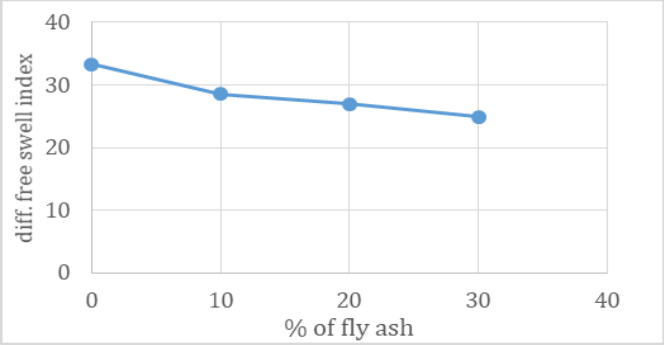

FIG-3: diff. free swell index of BCS with diff. % of fly ash

Test specimen	Penetration (mm)	Proving ring	Test load (kg)	CBR value (%)
BCS	2.5	7	8.65	0.63
	5	10	12.36	0.60
BCS + 10% FA	2.5	10	12.36	0.90
	5	14	17.30	0.84
BCS + 20% FA	2.5	17	21.01	1.53
	5	25	30.90	1.50
BCS + 30% FA	2.5	12.5	15.45	1.12
	5	18	22.24	1.08

TABLE- 4: CBR value for different specimen

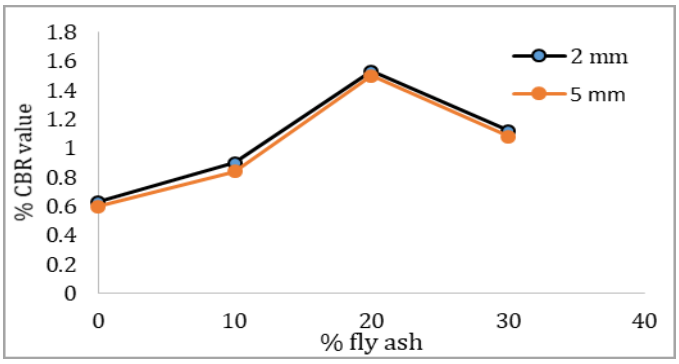

FIG-4: CBR value of BCS with diff. % of fly ash

3. CONCLUSIONS

The following results are obtained after performing the experiments.

- When 30% fly ash was added to normal soil the differential free swell index decreased about 24.93%.
- It is observed that the maximum dry density of soil is 1.543gm/cc determined. the value of maximum dry density was increased and optimum moisture content was decreased with the amount of fly ash increased. When the 20% fly ash is added in raw soil maximum dry density and optimum moisture content were obtained 1.559gm/cc and 18.60% respectively.
- The value of the liquid limit was decreased and the plastic limit was increased with the amount of fly ash increased. When 20% fly ash is added to black cotton soil value of the liquid limit, plastic limit, and plasticity index is 30%, 20.74%, and 9.26% respectively.
- The optimum percentage of fly ash observed is 20% for improving the properties of black cotton soil.
- The value of CBR varied from 0.63% to 1.53% at 2.5mm of penetration and 0.60% to 1.50% at 5mm of penetration. The maximum CBR value was obtained at 20% fly ash and at 30% of fly ash, the value of CBR was decreased.

REFERENCES

[1] I.S.2720 (part-V)-1985 "method of test for determination of liquid limit and plastic limit of soil."

[2] I.S.2720 (part-40)-1977 "Method of test for determination of the free swell index of soil."

[3] I.S2720 (part-3)-1980 "Method of test for determination of specific gravity of the soil."

[4] I.S.2720 (part-7)-1980 "To establish a relationship between water content and dry density by light compaction test."

[5] Sing S, Yadav R (2015) "effect of fly-ash on geotechnical characteristics of black cotton soil." IJARSE, Vol no.02, Issue 3, pp. 2349-6010.

[6] Debanath O, Rahman A, Rahman M, Farooq S (2019) "use of fly ash-based geopolymer for stabilization of expansive soil" 9th Int. Conf. on Geotechnique, Construction Materials, and Environment, ISBN: 978-4-909106025 C3051

[7] Kumar Jangid A, Khatti J, Dharm Raj sywalka, Amit Kumar Jangid E, Jitendra Khatti E (2018) "study of engineering properties of black cotton soil with pond ash." IJARSE, Vol no.07, Issue 2, pp. 2319-8354.

[8] Takhelmayum G, Gudi k, Savitha A.L (2013) "laboratory study on soil stabilization using fly ash mixtures." IJARSE, Vol no.02, Issue 1, pp.9001-2008.