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Stabilization of Black Cotton Soil by Using Plastic Granules as a Subgrade Material

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Abstract - *Construction of roads and other civil engineering structures on black cotton soil is risky due to its low shear strength, high compressibility and high permeability. In such situation the practice is to change the soil properties by adding different additives such as plastic granule, fly ash, etc., and it is known as soil stabilization. The stabilization of foundation soil constitutes gaining importance in the present civil engineering work*

In this study an attempt has been made to improve the engineering properties of Black Cotton soil; which plays a very vital role for improving its Maximum Dry Density (MDD) and California Bearing Ratio (CBR)value .In this study plastic granule are added in varying proportion. The plastic granules are added in % of dry weight of soil. The addition of plastic granules is varied from 3%, 6% & 9% of dry weight of soil. After adding plastic granules in different percentage it was observed that as % of plastic granules increases the maximum dry density and CBR value of soil increases. The maximum dry density was increases from 1.97 to 2.01 g/cc and CBR value from 1.31 to 1.97% at 6% of plastic granules. It was found that Engineering property of black cotton soil sustainably improves with the addition of Plastic granules.

Key Words: **Black Cotton Soil, plastic granules, Soil stabilization, MDD, CBR**

1. INTRODUCTION

Industrial development in India has demanded construction of infrastructure facility such as highways, airports seaports and residential, commercial buildings. There is a necessity to select a good soil conditions for proper safety consideration of all these projects. Such soils reveal extreme stages of consistency from very hard to very soft when saturated. Expansive soils have minerals that are capable of absorbing water. They incur severe volume changes corresponding to changes in moisture content. They increase in their volume when they consume water and reduce in their volume on evaporation of water. Because of their alternate shrinkage and swelling, they result in detrimental cracking of lightly loaded civil engineering structures such as foundations, retaining walls, canal beds and linings, pavements, airports, side -walks. Due to these motive Black Cotton Soils are generally poor material for construction. So to improve the engineering properties of soil, stabilization is done. Soil stabilization is the process of mixing materials to improve engineering properties of soil like increasing compressibility and permeability, shear strength, thus improving load bearing capacity of a sub-grade to support pavements and foundations.

In this study, effect of plastic granules in varying proportion on utter berg's Limit, Specific gravity, Maximum Dry Density (MDD), Optimum Moisture Content (OMC), and California Bearing Ratio (CBR) on Black Cotton Soil has been discussed. The percentage of plastic granules by weight of soil will take as 3%, 6%, and 9% in increasing order as per results. By using the above test on the black cotton soil the compressive strength and its property is increased by using plastic granules as an admixture.

2. MATERIALS USED

2.1 Black Cotton Soil

The black cotton soil was used for the study is collected from Solapur (Solapur dist., Maharashtra state, India). Major soil deposits in the Solapur is black cotton soils which is very fertile and suitable for agriculture but not good for construction of civil engineering structures by virtue of its low bearing capacity and severe shrink- swell process which results in development of cracks.

Fig -1: Black Cotton Soil

2.2 Plastic Granules

Plastic granule, i.e. Polyethylene terephthalate, is a significant material used in this project work for the stabilization of black cotton soil. It possesses a completely unique set of properties that make it extremely beneficial.

The main reason for selecting plastic granules is locally available and cheaper than any other conventional materials for stabilization. It is regarded as a good addition for soil stabilization to improve the engineering properties of soil due to its numerous benefits. Plastic granules were also found to be effective materials for stabilization, so they were chosen for the stabilization of black cotton soil.

Fig -2: Plastic Granules

2.3 Water

The potable water available in the area was used for mixing and soaking of black cotton soil specimen.

3. METHODS OF WORKING

A series of laboratory test are conducted on both black cotton soil as well as on plastic granules mixed with black cotton soil in various proportion. First we conducted experiment on black cotton soil without addition of any plastic granules. After that we had added 3%, 6% and 9% of plastic granules to that soil and compared with results. Tests are going too performed on black cotton soil:

a. Sieve Analysis- IS 2720(part 4):1985
b. Atterberg's Limits i.e. Liquid Limit And Plastic Limit - IS 2720(PART5):1985,
c. Modified Proctor Compaction Test (Heavy Compaction)- IS 2720(PART8):1983
d. CBR(California Bearing Ratio)- IS 2720(PART16):1987
e. Free Swell Test- IS 2720(PART40):1977
f. Specific Gravity- IS 2720(PART3):1980

1. Adding additives in soil in different proportions like 3%, 6% and 9%.
2. Find the percentage of which the maximum soil strength is obtained. Also a comparative study of the properties of untreated soil and treated soil with additives will also do.
3. The additive is effectively reduced optimum moisture content and increased maximum dry density and soil fit for pavement construction as a sub-grade of road.

3.1 Test Procedures

To determine the characteristics like Grading by Sieve Analysis, Atterberg's Limits i.e. Liquid limit using Casagrande Method, Plastic limit by rolling the sample to 3mm diameter thread, Optimum Moisture Content and Maximum Dry Density using Modified Proctor Compaction Test, California Bearing Ratio (four days soaked), Free Swell Test and Specific Gravity for black cotton soil with and without addition of different percentage of plastic granules. The different tests were conducted in order to identify the different characteristics and properties of the black cotton soil.

4. RESULTS AND DISCUSSION

4.1 Index Properties of Black Cotton Soil

The Sieve analysis, Atterberg's limits, Modified Proctor Compaction Tests, CBR, Free Swell and Specific Gravity tests were conducted on black cotton soil.

Table -1: Index Properties of Black Cotton Soil

SL.NO.	Properties	Limit	Result
1	Classification	CH-MH	CH
2	Liquid limit	50-120%	60.4%
3	Plastic limit	20-60%	24.29%
4	Plasticity index	30-60%	36.11%
5	Optimum moisture content	20-35%	15.15%
6	Maximum dry density	1300-1750 Kg/M^3	1970 Kg/M^3
7	Soaked CBR	2.68%	1.31%
8	Free swell	40-180%	63.07%
9	Specific gravity	2.6-2.75	2.69

The Liquid limit, Modified Proctor Compaction Tests, CBR Test and Free Swell tests were conducted on Black cotton soil with the addition of plastic granules in %. The results have been discussed in the following paragraphs.

4.2 Liquid Limit Test

The lowest liquid limit value of 47.3 % was recorded at 9% plastic granules replacement. Although, a constant decrease of liquid limit values was recorded with increase in plastic granules replacement. This shows that plastic granules as a positive effect in decreasing liquid limit of Black Cotton Soil, when Black Cotton Soil are replaced with plastic granules.

Table -2: Liquid Limit Value with Different % of Plastic Granules

% OF PLASTICS GRANULES	LIQUID LIMIT
0	60.4
3	57.8
6	49.1
9	47.3

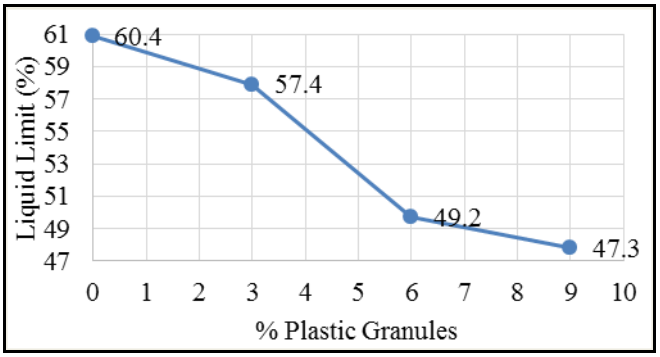

Chart -1: Liquid Limit Curve with Different % of Plastic Granules

4.3 Modified Proctor Compaction Test

Compaction Characteristics Changed by the Addition of Plastic Granules to investigate the variation in maximum dry density and optimum moisture content with the addition of plastic granules, modified Proctor Compaction tests were performed. The dry density of all samples increases with increasing water content until it reaches the optimum moisture content, at which point it decreases with increasing water content.

The variation of maximum dry density and optimum moisture content with Plastic granules content is shown in the table below. The addition of plastic granules constantly raises the dry density. However, a higher percentage of Plastic granules (above 6%) reduced dry density (d). At 6% stabilizers, the MDD was 2.01 g/cc. When more plastic granules are added, the amount of water adsorbed by the stabilizer in the mixing stage may be expelled under compactive effort, contributing to an increase in OMC at higher stabilizer content and decreasing after 6 percent stabilizer addition.

Table -3: OMC & MDD Values of Modified Proctor Compaction Test

% OF PLASTIC GRANULES	MDD (g/cc)	OMC (%)
0	1.97	15.15
3	1.99	8
6	2.01	6.38
9	1.8	11.54

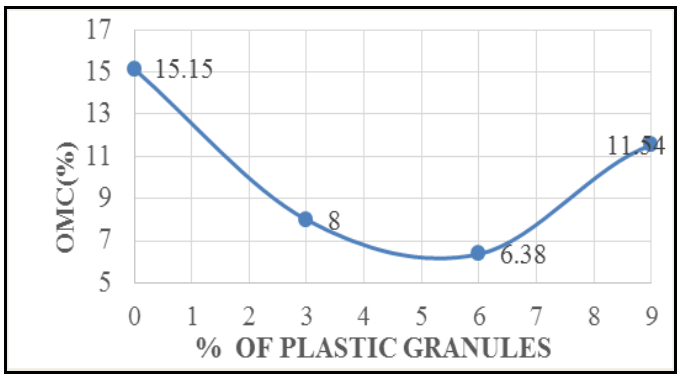

Chart -2: OMC Curve with Different % of Plastic Granules

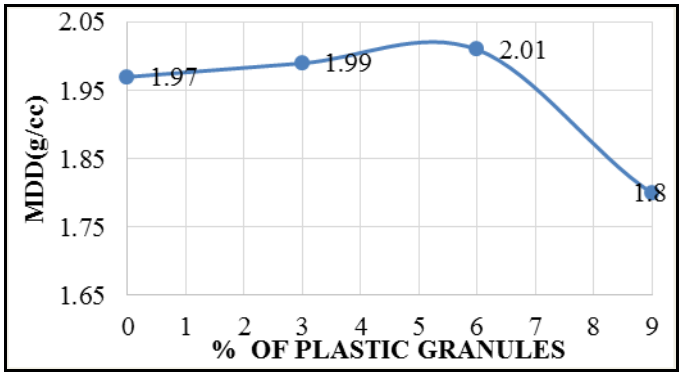

Chart -3: MDD Curve with Different % of Plastic Granules

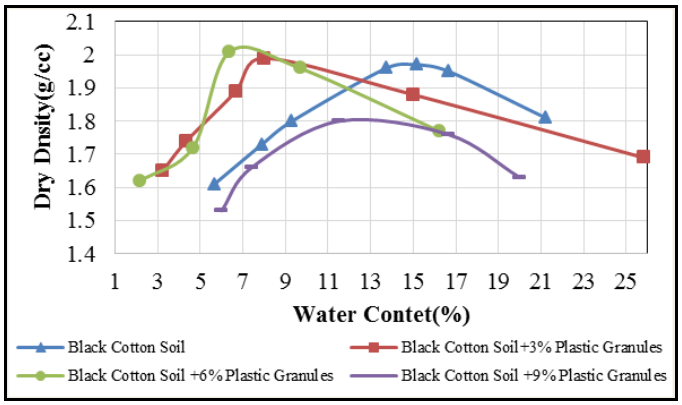

Chart -4: Mixed Modified Proctor Compaction Curve with Different % of Plastic Granules

From above test results, we can observe the decrease in the OMC (Optimum Moisture Content) with the addition of different percentage of plastic granules leads to decrease swelling of the soil and MDD (Maximum Dry Density) increases.

4.4 California Bearing Ratio (Soaked) Test

CBR Variation with Plastic Granules, CBR studies were conducted to determine the variation in the strength characteristics of the soil stabilized with Plastic granules. When plastic granules are added to soil, the soil's strength is initially increased. Increased plastic granules in soil above an optimum percentage resulted in a decrease in strength.
The CBR value of the soil increased initially in the soaked condition (compacted sample immersed in water for 96 hours) due to densification achieved by filling voids in soils with Plastic granules. When the stabilizer content is increased above the optimum percentage (6%), the CBR value decreases. This decrease could be attributed to the adsorption of water by plastic granules, which act as a cushion in the soil and do not provide enough water molecules to hold the soil particles together. A maximum CBR value of 1.97 percent was obtained at 6 percent stabilizer under soaked conditions, after which the CBR value decreases. The CBR value increases with the addition of varying percentages of plastic granules, with the optimum obtained at 6% of the sample. Based on the findings, we can conclude that 6 percent plastic granules are optimal for stabilizing Black Cotton soil.

Table -4: California Bearing Ratio (Soaked) with Different % of Plastic Granules

% OF PLASTICS GRANULES	2.5MM PENENTRATION	5MM PENENTRATION
0	1.31	1.17
3	1.75	1.46
6	1.97	1.61

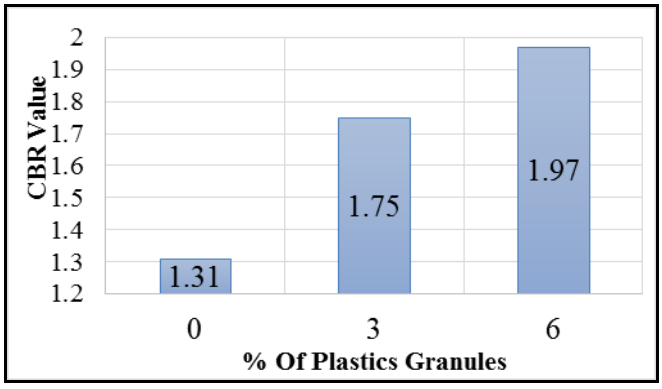

Chart -5: California Bearing Ratio Curve (Soaked) with Different % of Plastic Granules

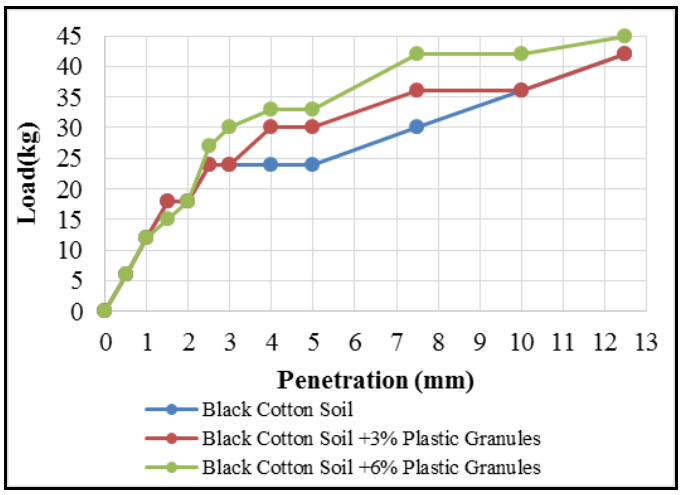

Chart -6: Mixed California Bearing Ratio Curve (Soaked) with Different % of Plastic Granules

4.5 DIFFERENTIAL FREE SWELL TEST

The differential free swell index test for different % of Plastic granules was conducted in the laboratory. The results show that the differential free swell index of black cotton soil is 63.07%. After soil stabilization, the differential free swell index value for the final optimum mix reduced to a 36.36%.. Also, as per Indian standard, the degree of the expansiveness of black cotton soil is very high i.e. 40-180%. But after soil stabilization, the differential free swell index is decreased appreciably and it belongs to a high i.e.35-50%.

Table -5: Differential Free Swell Values with Different %of Plastic Granules

% OF PLASTICS GRANULES	FREE SWELL
0	63.07
3	50
6	40
9	36.36

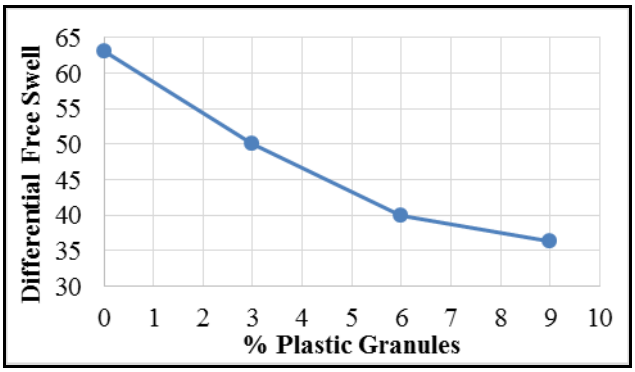

Chart -7: Differential Free Swell Curve with Different % of Plastic Granule

5. DISCUSSIONS OF RESULTS

5.1 Liquid Limit Test

1. The liquid limit of the black cotton soil was found to be 60.4%
2. The liquid limit of the black cotton soil with addition of 3%, 6% and 9% of plastic granules by weight of black cotton soil is found to be 57.8%, 49.1% and 47.3% respectively when compared to liquid limit of black cotton soil.

5.2 Modified Proctor Compaction Test

1. The Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of black cotton soil were found to be 1.97g/cc and 15.15% respectively.
2. The MDD of the black cotton soil with addition of 3%, 6% and 9% of plastic granules by weight of black cotton soil is found to be 1.99 g/cc, 2.01 g/cc and 1.8 g/cc respectively and the corresponding OMC is found to be 8%, 6.38% and 11.54% respectively.

5.3 California Bearing Ratio (Soaked) Test

1. The CBR value of black cotton soil was found to be 1.31%
2. The CBR value of the black cotton soil with addition of 3% and 6% of plastic granules by weight of black cotton soil is found to be1.75% and 1.97% respectively is found to be increased.

5.4 Differential Free Swell Test

1. The differential free swell of the black cotton soil was found to be 63.07%

The differential free swell of the black cotton soil with addition of 3%, 6% and 9% of plastic granules by weight of black cotton soil is found to be 50%, 40% and 36.36% respectively when compared to differential free swell of black cotton soil.

6. CONCLUSIONS

The experimental investigations done so as to bring out the effect of stabilization of black cotton soil using plastic granules gave a good result. From the series of tests conducted on black cotton soil mixed with various % of plastic granules, based on the results presented below, the following conclusions are drawn:

1. The black cotton soil sample has been categorized as well graded soil and depends upon the liquid limit and plastic limit test soil is classified as clay with high compressibility after sieve analysis.
2. There is substantial increase in MDD with increase in addition of plastic granules 6% by weight beyond which it decreased. The value of MDD was obtained as 2.01g/cc at 6% Plastic granules by weight of soil.
3. There is substantial decrease in OMC with increase in addition of plastic granules 6% by weight. The value of OMC was obtained as 6.38 % at 6% Plastic granules by weight of soil.
4. There is substantial decrease in Free Swell with increase in addition of plastic granules 6% by weight. The value of Free Swell was obtained as 40 % at 6% Plastic granules by weight of soil.
5. The California bearing ratio (CBR) of the original black cotton soil is obtained as 1.31 % and it increased to 1.97% after stabilizing it with 6 % plastic granules.
6. The percentage increase in Soaked CBR value after stabilizing it with optimum percentage of plastic granules is 50.40 %.

From the test results it can be concluded that the soft clay like black cotton soil can be effectively stabilized with the addition of plastic granules to check its stability characteristics, increase in strength.

From the obtained results of various tests conducted on the black cotton soil, an appreciative result was obtained at 6% plastic granules mixed with the black cotton soil. Hence addition of 6% of stabilizer was taken as the optimum percentage of plastic granules for stabilizing the black cotton soil. From the tests conducted and can be concluded that plastic granules can be used effectively for the stabilization of black cotton soil.

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