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Effect of Steel Mill Scale Dust and Bamboo Fibres on the Strength Characteristics of Expansive Soil

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----------ABSTRACT----------

In highway construction where unsuitable soil is present, it requires to improve its engineering properties. Due to fund restrictions we have to use economical material. As steel industry has a waste with good engineering properties, we can use steel waste with soil. Bamboo is recognized as a potential natural reinforcing material for improvement and stabilization of soil. Construction of foundation for structures on black cotton soil is highly risky on geo-technical grounds because such soil is susceptible to differential settlements, poor shear strength and high compressibility. The properties of the black cotton soils can be altered in many ways viz. mechanical, thermal and chemical means. Therefore, soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the Superstructure especially in case of soil which is highly active; also it saves a lot of time. In the present work, an attempt has been made to study the geotechnical characteristics of black cotton soil mixing with different percentages of Mill scale dust and Bamboo fibres with a view to determine the optimum percentage and its effect on strength characteristics. Test results shows that stabilizing clayey soils with Mill scale dust and Bamboo fibres enhance the strength.

KEYWORDS *- Bamboo Fibres, Compaction, CBR, Expansive Soil, Mill Scale Dust.*

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I. INTRODUCTION

Stability of any structure depends on strength properties of underground soil on which it is constructed.Excessive use of materials, leads to industrialization, which has an adverse impact on the environment. From industries, large amount of chemicals or other suspended particles as a waste are produced, which are mostly dumped that acquires large space leading to deterioration of soil properties. So, we should use these waste for some constructive or useful purposes. As steel industry releases waste with some good engineering properties so, we can use this type of waste with soil which has low strength and does not have good engineering properties. Various techniques are available like soil stabilization, providing reinforcement etc. to improve load bearing capacity of soil. Black cotton soil is one of the major soil deposits of India. Black Cotton soils absorb water heavily, swell, become soft and lose strength. These soils are easily compressible when wet and possesses a tendency to heave during wet condition. Soil stabilization is one of the modification techniques used to improve the geotechnical properties of soil and has become the major practice in construction engineering which enables the effective utilization of industrial wastes as a stabilizer. Bamboo is recognized as a potential natural reinforcing material for improvement and stabilization of soil. Effect of bamboo fibres on local soil and based on the current investigation when bamboo fiber quantity is increases, un-soaked and soaked California Bearing Ratio (CBR) value of soil are considerable increase and this increase is occurred up to 1.2% of bamboo fiber dosage. Usage of more than 1.2% of bamboo fiber dosage is not feasible and optimal proportion of bamboo fiber is found 1.2% by waterless weight of ordinary soil. The unsoaked and soaked CBR test value of soil increases with the increase in bamboo fiber length and diameter [1]. Stabilization of expansive soil treated with different percentages of Mill Scale and concludes that the coarse fraction decreases OMC, increases MDD and CBR, but effect is insignificant for course fraction less than 30% to 40% by weight of soil. Unconfined compressive strength decreases with coarse fraction but effect being insignificant for coarse fraction more than 30%to 40% by weight of soil. With increase in percentage of Mill scale the shear strength of the soil increased from 0.12 to 0.2974, obtained at 21% of mill scale added to the dry weight of soil. The Percentage increase is 147.83%. With increase in percentages of Mill scale the Unsoaked CBR value is increased from 1.66 to 10.29

and soaked CBR value is increased from 1.54 to 9.37 at 21% respectively. The percentage increase in un-soaked and soaked CBR value is 519.87% and 508.87% respectively compared to untreated soil [2]. Maximum dry density of the modified soil is increased by 9.20% and Optimum moisture content of the modified soil is reduced by 39.24% for 40% Steel Slag. CBR (Soaked and Un-soaked) for the modified Soil is increased by 180% and 122% for (40%) Steel slag respectively. So 40% steel slag is optimum value for stabilization of CI soil. The addition of ground Steel Slag reduced the plasticity of lateritic soil and thereby improved its workability and reduced its moisture-holding capacity and swell potential. The maximum dry unit weight of the soil increased with increasing steel slag contents while optimum moisture content decreased as the amount of steel slag in the mixture increased from 0 to 8 %. The uncured strength of the soil increased with increasing steel slag content until after 8 % steel slag. Consequently, the optimum steel slag content was determined to be 8 %, based on strength criterion. The permeability of the soil was generally increased with increasing steel slag contents [3]. Effect of flyash and bamboo fibres on expansive soil and it has been concluded that addition of 20% of flyash and 1% of Bamboo fiber provides maximum strength in black cotton soil. Flyash treated BC soil reinforced with 1% bamboo fiber increases the strength and reduces the brittle behavior of soil specimen, where as the other percentages of fibers used shows a marginal increase [4]. Shear strength parameters of a local soil without and with bamboo fiber reinforcement are studied and compared. The fibers are distributed randomly with 5 different percentages and 2 different lengths. The % of fiber considered is 1%, 2%, 3%, 4% and 5%. The lengths of the fibers considered are 20mm and 30mm. The results show that shear strength parameters of the fiber reinforced soils start rising till 4% of fiber for both the length of the fiber. The increase in the length of the fiber also causes an increase in the shear strength of the soil [5]. The addition of steel industry for stabilisation and from test results, steel waste increases maximum dry density up to 10% but at 12% it slightly decreases to value lesser than maximum dry density at 10%. The reason may be replacement of more soil particles by the steel waste which causes decrease in dry density [6]. Expansive soil blending with different percentages of mild steel dust and from experimental results, addition of mild steel dust with tropical black cotton soil shows the increment in maximum dry density by 28% i.e. from 1639Kg/m^3 t0 2094Kg/m^3 whereas optimum moisture content lowered by 45% which is satisfactory. The investigation also shows there is an increment of un-soaked CBR of 90% at 30% mild steel content. A peak un-soaked CBR value of 58.8% was obtained using the WAS compactive effort which is above the minimum CBR value of 40% required for sub base of lightly trafficked roads [7]. Effect of metal industry waste by conducting various experiments and concluded that ,Significant and desirable results have been found by adding the metal industry waste (mill scale) to the black cotton soil, as CBR value increased three times that of plain black cotton soil when 15% of mill scale were used. The permeability of has been increased by increasing percentage of mill scale and the plasticity property black cotton soil decreased from 35.71% to 30.60% by addition of 12% of mill scale[8]. In the present work, an attempt has been made to calculate the variations in Index properties, Compaction parameters and CBR of treated expansive soil with different percentages of mill scale dust and bamboo fibres. From the test results it is observed there is an improvement in engineering properties and the optimum percentages were arrived accordingly.

II. MATERIALS USED

Details of various materials used during the laboratory experimentation are reported in the following section.

2.1 Expansive Soil: Natural black cotton soil was obtained from Godilanka, Amalapuram, East Godavari district, Andhra Pradesh. The soil is dark grey to black in color with light clay content. The obtained soil was air dried, pulverized manually and soil passing through 4.75 mm IS sieve was used as shown in the Fig. 1. The physical properties of black cotton soil are furnished in Table.1.

Table.1: Physical Properties of Expansive Soil

Property	Value
Liquid Limit (%) W_L	88
Plastic Limit (%) W_P	38
Plasticity Index (%) I_P	50
Gravel (%)	0.0
Sand (%)	5.0
Silt (%)	12.0
Clay (%)	83.0
Soil Classification	CH
Specific Gravity G	2.69
Differential Free Swell (%) DFS	130
Optimum Moisture Content (%)OMC	27.68

Maximum Dry Density(g/cc)	1.451
Natural Moisture Content (%)	11

2.2 Mill Scale Dust: The steel mill scale dust used in this investigation was sourced from Vizag Steel Plant, a major steel rolling mill in Andhra Pradesh. Steel Mill Scale is a metal industry waste which is produced in large tons. It is mainly iron oxide formed in the surface of steel during casting, hot rolling and reheating of steel.
2.3 Bamboo Fibres: The bamboo fibre is made from the starchy pulp of bamboo plants. Bamboo fibres are procured from Sai Laxman Group, Guntur as shown in the Fig.3. Bamboo fibre is thinner as compared to hair and has a round and smooth surface which makes it abrasion proof. Bamboo fibre is naturally anti- bacterial, UV protective, green & biodegradable, breathable & cool, strong, flexible, soft. Bamboo fibres are remarkably strong in tension but have low modulus of elasticity. The main advantage of these materials is that they are locally available with practically little cost. Its low cost makes it attractive for geotechnical applications. Cellulose and lignin are the major constituents and higher lignin content makes the fibre stiffer and tougher.

Fig .1Black Cotton Soil

Fig.2 Mill Scale Dust

Fig 3. Bamboo Fibres

III. LABORATORY EXPERIMENTATION

Various tests were carried out in the laboratory for finding the index and other important properties of the expansive soil used during the study. Index Properties, Compaction and CBR tests were conducted by using different percentages of Mill Scale Dust and Bamboo Fibres mixed with black cotton soil materials for finding optimum percentages.

3.1 Index Properties: Standard procedures recommended in the respective I.S. Codes of practice [IS:2720 (Part-5)-1985; IS:2720 (Part-6)-1972], were followed while finding the Index properties viz. Liquid Limit and Plastic Limit of the samples tried in this investigation.

3.2 Compaction Properties: Optimum Moisture Content and Maximum Dry Density of black cotton soil with different percentages of Mill Scale Dust and Bamboo Fibres mixes were determined according to IS Heavy compaction test IS: 2720(Part VIII).

3.3 California Bearing Ratio (CBR) Tests: Different samples were prepared for CBR test using expansive soil material mixing with different percentages of Mill Scale Dust and Bamboo Fibres with a view to determine optimum percentages. The CBR tests were conducted in the laboratory for all the samples as per IS Code (IS: 2720 (Part-16)-1979).

IV. RESULTS AND DISCUSSIONS

Various tests were conducted in the laboratory as per IS Code provisions and the test results are furnished below with a view to determine the optimum percentages and the effect on strength characteristics.

4.1 Effect of Mill Scale Dust on Index Properties: Liquid limit values were reduced from 88%, 75%, 67.2%, 60.5% and 54.27 %, the plastic limit values are also decreasing from 50%, 39.37%, 37.13%, 34.13% and 30.04% respectively by adding 0 %, 5%, 10%, 15% and 20 % of mill scale dust respectively when blended with the expansive soil as shown in the Fig. 4. Effect of mill scale on Engineering Properties of Soil the liquid limit and plastic limit of soil decreases. The soil becomes more workable because of decrease in plastic properties of soil and due to formation of cementing material.

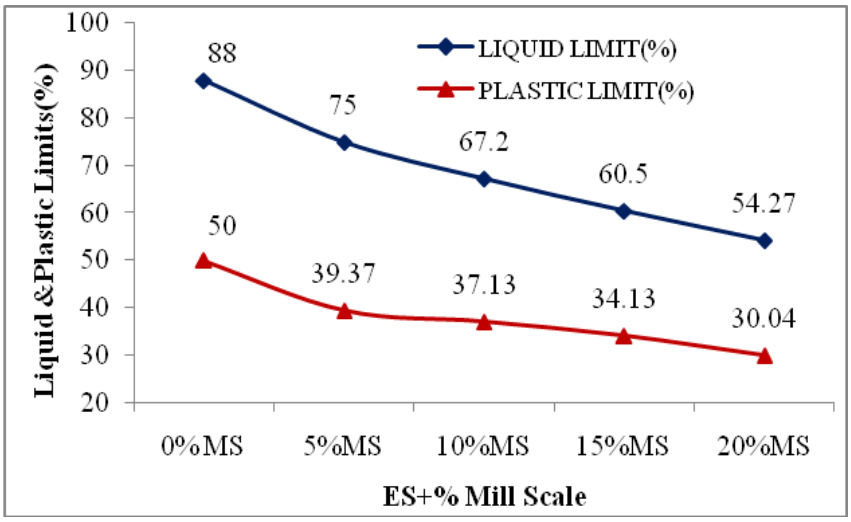

Fig.4 Variation of Liquid &Plastic Limit Values of Expansive Soil Treated with Different Percentages of Mill Scale Dust

4.2 Effect of Mill Scale Dust and Bamboo Fibres on Compaction: The Optimum Moisture Content and Maximum Dry Density values are calculated from the test results and are presented below form Figs.5 & 6. From the results the maximum dry density values are varies from 14.23kN/m^3,14.49 kN/m^3, 14.74 kN/m^3, 15.17 kN/m^3 and 13.96 kN/m^3; optimum moisture content values are decreasing from 27.68 %, 27.21%, 26.87%, 26.39 % and 25.55% respectively when the soil is mixed with 0 %, 5 %, 10 %, 10% and 15 % of mill scale dust blending in expansive soil respectively shown in the Fig.5. From the above test results the optimum percentage of mill scale dust is 15% at the maximum dry density is maximum. In the second phase expansive soil with 15 % optimum mill scale dust as a base soil mix, compaction tests were conducted by adding different% of Bamboo Fibres 0%, 0.25%, 0.5%, 0.75% and 1% and from the test results the MDD values are 15.37 kN/m^3,15.91 kN/m^3,16.17 kN/m^3,16.49 kN/m^3 and 14.764, OMC Values are 27.68%,27.47%,26.87%26.66% and 26.17% respectively as shown in the Fig.6. From the above results 0.75% Bamboo fibres shows maximum increase in dry density when compared to other samples tried in this investigation.

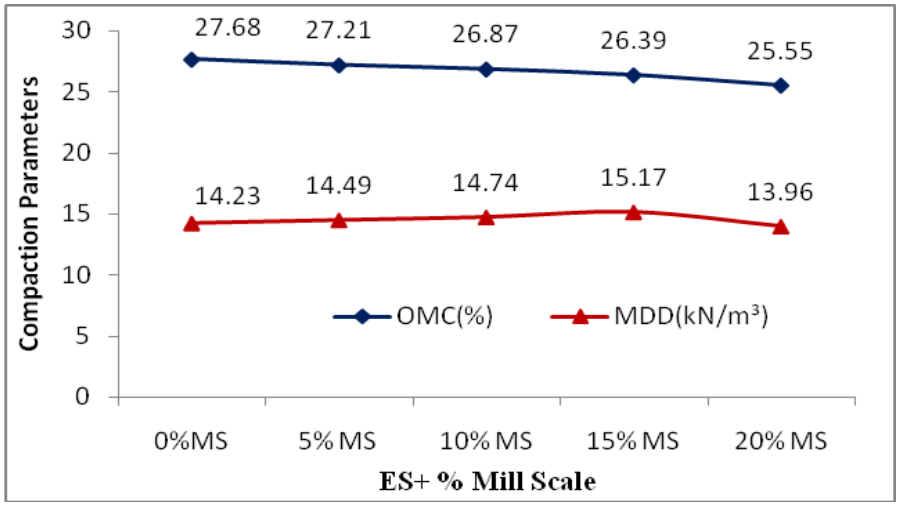

Fig 5: Variation of Compaction Parameters of Expansive Soil Treated with Different Percentages of Mill Scale Dust

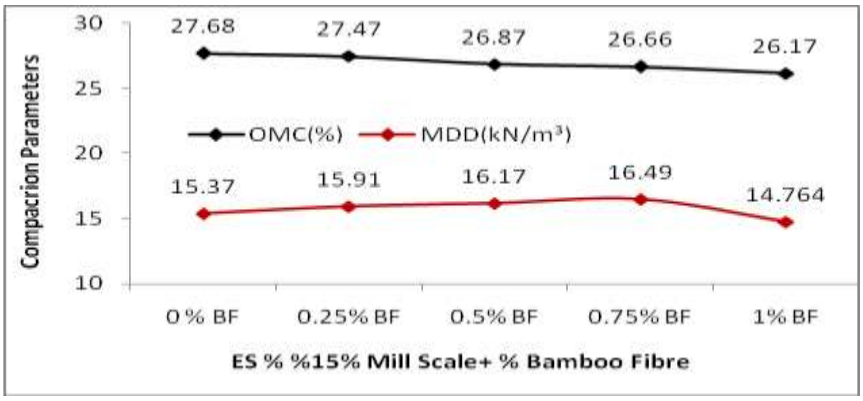

Fig 6: Variation of Compaction Parameters of Expansive Soil and 15% Mill scale dust with Different Percentages of Bamboo Fibres

4.3 Effect of Mill Scale Dust and Bamboo Fibres on California Bearing Ratio (CBR): Soaked CBR tests were conducted for expansive soil mixed with different percentages of Mill scale dust and Bamboo fibres and the results were presented in the Figs.7 & 8. It is observed from that expansive soil mixed with different percentages of Mill scale dust the soaked CBR values are 1.22%, 2.47%, 3.44%, 4.35% and 4.01% respectively at o%, 5%,10%, 15% and 20 % blending of mill scale dust as shown in the Fig.7.From the above results at 15% mill scale attains maximum CBR value. Considering 15% optimum mill scale dust blending with different percentages of bamboo fibres ,the soaked CBR values are 4.35%,5.15%,7.61%,8.52% and 6.72% at 0%,0.25%,0.5%,0.75% and 1% blending bamboo fibres respectively shown in the Fig.8. From the above Figure the optimum percentage of Bamboo Fibres is 0.75%.

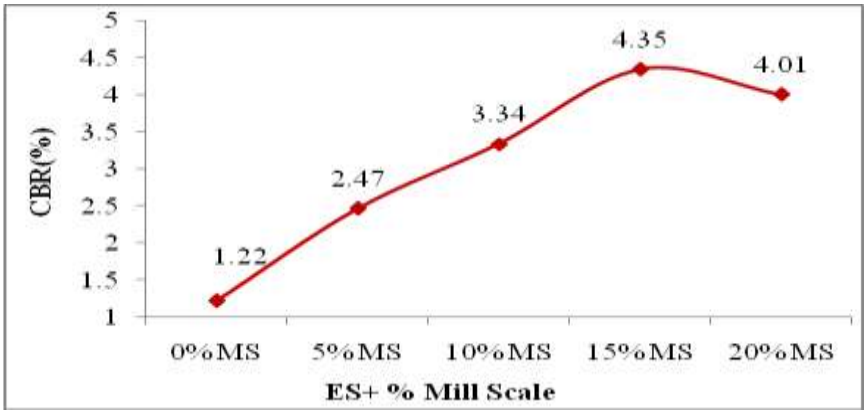

Fig 7: Variation of Soaked CBR Values of Expansive Soil Treated With Different Percentages with % of Mill Scale Dust

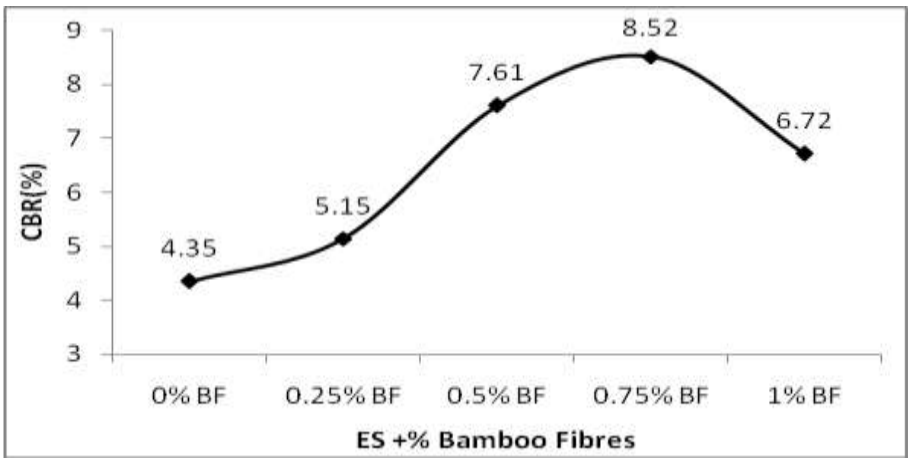

Fig 8: Variation of Soaked CBR Values of Expansive Soil and 15% Mill Scale Dust with Different Percentages of Bamboo Fibres

V.CONCLUSION

The following conclusions are drawn based on the laboratory studies carried out in this investigation.

- From the above experimental results the optimum percentage of Mill Scale Dust and Bamboo fibres are 15% and 0.75% respectively. From the above test results, that the use of Mill scale dust and Bamboo fibres in soil stabilization can improve the strength characteristics considerably. Overall it can be concluded that stabilized soil can be considered by the above material is to be good ground improvement technique especially in engineering projects on weak soils from economic consideration.
- Significant and desirable results have been found by adding the steel mill scale dust from metal industry waste to the expansive soil and promising results for use of expansive soil.
- For every increase in percentage of Mill scale there is a considerable increment in the Standard compaction test and CBR values of the soils.
- From the above results it has been observed that the MDD increases up to 7 % up to 15% addition of mill scale dust but there is decrease in MDD values. The reason may be replacement of more soil particles by the mill scale dust waste which causes decrease in dry density.

- It was also found that increasing the percentage of bamboo fiber increases the CBR value of reinforced soil, and this increment is significant at fiber dosage of 0.75 %. This significant increase of CBR value will diminish the thickness of pavement.
- The CBR test done for original expansive soil is observed to be very less when compared to the CBR values resulted for the soils samples treated with Mill scale as well as bamboo fibers.
- The addition of mill scale dust increased the soaked CBR of the tropical black cotton soil by about 256 % at 15 % mill scale dust content. The addition of 0.75% bamboo fibres to the mill scale dust at 15% to the expansive soil increased the soaked CBR up to 598 %.
- Based on the studies conducted bamboo fiber can be used as a strengthening material for mill scale dust treated expansive soil. Addition of fiber improves the ductility behavior and increases the CBR value of the expansive soil. The optimum percentages of mill scale dust and bamboo fibres are 15% and 0.75% respectively.

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