Experimental Study on Stabilization of Black Cotton Soil Using Polypropylene Fiber

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***Abstract*- Now a day, large across of land is occupied by industrial waste. It not only creates land problem but also creates environmental problems. In order to utilize the industrial waste, an attempt is made to stabilize the black cotton soil by adding polypropylene fibers. This project work aims to evaluate the effect of addition of 0%, 0.25%, 0.50%, 0.75%, 1.0%, 1.25% polypropylene fibers in order to stabilize the black cotton soil and to verify its suitability to be used as a construction material for road, embankment and structural fills. The polypropylene fiber is collected from AMAZON (online web.) and the black cotton soil is collected from the MOTA VARACHHA REGION for evaluating its suitability as a construction material for various geotechnical works. Its consistency properties, compaction properties, and strength parameter are tested. In this project the effect of addition of polypropylene fibers investigated and is compared with that of the virgin black cotton soil. The overall testing program was conducted in two phases. In the first phase, the physical, and chemical engineering properties of the black cotton soil samples were studied. In the second phase of the test program, black cotton soil was mixed with 0%, 0.25%, 0.50%, 0.75%, 1.0% and 1.25%of polypropylene fibers as percentage of dry weight of black cotton soil.**

***Index terms*- polypropylene fiber, stabilization; improve in SBC, economical, eco-friendly**

INTRODUCTION

The word ‘soil’ is obtained from Latin word “sodium” which means upper layer of soil (earth) that can be dugged or ploughed specially the loose surface material of earth in which plant grow soil is a mixture of organic matter most of which do not expand in presence of moisture. The term soil ‘soil engineering’ is defined as unconsolited (uncemented) material, accumulated of various soil particle generated by disintegration of rocks. It is one of the most important parts of earth eco system. It covers 29% of earth surface. The formation of soil from rock is very long process and its takes many years. The Indian council of Agriculture Research has divided Indian soils into 8 major groups like 1.Alluvial soil 2.Black soil 3.Red and yellow soils 4.Arid and desert soils 5.Saline and alkaline soil 6.Peaty and marshy soils 7.Forest and mountain soils. As top most layer of earth surface is soil most of the construction work is carried out on soil. All the construction work requires stable soil. If the soil is not stable the structure will get fail and the building will get collapse. So the soil needs to get stabilize before the construction work is began. The stabilization of soil can be done by chemical method, mechanical method etc.

MATERIALS AND METHODS

Black Cotton Soil:- It is found in Deccan plateau-Maharashtra, Madhya Pradesh, Gujarat, Andra Pradesh, Tamilnadu, valleys of Krishna and Godavari. It is rich in lime, magnesia and alumina, potash. It lacks of phosphorus, nitrogen, organic matter. In black soil crops like cotton, sugarcane, jowar, wheat, rice etc. are grown.

Polypropylene Fiber:-

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	12mm
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	Dispensability	Excellent

1. Liquid limit:-

Aim:-To determine the liquid limit of soil.

Apparatus:- 1.Balance 2.Liquid limit device (cone penetrometer) 3.Grooving tool 4.Mixing dish 5.Spatula 6.Electrical oven

Procedure:-Take 150gm of oven dry soil passing from 425 micron IS sieve. 1. Add water to the soil and form uniform paste. 2. Now take cylindrical cup of cone penetrometer and fill it with the wet paste and ensure that no air is trapped in the cylinder in this process. 3. Then level the top surface of cylinder with the help of spatula. 4. Now adjust the penetrometer is such a way that the cone point just touches the surface of soil paste in the cylinder and take the reading of dial. 5. Now release the vertical clamp and allow the cone to

Test of Soil with Untreated Soil:-

Sr No	Dish No.	Weight of Dish	Weight of Dish+ Wet Soil	Weight of Dish + Dry Soil	Penetration	Moisture Content%	Liquid Limit = Moisture Content/(0.65 + (0.0175*Penetration))
		W1(gm)	W2(gm)	W3(gm)	Y(mm)	W (%)	WL (%)
1	100	33	55.2	46.99	18.9	58.68	60.42
2	14	30.54	58.05	47.89	21.6	58.56	57.57
3	90	29.45	53.65	44.87	17.7	56.94	59.88
4	5	32.9	54.93	46.71	16.9	59.52	63.50
						Average	60.34

Test of Soil With 0.75% Polypropylene Fiber:-

Sr No.	Dish No.	Weight of Dish	Weight of Dish + Wet Soil	Weight of Dish + Dry Soil	Penetration	Moisture Content%	Liquid Limit= Moisture Content/(0.65 + (0.0175*Penetration))
		W1 (gm)	W2 (gm)	W3 (gm)	Y (mm)	W (%)	WL (%)
1	P1	26	65	50.1	24.5	61.82	57.31
2	P2	28	71	54.82	24.5	60.32	55.92
3	P3	27	68	53	24.5	57.69	53.48
						Average	55.57

2. Plastic limit test:-

Aim:- To find out plastic limit of soil.

Apparatus:- 1. Porcelain dish 2. Glass plate for penetrate the soil paste under its own weight for five seconds and after five second note the penetration of cone to the neared millimeter. 6. The test is repeated for four times having range of penetration between 14mm to 28mm. 7. The moisture content of each trail is determined. rolling the specimen 3. Air tight containers 4. Balance 5. Oven

Procedure:- 1. Take oven dried soil sample of 20 gm passing from 425 micron IS sieve. 2. Now add water to soil and mix thoroughly until the soil become plastic enough to be molded with help of fingers. 3. Now the mixture in kept for sufficient time for allowing water to spread throughout the soil mass. 4. Now take 10gm of mixture and roll gently on glass plate with help of fingers into a thread with uniform diameter throughout the length. 5. The rate of rolling shall be 60 and 90 stokes per minute. 6. The rolling is continued until the diameter of thread become 3mm. 7. The soil is then kneaded together to a uniform mass and rolled again. 8. The process is continued until the thread breaks with the diameter of 3mm. 9. The pieces of thread which are broken is collected in air tight containers for determine moisture content determination.

Test of Soil with Untreated Soil:-

Sr No.	Dish No.	Weight of Dish	Weight of Dish + Wet Soil	Weight of Dish + Dry Soil	Plastic Limit Moisture Content
		W1(gm)	W2 (gm)	W3 (gm)	Wp (%)

1	P1	20	23.8	22.89	27.33
2	P2	22	25.3	24.6	26.92
3	P3	23	26.85	26	28.33
				Average	27.53

Test of Soil with 0.75% Polypropylene Fiber:-

Sr No.	Dish No.	Weight of Dish	Weight of Dish + Wet Soil	Weight of Dish + Dry Soil	Plastic Limit= Moisture Content
		W1(gm)	W2(gm)	W3 (gm)	Wp (%)
1	P1	24.5	27.19	26.56	30.58
2	P2	25.4	28.5	27.77	30.80
3	P3	24	27.2	26.45	30.61
				Average	30.66

3. Grain size analysis:-

Aim :- To do grain size analysis of soil, Obtain percentage of soil retain of particular sieve.

Apparatus:- 1. Balance 2. I.S. sieves 3. Mechanical Sieve Shaker.

Procedure:- 1. Take 1000gm of over dry soil. 2. Arrange the sieves in order of 4.75 mm, 2.36 mm, 1.18 mm, 0.60 mm, 0.30 mm, 0.15 mm, 0.075 mm.

3.Now add the soil in the sieves and shake it manually or with the help of mechanical sieve shaker.

4. Now take the weight of soil that is retaining on each sieve.

4. Standard Proctor test:-

Aim:- To determine maximum dry density and optimum moisture content of given soil sample using standard proctor test.

Apparatus:- 1. Standard proctor mould 2. Standard proctor rammer of weight 2.5 kg having a fall of 30.5 cm 3. 2.5 kg oven dry soil sample 4. Fiber hammer 5. Measuring cylinder

Procedure:- 1. Calculate the volume of proctor mold from the measured dimensions i e. from diameter and height of the mold. 2. Take the weight of the empty mold without base plate & collar. 3. Take 2.5 kg of dry soil samples, passing through 4.75 mm sieve and add water 10% by its volume with the help of measuring cylinder. 4. Mix the soil and water thoroughly and divide the mix in to 3 parts. Put one part of soil into the mold after oiling the mold. 5. Apply full height 25 blows with the rammer put the other two layers of soil & repeat ramming in a similar fashion while scratching the previous layer for proper bonding.

6. Measure the weight of soil &mold after leveling the mold& note it. Find bulk density for the particular reading. 7. From top, bottom and center of the mold keep sample for water content determination. 8. Then by an increment of 2% of water added every time repeat the procedure till the weight of sample starts decreasing, after reaching the maximum bulk density. 9. Take 2 reading once there is decrease in weight of mold& soil (i.e. decrease in the bulk density).

Test of Soil with Untreated Soil:-

Determination Number	1	2	3	4	5	6
Wt. of mould + Compacted Soil W(gm)	5231	5312	5409	5450	5412	5394
Wt. of mould Wm(g)	3748.5	3748.5	3748.5	3748.5	3748.5	3748.5
Wt. of compacted	1482.5	1563.5	1660.5	1701.5	1663.5	1645.5

Water Added (%)	8	10	13	16	19	22
Wet Density Ym (Wd)	1.48	1.56	1.66	1.70	1.66	1.64
Moisture Content						
Crucible Dish No.	P1	P2	P3	P4	P5	P6
Wt. of Empty CrucibleW1(g)	23.86	21.00	20.95	23.41	25.06	27.16
Wt. of crucible + Wt. of Wet soil W2 (g)	38.56	39.25	42.36	45.75	49.30	54.32
Wt. of crucible + Wt. of Dry Soil W3(g)	37.00	37.10	39.65	42.68	45.62	50.14
Moisture Content W%	12.55	13.35	14.49	15.93	17.89	18.19
Dry Density (g/cc)	1.32	1.38	1.45	1.47	1.41	1.39

Test of Soil with 0.75% Polypropylene Fiber:-

Determination Number	1	2	3	4	5	6
Wt. of mould + Compacted Soil W(gm)	5486	5595	5742	5885	5835	5842

Wt. of mould Wm(g)	3748.5	3748.5	3748.5	3748.5	3748.5	3748.5
Wt. of compacted Soil (g)	1737.5	1846.5	1993.5	2136.5	2086.5	2093.5
Water Added (%)	8	10	13	16	19	22
Wet Density Ym (Wd)	1.73	1.84	1.99	2.13	2.08	2.09

Moisture Content						
Crucible Dish No.	P1	P2	P3	P4	P5	P6
Wt. of Empty Crucible W1(g)	13.85	16.16	16.34	12.70	12.00	12.54
Wt. of crucible + Wt. of soil W2 (g)	39.24	39.43	45.65	48.42	45.62	48.25
Wt. of crucible + Wt. of Dry Soil W3(g)	36.25	36.39	41.48	42.80	39.25	40
Moisture Content W%	13.34	15.02	16.58	18.67	23.37	30.04
Dry Density (g/cc)	1.53	1.61	1.71	1.80	1.69	1.61

5. California bearing ratio test:-

Aim:- The ratio of force per unit area required to penetrate into a soil mass with a circular plunger of 50mm diameter at the rate of 1.25 mm/min is called California Bearing Ratio.

Apparatus:- 1. Compression machine 2. Proving ring 3. Dial gauge 4. Timer 5. Sampling tube 6. Split mould 7. Vernier caliper 8. Balance

Procedure:- 1. In this test, take the sample of soil weighing about 6 kg and mix thoroughly at Optimum Moisture Content. Weigh the mould with base plate and extension collar removed and then replace it. Place a spacer disc over the base plate and place a coarse filter paper on the spacer disc.

2. Place the mould on a solid base such as plinth or a concrete floor and compact the wet soil in to the mould in five layers by giving 56 blows with 4.90 kg rammer equally distributed and dived from a height of 450 mm. 3. Remove the extension collar from the mould and trim the compacted soil with the top of mould using a straight edge and record the weight. Remove the spacer disc by arranging the mould and record the weight of the mould with compacted soil. 4. Place a filter paper between the base plate and the mould. Replace the extension collar of the mould. Repeat the procedure to prepare two more specimens. Place the perforated plate and stem on the compacted soil specimen in the mould. 5. Insert the weights to produce equal surcharge to the weight of base material and pavement to the nearest 2.5kg on the perforated plate. 6. Submerge the whole mould and weights in a tank of water allowing free access of water to the top and bottom for 96 hours.

6. Free swell index test:-

Aim:- For determination of free swell index of soil.

Apparatus:- 1. Oven 2. Balance 3. Sieve 4. Graduated glass cylinder 5. Kerosene oil

Procedure:- 1. Take two batch of 10gm oven dried soil specimens passing through 425 micron IS sieve. 2. Poured each specimen in 100ml glass graduated cylinders. 3. Fill the glass graduated cylinder with water and kerosene respectively upto 100 ml mark. 4. Remove air entrapped in it with the help glass rod and allow settling for 24 hours. 5. After 24 hours the final volume of soil in each cylinder is read out.

CONCLUSION

1. Black cotton soil, characterized as highly plastic, with WL=60.34 % & P.I. =32.81% exhibited a low CBR value of 5.58% at 2.5mm penetration and 5.31% at 5 mm penetration and OMC=15.93% , MDD=1.47gm/cc respectively.
2. The plastic inclusions can improve the strength thus increasing the bearing capacity of the soil.
3. Addition of 0.25%, 0.5%, 0.75%, 1.0% Polypropylene fiber to the soil resulted in reduction in liquid limit and increase plastic limit. Thus reduction in plasticity index.
4. Addition of Polypropylene fiber (0.25 % to 1.00%), the CBR increased marginally from 5.58 % to 9.47% for 2.5 mm penetration, 5.31% to 8.92 % for 5 mm penetration. Maximum value of CBR is 9.47% at 2.5 mm penetration and 8.92% at 5mm penetration in 0.75% Polypropylene fiber and then value start decreasing at 1%. Thus Optimum percentage of Polypropylene fiber is decided 0.75%.
5. The soaked CBR value of sub grade BC soil improved by addition of Polypropylene fiber and therefore it is possible to reduce the thickness of road.
6. The Maximum dry density (MDD) increase with different percentages of addition of polypropylene fiber. As MDD increases strength of soil also increases.
7. The MDD increases from 1.47 gm/cc to 1.8 gm/cc after that MDD gradually decreases with

further addition of polypropylene fiber. So optimum dosage is found at 0.75% of polypropylene fiber.

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