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An Experimental Study on Crumb Rubber Concrete-Solution to Tyre Waste Disposal

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ABSTRACT: Throughout the world, the disposal of used tires is a major environmental problem causing environmental hazards such as breeding ground for mosquitoes, producing uncontrolled fire and they are contaminating the soil and vegetation.. Concrete is an excellent structural material and considered as essential for the modern civilization and human society. This study reviews the feasibility of using waste tires in the form of chips with different sizes in concrete to improve the strength as well as protecting the environment. A control Portland cement concrete M40 mix is designed as per Indian standards .Crumb rubber contents of 5,10, 20 and 30 % by volume was partially replaced as coarse aggregate with crumb rubber. To improve the strength the same procedure was repeated on the same percentage replacement of tyre coated with cement. Water cement ratio used is 0.4. Laboratory test for compressive strength, splitting tensile strength, flexural strength and modulus elasticity was done. The results revealed that there is a reduction in strength for plain crumb rubber mixture, but 5% coated crumb rubber mixture showed increase in strength. Slump values increase as the crumb rubber content increase from 0% to 30%. The results indicated that inclusion of crumb rubber in concrete reduced the static modulus elasticity. In this study, the use of tyre chips in concrete construction is shown and how it is suitable for the concrete, its uses, barriers, benefits and way to future study. It is evident from the test results that adding rubber aggregate into Ordinary Portland Cement concrete has a marked effect on the strength properties of the concrete, specifically a significant reduction in the compressive and splitting tensile strength. As per the test and analysis carried out we came to the conclusion that the waste tyre can be diverted to the construction field as a part of pollution control.

Keywords: Compressive strength; crumb rubber; split tensile strength; tyre waste disposal

INTRODUCTION

Over the years, disposal of tires has become one of the serious problems in environments. The aim of this study is achieved to use of rubber waste as partial replacement of coarse aggregate to produce rubberize concrete in M30 mix. Different partial replacements of crumb rubber (0, 2.5, 5, 10, and 15%) by volume of fine aggregate are cast and test for compressive strength, flexural strength, split tensile strength. With the phenomenal increase in number of automobiles in India during recent years the demand of tyres as original equipment and as replacement has also increased from 22,846 thousand tyres in the year 1990-91 to 31,213 thousand tyres in the year 1994-95. Various advantages include improved skid resistance, better crack reflection control increased flexibility, toughness, tenacity of road surface, reduced noise level of traffic, improved performance under extreme temperature conditions etc.

MATERIAL NAD METHODS

The materials used to develop the concrete mixes in this study were 53-grade Ordinary Portland Cement, Natural River Sand, Rubber aggregate, Crushed Coarse Aggregate of maximum size 20mm, tap water for mixing and curing.

Cement: IS Ordinary Portland Cement was used throughout the investigation. Specific gravity of the cement is found to be 2.5.

Fine Aggregate: Sand of 2.8 specific gravity from Quarry was used. The sand was air-dried in the laboratory.

Coarse Aggregate: 20 mm and 10 mm crushed gravel of 2.69 specific gravity from the same source were used. The coarse aggregate was of irregular shape. The gravel were air-dried in the laboratory and stored.

Tyre Chip Aggregate: Rubber aggregates are obtained by reduction of scrap tyres to aggregate sizes using two general processing technologies: mechanical grinding at ambient conditions (at room temperature) or cryogenic grinding . Coarse rubber aggregate (tyre chips) of 20 mm maximum size was used in this investigation. The shape of the rubber aggregate was long and angular with a specific gravity of 1.14.

Mixture Preparation: The present project is done by considering mix, containing tyre chips coated with cement paste. The tyre chips were washed cleaned and dried for 24 hours and was then used for testing to improve the strength characteristics. Rubber aggregates coated with cement paste were produced as follows:

The rubber aggregates were first immersed in water paste, are shown in Figure 1 and Figure 2.

Figure 1: 20 mm plain rubber aggregate

Figure 2: 20 mm rubber aggregate coated with cement paste

All mixtures were mixed manually. Mixing procedures were the same for all concrete mixes. As for the rubberized concrete mixtures, the fine aggregate, rubber tyre chips and cement were added gradually to the mix and mixed thoroughly. Water was then added gradually to the mix for a period of 2 minutes and followed by mixing for 5 minutes to produce a uniform mix.

Standard 150 mm cubes, cylinders (150 mm diameter x 300 mm long) and beams (100 mm x 100 mm x 500 mm) specimens were prepared for compressive strength, splitting tensile strength and flexural strength respectively. Moulds were filled with fresh concrete in two layers and tamped 25 times to drive out air trapped in the mix and to ensure full compaction. It is then put on curing water tank for the required number of days.

Experimental Programmes: The method adopted for finding the Compressive, Flexural and Split Tensile Strength of concrete specimens are done as per IS: 516-1959 and IS: 5816-1999.

Testing of Specimens:

1. Slump Tests: The mould for the slump test is in the form of a frustum of a cone, which is placed inside a hollow cylinder on the top of a plate. The value of the slump is obtained from the distance between the underside of the round tamping bar and the highest point on the surface of the slumped concrete sample (Figure 3).

Figure 3: Slump test

2. Compacting Factor Test: The compacting factor test was conducted using the apparatus, which consists of a column supporting two funnel-shaped hoppers mounted above each other. Each of the hoppers is fitted with a quick-release trap door. The Compacting Factor is given as follows (Figure 4):

Compacting factor, CF = m1/m2

Figure 4: Compaction factor test

3. Compressive Strength: After 7 days and 28 days of curing the cubes were taken out of the curing tank and tested for their Compressive Strength in a Compression Testing Machine. The load was applied at a rate of 14 N/mm2 per minute as per the code IS-6:1959 (Figure 5).

Figure 5: Compressive strength test

4 Flexural Strength: In this test, a load is applied through two rollers at the third points of the span until the specimen breaks. After 7 days and 28 days of curing the beams were taken out from the curing tank and tested for their Flexural Strength by two point loading method (IS – 516:1959).

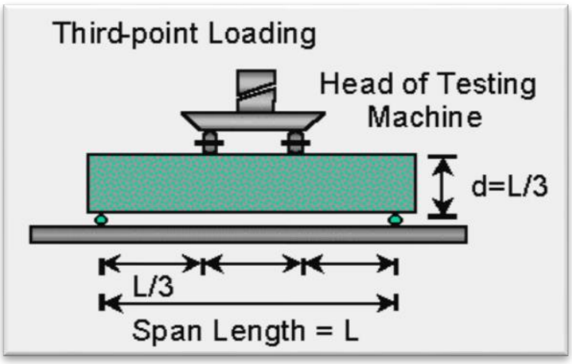

Figure 6: Flexural strength test

5 Split Tensile Strength: The splitting tensile strengths of concrete specimens were determined after 14 days of standard curing. The tests were carried out by splitting the cylinders in the machine used for compressive testing in accordance with IS – 516:1959. From the maximum applied load at failure the splitting tensile strength is calculated as follows:

$$\sigma = 2F/\pi ld$$

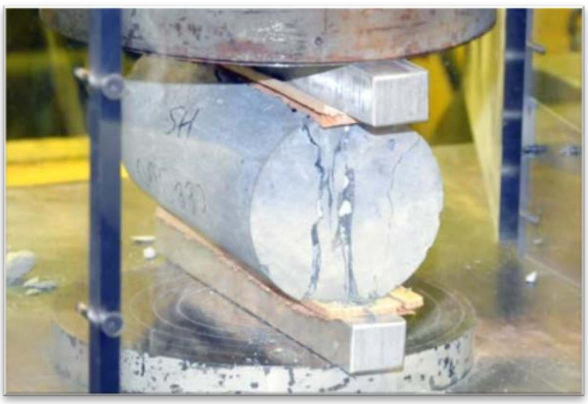

Figure 7: Split tensile test

RESULTS AND DISCUSSION

1. Workability Tests (Slump test and Compaction factor test): Nevertheless, the results show that increasing the percentage of rubber aggregate increases the workability of the concrete. With a rubber content of 15% produces a stiff plastic mix. This is due to the low water absorbing capacity of the mix. Mixes containing higher rubber aggregate content required less effort and work to smoothen the finished surface (Table 1).

2 Mechanical Property Tests:

Compressive Strength Test: The compressive tests were tested at the ages of 7 and 28 days. It is observed that there was a reduction approximately 58% in compressive values when coarse aggregate replaced with crumb rubber compared with control mix. Because the coarse aggregate was partially replaced by crumb rubber, the reduction in strength is anticipated.

Based on the result, the maximum compressive strength value for crumb rubber concrete increased from 7 to 28 day and decreased with increasing the amount of crumb rubber from 0% to 15% (Figure 7).

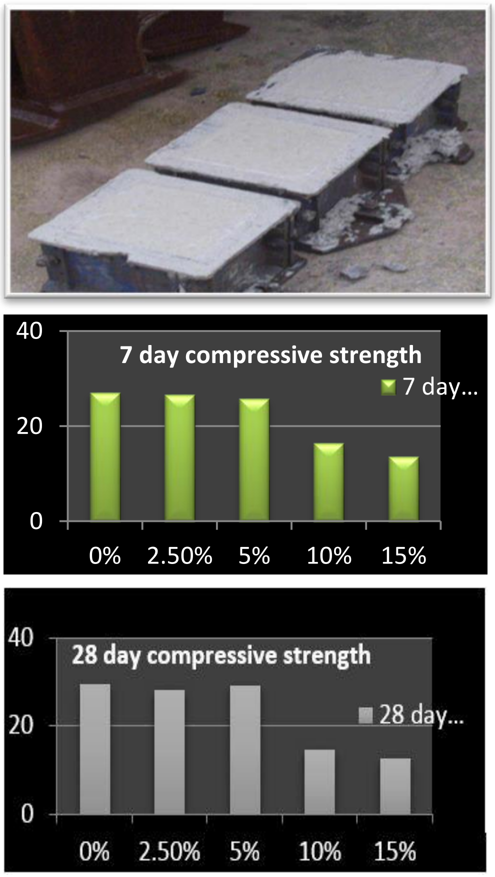

Figure 8: Compressive strength tests – cubes containing rubber aggregate without cement paste coating

Table 1: Slump value and compaction factor for different samples

Sample	Slump value (mm)	Type of workability	Sample	Compaction factor	Workability
C	28.0	Stiff plastic	C	0.830	Stiff
2.5%	26.5	Stiff plastic	2.5%	0.836	Stiff
5.0%	26.5	Stiff plastic	5%	0.846	Stiff
10%	26.5	Stiff plastic	10%	0.793	Stiff
15%	26.5	Stiff plastic	15%	0.794	Stiff

Split Tensile Strength: It can be observed that the control mixes gave a wider range of splitting tensile strengths than for compressive strength, with Mix 2.5% recording a significantly higher strength. For rubberized concrete, the results show that the splitting tensile strength decreased with increasing rubber aggregate content (Table 2).

Table 2: Split tensile strength results

SAMPLE	SPLIT TENSILE STRENGTH(N/mm2)	
	7 DAY	14 DAY
C	2.12	2.61
2.5%	2.82	2.475
5%	1.90	2.43
10%	1.625	2.33
15%	1.528	2.15

However, there was a smaller reduction in splitting tensile strength compared to the reduction in the compressive strength. The control concrete shows a clean split of the sample into two halves, whereas the rubber aggregate tends to produce a less well defined failure.

Flexural Strength Test: The control mix 28 day flexural strength is obtained as 3.49 comparing to that value, mostly all the mixes showed an increase in strength, thus proving higher efficiency in flexural strength. The maximum percentage gain in 28 day strength is obtained for 2.5% mix and the minimum gain in strength is obtained for 15% (Table 3).

Table 3: Flexural strength test results

SAMPLE	FLEXURAL STRENGTH TEST(N/mm^2)	
	7 DAY	28 DAY
C	2.49	3.49
2.5%	2.39	2.99
5.0%	2.39	2.59
10%	1.49	2.19
15%	1.60	1.79

CONCLUSIONS

Coating the rubber aggregate particles with cement paste produced the lowest strength reduction at higher rubber contents. The trend of the data suggests that it may be possible to increase the rubber content further without too great a reduction in compressive strength.

1. Workability increases with increase in rubber content, due to less water absorption capacity of tyre chips.
2. The unit weight decreases with increasing tyre chips and hence suitable for light weight construction.
3. The compressive strength of tyre chip mix does not show remarkable decrease in mix up to 1.5% replacement.

This study proved that there is a great potential for the used rubber tires to be used effectively in concrete. Even though, the addition of rubber aggregates decreases the concrete compressive and tensile strength, there are several properties that can be improved by adding rubber aggregate to the concrete. The use of rubber in concrete is an excellent choice for attaining sustainability, a cleaner environment, and a reduction in insulation cost. As per the test and analysis carried out we came to the conclusion that the waste tyre can be diverted to the construction field as a part of pollu tion control. However, increasing the rubber aggregate content increases the workability of the mix.

The test results show that the use of rubber aggregate in OPC concrete mixes produces a significant reduction in concrete compressive strength which increases with increasing rubber aggregate content. From the above tests conducted, we have seen that the concrete with 5% coarse aggregate replacement gave higher 28 day compressive strength. Hence making it favourable in the construction field with great advantage. Also it provides great economy in construction projects.

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