Engineering/Science/Technology Civil/GET/TE

Improvement of Sub Grade Cbr Value with Addition of Tile Dust and Silica Fume at Varying Percentages

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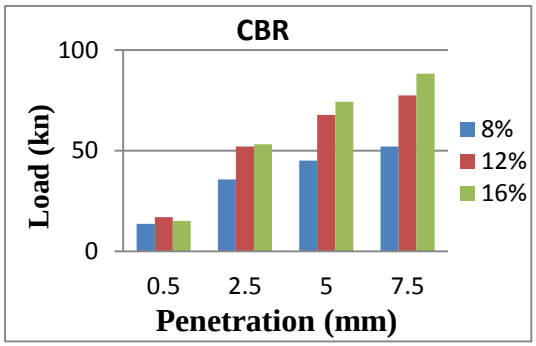
GRAPHICAL ABSTRACT



ABSTRACT

In many cases, soils in natural state do not provide adequate geotechnical properties to be used as a sub grade in flexible pavement. Expansive soils are problematic soils for civil engineers because of its low strength and cyclic swell shrink behaviour. In order to improve their geotechnical properties to meet the structural specifications, soil stabilization techniques have to be emphasized. The main objective of the study is to improve the CBR value of the sub grade with the addition of tile dust powder and silica fume at varying percentages. A series of laboratory tests were performed to know the properties of soil and to evaluate the properties of soil such as specific gravity, liquid limit, plastic limit, grain size distribution, atterbergs limits, unconfined compression test, standard proctor test for obtaining Maximum dry density, Optimum moisture content when added with tile dust at 5%, 10%, 15%,20% and silica fume at 3%,5%,7%, and 9% variations. After performing these tests, both the tile dust and silica fume are added with a combination of 8%, 12% and 16%.Based on the experiments that were performed in the laboratory we have observed that the cohesion of soil increased from 0.55 kg/cm^2 to 0.65 kg/cm^2.We have observed that liquid limit and dry density initially increased and then decreased with the increase in addition of tile dust and silica fume percentages. The plasticity index decreased from 10.49% and 3.34% and the specific gravity of the soil was 2.33.C.B.R value increased from 2.4 to 3.88% at 2.5mm penetration when the materials were added at 10%.At 5mm penetration from 1.913 to 3.62% when both the materials were added at 16%.

Key words —Expansive soil, Tile dust, Silica fume, Standard proctor test, Atterberg limits, OMC, CBR

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I. Introduction

Soil as in natural state couldn't provide the geo-technical properties. Expansive soils of central India, commonly known as black cotton soils, cover approximately one-sixth of the total area of our country. In India expansive soils are found in major parts of Andhra Pradesh and Madhya Pradesh as it covers 0.75*10^{6}km^2 i.e., approximately 21 to 24% of land area. The main cause of this expansion in black cotton soils is due to presence of bentonite and montmorillonite clay minerals. As expansive soil is a problematic soil for the structural stability in flexible pavements because of its low strength and cyclic swell shrink behavior. Hence the expansive black cotton soils are need to be stabilized in order to change their properties and make them suitable for bearing the structural load in sub-grade soils of flexible pavements. Stabilization techniques are adopted in general in order to improve the durability and also increase the strength of sub grade soils. Stabilization of soil can be done using different materials like lime, cement, fly ash, bagasse ash, pond ash, jute fibers, egg shell powder, tile dust powder, silica fume and geo synthetics, etc., here in this study the sub grade CBR strength value is increased by addition of tile dust and silica fume at varying percentages. i.e.., Tile Dust powder at 5, 10, 15 & 20 percentages and Silica Fume at 3, 5, 7& 9 percentages addition to soil. Firstly the materials are individually blended with soil at these percentages and properties were studied then after both the materials are added at 8%, 12% and 16% and the

properties of soil were studied. Optimum results obtained at addition of both tile dust & Silica Fume at 12 %.

II. MATERIALS USED

1. SOIL: Soil used in this investigation is collected from Jujjuru, verullapadu, kanchikacherla, Krishna, AP. The following tests were carried out to find out the properties of soil as per [IS 2720-1980] and results are tabulated below.

Table 1.0: Properties of Soil

S .No	Particulars	Test results
1.	Soil classification	GP
2.	Specific gravity	2.33
3.	Liquid limit (%)	18.18
4.	Plastic limit (%)	8.33
5.	Plasticity index (%)	9.85
6.	Optimum moisture content (%)	11
7.	Maximum dry density (g/cc)	0.106
8.	Unconfined comp strength (kg/cm^2)	1.10
9.	CBR (%)	2.40

2. TILE DUST POWDER : The tile dust powder used in this investigation is obtained from Madiga Gudem, kanchikacherla, AP and its properties were studied for suitability of usage of soil.

Fig. 1 Tile Dust Powder

Table 1.2: Properties of tile Dust Powder

PHYSICAL PROPERTIES	
Specific gravity	2.66
Density	Approx 1.05g/ml^3
CHEMICAL PROPERTIES	
Silica (SiO_2)	63.29
Alumina (Al_2O_3)	18.29
Ferric oxide (Fe_2O_3)	4.32
Titanium oxide (TiO_2)	0.61
Calcium oxide (CaO)	4.46
Magnesium oxide (MgO)	0.72
Potassium oxide (K_2O)	2.18
Sodium oxide (Na_2O)	0.75
Loss on ignition	1.61

3. SILICA FUME: Silica fume used in this investigation is collected from Moores road, Thousand lights, Chennai. Physical and chemical properties of silica fume were given.

Table 1.3: Properties of Silica Fume

PHYSICAL PROPERTIES	
Ph of 5% solution	6.90
Specific gravity	2.63
Moisture	0.058%
CHEMICAL PROPERTIES	
Silica (SiO_2)	99.886%
Alumina (Al_2O_3)	0.043%
Ferric oxide (Fe_2O_3)	0.040%
Titanium oxide (TiO_2)	0.001%
Calcium oxide (CaO)	0.001%
Magnesium oxide (MgO)	0.000%
Potassium oxide (K_2O)	0.001%
Sodium oxide (Na2O)	0.003%
Loss on ignition	0.015%

Fig. 2 SILICA FUME

WATER

In this investigation potable water with a pH value 7 to 7.5 was used.

III. EXPERIMENTAL INVESTIGATION

1. SOIL

Firstly the properties of soil were evaluated and the results are tabulated in Table 1.

2. SOIL + TILE DUST (5%, 10%, 15% & 20%)

Then the soil is added with tile dust powder at 5 %, 10%, 15%, 20% variations and the properties of soil i.e.., Liquid Limit, Plastic Limit, Plasticity Index, OMC, MDD, Unconfined Compressive Strength and CBR value were evaluated.

Table 2.0: Properties of Soil + Tile Dust at (5 %, 10%, 15%, 20%)

	Particulars		Test results			
1.	%ge Addition of tile dust to soil		5%	10%	15%	20%
2.	Liquid limit (%)		21.42	22.22	23.07	20
3.	Plastic limit (%)		20	21.42	22.22	18.18
4.	Plasticity index (%)		1.42	0.80	0.85	1.82
5.	Optimum moisture content (%)		9%	9%	11%	9%
6.	Maximum dry density (g/cc)		0.203	0.241	0.26	0.204
7.	Unconfined comp strength (kg/cm^2)		1.086	1.17	1.23	1.419
8	CBR (%)	2.5mm	1.68	2.85	2.9	2.93
		5.0mm	2.13	3.64	3.74	3.85

3. SOIL + SILICA FUME at (3%, 5%, 7% & 9%)

Then the soil is added with silica fume at 3%, 5 %, 7% & 9% variations, the properties of soil i.e.., Liquid Limit, Plastic Limit, Plasticity Index, OMC, MDD, Unconfined Compressive Strength and CBR value were evaluated with addition of silica fume and the results are tabulated in Table 3.0

Table 3.0: Properties of Soil + Silica fume at (3%, 5%, 7% & 9%)

Particulars			Test results			
1.	%ge Addition of Silica Fume to soil		3%	5%	7%	9%
2.	Liquid limit (%)		25	33.33	30.76	23.07
3.	Plastic limit (%)		21.42	30.76	28.42	21.42
4.	Plasticity index (%)		3.6	2.57	2.6	1.65
5.	Optimum moisture content (%)		11%	11%	13%	13%
6.	Maximum dry density (g/cc)		0.149	0.280	0.259	0.248
7.	Unconfined comp strength (kg/cm^2)		1.101	1.215	1.39	1.48
8.	CBR (%)	2.5mm	1.83	2.43	2.075	1.17
		5.0mm	2.345	3.02	2.978	1.65

4. SOIL + TILE DUST + SILICA FUME

Then the soil is added with both the tile dust powder and silica fume at a combination of 8% (4% TD+4% SF), 12% (6% TD+6% SF) and 16% (8% TD+8% SF) were added to the soil and properties of soil were studied. The results were tabulated in Table 4.

Table 4.0: Properties of Soil +Tile Dust + Silica Fume at (8%, 12% and 16%)

	Particulars		Test results		
1.	%ge Addition of TD & SF to soil		8% (4%TD + 4%SF)	12% (6%TD + 6%SF)	16% (8%TD + 8%SF)
2.	Liquid limit (%)		20	30.76	31.25
3.	Plastic limit (%)		18.75	20	23.07
4.	Plasticity index (%)		1.25	11.25	7.69
5.	Optimum moisture content (%)		11	11	11
6.	Maximum dry density (g/cc)		0.14	0.162	0.128
7.	Unconfined comp strength (kg/cm^2)		1.037	1.19	1.31
8.	CBR (%)	2.5mm	1.77	2.58	2.64
		5.0mm	2.24	3.27	3.70

IV.RESULTS & DISCUSSIONS

4.0 Soil : As per grain size distribution the soil is classified as poorly graded soil. Based on the specific gravity value 2.33 the soil is classified as medium grained soil.

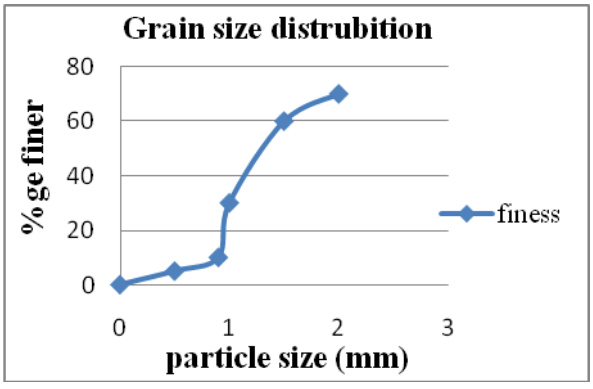

Fig. 3 Variation of particle size

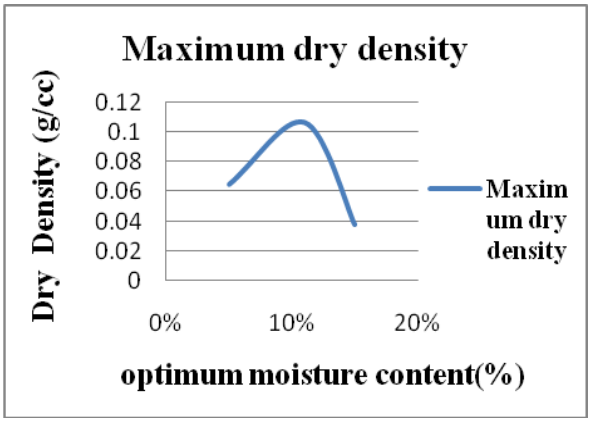

Fig. 4 Variation of Dry Density with Optimum Moisture Content

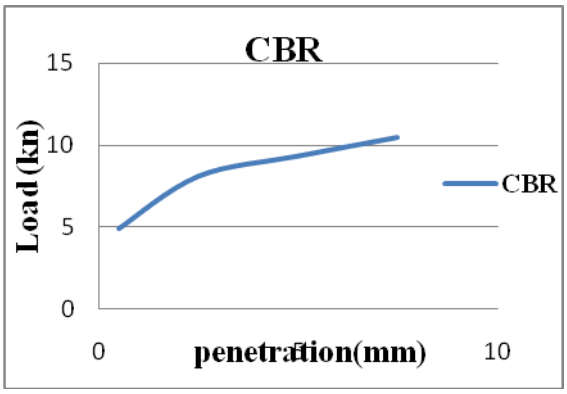

Fig. 5 California bearing ratio

4.1 SOIL + TILE DUST (5%, 10%, 15% & 20%)

Tile Dust when added to soil at varying percentages the liquid limit, plastic limit and maximum Dry density showed the maximum value at 15% addition of tile dust with soil. The maximum value of optimum moisture content showed 11% at 15 % addition of tile dust to soil.

The Unconfined Compressive Strength of soil and California Bearing Ratio value showed the maximum values at 20% addition of tile dust to soil.

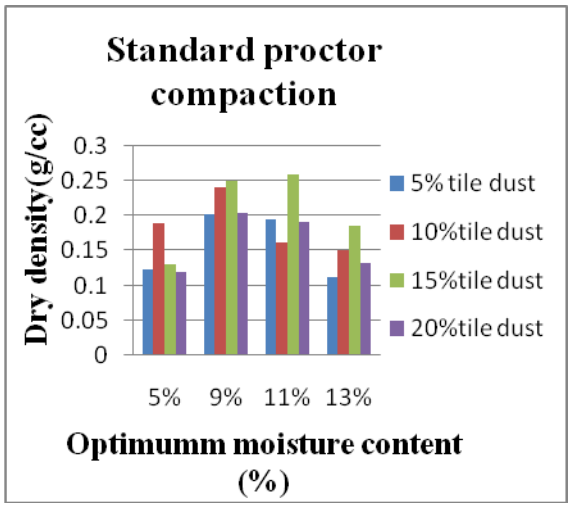

Fig.6 Standard Proctor Compaction Test

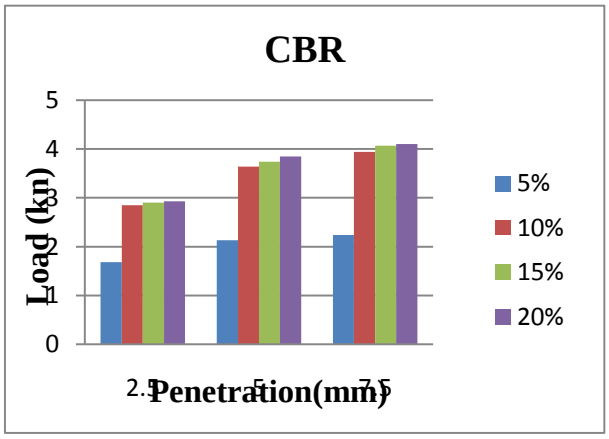

Fig.7 California bearing ratio

4.2 SOIL + SILICA FUME at (3%, 5%, 7% & 9%)

Silica Fume when added to soil at varying percentages the liquid limit, plastic limit, Maximum Dry density and CBR showed the maximum value at 5% addition of Silica Fume to the soil. The maximum value of optimum moisture content showed 13% at 9% addition of silica fume to soil. The Unconfined Compressive Strength of soil also showed the maximum value at 9% addition.

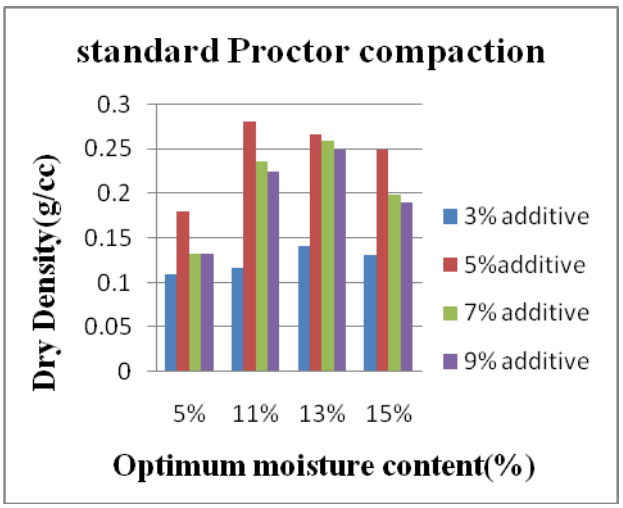

Fig.8 Standard Proctor Compaction Test

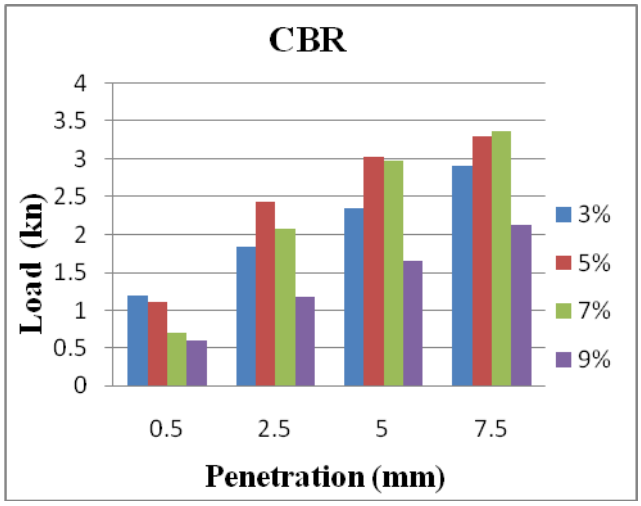

Fig.9 California bearing ratio

4.3 SOIL + TILE DUST + SILICA FUME (8%, 12% and 16%)

When the soil is added with both the materials tile dust and silica fume at varying percentages i.e.., 8%, 12% and 16%, the liquid limit and plastic limit showed their maximum value at 16%(8% TD + 8% SF) addition. Only the maximum dry density value occurred at 12% (6% TD + 6% SF) addition of both the materials and Optimum moisture content occurred at 11%. The unconfined compressive strength and CBR value also showed the maximum strength at 16%(8% TD + 8% SF) addition.

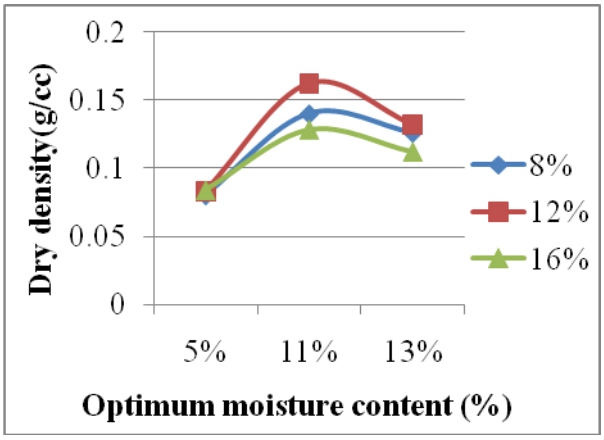

Fig.10 Standard Proctor Compaction Test

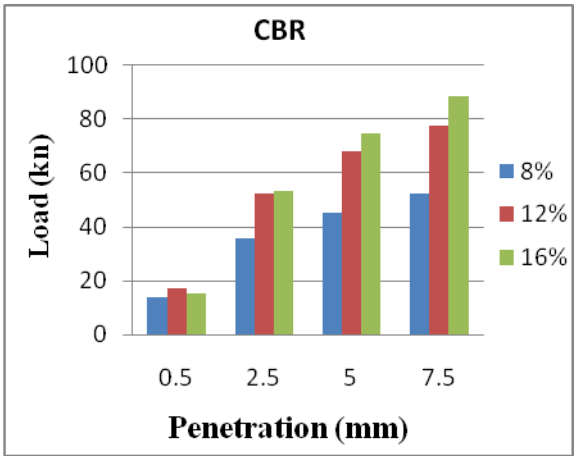

Fig.11 California bearing ratio

Conclusions

Based on the experimental study carried out the following conclusions were drawn. A series of laboratory tests were conducted to study the properties of soil when added with tile dust and silica fume. The tests performed to evaluate the properties are liquid limit, plastic limit, maximum dry density, optimum moisture content, unconfined compressive strength, California bearing ratio of an expansive soil. Based on the observations the following conclusions were drawn.

1. From the uniformity coefficient value of soil 1.578 is classified as uniform soil
2. From coefficient of gradation 0.7017 it is classified as well-graded soil.
3. From grain size analysis the soil is classified as uniform and well-graded soil.
4. For tile dust and silica fume with specific gravity of 2.66 it is classified as silt.
5. The liquid limit and plastic limit decreases with increase in 15% tile dust.
6. The optimum moisture content has no changes even with the addition of tile dust.
7. The maximum dry density value occurred at 15% of tile dust.
8. The California bearing increased with an addition of 20% of tile dust.

9. The California bearing ratio value of expansive soil improved from 2.90 to 4.30 with the addition of 20% of tile dust.
10. The liquid limit and plastic limit decreases with increase in 5% of silica fume.
11. The optimum moisture content has no changes even with the addition of silica fume.
12. The maximum dry density value occurred at 5% of silica fume.
13. The California bearing increased with an addition of 5% of silica fume
14. The California bearing ratio value of expansive soil improved from 2.69 to 3.81 with addition of silica fume
15. The liquid limit decreases with increases with the combination of tile dust and silica fume at 12%(6% of tile dust +6% of silica fume)
16. The plastic limit increases with increase with the combination of tile dust and silica fume at 12% (6% of tile dust+6% of silica fume).
17. The optimum moisture content has no changes even with the addition of tile dust and silica fume combination.
18. The maximum dry density value occurred with the combination silica fume and tile dust at 11% of water content.
19. The maximum dry density decreases with increase in percentage 12% (6%of tile dust + 6% of silica fume) combination of tile dust and silica fume.
20. The unconfined compressive strength increased with an increase of tile dust and silica fume at 16% (8%of tile dust +8% of silica fume).
21. The California bearing ratio value of expansive soil improved significantly from 2.40% to 3.88% with the addition of combination of 12%(6% of tile dust+6% silica fume) of tile dust and silica fume.
22. The CBR value increases with increase of tile dust, silica fume and combination of tile dust and silica fume.
23. According to I.R.C 37-2001 if the CBR value is less than 4 it is very poor condition of sub grade. By adding 20% tile dust expansive soil is suitable for pavement construction.
24. From the above analysis it is found that the combination of tile dust and silica fume up to 12%(6% of tile dust+6% of silica fume) can be utilized for strengthening the expansive soil sub grade of flexible pavements.

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