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STABILIZATION OF SOIL USING WASTE FIBER POLYPROPYLENE

Riddhi Vashi[1], Amit Patel[2]

[1]*G.H.Patel College of Engineering and Technology, Anand, Gujarat-388120, India,*
[2]*B.V.Patel Institute of Technology, Umrakh, Bardoli Gujarat-394345, India*

Abstract— ***To utilize the industrial waste, a challenge is made to stabilize the black cotton soil by adding polypropylene fibers. Large acres of land are occupied by industrial waste, which creates environmental problems also with a scarcity of land. To evaluate the effect of the addition of 0%, 0.25%, 0.50%, 0.75%, 1.0%, 1.25% polypropylene fibers to stabilize the black cotton soil and verify its suitability to be used as a construction material for road, embankment and structural fills is investigated in the region of Black cotton soil. Its consistency properties, compaction properties, and strength parameter are also analyzed in this paper.***

Keywords— Black cotton soil, polypropylene fibres, industrial waste

I. INTRODUCTION

The stabilization of soil in a wider sense is to improve the strength and modification of soil to its engineering performance. Soil stabilization is broadly used in connection with road, pavement and foundation construction and it improves the engineering properties of the soil in terms of volume stability, strength, and durability [1]. A soil that is treated with polypropylene fiber is modified and its properties are changed which may lead to stabilization. When a sufficient amount of polypropylene fibres is added to the soil. Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, hence, we need to stabilize the soil which makes it easier to predict the load-bearing capacity of the soil and even improve the load-bearing capacity. The gradation of the soil is also a very important property to keep in mind while working with soils. The soils may be well-graded which is desirable as it has a smaller number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils to improve soil strength properties. It is very expensive to replace the inferior soil entirely soil and hence, soil stabilization is the thing to look for in these cases. [2-7]

Black cotton soil is generally, derived from weathering of ancient metamorphic rocks of the ancient Deccan plateau. Black cotton soil is usually that group of soil that develops in warm temperature and is generally abundant in moist climate where deciduous or mixed forests are present. They generally have thin organic and inorganic mineral layer overlaying a yellowish-brown layer resting on the alluvial deposits. Black cotton soil is available in many states of India like Odisha, Tamil Nadu, Karnataka, Maharashtra, Chhattisgarh, Birnbaum (West Bengal), Mirzapur, Jhansi, Haripur (Uttar Pradesh), Udaipur, Durgapur, Batswana, and Bhilwara districts (Rajasthan), Hastinapur of Jharkhand, and Andhra Pradesh[8-9] There are different four methods to stabilize the soil is, Mechanical method of stabilization, Additive method of stabilization, Oriented fiber reinforcement, and Random fiber reinforcement.

Polypropylene fiber is used to make iron operate on temperatures capable of 2000°C and are feed with carefully to an inhibited mixture of stone, iron ore, and coke. The iron ore transfer to iron which sinks to the base of the furnace. Polypropylene fibres a by-product material generates by thermal power plants from the combustion of iron, iron ore, iron scrap, and fluxes (limestone or dolomite) are charged into a blast furnace along with coke for fuel. The coke is combusted to produce carbon monoxide, which reduces the iron ore to molten iron product. This molten iron product can be iron products, but it is most often used as a feedstock for steel production. Polypropylene fibres a non-metallic co-product produced in the process. It consists primarily of silicates, alumina silicates, and calcium alumina silicates. The molten slag, which absorbs much of the Sulphur from the charge, comprises about 20 percept by mass of iron production. The polypropylene fiber is considered as a waste disposal which can be used in the construction material like road, pavement, railway ballast, landfills, etc. [10-12].

II. MATERIAL SPECIFICATION & EXPERIMENTAL SET-UP

Black cotton soil is derived from weathering of ancient metamorphic rock of the Deccan plateau. Black cotton soil is any of a group of soil that grows in a humid temperature, moist climate under deciduous sand mix forests and that have raw mineral. Thin organic layers overlying a yellowish-brown leached deposit resting on an alluvial. Their colour is mostly ferric oxides occurring a slight coating on the soil particle through the iron oxide arise as hematite as hydrous ferric oxide, the colour is red and when it happens in the hydrate system as limonite the soil become to be a yellow colour. Generally, the surface soils are red while the horizon under gets yellowish colour.

Particle size distribution (IS 2720 part IV) is Prepared from the field of cotton soil and let it dried in air or the sun. In wet weather, the drying apparatus may be used in which case the temperature of the sample should not exceed 60°C. Tree roots and pieces of bark removed from the sample. Big clods may be broken with the help of wooden mallets also care should be taken not to break the individual soil particles. A representative soil sample of the required quantity is taken and dried in the oven at 105°-120°C. The material retained on 75µ IS sieve is collected and dried in an oven at a temperature of 105-120°C for 24 hours. The dried soil sample is sieved through 2mm, 600µm, 425µm, and 212µm are sieves. Soil retained on each sieve is weighed. **Plastic limit test (IS 2720 Part V)** is taken out 30 gm of air-dried soil from a thoroughly mixed sample of soil passing through 4.25 µ m IS sieve. Mix the soil with the distilled water in an evaporating dish and leave the soil mass for nurturing. This period may be up to 24 hrs.

(A) (B) (C)

Fig.1: -(A) Geo-Graphical Map of Resources. (B) Black Cotton Soil (C) % polypropylene fibres.

TABLE I

PHYSICAL AND CHEMICAL PROPERTIES OF FIBER

Sr. No.	Physical and Chemical Properties	Values
1	Fiber type	Single fiber
2	Unit weight	0.91 g/cm3
3	Average diameter	0.034 mm
4	Average length	12 mm
5	Breaking tensile strength	350 M Pa
6	Modulus of elasticity	3500 M Pa
7	Fusion point	165 °C
8	Burning point	590 °C
9	Acid and alkali	Very good
10	Dispersibility	Excellent

Liquid limit test (IS 2720 Part V) is done with Air dry soil sample and break the clots. Remove the organic matter like tree roots pieces of bark, etc. About 100g of specimen passing through 425µm IS sieve is mixed thoroughly with distilled water in the evaporating dish and left for 24 hours for soaking. **Free swell index test (IS: 2720 Part XL)** is take two specimens of 10g each of pulverized soil passing through 425µm IS Sieve and oven-dry. **Standard proctor test (IS 2720 Part VIII)** test consists of compacting soil at various water contents in the mould, in three equal layers, each layer being given 25 blows of the 2.5 kg rammer dropped from a height of 30.5cm. The dry density obtained in each test is determined by knowing the mass of the compacted soil and its water content. The compactive energy used for this test is 6065 kg-cm per 100 ml of soil. **California Bearing Ratio Test (CBR) (IS 2720 Part XVI)** is developed by the California division of highways as a method for evaluating the stability of soil sub Grade and other flexible pavement materials. However, if the CBR value obtained from the test at 5.0mm penetration is higher than 2.5 mm then the test is to be repeated for checking if it comes at 5mm it is reported as CBR value of test material. An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

III. EXPERIMENTAL RESULTS OUTCOME & DISCUSSION

Experimental results are discussed in two parts as Properties of natural black cotton soil and black cotton soil polypropylene fibres added.

TABLE II
PROPERTIES OF BLACK COTTON SOIL

SR. NO.	LABORATORY TEST	RESULT	RELEVANT IS- CODES
1	Grain Size Distribution		IS 2720 Part IV
	Gravel	1.05%	
	Sand	7.45%	
	Silt & Clay	91.50%	
2	Liquid Limit (W_L)	55.72%	IS 2720 Part V
3	Plastic Limit (W_P)	28.65%	IS 2720 Part V
4	Plasticity Index (P.I)	37.07%	IS 2720 Part V
5	Free Swell Index (F.S.I)	75.10%	IS 2720 Part XL
6	Optimum Moisture Content (O.M.C)	15.65%	IS 2720 Part VIII
7	Maximum Dry Density (M.D.D)	1.486	IS 2720 Part VIII
8	California Bearing Ratio (C.B.R.)		IS 2720 Part XVI
	4 days Soaked	1.75 %	
	4 days Soaked & 7 days curing	2.05 %	
	4 days Soaked & 28 days curing	2.20 %	

Addition of polypropylene fiber added to the Black Cotton soil was treated with 0.25%, 0.50%, 0.75%,1.00% 1.25% polypropylene fiber and cured for 3days,7 days and 28 days to study its effect on consistency limits, compaction characteristics, CBR to verify the effect on consistency limit of Liquid limit and plastic limit of the soil mixed with varying percentage of Polypropylene fiber set table 2. The study of Atterberg's limits indicates that LL and PI reduce with an increasing percentage of Polypropylene fiber. It is observed that the plastic limit of Polypropylene fiber mixed soil increases with the increasing proportion comparatively substantial improvement in PI observed with Polypropylene fiber dosage up to 0.75% but thereafter improvement is reduced.

TABLE NO III

VARIATION OF LL, PL & PI UNDER VARYING % OF POLYPROPYLENE FIBER

% of fiber	LL (%)	PL (%)	PI (%)
0.00%	55.72	28.65	37.07
0.25%	54.95	29.10	25.85
0.50%	52.17	30.15	21.02
0.75%	50.15	30.90	19.15
1.00%	51.03	29.98	21.05
1.25%	51.45	28.55	22.29

Effect on compaction characteristics of standard proctor compaction tests were also performed on the Polypropylene fiber mixed soil samples. As the dosage of Polypropylene fiber increased from 0.00%, 0.25 % to 1.25%, the optimum moisture content increased gradually from 15.65 % to 22.25% and maximum dry density Increased marginally from 1.486 g/cc to 1.990 g/cc. The reason for the increase in water content may be attributed to the flocculation of particles requiring more water to coat the particles. The results of the Standard proctor test as per Table IV.

TABLE IV

VARIATION OF COMPACTION CHARACTERISTIC UNDER VARYING % OF POLYPROPYLENE FIBER

% OF POLYPROPYLENE FIBER	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY (gm/CC)
0.00%	15.65	1.486
0.25%	16.85	1.540
0.50%	17.90	1.650
0.75%	18.54	1.990
1.00%	19.64	1.785
1.25%	22.25	1.650

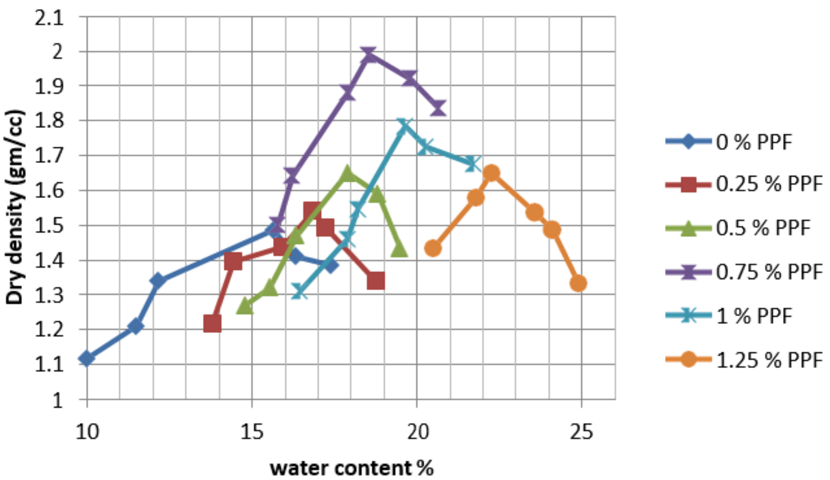

Fig. 2 compaction curve for soil treated with different percentages of polypropylene fiber.

Effect of polypropylene fiber on CBR. Three identical specimens were prepared as per IS 2720-PART XVI for each curing period (0, 7, & 28 days), soaked for 4 days and tested for CBR. The results are shown in fig. 2. It has been observed that untreated soil exhibits CBR of1.75%. Upon treatment with Polypropylene fiber, there is an increase in CBR value. As the dosage of Polypropylene fiber increased from 0.25% to 1.25%, for specimens soaked & cured for 0 days CBR increased from 1.75% to 9.00%. Upon further curing up to 28 days, an overall increase ranging from 24.12% to 39.02% in CBR was observed. This indicates that an increase in the percentage of Polypropylene fiber and curing period results in improvements in the CBR Value of the treated specimens. For the curing period 0 to 7 days, the maximum increase of CBR is 25% for 0.75% PPF replacement and for the curing period 7 to 28 days, the maximum increase of CBR is 14% for 0.75% PPF replacement.

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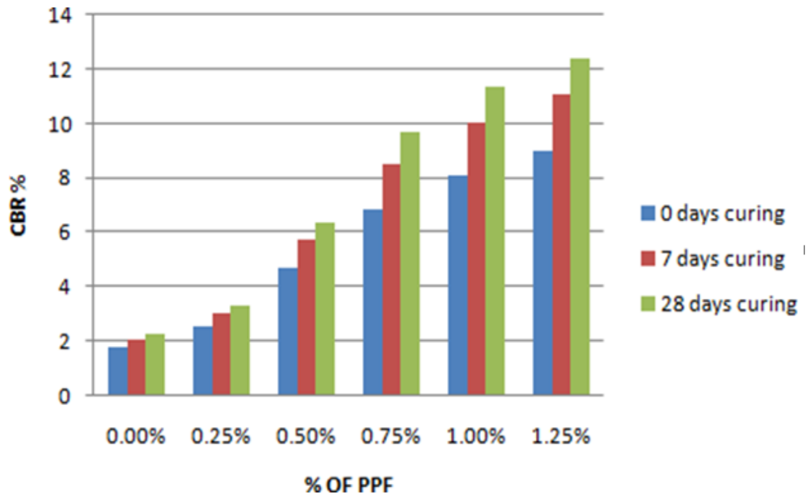

Fig. 3 Effect of additives and curing periods on CBR value.

TABLE V
% INCREASE COMPARISON OF CBR VALUE UNDER VARYING, % OF POLYPROPYLENE FIBER

Curing Days after 4 days soaking period	**0% P.P. F**	**0.25% P.P. F**	**0.50% P.P. F**	**0.75% P.P. F**	**1.00% P.P. F**	**1.25% P.P. F**
0.00	1.75	2.50	4.70	6.80	8.10	9.00
7.00	2.05	3.00	5.71	8.50	10.05	11.08
28.00	2.20	3.30	6.35	9.70	11.38	12.41
% Increase up to 7 days	17%	20%	21%	25%	24%	23%
% increase up to 7-28 days	7%	10%	11%	14%	13%	11%

Optimum dosage of polypropylene fiber is fetched as per Table IV of CBR & it is increased up to 7 days & 28 days of curing. After that soaking period of 4 days, fiber is varied from 0.25 % to 1.25 %. The percentage increase in CBR value up to 7 days is more compared to 7 to 28 days. Maximum increase in CBR value is 25% &14% in 0.75% polypropylene fiber for 7 days & 28 days curing respectively. The optimum percentage of polypropylene fiber is decided by 0.75%.

IV. CONCLUSIONS

Based on the experimental investigation on the effect of Polypropylene fiber on black cotton soil, characterized as highly plastic, with WL=55.72% & P.I. =37.07% exhibited with a low CBR value of 1.75%, 2.05%, 2.20% for 0, 7- & 28-days curing, OMC=15.65%, MDD=1.486% gm/cc respectively. Besides 0.25%, 0.5%, 0.75%, 1.0%, 1.25% Polypropylene fiber to the soil resulted in a reduction in liquid limit and increase the plastic limit which reduces the plasticity index. It also investigated that Polypropylene fiber range of 0.25 % to 1.25% in the CBR increased 1.75% to 9.00% for Zero (0) days curing, 2.05% to 11.08% for 1 week curing and 2.20% to 12.41% for 4-week curing. The maximum increase in CBR value is 25% & 14% in 0.75% Polypropylene fiber for 7 days & 28 days curing respectively is achieved in the experimental analysis. Thus, Optimum percentage of Polypropylene fiber is decided by 0.75%. The soaked CBR value of subgrade BC soil improved by the addition of Polypropylene fiber and therefore it is possible to reduce the thickness of the road. The MDD increases from 1.486 gm/cc to 1.990 gm/cc after that MDD gradually decreases with a further addition of polypropylene fiber. So optimum dosage is found at 0.75% of polypropylene fiber.

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