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Effect of Crusher Dust, Stone and Tire Wastes as Granular Pavement Materials

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ABSTRACT: *The scarcity of soil which suits for construction activities by fulfilling geotechnical characteristics is forcing the pavement engineers to look for alternative materials for construction activity. On the other hand due to the rapid industrialization there is sharp increase in the number of crushing units in so many states and the country as well. There is also a sharp increase the quantum of another industrial waste namely discarded tires due to increase in the number of vehicles year after year. Hence an attempt is made in this paper to suggest a viable solution for the above mentioned industrial wastes to use the same in an optimum manner in order to help in reducing the excessive usage of conventional soil.*
Key words*: Crusher dust, Crushed stone, Tire waste, Compaction, CBR.*

I. INTRODUCTION

Natural soils, broken stones, gravels, sands etc are the popular conventional materials used in the construction of road pavement materials. The durability of the pavement depends on the performance of the component layers. There are numerous examples about the functional failures of pavement component layers as they failed in fulfilling their specifications laid by standard codes and gradation requirements.

The presence of plastic fines in the natural soils cause deformations in the pavement component layers and this development finally results in causing the undue deformations under the repeated application of traffic loads. Hence road engineers need to concentrate on the quantities of fines in either partial or full replacement. Several researches have attempted in partial modification of natural soils with crusher dust and crushed stone.

In the present investigation crusher dust, crushed stone and tire waste were considered as road construction materials in accordance with MORTH specifications. Tests like gradation, compaction, CBR were identified to study their grain size distribution, compaction and strength behavior and finally suitability as sub base & base coarse materials and the utilization of crusher dust, crushed stone and tire waste in bulk quantities to reduce their impact on environment and in turn to reduce the maintenance cost and to increase the durability of the road pavement. Soosan et.al(2001)[8] studied crusher dust as embankment and sub-base material, Praveen kumar et.al(2006)[5] studied crusher dust as sub-base material .Satyanarayana P.V.V. et.al (2013)[6,7]observed improved soil characteristics with addition of crusher dust, Tatlesoz,Edil&Benson (2001)[4] assumed the shear strength of soil-tire chips in reinforced walls, Prasada raju.G.V.R et.al(2008)[3] carried out CBR tests on plastic wastes and rubber tire chips in gravel sub-base materials and Arun Kumar.U et al (2016)[1,2] studied the effect of crusher dust, crushed stone and tire waste in different layers of flexible pavement component for increased strength characteristics.

II. MATERIALS

2.1 CRUSHER DUST:

Crusher Dust was obtained from local stone crushing plants near Visakhapatnam, Andhra Pradesh and subjected to various geotechnical characteristics and results are shown in table-1 and figure-1(a) &1(b)

Table -1: Geotechnical properties of Crusher dust

Property	Values
Gravel (%)	4
Sand (%)	92
Fines (%)	4
a. Silt (%)	4
b. Clay (%)	0
Liquid Limit (%)	NP
Plastic Limit (%)	NP

I.S Classification	SW
Specific gravity	2.66
Optimum moisture content (OMC) (%)	11
Maximum dry density (MDD) (g/cc)	2.02
Angle of shearing resistance(°)	38
California bearing ratio CBR (%) (Soaked)	12
Coefficient of uniformity (Cu)	10.83
Coefficient of curvature (Cc)	1.02
Coefficient of Permeability(k) (cm/s)	$3.4*10^{-3}$

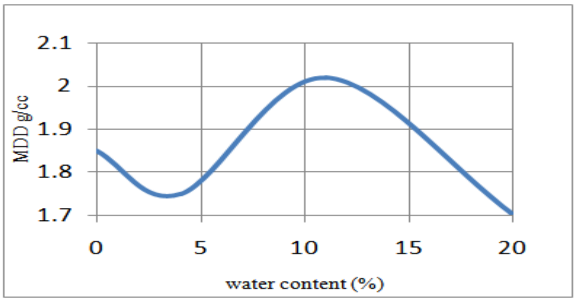

Fig-1(a): Compaction curve for Crusher Dust

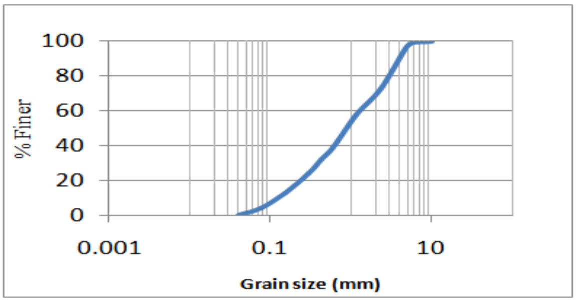

Fig1 (b): Grain size distribution curve of crusher Dust

From the test results of crusher dust, the following identifications are made. The grain size distribution of crusher dust shows that it consists of 92% of sand size and 4% of silt size particles. It is equally dominated by particles of coarse, medium and fine sand sizes with rough surface texture. Based on BIS, it is classified as well graded particles with non-plastic fines (SW) with C_u as 10.83 and C_c as 1.02. Compaction characteristics of crusher dust under modified compaction test have an Optimum Moisture Content of 11% and Maximum Dry Density of 2.02 g/cc. From the compaction curve it can also be seen that crusher dust attains higher densities with wider range of moisture contents and increases the workability at high moisture contents. Regarding strength characteristics, it has an angle of shearing resistance (Ø) of 38^0 under un drained condition and CBR of 12% .It has coefficient of permeability of 3.4 $x10^{-3}$cm/sec. Hence it is identified that it has good strength and drainage characteristics.

2.2 CRUSHED STONE:

Crusher Stone was obtained from local stone crushing plants near Srikakulam, Andhra Pradesh and subjected to various geotechnical characterizations.

Table 2: ENGINEERING PROPERTIES OF CRUSHED STONE:

PROPERTY	**VALUE**
Specific gravity	**2.8**
Angularity number	**13**
Crushing value (%)	**22**
Impact value (%)	**23**
Density in loose state (g/cc)	**1.85**
Density in dense state (g/cc)	**1.76**

2.3 TIRE CHIPS:

Tire chips of sizes from 10mm to 4.75mm have taken, these were obtained from used tires and tested for following properties.

Table 3: ENGINEERING PROPERTIES OF TIRE CHIPS:

Property	value
Specific gravity (G)	1.2
Density in loose state (g/cc)	0.7
Density in dense state (g/cc)	0.5

III. METHDOLOGY

To study the interaction between crushed stone of sizes from 26.5mm to 4.75mm and crushed dust sizes less than 4.75mm were graded to the following gradations listed as G1,G2,G3,G4,G5 as listed below.

Table 4: Gradation characteristics of various crushed stone

PARTICLE SIZE(mm)	G_1	G_2	G_3	G_4	G_5	RANGE
26.5	100	100	100	100	100	100
12.5	55	64	72	81	90	55-90
9.5	35	43	50	58	65	35-65
4.75	25	33	40	48	55	25-55
2.36	20	25	30	35	40	20-40
0.425	10	11	12	14	15	10-15
0.075	5	5	5	5	5	5
D_{10}	0.425	0.38	0.3	0.21	0.16	0.16-0.425
D_{30}	7.5	3.9	2.4	1.6	1.5	1.5-7.5
D_{60}	13	11.5	11	9.8	7	7-13
C_U	30.59	30.26	36.67	46.67	43.75	30.26-46.67
C_C	10.18	3.48	1.75	1.24	2.01	1.24-10.18

Using MORTH grading 1 of table3,Tire chips of sizes 10mm to 4.75mm were added to the above gradations in partial replacement of the range of particles in between 9.5mm to 4.75mm at their percentages varying from 0.5 to 3 % by dry weight of the respective gradation. These gradation mixes were subjected to compaction, CBR characteristics and the results are shown below Table 5&6.

IV. RESULTS AND DISCUSSIONS:

4.1 Compaction characteristics:

The compaction characteristics like OMC and maximum dry density were obtained by performing modified proctor test on crushed stone +crushed dust and tire chips as per IS:2720:(part 8-1983) and the results are shown in Table 5.

Table 5: Compaction characteristics of various Gradation-Tire chips mix

GRADATION	PROPERTY	% Of Tire waste						
		0	**0.5**	**1**	**1.5**	**2**	**2.5**	3
G_1	OMC (%)	3.8	4	4.2	4.4	4.7	4.9	5.1
	MDD(g/cc)	2.18	2.17	2.16	2.15	2.14	2.13	2.12
G_2	OMC (%)	4	4.2	4.4	4.6	4.8	5	5.2
	MDD(g/cc)	2.2	2.19	2.18	2.17	2.16	2.15	2.14
G_3	OMC (%)	4.3	4.5	4.7	4.9	5.1	5.2	5.4
	MDD(g/cc)	2.22	2.2	2.19	2.18	2.17	2.16	2.15
G_4	OMC (%)	4.5	4.7	4.9	5	5.2	5.3	5.5
	MDD(g/cc)	2.2	2.18	2.17	2.16	2.15	2.14	2.13
G_5	OMC (%)	4.8	4.9	5.1	5.3	5.5	5.7	5.8
	MDD(g/cc)	2.19	2.17	2.16	2.14	2.13	2.12	2.11

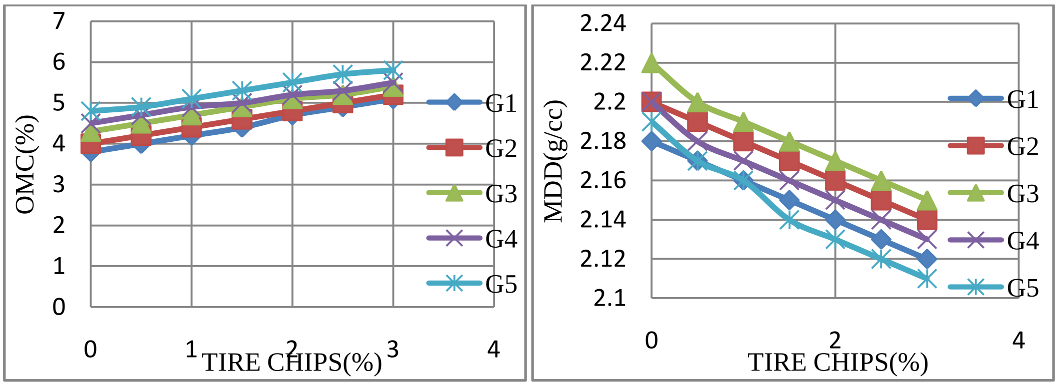

Fig 2: Compaction curves of various Gradations Tire mixes

From the test results it is identified that increasing percentages of tire chips in the mixes OMC values are continuously increasing and MDD values are decreasing. It is also identified that with increasing the percentage of crusher dust in the above mixes MDD values are increasing up to G3 for all dosage of tire chips and for G4 to G5 decreasing .The OMC values are increasing from G1 to G5. The range of OMC is 3.8 to 5.8% and MDD is 2.11 to 2.22(g/cc). The increasing in OMC is due to adhesion of more crusher dust particles on to the surfaces of tire waste particles require more water. This behavior is predominant at higher percentages of crusher dust and higher dosage of tire chips. The decreasing MDD is due to the partial replacement of crusher stone particles by tire chips and light weight of the tire chips compare to crushed stone and crusher dust particles. This behavior is pronounced at higher percentages of tire chips. Hence the behavior can be explained by light weight of tire chip particles make the composite mix as lesser weight than the original conventional mix.

4.2 California bearing ratio characteristics:

The CBR values were obtained by performing CBR test on crushed stone +crushed dust and tire chips as per IS:2720:(part 16-1987) and the results are shown in table 6

Table 6: CBR characteristics of various gradations tire chips mixes:

GRADATION	PROPERTY	Tire chips (%)						
		0	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**
G_1	**CBR (%)**	54	62	70	74	77	72	66
G_2	**CBR (%)**	60	68	76	80	82	76	70
G_3	**CBR (%)**	68	74	80	85	83	78	71
G_4	**CBR (%)**	56	70	76	80	72	67	65
G_5	**CBR (%)**	48	63	72	73	66	62	60

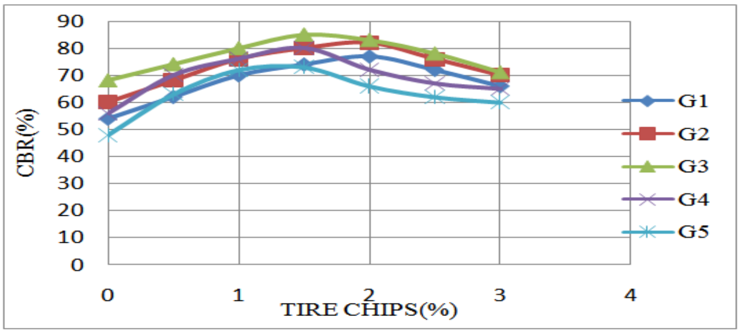

Fig 3: CBR characteristics for various gradation tire chips mixes

From the test results it is identified that with increasing the percentage of tire chips in the gradation mixes the CBR values are increasing up to 2% for G1,G2 and 1.5% for G3,G4, G5. It is also observed that with decreasing the crushed stone particles and increasing crushed dust particles in the given mixes maximum values of CBR are obtained at G3 gradation for all dosages of tire chips. Addition of tire chips offers high resistance against shear deformation at a given penetration; it is due to more elastic nature of composite mixes than conventional mixes.

V. SUMMARY AND APPLICATIONS:

Addition of 1.5-2% of tire chips for gradation mixes in G2, G3, G4 attain CBR values greater than 80% can be effectively used as base coarse material for high traffic loads. Partial replacement of crusher stone with tire chips can yield high elastic condition for the above gradations.

VI. CONCLUSIONS

Modified mixes could attain high CBR values to suit as Sub-base coarse materials as the presence of plastic fines hampers the strength features under saturation. Addition of 0-3% tire wastes could meet the requirements of MORTH specifications to suit as Sub-base coarse material due to the light weight nature of tire waste.

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