Effect of Fly Ash and Polypropylene on the Engineering Properties of Black Cotton Soil

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Abstract

Disposal of fly ash is a problem to the environment as it is produced in large scale from the thermal power plants. Polypropylene is having a highly tensile nature as well as it is cheap in cost. The purpose of this research was to study the effect on various engineering properties of black cotton soil by mixing fly ash and polypropylene fiber with it. The maximum dry density decreased and optimum moisture content increased as polypropylene content was increased. The unconfined compressive strength of soil increased with the increase in polypropylene percentage. The optimum percentage of fly ash and polypropylene fiber was found to be 15% and 1.5% respectively.

Keywords - *Soil Stabilization, Black cotton soil, Fly Ash, Polypropylene*

I. INTRODUCTION

The soil stabilization is the process of improving the engineering properties of soil and thus making it more stable. There are many methods of soil stabilization practiced in the construction industry. Out of these methods, soil stabilization by admixtures is a popular one and used widely. Fly ash is produced in a large quantity from thermal power plants and coal burning industries. Its disposal has now become matter of concern for the environment of society. Fly ash is now being used in constructions of road, buildings in various applications. The polypropylene fiber is generally used for concreting work as reinforcement material. It is rarely used for stabilization of the soil. Polypropylene is cheap in cost and has high tensile strength. The present work is focused on studying the effect of use of combined fly ash and polypropylene mixture on the engineering properties of soil. The engineering properties considered here are maximum dry density (M.D.D.), optimum moisture content (O.M.C.), cohesion (c) and angle of internal friction (ϕ) of soil and unconfined compressive strength (U.C.S.) of soil.

II. LITERATURE REVIEW

A number of investigations have been conducted on soil stabilization using fly ash, lime or other waste materials. Also, some researchers have worked on behavior of soil when polypropylene fiber is mixed with it. A literature review was carried out to study findings of previous researches and to plan the methodology for the present research work. The literature review is briefly discussed below:

Ayyappan *et al.* in 2010 studied the influence of polypropylene fibers on engineering behavior of soil–fly Ash mixtures for road construction. The purpose of this investigation was to identify and quantify the influence of fiber variables (content and length) on performance of fiber reinforced soil- fly ash specimens. It was observed that inclusion of randomly distributed fibers significantly improved the unconfined compressive strength of soil fly ash mixtures, increase in fiber length reduced the contribution to peak compressive strength while increased the contribution to strain energy absorption capacity in all soil fly ash mixtures, optimum dosage rate of fibers was identified as 1.00 % by dry weight of soil- fly ash, for all soil fly ash mixtures and maximum performance was achieved with fiber length of 12 mm as reinforcement of soil fly ash specimens [1].

Nadgouda and Hegde in 2010 studied the effect of lime stabilization on the properties of black cotton soil. Changes in various soil properties such as liquid limit, plastic limit, maximum dry density, optimum moisture content, differential free swell, swelling pressure and california bearing ratio were studied. The inclusion of lime reduced the swelling of soil. Also, the plastic nature of the soil decreased and the stiffness of the soil increased as the lime content increased [2].

Malekzadeh and Bilsel in 2012 studied the effect of polypropylene fiber on mechanical behavior of expansive soils. It was concluded that mitigation of expansive soils using polypropylene fiber might be an effective method in enhancing the physical and mechanical properties of sub-soils on which roads and light buildings are constructed [3].

Kharade *et al*. in 2014 studied the effect of bagasse ash from sugar industry on the stabilization of expansive soils. The study laboratory experiments were conducted on black cotton soil with partial replacement by bagasse ash. It was found that increase in properties of black cotton soil obtained at 6 %

replacement of bagasse ash without any cementing or chemical material [4].

From the review it was found that limited research is done on the effect of combined fly ash and polypropylene mix on the soil stabilization. Hence, the research work was focused on effect of fly ash and polypropylene on the engineering properties of black cotton soil by adopting different percentages of fly ash and polypropylene fiber.

III. EXPERIMENTAL PROGRAMME

A. Materials Used

Locally available black cotton soil at SGGSI E & T, Nanded area was used. The fly ash was obtained from the thermal power plant at Parali, Maharashtra. The polypropylene fiber was obtained from Dolphin Floats Pvt. Ltd. in Pune. Straight type polypropylene fiber was used. Fibers of two different lengths 12 mm and 20 mm were used. Fig. 1 shows the materials used in the research.

(a) Black Cotton Soil

(b) Fly Ash

(c) Polypropylene Fiber

Fig. 1: Materials Used in the Experimental Study

Table I gives the properties of soil and fly ash and Table II gives the essential properties of polypropylene fiber.

TABLE I
PROPERTIES OF MATERIALS USED

Sr. No.	Property	Materials	
		Soil	Fly Ash
1	Specific Gravity (G)	2.47	1.82
2	Shrinkage Limit (W_S)	26.3 %	-
3	Plastic Limit (W_P)	45.22 %	-
4	Liquid Limit (W_L)	65 %	-
5	Angle of Internal Friction (ϕ)	7°	-
6	Classification	MH	SP-SM

TABLE II
PROPERTIES OF POLYPROPYLENE FIBER

Sr. No.	Property	Description
1	Length	12 mm and 20 mm
2	Diameter	40 Microns
3	Aspect Ratio	450 and 500
4	Construction	Straight type
5	Melting point	165 Deg C
6	Absorption	Nil
7	Acid Resistance	High
8	Salt Resistance	High
9	Thermal Conductivity	Low
10	Electrical Conductivity	Low

B. Proportioning of Samples

The general expression for the total dry weight 'W' of a soil fly ash fiber mixture was as given in Eq. 1..

$$W = W_s + W_f + W_{ps} \quad \text{…(Eq. 1)}$$

where, W_s, W_f and W_{ps} are weights of soil, fly ash and polypropylene fibers respectively. The material proportions considered for the study were as follows:

Proportion of fly ash = $0.15W_s$, $0.30W_s$ and $0.5W_s$

Proportion of polypropylene = $0.0075(W_s + W_f)$, $0.015(W_s + W_f)$, $0.0225(W_s + W_f)$ and $0.03(W_s + W_f)$

C. Test Programme

First of all, dry mix of soil, fly ash and polypropylene was prepared and then required amount of water equal to optimum moisture content (OMC) was added to the mix. Following tests were then conducted on the prepared mix.

1) ***Standard Proctor Test:***

Standard Proctor tests on soil - fly ash - polypropylene mixes were conducted according to guidelines of IS 2720- 1980.

2) ***Unconfined Compression Test:***

Test Specimens of size 38 mm x 76 mm were prepared using mould by compacting samples in the three layers at maximum dry unit weight and optimum moisture content determined by Standard Proctor Test. Unconfined Compression tests were conducted according to IS 2720- 1973.

3) ***Tri-axial Shear Test:***

Test Specimens similar to those were prepared in case of unconfined compression test. Tri-axial Shear Tests were conducted in accordance with IS 2720- 1973.

IV. RESULTS AND DISCUSSIONS

The results of various tests performed on the soil - fly ash - polypropylene mix are discussed suitably.

A. Effect on M.D.D. and O.M.C.

The M.D.D. and O.M.C. of soil – fly ash – polypropylene mix was determined for different percentages of fly ash and polypropylene. Fig. 2 shows the variation of M.D.D. for different percentages of fly ash as the polypropylene percentage is varied. It is observed that M.D.D. decreases with the increase in polypropylene percentage for each percentage of fly ash.

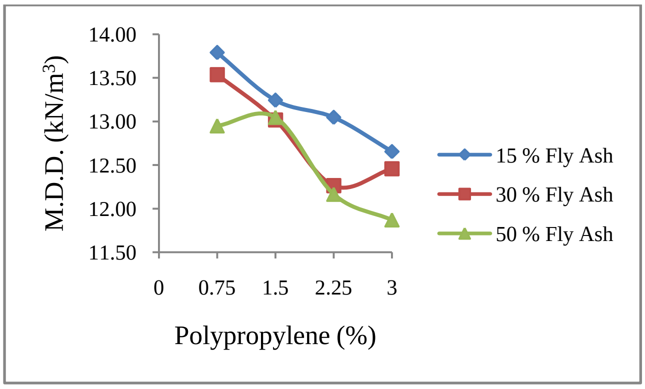

Fig.2: Effect of Fly ash and Polypropylene on M.D.D.

Similarly, Fig. 3 shows the variation of O.M.C. It is observed that O.M.C. increases with the increase in polypropylene content for each fly ash percentage.

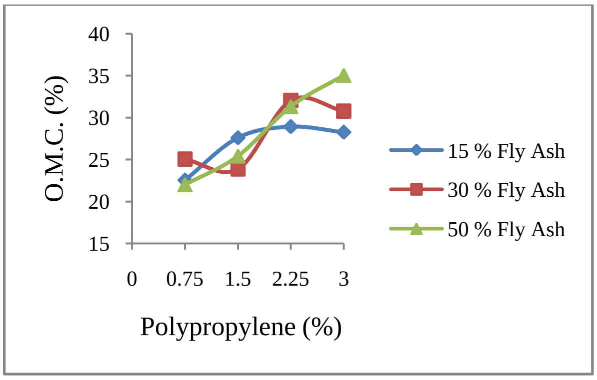

Fig. 3: Effect of Fly ash and Polypropylene on O.M.C.

B. Effect on Cohesion (c)

The cohesion (c) of the soil – fly ash – polypropylene mix was determined using the results of tri-axial shear tests. Fig. 4 shows the variation of cohesion for different percentages of fly ash and polypropylene. The maximum cohesion was found with the 1.5 % of polypropylene.

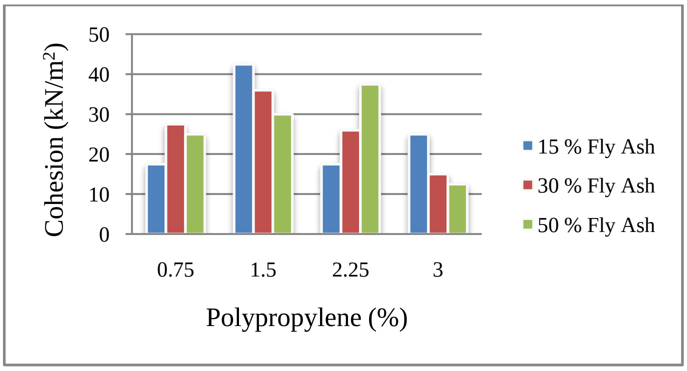

Fig. 4: Effect of Fly ash and Polypropylene on Cohesion

C. Effect on Angle of Internal Friction (ϕ)

Fig. 5 shows the variation of angle of internal friction for different fly ash and polypropylene percentages. It is found that the angle of internal friction increased with the increase in polypropylene percentage.

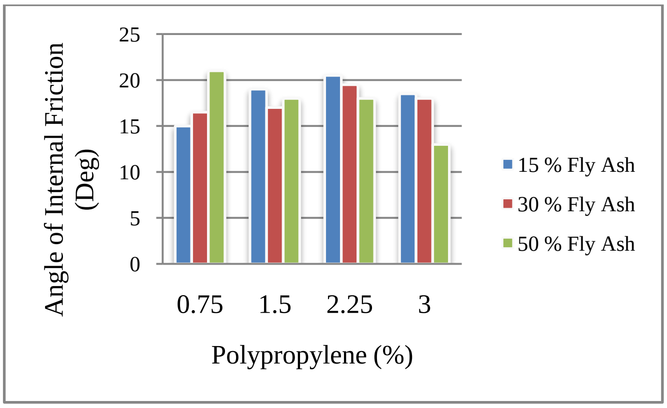

Fig. 5: Effect of Fly ash and Polypropylene on Angle of Internal Friction

D. Effect on U.C.S.

The unconfined compressive strength of the soil – fly ash – polypropylene mix for each percentage of fly ash and polypropylene was determined. Fig. 6 shows the variation of U.C.S. for each percentage of fly ash and polypropylene. It is observed that the U.C.S. increases up to 2.25 % polypropylene percentage and then decreases.

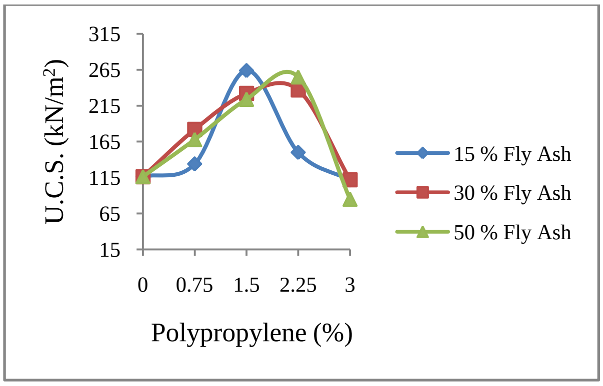

Fig. 6: Effect of Fly ash and Polypropylene on U.C.S.

V. CONCLUSIONS

The black cotton soil was mixed with fly ash and polypropylene as admixtures. The percentages of both the admixtures were varied. The effect of these admixtures on engineering properties of soil was studied by performing laboratory tests. From the results few conclusions were drawn as below:

- The Maximum Dry Density of black cotton soil decreases and the Optimum Moisture Content increases as the polypropylene percentage increases for each fly ash percentage. This causes because the particle size of fly ash is greater than that of soil and specific gravity of fly ash is less than that of soil.
- The optimum value of polypropylene percentage is 1.5 % and that of fly ash is 15 % from cohesion point of view.
- The angle of internal friction (ϕ) increases with the addition of fly ash and polypropylene.
- The Unconfined Compressive Strength of soil increases with the increase in polypropylene percentage. The optimum percentage of fly ash is 15 % and that of polypropylene is 1.5 % from the U.C.S. point of view.

Overall it is concluded that the black cotton soil mixed with fly ash and polypropylene fibers can be considered to be good ground improvement technique especially in engineering projects on expansive soils where it can act as a substitute to deep/raft foundations, reducing the cost. The optimum percentage for fly ash and polypropylene can be taken as 15 % and 1.5 % respectively.

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