Replacement of Coarse Aggregate By Rubber Fragments in Concrete

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Abstract- *A large variety of waste materials is considered feasible and even much valuable additives for concrete. Some of these materials include cellulose, fly ash, silica fumes and wood particles. Rubber obtained from scrapped tyres is considered as the most recent waste materials that have been examined because of its vital use in the construction field. By replacing course aggregates with rubber aggregate in the form of cubical or angular aggregates which increase the shrinkage properties of the concrete. It was also seen from the past studies that it also increases the freeze – throw characteristics of the concrete. It does not only increase the freezing and throwing characteristic but also the expansion and contraction of the concrete were cut in half. And hence the overall advantages is that cracking is reduced. Obviously, these are all excellent advantages when they are used in the optimum proportion otherwise if the rubber content is more then there will be a strength reduction of the concrete. In this paper, cubical and angular rubber fragments were mixed with the concrete and its cube was made. The compressive strength of the concrete cubes was tested with the help of Universal Testing Machine (UTM).*

Keywords- Rubber, Coarse Aggregate, Concrete, Scrapped tyres, Waste material

I. INTRODUCTION

A large variety of waste materials are considered feasible and even much valuable additives for concrete. Some of these materials include cellulose, fly ash, silica fumes and wood particles. Rubber obtained from scrapped tyres is considered as the most recent waste materials that have been examined because of its vital use in the construction field. By replacing course aggregates with rubber aggregate in the form of cubical or angular aggregates which increase the shrinkage properties of the concrete. It was also seen from the past studies that it also increases the freeze – throw characteristics of the concrete. It does not only increase the freezing and throwing characteristic but also the expansion and contraction of the concrete were cut in half. And hence the overall advantages is that cracking is reduced. Obviously, these are all excellent advantages when they are used in the optimum proportion otherwise if the rubber content is more then there will be a strength reduction of the concrete. In this paper, cubical and angular rubber fragments were mixed with the concrete and its cube was made. The compressive strength of the concrete cubes was tested with the help of Universal Testing Machine (UTM).

Bekir et al., (1997) analyzed rubberized concrete according to composite material rules and it was observed that experimental results complied conclusively with equations used for composite material rules. Abdollahzadeh et al., (2011) were modeled rubberized concrete using the artificial neural network and obtained results were compared to experimental data. Results demonstrate the high ability of ANN in the prediction of the compressive strength of rubberized concrete compared to MLR (R^2= 0.9650 and RMSE=0.017). The possibility of using rubber waste from scrap tires as replacement of coarse aggregate in concrete was investigated by Shah et al., (2014). Performance of concrete mixtures incorporating 5, 10 and 15% of scrap rubber as volume replacement for coarse aggregate was investigated and observed that no remarkable changes in concrete properties up to 5% substitution occurred. Beyond 5% substitution, concrete properties change appreciably. Compressive strength, flexure strength, workability, stiffness and unit weight of rubberized concrete decreased as rubber content increased. Even Chen and Liu (2014) use the tire-rubber particles has replaced by coarse aggregate at content levels of 25, 50, 75, and 100% in concrete by volume and observed the same results to that of Shah et al., (2014). The experimental program was carried out by Dai et al., (2013) to investigate strength performance and flexural properties of concrete containing recycled crumb rubber. The rubber contents of 10, 20, 30 and 40% by volume were selected and it is notable that strength properties of crumb rubber concrete and the failure mode tends to become ductile failure due to the rubber inclusion rather than a brittle failure of normal concrete. Tire-derived aggregate (TDA) has been proposed as a possible lightweight replacement for mineral aggregate in concrete by Siringi et al., (2015). The role played by the amount of TDA replacing coarse aggregate as well as different treatment and additives in concrete on its properties is examined and results indicate that while replacement of coarse aggregates with TDA results in a reduction in strength, it may be mitigated with the addition of silica fume to obtain the desired strength. The greatest benefit of using TDA is in the development of a higher ductile product while utilizing recycled TDA. More et al., (2015) study the use of waste tyre rubber as partial replacement of fine aggregate to produce rubberize concrete in the M25 grade of the mix. Different partial replacements of crumb rubber (0, 3, 6, 9 and 12%) by volume of fine aggregates are cast and tested for flexural strength and split tensile strength and the results show that there is a reduction in all type of strength for crumb rubber mixture, but crumb rubber content concrete becomes leaner due to increasing in partial replacement of crumb rubber fine aggregates from 0% to 12%, therefore, such type of concrete of is useful in making light weight concrete.

II. CASTING AND USEFULNESS OF THE PRODUCT

This paper aims at utilizing rubber waste tyres as a constituent in concrete mixes and its products as a partial replacement of natural and artificial fine aggregate components. Scrap rubber tyres of a cubical shape having a size of 20 mm were taken for the study. The rubber tyre was manually cut with the help of hammer and chisel as shown in the (Fig.1). The coarse aggregate was replaced by the cubical rubber aggregate as shown in the (Fig.2). Similarly, the angular rubber was cut in the size of aggregates less than 12mm as shown in the (Fig.3). The M20 grade of concrete was selected. The specific gravity of rubber is 1.15 and average compacted density is 710 kg/m^3. (Fig.4) shows the mixing of concrete and (Fig.5) shows the tamping the concrete while casting the cubes. The sample was tested after 7 days and 28 days. Table 1 shows the results of a compressive test of M20 rubberized concrete having cubical rubber aggregate. Table 2 shows the results of a compressive test of M20 rubberized concrete having angular rubber aggregate. Table 3 shows the results of a compressive test of M20 standardized concrete.

Fig. 1 Rubber tyre manually cut

Fig. 2 Cubical Rubber Sample

Fig. 3 Angular rubber aggregates of less than 12 mm

Fig. 4 Mixing of Concrete

Fig. 5 Tamping the concrete while casting the cubes

If tyres are reused as a construction material instead of being burnt, the unique properties of tyres can once again be exploited in a beneficial manner. In this context, the use of tyre chips in lightweight concrete is considered a potentially significant avenue. Thus, the use of scrap tyres in concrete manufacturing is a necessity than a desire. The use of scrap tyres in concrete is a concept applied extensively over the world. The use of scrap tyres rubber in normal strength concrete is a new dimension in concrete mix design and if applied on a large scale would revolutionize the construction industry, by economizing the construction cost and increasing the worn out tyre disposal. It is with this intension, an experimental study is proposed to be conducted by using crumb rubber as sand in cement concrete.

Table 1. Test Reports of M20 Rubberized Concrete having Cubical Rubber Aggregate

Material kg/cum	Mixed design in SSD condition	Moisture	Absorption	Correction	Corrected mix	Trial batch kg
Cement	250	-	-	-	250	9.15
Flyash	100	-	-	-	100	3.66
Rubber	36	-	-	-	36	1.32
20mm (Metal 2)	559	0 %	0.90 %	5.0	554	20.27
10mm (Metal 1)	412	0 %	1.10 %	4.532	407	14.91
Crushed Sand	931	0 %	2.90 %	26.999	904	33.07
Water	168	-	-	-	205	7.48
Admixture	4.025	-	-	-	4.025	0.147
Density	2460	-	-	-	2460	89.85
Mix appearance		Mix is homogeneous and workable				
Workability		Initial		170 mm		
		60 min		150 mm		
		120 min		140 mm		
		180 min		70 mm		
Cube Compressive Strength Results						
Age	Weight (kg)		Strength (N/mm²)		Average (N/mm²)	
7 Days	8390		12.10		12.56	
	8490		11.50			
	8450		14.08			
28 days	8430		22.95		22.25	
	8410		21.16			
	8540		22.65			

Table 2. Test Reports of M20 Rubberized Concrete having Angular Rubber Aggregate (less than 12mm)

Material kg/cum	Mixed design in SSD condition	Moisture	Absorption	Correction	Corrected mix	Trial batch kg
Cement	250	-	-	-	250	8.13
Flyash	100	-	-	-	100	3.25
Rubber	36	-	-	-	36	1.17
20mm (Metal 2)	559	0 %	0.90 %	5.0	554	18.02
10mm (Metal 1)	412	0 %	1.10 %	4.532	407	13.25
Crushed Sand	931	0 %	2.90 %	26.999	904	29.40
Water	168	-	-	-	205	6.65
Admixture	4.025	-	-	-	4.025	0.131
Density	2460	-	-	-	2460	79.87
Mix appearance		Mix is homogeneous and workable				
Workability		Initial		180mm		
		60 min		160mm		
		120 min		120mm		
		180 min		80mm		
Cube Compressive Strength Results						
Age	Weight (kg)		Strength (N/mm²)		Average (N/mm²)	
7 Days	8500		14.74		14.75	
	8390		13.06			
	8478		16.45			
28 days	8440		26.46		26.55	
	8530		26.46			
	8410		26.72			

Table 3. Test Reports of M20 Standardized Concrete

Material kg/cum	Mixed design in SSD condition	Moisture	Absorption	Correction	Corrected mix	Trial batch kg
Cement	250	-	-	-	250	9.15
Flyash	100	-	-	-	100	3.66
Rubber	0	-	-	-	0	0
20mm (Metal 2)	595	0 %	1.0 %	6.0	589	21.55
10mm (Metal 1)	412	0 %	1.10 %	4.532	407	14.91
Crushed Sand	931	0 %	3.10 %	28.861	902	33.00
Water	168	-	-	-	207	7.59
Admixture	4.2	-	-	-	4.2	0.154
Density	2460	-	-	-	2460	89.85
Mix appearance		Mix is homogeneous and workable				
Workability		Initial		Collapse		
		60 min		180mm		
		120 min		170mm		
		180 min		130mm		
Cube Compressive Strength Results						
Age	Weight (kg)		Strength (N/mm²)		Average (N/mm²)	
7 Days	8510		14.22		14.18	
	8540		15.11			
	85600		13.22			
28 days	8620		25.22		24.80	
	8570		24.21			
	8609		24.97			

III. COMPARATIVE ANALYSIS

After carrying out the experiments using rubber aggregates, a comparison between the three samples was made. These three samples consisted of standard M20 cubes, cubical rubberized M20 concrete cubes, and angular rubberized M20 concrete cubes. The compressive strength of the three different samples is shown below in Table 4.

Table 4. Comparison of the compressive strength

Age (Days)	Standard (MPa)	Cubical (MPa)	Angular (MPa)
7	14.18	12.56	14.75
28	24.8	22.25	26.5

IV. COST ANALYSIS

The cost analysis for rubberized concrete v/s standard M20 concrete was carried out for the 1-meter cube to check its economic feasibility. Table 5 Shows the detailed cost analysis of standard M20 concrete cube and rubberize concrete cube. It is observed that only about 3 % of the cost is increased in case of utilization of rubberized concrete.

Table 5. Cost comparison of rubberized concrete with standard M20 concrete cube

Concrete Rate Per Cum M-20 Part A (March 2016) – With Rubber				
Ingredients	Unit/Cum	Rate (INR)	Rate /Kg	Amount (INR)
Cement	250	5700	5.7	1425
Flyash	100	2205	2.21	221
Rubber	36	200	3	108
M/Sand	931	4200	0.89	832
CA-1	412	2940	0.73	301
CA-2	595	2940	0.72	429
Water	168	900	0.09	15
Admixture	3.5	53000	53	186
Total		3510 Rs/-		
Concrete Rate Per Cum M-20 Part A (March 2016) – Without Rubber				
Ingredients	Unit/Cum	Rate (INR)	Rate /Kg	Amount (INR)
Cement	250	5700	5.7	1425
Flyash	100	2205	2.21	221
Alccofin	0	0	0	0
M/Sand	931	4200	0.89	832
CA-1	412	2940	0.73	301
CA-2	595	2940	0.72	429
Water	168	900	0.09	15
Admixture	3.5	53000	53	186
Total		3409 Rs/-		

V. CONCLUSION

As seen in the test reports the compressive strength of rubberized M20 concrete having angular aggregates was found out to be higher than the compressive strength of standard M20 concrete and rubberized M20 concrete having cubical aggregates. Thus we conclude that rubberized concrete can be used for the following purposes:

1. PCC (Plain Cement Concrete)
2. Partition Walls: Light in weight than regular concrete, therefore, reducing dead load of the structure.
3. Road Pavements: Due to high permeability the water can percolate inside the soil and help in recharging the water table.
4. Reducing the cost of footing.

The future scope of the study is discussed as follows:

1. The scrap rubber can be cut in different sizes and used in various samples.
2. The aggregates can be replaced by different percentages
3. Different constituents can be used in concrete such as the grade of cement, admixtures & fly ash.
4. Numerous cubes having different constituents and percent -age replacements of aggregates can be cast and their results can be compared.

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