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Crumb Rubber Modified Crushed Stone–Crusher Dust Gradation Mixes as Base Course Material

Charan Deepak.P[1], Satyanarayana.P.V.V[2], Rama Krishna.T[3], Arun Kumar.U[4]

PG Student, Professor, PG Student & Ph.D Scholar Civil Engineering& Andhra University, Visakhapatnam, India

Abstract: **Bulk utilization of crusher dust requires experimentation to suit as construction material. Inherently crusher dust has characteristics similar to sand can be identified as an alternative. In the present investigation. crushed stone and crusher dust were used to prepare gradations. In accordance with MORTH by limiting their sizes to 26.5mm. These were further exposed to tire chips of sizes (square) 10mm-4.75mm in partial replacement to the corresponding sizes of crushed stone and subjected for tests like compaction and CBR. Test results showed improvements in CBR values which are 80%. Addition of 1.5 to 2% of tire chips with CBR values greater than 80% can be used as Base course material in flexible pavement construction.**

Keywords**: Crusher dust, Crushed stone, Tire waste, Compaction, CBR.**

1. INTRODUCTION

Crusher dust is an industrial waste obtained from crushing stone plants. It is a residue after making required size of coarse aggregate which is nearly 25lakhs in Andhra Pradesh state in India. Tire waste is a scraped portions of used tires obtained from automobile industries. These require huge quantities of lands for their disposal. Coarse grained and non-plastic nature of crusher dust and light weight and shaping to the required sizes of waste tire attracts researchers to study their interaction with various materials such as crushed stone, sand, fly ash and other materials. . Several researches have attempted in partial modification of natural soils 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)9 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)[7,8]observed improved soil characteristics with addition of crusher dust, Rama Krishna.T et.al(2016)[6] studied Effect of Crusher Dust, Stone and Tire Wastes as Granular Pavement Materials 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.

2. 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(º)	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)	$3.4*10^{-3}$

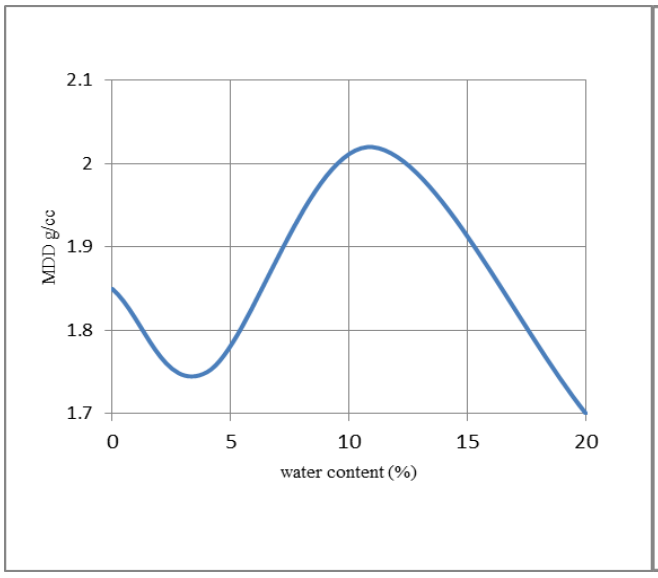

Fig-1(a): Compaction curve for Crusher Dust

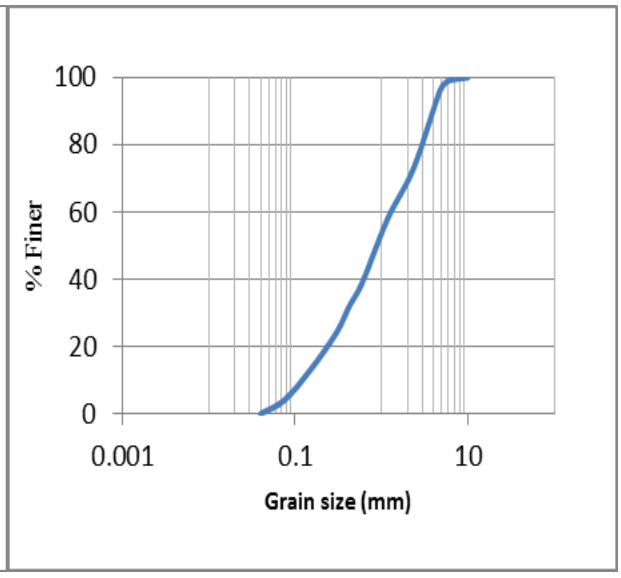

Fig1 (b): Grain size distribution curve of crusher Dust

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	1.2
Density in loose state(g/cc)	0.7
Density in dense state(g/cc)	0.5

3. 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

Table 5:Compaction and strength characteristics of crusher dust and crushed stone:

GRADATION	PROPERTIES		
	OMC(%)	MDD(gm/cc)	CBR(%)
G_1	3.8	2.18	54
G_2	4	2.2	60
G_3	4.3	2.22	68
G_4	4.5	2.2	56
G_5	4.8	2.19	48

From the test results it is identified that CBR values in the range of 48-68% and Maximum dry densities are in the range of 2.18-2.22gm/cc and OMC are in the range of 3.8-4.8%. High CBR values are attained and these are increasing with crusher dust with respect to crushed stone up to 40% and then decreasing. High CBR and dry densities are due to attainment of dense condition along with well graded nature of these gradation mixes.

4. RESULTS AND DISCUSSIONS

4.1 *Interaction between Crumb Rubber crushed stone-crusher dust gradations*

To study the effect of ground granulated waste tire(CRWT) The gradations and crushed stone crusher dust various percentages of Crumb rubber such as 0.5 to 3% were added by their dry weights and these were subjected for compaction and CBR characteristics as per IS2720 and test results are shown in table and figure

4.1.1 *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 6

Table 6: 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	3.9	4	4.2	4.4	4.6	4.8
	MDD(g/cc)	2.18	2.17	2.16	2.15	2.13	2.12	2.1
G_2	**OMC (%)**	4	4.1	4.2	4.4	4.6	4.8	5
	MDD(g/cc)	2.2	2.19	2.17	2.16	2.14	2.13	2.11
G_3	**OMC (%)**	4.3	4.4	4.6	4.8	5	5.3	5.5
	MDD(g/cc)	2.22	2.2	2.18	2.16	2.15	2.14	2.13
G_4	**OMC (%)**	4.5	4.6	4.8	5	5.2	5.4	5.7
	MDD(g/cc)	2.2	2.19	2.17	2.15	2.14	2.13	2.11
G_5	**OMC (%)**	4.8	4.9	5	5.2	5.3	5.5	5.8
	MDD(g/cc)	2.19	2.18	2.16	2.14	2.13	2.12	2.1

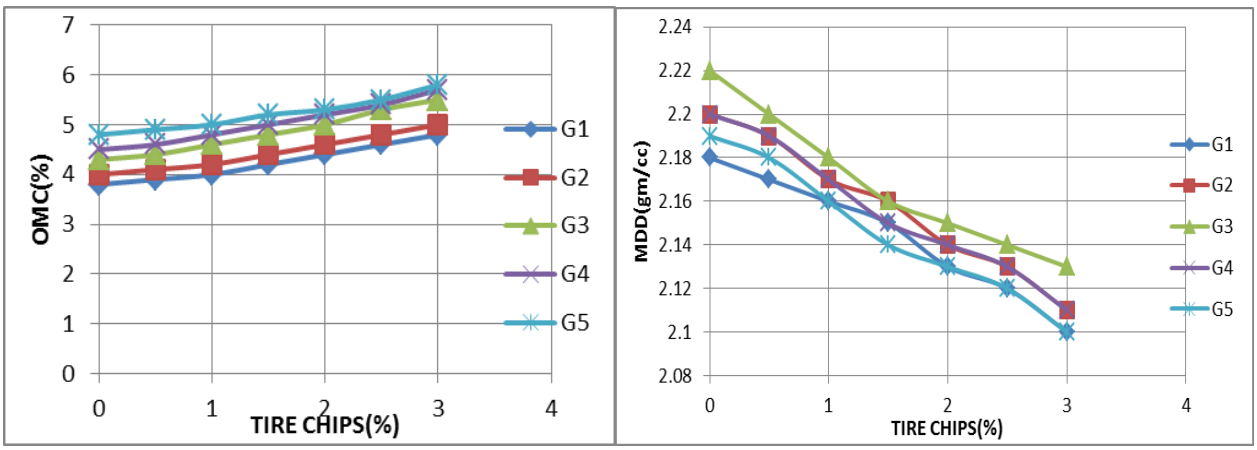

Fig 2: Compaction curves of various Gradations Tire mixes

From the test results it is identified that increasing percentages of CRWT 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 CRWT 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 2.1 to 2.18(g/cc). The increasing in OMC is due to adhesion of more crusher dust particles on to the surfaces of CRWT particles require more water. This behaviour is predominant at higher percentages of crusher dust and higher dosage of CRWT. The decreasing MDD is due to the partial replacement of crusher dust particles by CRWT and light weight of the CRWT compare to crushed stone and

crusher dust particles. This behaviour is pronounced at higher percentages of CRWT. Hence the behaviour can be explained by light weight of CRWT 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 7

Table 7: 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	60	67	72	75	71	64
G_2	CBR	60	66	73	80	82	75	70
G_3	CBR	68	72	78	82	80	72	65
G_4	CBR	56	66	72	76	70	65	62
G_5	CBR	48	60	65	70	65	60	57

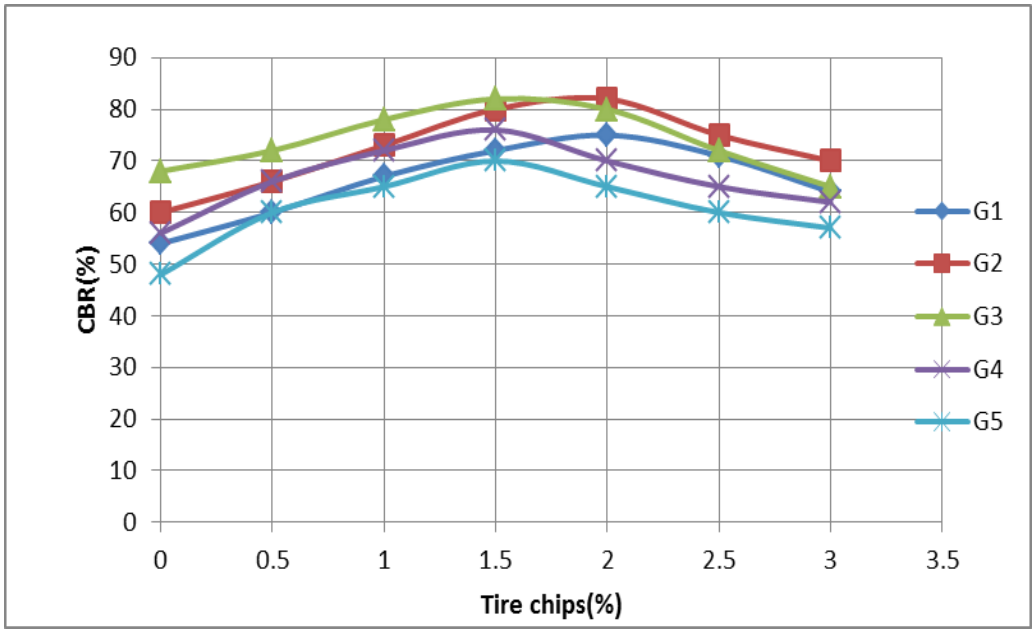

Fig 3: CBR characteristics for various gradation tire chips mixes

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 1.5% for G1,G2,G5 and 2% for G3,G4. 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 CRWT offers high resistance against shear deformation at a given penetration; it is due to more elastic nature of composite mixes than conventional mixes.

5. APPLICATIONS

1.0 Gradation mixes of crushed stone-crushed dust attained high dry densities in the value of 2.18-2.22 and CBR in the range of 48-68% can be used as sub-base material(CBR>30) and base course material for low traffic volume roads(CBR>60).

2.0 Addition of 1.5-2% CRWT to the gradation mixes have attained CBR values greater than 80% can be used as Base course material for high traffic volume roads.

3.0 Presences of CRWT improves the elastic properties and these taken care of impact, shock and dynamic loads and acts as isolated material and also used as friction fill material dynamic loads

6. CONCLUSIONS

Modified CRWT (crumb rubber)gradation mixes could attain high CBR values to suit as Base course materials as the absence of plastic fines which hampers the strength features under saturation. Addition of 1.5-2% Crumb rubber could meet the requirements of MORTH specifications to suit as Base course material

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