A STUDY ON IMPACT OF INDUSTRIAL WASTES UTILIZATION AS BASE COURSE MATERIAL IN FLEXIBLE PAVEMENT CONSTRUCTION

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ABSTRACT
Geotechnical properties of soils used in pavement base course needs to be improved by adopting some sort of stabilization techniques, if required so as to make them suitable for pavement construction. Stabilization of pavement base course soils typically deals with treatment of lime, cement, fly ash, slag, fiber, coir, etc. The recent global industrial revolution has brought mind-blowing transformations in the trade and transportation sector resulting in continuous development and growth of motorized vehicles usage with increased axle load all over the world. The tremendous growth in usage of these motorized vehicles has not only caused design and execution problems along with noise and air pollution but has also created problems in disposing off the tyres. The raw material of Crumb Rubber used in tyres manufacturing does not decompose easily and hence an economically feasible and environmentally sound disposal method has to be found out. One such widespread and feasible way is to utilize these waste end products in the construction of roads, highways and embankments. By doing so, the pollution menace caused by the industrial wastes can be reasonably reduced. As huge quantity of soil is used in the construction of roads and highways, adequate amount of soil with required quality is not available naturally and effortlessly. Hence an attempt has been made in this study to utilize industrial wastes like Crusher Dust, Aggregates and Crumb rubber tyre chips for soil replacement to not only address environmental hazards but also to prove them as alternate economical resources for soil stabilization.

KEYWORDS: *Crusher Dust, Aggregates, Crumb rubber tyre chips, OMC, MDD, CBR*

I. INTRODUCTION

Among all the flexible pavement road components, base course is the one which is expected to transfer the vehicular traffic loads in much smoother manner as it is more effective layer as far as the pavement functions are concerned. The performance of a road pavement will very much depends upon the nature of penultimate top layer like base course. The Base course should be strong enough to reduce the stresses on lower layers. In the Early days of Civilization, gravel roads and gravel stabilized roads are used and later on WBM and WMM are tried in the construction of flexible roads on large scale. All the above mentioned roads are resulted in catastrophic failure due to improper gradation of the particles along with other inherent deficiencies. For improved structural performance the materials used in the base course should meet graduation requirements as per MoRT&H specifications so that they are adequately strong and durable throughout the design period. Comparing the gradation of WMM and Sub-base course, it is identified that there is a similarity to the maximum gradation ranges. In this connection an attempt is made to utilize the sub-base gradation itself as base course layer with an aim of increasing the elastic properties of the particles by improving their gradation.
Normally, conventional soil and aggregates are used for base course construction and they naturally deliver the much required strength and durability. But in the modern construction world on one hand these conventional materials availability is becoming scarce and on the other hand industrial waste materials accumulation is compounding day by day. Many industrialized nations are generating one waste tyre per capita every year approximately. As the disposal of these waste tyres in sanitary

landfills is prohibited, stockpiling of the same results in the problems like land allocation, susceptibility to ignition etc. Hence an environmentally sound and economically viable application in the form of tyre chips is tried as an option in the usage of various geotechnical engineering applications especially in pavement construction projects.

A Srinivas et al (2015)[1] studied the utilization of waste materials in the construction of roads and concluded that maximum load carrying capacity obtained for gravel/flyash reinforced subbase compared to unreinforced subbase courses. P.V.V. Satyanarayana et.al (2013)[2] studied the CBR characteristics of Crusher dust and identified that crusher dust attained high CBR values(10%) at high moisture contents compared to sand and red soils. Madan Mohan Reddy et al (2012)[3] studied the effect of recycled aggregate by using local quary dust. Soosan T.G. et.al (2001)[4] studied the effect of quarry dust in highway construction as embankment and sub base material. Sridharan A, et.al (2005,2006)[5,6] studied strength characteristics of soil and quarry dust mixtures in highway pavement construction. Quadri syed Ghausuddin et al (2011)[7]evaluated soil-quarry dust mixtures reinforced with Polypropylene and concluded that fibers of 24mm length showed optimum performance in dosage of 1.00% by weight of soil quarry dust mixtures. Kumar P Rateesh (2007)[8] studied the effect of demolished waste products in concrete for improving strength. Rao et al (2006)[9] studied the use of aggregates from recycled construction and demolition waste in concrete and found promising results. H.Venkateswarlu et.al (2015)[10] studied the quarry dust effect on behavior of expansive soil with regard to strength aspects in pavement construction. K V Subramanyam et al (2014)[11] studied on the utilization of waste materials and concluded that the CBR increase is from 4.71% to 7.7% with waste tyres. Mandeep singh (2014)[12] studied the effect of waste materials for soil stabilization using waste tyres in geotechnical engineering applications and found feasible to consume the scrap tyres. Bernal, A. et al (1997)[13] analysed the impact of tyre shreds and rubber-sand as Lightweight Backfill Material. Lee, J.H et al (1999)[14] studied the shredded tyres and rubber-sand effect in back filling.

Grading I of Table 400-1 of section 400 - MoRT&H specification strictly advocates about the minimum CBR requirement as 30% with a plasticity index less than 6 and a liquid limit less than 25, for natural soil and gavel. But this natural soil used in base course is subjected to undue development of plasticity characteristics over a period of time by effecting the CBR value and elasticity characteristics significantly. As a result the base course undergoes significant deformation leading to the settlement and ultimate disastrous failure of the pavement components. In order to address MoRT&H specifications shortfall in the base course construction apart from maintaining the ecological balance an attempt has been made in this study to develop a new gradation with the combined mix of crusher dust, aggregate and crumb rubber tyre chips of 10mm size so that it satisfies the MoRT&H stipulations along with improvement in elastic properties. For the sake of convenience three different gradations namely WMM_L, WMM_M, WMM_U are designated by using a set of sieves of the order 53 mm to 0.075 mm as shown below.

The organization of the present research work is as mentioned below. Section 2.0 describes the geotechnical characteristics of the industrial waste materials used in the study along with the trends of their graphical variations. Section 3.0 describes the methodology adopted for conduction of tests by giving the details such as sieve sizes as per new gradation, size and percentage of Crumb rubber tyre chips used in the preparation of modified mix etc. Section 4.0 deals with the results and discussion part of the study. Section 5.0 describes the Conclusions. Section 6.0 describes the scope of future work. Section 7.0 gives the details of the references used in the study.

II. MATERIALS USED

Crusher Dust is obtained from local stone crushing plants nearer to Visakhapatnam City, Andhra Pradesh. The sample is subjected to various geotechnical characterizations. Dry sieve analysis is conducted in accordance with IS 2720 Part IV-1985 in order to obtain the grain size distribution analysis of crusher dust. Coefficient of Uniformity (Cu) and Coefficient of Curvature (Cc) of crusher dust are determined from grain size distribution curves as shown in Table:1,2 and Fig.1,2. Crushed stone aggregate is collected from the same crushing unit as mentioned above. Crumb rubber tyre chips (CRTC) are collected from a tyre re-retreading unit in Visakhapatnam city and the same are cut in to pieces of 10mm square size. Table:3,4 shows the properties of Stone Aggregate and CRTC while

Fig.3,4,5 shows the photographs of the Crusher Dust, Stone Aggregate and Crumb Rubber respectively which are used in the study.

Table: 1

Property	Values
Grain size distribution:	
Gravel Sizes(%)	5
Sand Sizes (%)	88
Fines Sizes (%)	7
a. Silt Sizes (%)	7
b. Clay Sizes (%)	0
Consistency:	
Liquid Limit (%)	Non-Plastic
Plastic Limit (%)	Non-Plastic
I.S Classification	SWN
Specific gravity	2.65
Compaction characteristics:	
Optimum moisture content (OMC) (%)	11.5
Maximum dry density (MDD) (g/cc)	2.08
Shear parameters:	
Coefficient of uniformity (Cu)	6.25
Coefficient of curvature (Cc)	1.0
CBR:	
California bearing ratio CBR (%) (Soaked)	11

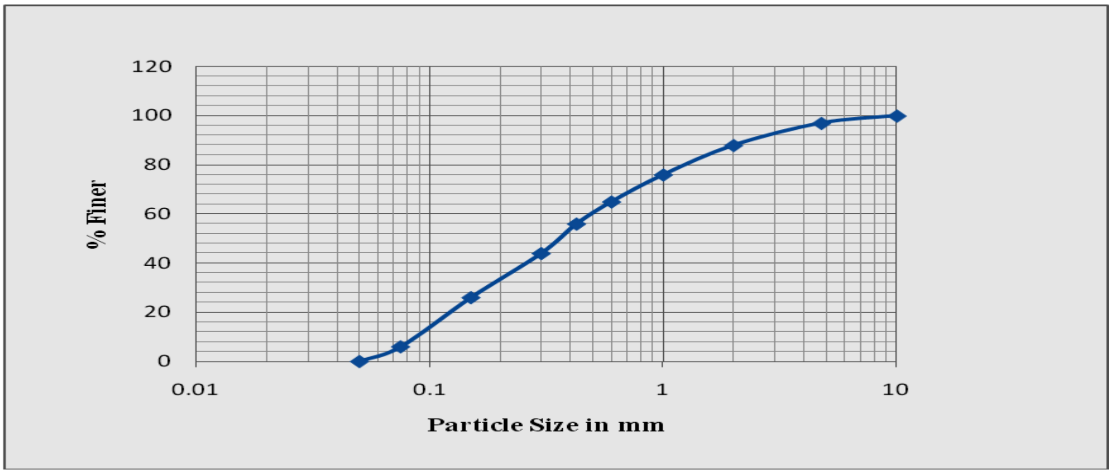

Fig: 1 Grain Size Analysis

Table: 2 Water content and Dry density

Water Content (%)	Dry Density (g/cc)
2	1.89
4.5	1.84
11.5	2.08
18	1.82

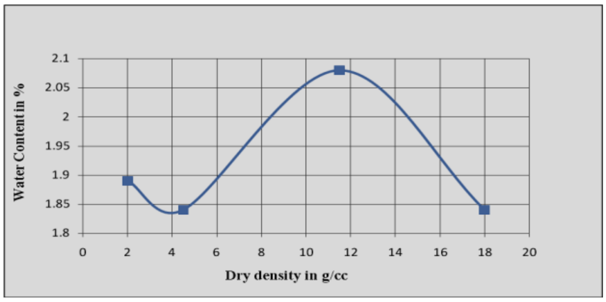

Fig: 2 Compaction curve

Fig: 3 Crusher dust

Fig: 4 Stone aggregate

Fig: 5 CRTC

Table: 3 Aggregate Properties

Aggregate Properties	**Value**
Deval Abrasion Test Value	22%
Aggregate Impact Test Value	18.52%
Aggregate Crushing Value	19.64%
Water absorption	0.48%
Specific gravity	2.34

Table: 4 GGWT Properties

GGWT Properties	**Value**
Max. density g/cc	0.244
Min. Density g/cc	0.224
Specific gravity	1.06

III. METHODOLOGY

A set of sieves of the order 53mm, 45mm, 22.4mm,11.2mm, 4.75mm, 2.36 mm, 0.600 mm and 0.075 mm sizes are identified for the gradation of combined mix. Now in order to cater to the higher cumulative standard axles load of traffic i.e for urban roads, crusher dust and aggregate is mixed with crumb rubber tyre chips of 10mm size with 0.5,1.0,1.5,2.0,2.5 percent by weight of total weight of crusher dust and aggregate is tried to get higher CBR. From the newly developed gradation as shown below in Table:5,strength tests like Compaction, CBR are carried out. IS Heavy compaction tests are carried out on modified mix as per IS:2720 (Part VIII)-1983 for finding the Optimum moisture content (OMC) and Maximum dry density (MDD). The collected modified mix is also subjected for California Bearing Ratio(CBR) test confirming IS: 2720- part 16- 1987.

Table: 5 New WMM Gradation

Sieve Size in mm	**% Passing**	**WMM_L**	**WMM_M**	**WMM_U**
53	100	100	100	100
45	95-100	95	98	100
22.4	60-80	60	70	80
11.2	40-60	40	50	60
4.75	25-40	25	33	40
2.36	15-30	15	22	30
0.600	8-22	8	15	22
0.075	0-5	0	3	5

IV. RESULTS AND DISCUSSIONS

The results obtained by the conduction of the above mentioned tests are as shown below in Table:6 and their trends of variation are shown in Figures 6,7,8.

Table: 6 Results of OMC, MDD and CBR

CRTC %	(WMM+10mmTyre Chips)								
	WMM_L			WMM_M			WMM_U		
	OMC %	MDD g/cc	CBR %	OMC %	MDD g/cc	CBR %	OMC %	MDD g/cc	CBR %
0.5	4.2	2.16	114	4.4	2.18	122	4.5	2.17	116
1.0	4.6	2.14	120	4.7	2.16	129	4.8	2.15	121
1.5	4.9	2.12	128	4.9	2.15	138	5.0	2.14	130
2.0	4.7	2.10	116	5.2	2.14	140	5.3	2.12	126
2.5	4.5	2.09	109	5.0	2.12	118	5.5	2.10	112

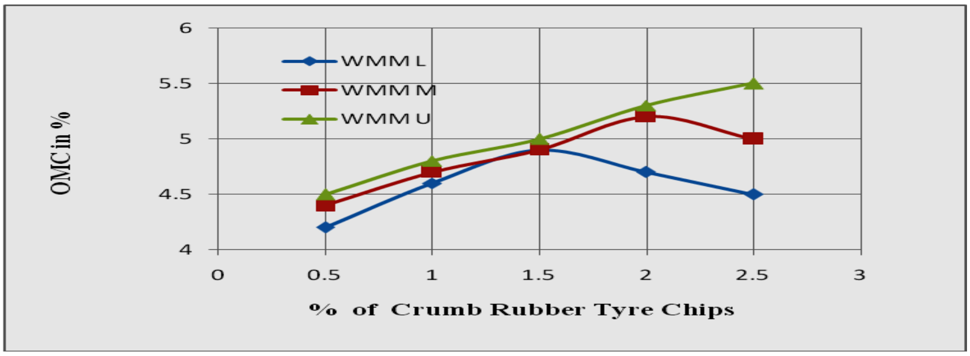

Fig: 6 % Crumb Rubber Tyre Chips Vs OMC

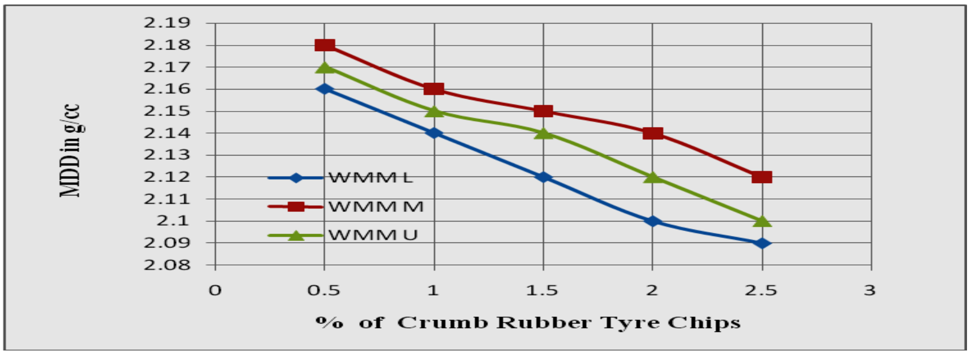

Fig:7 % Crumb Rubber Tyre Chips Vs MDD

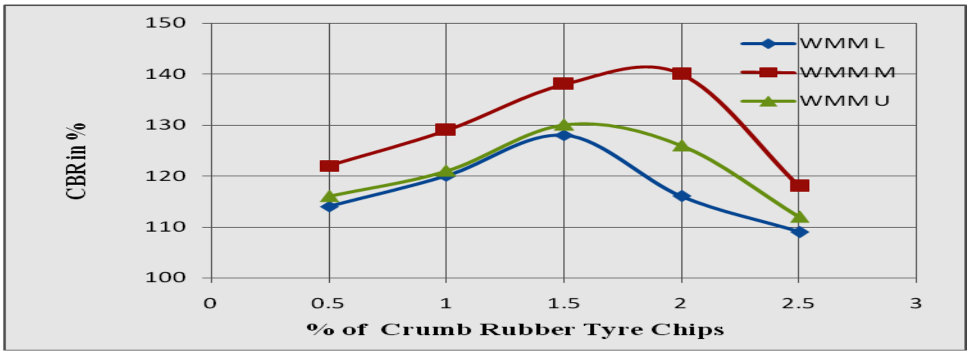

Fig: 8 % Crumb Rubber Tyre Chips Vs CBR

For 10mm crumb rubber tyre chips, in the Lower gradation range the OMC is increasing from 0.5 to 1.5 % and it is decreasing from 2 to 2.5%. For the Middle gradation range the OMC is increasing from 0.5 to 2 % and it is decreasing beyond 2%. For the Upper gradation range the OMC is keep on increasing from 0.5 to 2.5%.For 10mm crumb rubber tyre chips, in the Lower gradation range the MDD is decreasing from 0.5 to 2.5 %. For the Middle gradation range the MDD is decreasing from 0.5% to 2.5%. For the Upper gradation range the MDD is also decreasing from 0.5 to 2.5%. For 10mm crumb rubber tyre chips, in the Lower gradation range the CBR is increasing from 0.5 to 1.5% and from there onwards it is decreasing from 2 to 2.5% . For the Middle gradation range the CBR is increasing from 0.5% to 2.0% and beyond 2% it is getting decreased. For the Upper gradation range the CBR is also increasing from 0.5 to 1.5% and from 2 to 2.5% the value is decreasing.

V. CONCLUSIONS

- The increasing trend of optimum moisture content (OMC) and decreasing trend of maximum dry density (MDD) put forward a remarkable improvement of the modified mix in gaining the strength. As the crumb rubber tyre chips are elastic in nature they offer much required flexibility to the modified mix.
- Crusher dust grain sizes are similar to sand particles and when they are mixed with aggregates and crumb rubber tyre chips, their combined effect of the modified mix results in attaining higher CBR value with much required elastic property due to the reduction in percentage of voids.
- WMM_M mix appears to be the more promising gradation as far as the CBR value is concerned as the maximum CBR value obtained is 140% at 2.0% of CRTC.
- As the CBR values are in the range of 109-140, these modified mix could be used for heavier traffic roads where the expected cumulative standard axle loads are higher as per MoRT&H specifications.

VI. SCOPE OF FUTURE WORK

Crumb rubber tyre chips of 20mm,30mm and 40mm size may be tried with the new gradation in order to explain the further improvement in the CBR with the much required behavior of elasticity in a better way. As the present study is a laboratory confined work, a test track may be constructed to better understand the modified mix response in enhancing some of the predominant geotechnical characteristics of the base course.

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