Utilization of Rubber Tyre Waste in Subgrade Soil

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Abstract

The management of scrap tires has become a growing problem in recent years. Scrap tires represent one of several special wastes that are difficult for municipalities to handle. Whole tires are difficult to landfill because they tend to float to the surface. Stockpiles of scrap tires are located in many communities, resulting in public health, environmental, and aesthetic problems .The paper presents the study carried out with crumb rubber tyre used in strengthening the subgrade. The Standard Proctor test carried out on black cotton soil showed moisture content and dry density as 18% and 2.43 respectively The CBR test has shown the range of values from1.16 to 1.54. Therefore it is suggested that the waste crumbed tyres can be safely used in the sub grade as a soil binder which will effectively hold the soil with increased strength values.

Key words: Crumb Rubber, California Bearing Ratio, Municipal Solid Waste.

Abbreviations: MSW- Municipal Solid Waste, MDD-Maximum Dry Density, OMC- Optimum Moisture Content, CR- Crumb Rubber, CBR- California Bearing Ratio.

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Introduction: The term municipal solid waste (MSW) describes the stream of solid waste generated by household and apartments, commercial establishments, industries and institution. MSW consist of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint and batteries (Pevey et al., 1987). Municipal solid waste (MSW) reflects the culture that produces it and affects the health of the people and the environment surrounding it. Globally, people are discarding growing quantities of waste, and its composition is more complex than ever before, as plastic and electronic consumer products diffuse. Concurrently, the world is urbanizing at an unprecedented rate (Tchobanoglous*et* a*l, 2012*). . These trends pose a challenge to cities, which are charged with managing waste in a socially and environmentally acceptable manner (Erdogan *et al,* 2008). Effective waste management strategies depend on local waste characteristics, which vary with cultural, climatic, and socioeconomic variables, and institutional capacity. Globally, waste governance is becoming regionalized and formalized (Chanakya *et al,* 2009). The MSW generation in various Indian states is presented in Table 1.0.

Table 1.0 Municipal Solid waste generation in India

S. No	Name of State	No. of Cities	Municipal Population	Municipal solid waste (t/day)	Per capita generated (kg/day)
1	Andhra Pradesh	32	10,845,907	3943	0.364
2	Assam	4	878,310	196	0.223
3	Bihar	17	5,278,361	1479	0.280
4	Gujarat	21	8,443,962	3805	0.451
5	Haryana	12	2,254,353	623	0.276
6	Himachal Pradesh	1	82,054	35	0.427
7	Karnataka	21	8,283,498	3118	0.376
8	Kerala	146	3,107,358	1220	0.393
9	Madhya Pradesh	23	7,225,833	2286	0.316
10	Maharashtra	27	22,727,186	8589	0.378
11	Manipur	1	198,535	40	0.201
12	Meghalaya	1	223,366	35	0.157
13	Mizoram	1	155,240	46	0.296
14	Orissa	7	1,766,021	646	0.366
15	Punjab	10	3,209,903	1001	0.312
16	Rajasthan	14	4,979,301	1768	0.355
17	Tamil Nadu	25	10,745,773	5021	0.467
18	Tripura	1	157,358	33	0.210
19	Uttar Pradesh	41	14,480,479	5515	0.381
20	West Bengal	23	13,943,445	4475	0.321
21	Chandigarh	1	504,094	200	0.397
22	Delhi	1	8,419,084	4000	0.475
23	Pondicherry	1	203,065	60	0.295
		299	128,113,865	**48,134**	0.376

(Source: Status of MSW generation, collection, treatment and disposal in class-I cities (CPCB, 2000).

Out of the above mentioned wastes presented in **Table 1.0**, Organic waste can be treated using mulching, Composting, Vermicomposting, Anaerobic digestion leading production of biogas, and mixed waste along with reminder organic waste will be carried to landfills specially designed for the purpose. The inert debris is used in the construction of pavements and pitching and finally filling in low lying lands.

Another major quantity of solid waste due to continuous growth system and number of vehicles is rubber tyres. In the recent years, there is a predominant increase in tyre and tube wastes due to phenomenal increase in number of vehicles around the globe. There have been three main methods for the disposal of waste tyres and tubes: stockpiling, landfilling and burning (Rokade, 2012). Stockpiling is both unsightly and potential health hazard. The combination of rainwater, windblown, pollen and dust trapped within discarded tyres creates an environment, which can increase the breeding rate of diseases carrying vermin and mosquitoes by a factor of 4000 (Grady, 1987). Stockpiling present a fire hazard, once a blazed very difficult to extinguish, release toxic smoke and contaminate groundwater (Barlaz M.A. *et al,* 1993). When placed in landfills with municipal solid waste, tyres do not get compacted thereby reducing landfill capacity; whole tyres can rise to the surface of landfills, causing damage to the final cover of a closed landfill. Burial of sliced tires in landfills is still permitted its slicing minimizes the potential of tyres to rise to the surface (Allen & Turgeon, 1990). Open burning of tyres has hazards associated with air pollution, particulates, odour, visual impacts and other harmful contaminants such as fumes, polycyclic aromatic hydrocarbon, furans, dioxin and oxides of nitrogen (Rokade 2012).In order to utilize waste rubber tyres as resource, there must be proven, cost effective & environmentally sound alternatives in place. Therefore, a study is undertaken to use of waste rubber tyres as an alternative energy recovery or its potential use in other flexible road pavements.

Waste rubber tyre generation (Global Scenario):

A steady stream of large volumes of waste rubber tyres is generated annually owing to the continual increase in the numbers of all kinds of vehicles. This rapid annual increase in the number of tyres has become more severe in developed countries like UK, USA due to expanding cities and ban on stockpiling and landfilling of tyres in many countries.

The waste rubber generation quantity of selected developed and developing countries are placed (Table 2.0).

Table 2.0 : Waste Tyre generation in the World

S. No.	Country	Waste Generation(MY^{-1})	Reference
1	United Kingdom	475	Reschner Kurt, 2006
2	U S A	290	Fikselet.al, 2009
3	Canada	240	Pehlken et.al, 2005
4	France	398	ETRMA, 2006
5	Germany	585	Reschner Kurt, 2006
6	Italy	380	ETRMA, 2006
7	Spain	305	Reschner Kurt, 2006
8	China	239	Zhao Shulanet.al, 2009
9	South Africa	160	Mahlangu et.al, 2009
10	Nigeria	15	Aisien et.al, 2006
11	Bangladesh	23	Rofiqulet.al, 2011
12	Sri Lanka	190	Anonymous, 2003

Waste Rubber Tyre Generation (Indian Scenario):

India being one of the developing countries, there has been rapid annual increase in the number of vehicles leading to steady increase in the volume of consumption waste rubber tyres year by year It has been observed that the production of tyres and tube has been increased year wise. This sector wise annual rubber consumption in India is presented in the Table 3 and associated environmental health hazards is placed in Table 4.0.

Table 3.0 : Rubber Consumption in India sector wise (Quantity in Metric Tonnes)

Sector	Rubber	2005-06	2006-07	2007-08	2008-09	2009-10
Tyre Sector	Natural	442921	462081	495526	508121	576210
	Synthetic	141580	1708091	190987	185094	238153
	Reclaim	21978	23714	27319	29191	34986
Grand Total		606479	656604	713904	722406	894331

Source: Indian Rubber Industry at a Glance. http://allindiarubber.net.

Table 4.0: Environmental health hazards associated with present disposal of scrap tyres.

S. No.	Disposal methodology	Health hazard	Reference
1	Dumping/Stock piling	Breeding place for mosquitoes, vermin, rats and snakes	Naik and Singh, 1991
2	Stock Piling	Fire hazard lasting months releasing toxic fumes	Mavroulidou*et al*, 2010
3	Stock Piling	Oily residue left after a tire fire is difficult to eliminate from the environment.	USEPA, 1993
4	Landfilling	Whole scrap tires eventually come up to the top, damage caps and liners of a landfill.	USEPA, 1993
5	Landfilling	Requires a large amount of space	Garrick G.M., 2005
6	Landfilling	Not easily biodegradable even after long period of landfill treatment	Guneyisi*et al,* 2004.
7	Dumping	Tires are bulky, and 75% of the space a tire occupies is void.	Garrick G.M., 2005
8	Dumping	Shredding the tire eliminates the above problems but requires high processing costs.	Mavroulidou and Figueredo, 2010

A survey was conducted around Hubli-Dharwad Karnataka state (INDIA) to know about the mode of disposal of Waste Rubber Tyres. The tyres were either burnt or sent to kiln which results in serious issues such as cancer. Therefore an attempt is made to use crumb rubber tyre in subgrade soil as soil binder as to utilize it for a safe and useful purpose.

Materials and Methods.

Collection of rubber tyres: The waste rubber tyres are collected from local area which are either burnt or sent to kiln.

Shredding of tyre: The rubber tyres are then shredded by Buffing machine was carried out at Karnataka Tyres, Dharwad and the CR of size 4.75mm and less was taken.

Soil sample: Black cotton soil was collected from Krishi Nagar, Dharwad, Karnataka and was stored in polythene bags openly at Soil Mechanics Laboratory of SDM College and Technology, Dharwad.

Tests for Sub-grade:

Standard Proctor Test: The standard proctor test is carried as to obtain the values of OMC & MDD which will is used in the California Bearing Ratio test as per IS : 2720.

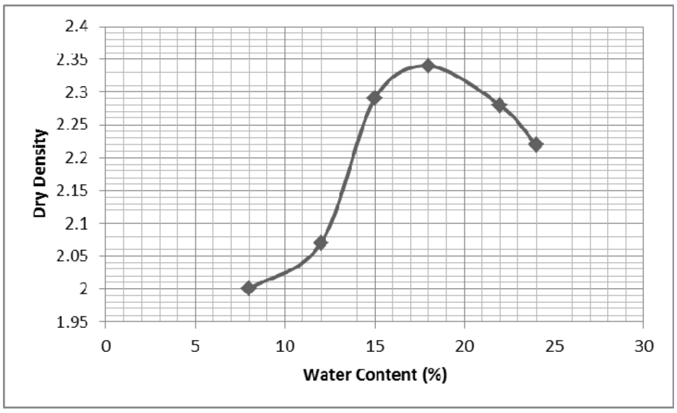
California Bearing Ratio Test: CBR test is performed, firstly a standard sample is prepared and then different percentage of crumb rubber (<4.75mm) is added to the soil. The percentage of crumb rubber is increased till the agreeing values with standard sample are obtained. The CBR tests were conducted in the laboratory for all the samples as per I.S.Code (IS: 2720 (Part-16)-1979).

Results and discussion:

The OMC and MDD of Black Cotton soil was calculated after Proctor test was 18% and 2.34 respectively.

Table 5.0 :Specifications of Apparatus and materials

I.S Sieve	4.75mm
Soil sample taken	3 kg.
Height of mould	12.5 cm
Diameter	10 cm
Volume	981.875 cm^3
Empty weight of mould without collar:	4667 gm.



The CBR results are as shown in the Table 6.0:

Table 6.0: Results of the soaked CBR test conducted

	Pilot Reading	1^{st} trail	2^{nd} Trail	3^{rd} Trail	4^{th} Trail	5^{th} Trail
CR	-	6%	8%	10%	12%	14%
Result	1.63	1.16	1.37	**1.54**	1.03	0.91

There are few reports on use of crumbed rubber tyre in subgrade soil according to which the waste rubber mixed with flash ash has the best performance at 6% (Prasad S. V*et al,* 2009).The present study revealed that on black cotton soil 10 % addition of CR has shown better performance with CBR value. There is further scope to this kind research to be carried with various types of soil and CR combinations. The application of this will be for both rural and urban roads with moderate speeds of vehicles. The black cotton soil subgrade study also can be undertaken by varying the particle size of CR.

Conclusions: The OMC of 18% and corresponding Dry Density 2.34 of Black Cotton soil, further when subjected to CBR test showed increasing trend till 10% of CR and decreased as the percentage of CR tyre is increased to 12% and 14%. The CBR value at 10% is 1.54 which is the highest and also close to the control CBR without CR 1.63.Therfore it is concluded that the addition of CR has the characteristics of increased strength values, and also solves the problem associated with disposal of waste rubber tyres to some extent.

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