USE OF CRUMB RUBBER AS FINE AGGREGATE IN CONCRETE TO INCREASE THE STRENGTH OF CONCRETE BLOCK

[1]Abhay Kumar, [2]Dr. Salini Yadav
M. E. Scholar, Civil Engineering, AISECT University, Bhopal, MP, India
Associate Professor, Civil, AISECT University, Bhopal, MP, India

Abstract: It was need of society to identify areas where tyre rubber can be used without much investment and at mass scale. The use of scrap tyre rubber in the preparation of concrete has been thought as an alternative for disposal of such waste to protect the environment. In this study an attempt has been made to identify the various properties necessary for the design of concrete mix by replacing aggregates with crumb tyre rubber. M20 grade concrete has been chosen as the reference concrete specimen. Scrap tyre rubber powder, has been used as fine aggregate with the replacement of conventional fine aggregate. This will not only allow the sustainable use of aggregates available to us but also provide an effective and mass management of rubber tyre waste. The rubber tyre waste is powdered into fine crumb and then this crumb tyre aggregate is added as 5%, 10%, and 15% to replace the fine aggregate. In this study, workability, homogeneity, compressive and flexural strength of rubberized concrete are evaluated to investigate the optimal use of crumb rubber as fine aggregate in concrete.

1. INTRODUCTION

A very Large amounts of used rubber tyres cumulate in the world every year out of which 275 million in the India [1] and around 180 million in European Union [2]. One of the most popular methods to get rid of this rubber waste is to pile these tyres in landfills, and since they have low density and poor degradation, we cannot burry them as landfills [3]. These tyres are also placed in a dump, or disposed of by simply piling them in large holes in the ground. And these dumps serve as a great homage to mosquitoes and these mosquitoes spread many diseases, this becomes a serious & dangerous health hazard [4]. However, this rubber waste's higher amounts can be utilized as fuel, pigment soot, in bitumen, roof and floor covers etc. One of such applications that could use old rubber tyres effectively is rubberized concrete. Concrete can be made cheaper by replacing a fixed percentage of fine aggregate with granulated rubber crumbs from rubber waste. These granulated rubber crumbs can be achieved through a process called continuous shredding, which is done to create crumbs small enough to replace aggregates as fine as sand effectively. Such kind of concrete can be used in manufacturing process of reinforced pavement and bridge structures because this have better resistance to frost and ice thawing [5, 7, 8].

In present scenario, the disposal of waste tyre rubber is a major concern in waste management throughout the world. It is estimated that around 1.2 billion of waste tyre rubber is produced per year around the world. It is also estimated that around 11% of tyres are exported post consumption and 27% are piled as landfill, stockpiled or dumped illegally and only 4% of it is utilized for civil engineering works. Hence, efforts have been made to identify the potential of this waste tyre rubber in civil engineering projects. Our present study aims to investigate in the same context i.e. the optimal use of crumb rubber as fine aggregate in concrete composite. With the increase in urbanization in countries like India the total number of vehicles and consequently the amount of used rubber tyres is increasing significantly. Hence, this waste is going to be a big environmental threat. This study shows us an alternative way of recycling tyres by incorporating them into concrete. Of course, the concept that if the problem emerges from urbanization and the solution must go along with it should also be appreciated. Therefore, the aim of this study is to introduced an environmental friendly technology, which will benefit the society and the nation.

Figure.1 Tyre waste dump yard

2. MATERIAL USED

2.1 Ordinary Portland cement

The ordinary Portland cement of 53grade manufactured by the ULTRATECH Cement Company was used in the study, which is in accordance with IS 12269:1987.Having design strength for 28 days being a minimum of 53 MPa or 530 kg/ sqcm.

2.2 Coarse Aggregates

Locally available coarse aggregates were used for the preparation of test samples using rubberized concrete. Graded coarse aggregate were used & is described by its nominal size i.e. 40mm, 20mm, 16mm, 12.5mm etc. The coarse aggregate having nominal size 20mm has been used in this study. Sieve analysis on the coarse aggregate samples was carried out in the laboratory and the results obtained are shown in the Table. The properties of the coarse aggregates used for the experiment are shown in Table 1

Table.1 Properties of coarse aggregates

Properties	Value as per test Results	Value as per IS standards for R.C.C work
Specific gravity	2.62	2.60
Water absorption	1.1 %	< 2 %
Impact factor	6.16 %	< 45 %

2.3 Crumb Rubber

Crumb rubber is defined as the fine pieces of rubber obtained from vehicle tires. This type of rubber is obtained by a process called Ambient Grinding. This type of grinding is a multi-step process and uses car or truck tires in the form of shred, or sidewalls, chips, or treads. By following the process, the rubbers, metals and textiles are separated out sequentially. After this, the tires are passed through a shredder, where the tires are broken into smaller chips. The small chips are then supplied into a granulator that breaks them further into even more smaller pieces while removing steel and fiber in the process.

2.4 Preparation of Cube & Beam Samples

Cube samples of size 15 x 15 x 15 cm & beam samples of size 50 x 10 x 10 cm were prepared for this project. M20 grade of concrete was considered for the preparation of samples.

Table.2 Material Proportions (per m^3 of concrete)

replacement % age	cement	fine aggregate	coarse aggregate	water	crumb rubber	no. of cubes prepared	no. of beams prepared
0 %	373.38	609.60	1220.8	186.69	0	6	6
5 %	373.38	579.12	1220.8	149.31	30.48	6	6
10 %	373.38	548.64	1220.8	149.31	60.96	6	6
15 %	373.38	518.16	1220.8	149.31	91.44	6	6

Figure.2 batching of materials

2.5 Mixing of materials

After the process of batching, the materials were selected in a ratio given in Table 3-3 and they were mixed together, the process is called the Mixing. Mix were prepared using volumetric proportions for M20 i.e. a ratio of 1:1.5:3. The following figure 3.2 shows the process of manual mixing done in the laboratory;

(a) (b)

Figure.3 (a) Mixing of materials (b) curing of samples

3. TESTING

3.1 Compression test

This test helps us in determining the compressive strength of the concrete cubes. The obtained value of compressive strength can then be used to assess whether the given batch of that concrete cube will meet the required compressive strength requirements or not. For the compression test, the specimen's cubes of 15 cm x 15 cm x 15 cm were prepared by using crumb rubber concrete as explained earlier. These specimens were tested under universal testing machine after 7 days and 28 days of curing. Load was applied gradually at the rate of 140kg/cm2 per minute till the specimens failed. Load at the failure was divided by area of specimen and this gave us the compressive strength of concrete for the given sample.

Figure.4 Compressive Strength test of cube samples in UTM

3.2 Flexural Test

Flexural strength is the measure of strength of the concrete in bending. The flexural strength of concrete is said to be an indirect measure of the tensile strength. The flexural strength is also expressed as modulus of rapture and can be determined by standard test methods (third point loading) or (center-point loading). For the present study the method of three points loading was used.

Figure.5 Flexural Strength tests of beam samples in UTM

4. RESULT

4.1 Compressive Strength Test

The compressive strength test was performed on the cubes of size 15 cm x 15 cm x 15 cm to check the compressive strength of rubberized concrete and the results obtained are given in Table 3.

Target mean strength for 28 days for M20 concrete (f'_{ck}) = f_{ck} + 1.65*s
= 20 + 1.65 x 4
= 26.6 N/mm2

Where, f'_{ck}= target mean strength at 28 days
f_{ck} = characteristic compressive strength at 28 days &
s = standard deviation = 4 (for M20 concrete)

Table.3 Results of compressive strength test

S. No.	% of crumb rubber	Compressive Strength(N/mm2)	
		7 Days	28 Days
1	0%	16.03	26.75
2	5%	19.34	28.73
3	10%	18.53	27.46
4	15%	16.67	25.63

From the above results it was observed that with the increase in percentage of crumb rubber from 0% to 15% in concrete the compressive strength decreased.

4.2 Flexural Strength Test Result

The Flexural test was performed on the beams of size 50 x 10 x 10 cm to check the flexural strength of the rubberized concrete and the results obtained while performing the flexural test on UTM are given in Table.4

Table.4 Result of flexural strength

S.No.	% of crumb rubber	Flexural Strength (N/mm2)	
		7 Days	28 Days
1	0 %	3.8	5.05
2	5 %	5.9	7.33
3	10 %	5.10	6.63
4	15 %	4.86	5.90

From the above results it was observed that the flexural strength of crumb rubber concrete was better than that of conventional concrete (i.e. at 0% replacement). It was also observed that the flexural strength of beam decreased with the increase in crumb rubber content in the concrete.

4.3 Compaction Factor Test Result

The compaction factor test was performed on the rubberized concrete to check the work ability of it at different replacements viz. 5 % , 10 % , 15% and the following results were obtained, according to which it can be concluded that with the increase in % of rubber from 0 to 15 % , workability decreases. Theoretical maximum value of compaction factor can be .96 to 1.0. The results obtained for compaction factor test are shown below in Table 5

Value of compaction factor for 0% replacement
Wt. of partially compacted concrete / wt. of fully compacted concrete = 9.63/11.83 = 0.81
Similarly,
Value of compaction factor for 5% replacement =12.00/10.43 = 0.87
Value of compaction factor for 10% replacement = 11.69/9.52 = .82
Value of compaction factor for 15% replacement = 10.92/8.76 = 0.80

Table.5 Results of compaction factor test

S.No.	% of rubber	Wt. of partially compacted concrete (kg)	Wt. of fully compacted concrete (kg)	Value of compaction factor
1	0 %	9.63	11.83	0.81
2	5 %	10.43	12.00	0.87
3	10 %	9.52	11.69	0.82
4	15 %	8.76	10.92	0.80

The variation of the compressive strength of the rubberized with respect to the variation of percentage of crumb rubber is shown in figure 6.

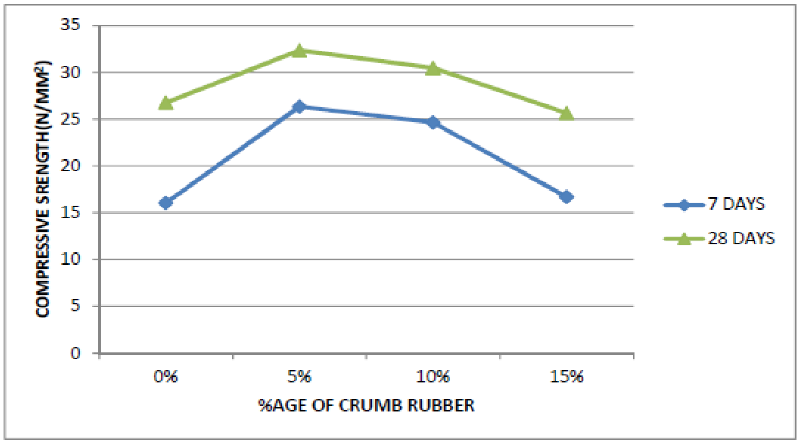

Figure.6 Compressive strength v/s %age of crumb rubber

From this study, it can be concluded that a replacement of up to 10% of crumb rubber can be made safely in flexural members. The variation in flexural strength with respect to the given percentage of crumb rubber is shown in figure 7.

Figure.7 Flexural strength v/s % age of crumb rubber

The compaction factor test was conducted by adding different percentages of crumb rubber as fine aggregates to M20 mix. The studies proved that with the addition of crumb rubber aggregates the value of compaction factor decreases that means workability decreases with increase in rubber content as shown in figure 8.

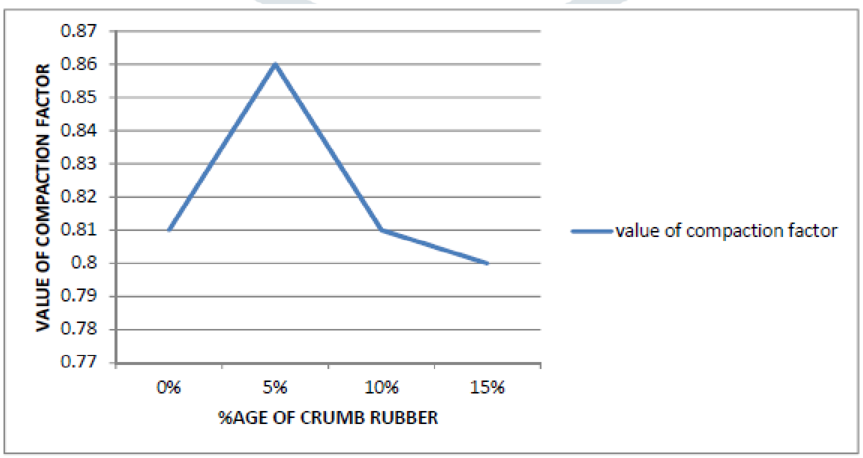

Figure.8 Compaction factor v/s % age of crumb rubber

5. CONCLUSION

- Concrete with higher percentage of crumb rubber possess low workability i.e with increase in percentage of crumbed rubber the concrete workability decreases.
- The flexural strength of the concrete decreases about 56% when 15% of sand is replaced by crumbed rubber. The compressive strength of the concrete decreases about 25% when 15% of sand is replaced by crumb rubber. With the addition of the crumb rubber, the

reduction in strength cannot be avoided. However, these data provides only preliminary guideline for the strength-loss of locally produced modified concrete in comparison with the conventional concrete of 20 MPa targeted strength.

- Rubberized concrete is also used for insulation work like insulation from noise and heat. So it can be used as an insulating material in walls in residential as well as commercial buildings and as a noise insulator in theatres, cinema halls, noise proof rooms and auditoriums etc.

6. REFERENCES

[1] Rubber Manufacturer's Association, NW Suite 900, Washington DC 20005,2000.

[2] Tantala, M.W., Lepore, J.A., and Zandi, I., "Quasi-elastic behavior of rubber included concrete", Proceedings 12th International Conference on Solid Waste Technology and Management, Philadelphia, 1996.

[3] Paul, J., Encyclopedia of polymer science and engineering, Vol. 14, 1985, pp. 787-802.

[4] Takallou, H.B. and Takallou, m.B., Elastomeric, Vol. 123, 1991, pp.9.

[5] O'Keefe, W., Power, Vol. 128, No. 10, October 1984, pp. 115.

[6] Read, J., Dodson, T., and Thomas, J., "Experimental project – use of shredded tyres for lightweight fill, Oregan Department of Transportation, Post Construction report for Project No. DTFH -71-90-501-OR-11, Salem, Oregan, 1991

[7] Heitzman, M., "Design and Construction of Asphalt Paving Materials with Crumb Rubber", Transportation Research Record No. 1339, Transportation Research Board, Washington DC, 1992.

[8] Scrap Tyre Management Council, Scrap Tyres Use, Washington DC, 1995.

[9] Esch, D. C., "Asphalt pavement modified with coarse rubber particles: Design, construction and ice control observations," Alaska Department of Transportation and Public Facilities, 1984.

[10] Adams, C., Lamborn, M., and Shuler, S., "Asphalt-rubber binder laboratoryperformance," Report FHWA/TX-8571, 347-1F, Texas Department of Highways and Public Transportation, 1985.

[11] Estakhri, C., "Use, availability and cost effectiveness of asphalt rubber in Texas, Research Report 1902 –1F, Texas Transportation Institute, Texas A&M University System, 1990

[12] Khosla, N.P. and Trogdon, J. T., "Use of ground rubber in asphalt paving mixtures," Technical Report, Department of Civil Engineering, North Carolina State University, Raleigh, May 1990.

[13] Raghvan, D., Huynh, H., and Ferraris, C.F., "Workability, mechanical properties and chemical stability of a recycled tyre rubber-filled cementitious composite," Journal of Materials Science, Vol. 33, No. 7, pp. 1745-1752.

[14] Khatib, Z.K. and Bayomy, F.M., "Rubberized Portland cement concrete," Journal of Materials in Civil Engineering, 1999, pp. 206-213.

[15] Fedroff, D., Ahmad, S., and Savas, B. Z., "Mechanical properties of concrete with ground waste tyre rubber," Transportation Research Board, No. 1532, 1996, pp.66-72.

[16] Ali, N.A., Amos, A.D., and Roberts, M., "Use of ground rubber tyres in Portland cement concrete," Proceedings, International Conference on Concrete 2000, University of Dundee, UK, 1993, pp. 379-390.

[17] Rostami, H., Lepore, J., Silverstraim, T. and Zundi, I., "Use of recycled rubber tyres in concete," Proceedings, International Conference on Concrete 2000 University of Dundee, UK, 1993, pp. 391-399.

[18] Eldin, N.N. and Senouci, A.B., "Rubber-tyre particles as concrete aggregates," Journal of Materials in Civil Engineering, ASCE, Vol. 5, No. 4, 1993, pp. 478- 496.

[19] Topcu, I.B., "The properties of rubberized concrete," Cement and Concrete Research, Vol. 25, No. 2, 1995.

[20] Fatuhi, N.I., and Clark, N.A., "Cement-based materials containing tyre rubber," Construction Building Materials, Vol. 10, No. 4, 1996, pp. 229-236.

[21] Segre, N. and Joekes, I., "Use of tyre rubber particles as addition to cement paste," Cement and Concrete Research, Vol. 30, No. 9, 1998, pp.1421-1425.

[22] Lee, H.S., Lee H., Moon, J.S., and Jung, H.W., "Development of tyre-added latex concrete," ACI Materials Journal, Vol. 95, No. 4, 1998, pp.356-364.

[23] Biel, T.D. and Lee, H., "Magnesium oxychloride cement concrete with recycled tyrerubber," Transportation Research Record No. 1561, 1996, pp. 6-12.

[24] Goulias, D.G., and Ali, A.H., "Non-destructive evaluation of rubber modified concrete," Proceedings, Special Conference, ASCE, New York, 1997, pp. 111- 120.

[25] Topcu, I.B. and Avcular, N., "Analysis of rubberized concrete as a composite material," Cement and Concrete Research, Vol. 27, No. 8, pp. 1135-1139

[26] Topcu, I.B. and Avcular, N., "Collision behaviors of rubberized concrete," Cement and Concrete Research, Vol. 27, No. 12, pp. 1893-1898.

[27] Savas, B.Z., Ahmad, S., and Fedroff, D., "Freeze-thaw durability of concrete with ground waste tyre rubber," Transportation Research Record No. 1574, November 1996, pp. 80-88.

[28] Topcu, I.B. and Avcular, N., "Analysis of rubberized concrete as a composite material," Cement and Concrete Research, Vol. 27, No. 8, pp. 1135-1139

[29] Topcu, I.B. and Avcular, N., "Collision behaviors of rubberized concrete," Cement and Concrete Research, Vol. 27, No. 12, pp. 1893-1898.

[30] Savas, B.Z., Ahmad, S., and Fedroff, D., "Freeze-thaw durability of concrete with ground waste tyre rubber," Transportation Research Record No. 1574, November 1996, pp. 80-88.