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Using Shredded Tires as an Aggregate in Concrete

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Abstract

An experimental program was carried out to investigate the compressive strength of concrete with shredded tires as a fine and coarse aggregates. Seventy two concrete (100x100x100) mm cubes were prepared for this study. The replacement of aggregates with shredded tires was partially or completely in the concrete cubes according to the mix designs required in terms of weight and strength. The specimens were cured in water for up to ninety days before testing. Test Results indicate clear substantial reduction in strength of the concrete cubes where aggregate is replaced by shredded tires compared with the compressive strength of concrete cubes with no shredded tires. Based on the results of tests, concrete containing shredded tire particles as aggregates is still not recommended for structural uses because of the low compressive strength comparing with the normal concrete containing natural rock aggregates.

Keywords: Concrete compressive strength, aggregates, shredded tires.

1. Introduction

Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space between the aggregate particles and glues them together. Aggregates can be obtained from many different kinds of materials, in this study; shredded tires are used as filler in concrete instead of common natural rock aggregates. The replacement of aggregates was partially or completely in the concrete according to the mix designs required in terms of weight and strength.

1.1 Shredded tires

Old abandoned tires from cars, trucks, farm and construction equipment and off-road vehicles were used in this research. Tires were shredded into different sizes within two groups:

a. Pieces with dimensions not larger than 25mm.
b. Pieces with dimensions not larger than 10mm.

Using a (19mm, ¾") and (9.5mm, ⅜") sieves, a sieve analysis were set to control the size of the shredded tires. The tire chips used in this research (shown in Figures 1, 2 and 3) were supplied by Advanced Technical Recycling Materials (**ATRM)** CO. Ltd in Jordan. The steel wires were removed from the rubber chips by electromagnetic equipment during the shredding process.

Figure 1: Shredded tires (25mm) **Figure 2:** Shredded tires (19mm)

Figure 3: Shredded Tires (9.5mm)

1.2 Experimental Program: Mix Proportions and Sample preparation

Six concrete mixes were made up. The ratios of the mix designs are given in the Table 1

Table 1 : Design mix ratios proposed for the tests

Mix No.	Cement	Water	Sand	Fine Aggregate	Coarse Aggregate	Fine Rubber	Coarse Rubber	Crumb Rubber
1	1	1	2	2	2	-	-	-
2	1	1	2	-	2	2	-	-
3	1	1	2	2	-	-	2	-
4	1	1	2	1	1	1	1	-
5	1	1	2	-	-	1	1	-
6	1	1	-	1	1	1	1	2

The binder, sand and aggregates were first premixed dry for 1 min. to ensure homogeneity. Wet mixing was carried out with a total mix time of 4.5 min. The concrete was cast into steel molds with the dimensions of (100 x 100 x 100) mm.

The concrete specimens were demolded after 24 hours, and then the cubes are water-cured in an opened container. Three cubes were tested for compressive strength after 7, 28, 56 and 90 days with a total of 72 cubes.

1.3 Testing for compressive strength

The concrete cubes were tested using a compression testing machine. A constant loading rate of 150 $kN/cm^2/min$ was employed, and the quoted strength values are the averages of three cubes per test.

This compression test is conducted to assist the compressive strength of the concrete cubes prepared based on the proposed six different design mix ratios given in Table 1, after exposure to tap water for up to 90 days, and to evaluate the effect of replacing coarse and fine aggregates by shredded tires partially or completely.

2. Results and discussion

Test Results are represented in Figures 4, 5, 6, 7, 8, 9, 10 and 11. These figures indicate clear substantial reduction in strength for the concrete cubes where aggregate is replaced by shredded tires partially or completely (i.e. design mixes 2 to 6) compared with the compressive strength of concrete cubes with no shredded tires (design mix No. 1).Figures 12,13,14,15 and 16 show concrete specimens with shredded tires before testing.

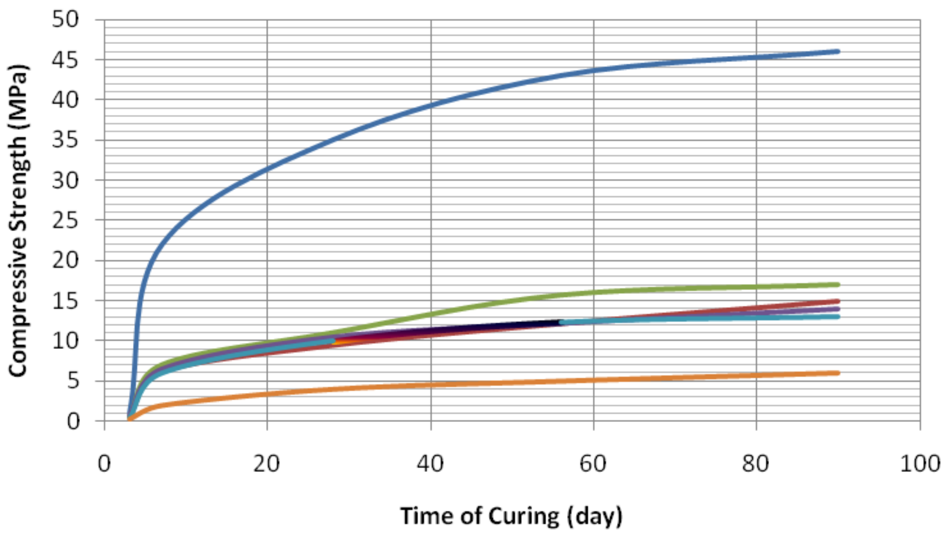

Figure 4: Compressive strength for all design mixes tests

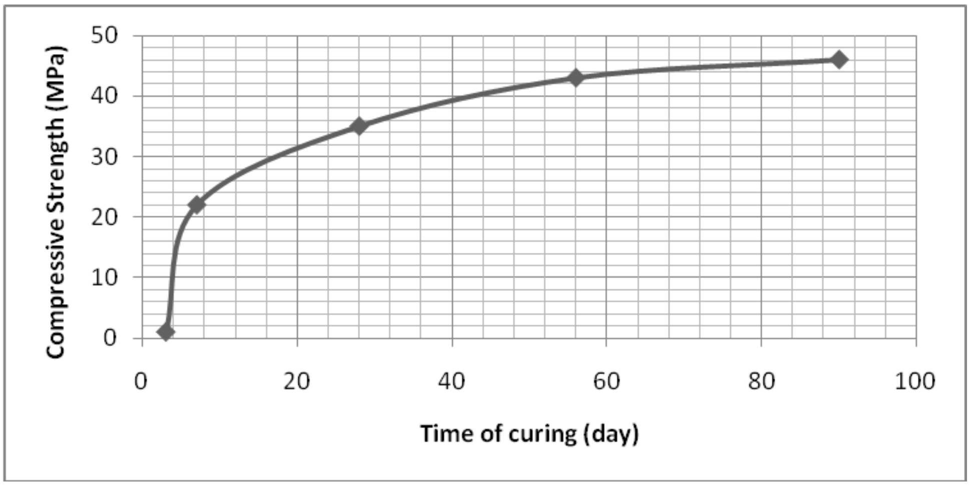

Figure 5: Compressive strength vs. time of curing for design mix No. 1

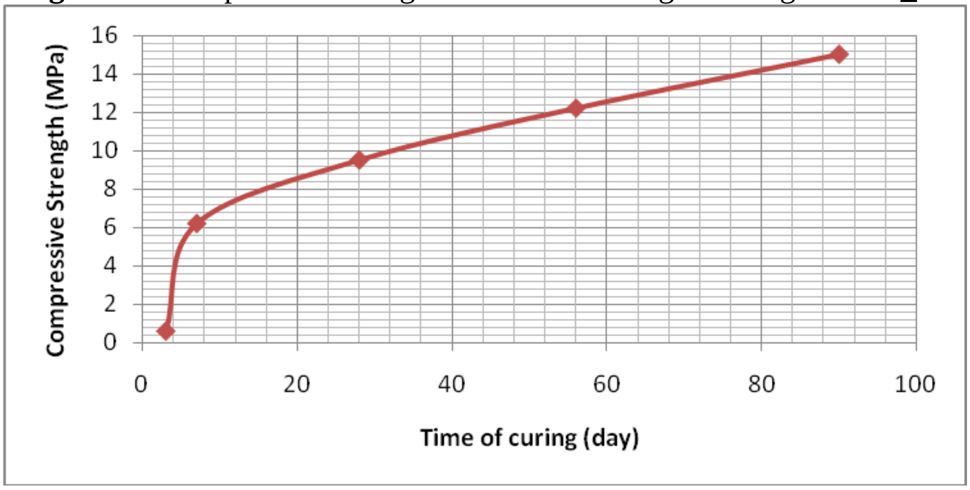

Figure 6: Compressive strength vs. time of curing for design mix No. 2

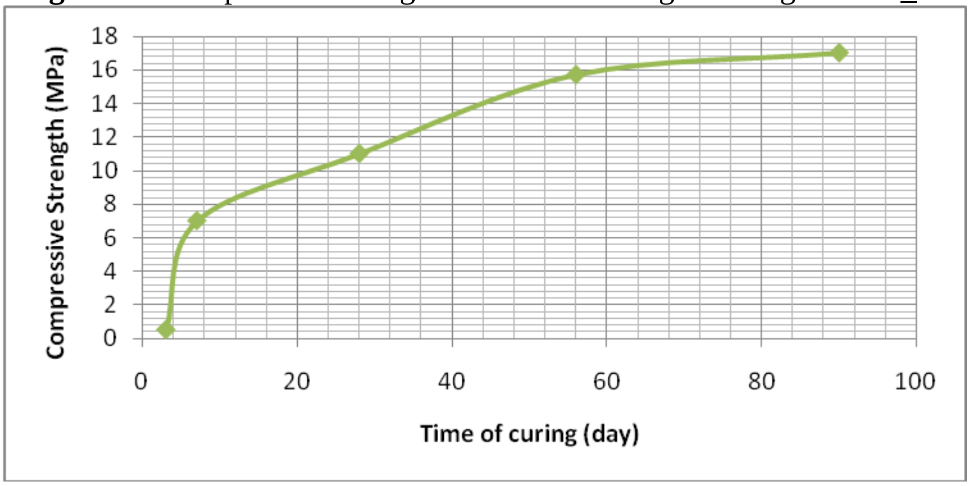

Figure 7: Compressive strength vs. time of curing for design mix No. 3

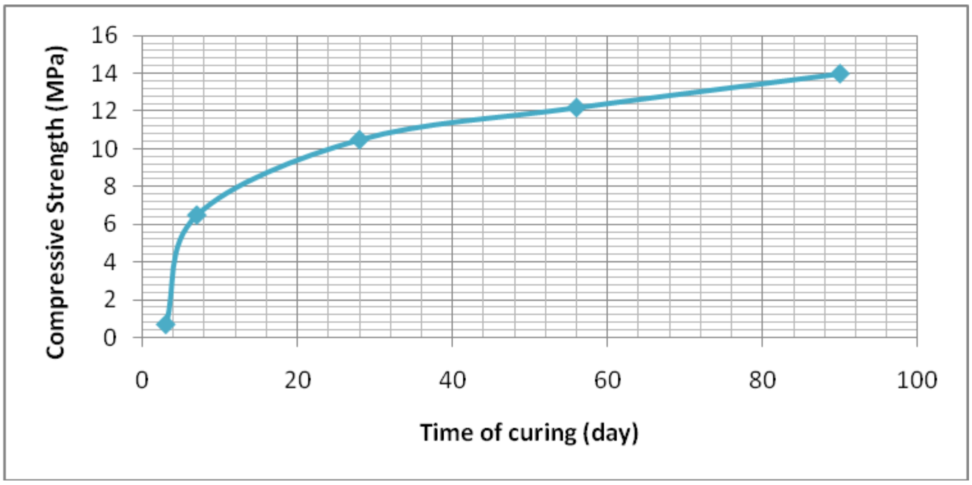

Figure 8: Compressive strength vs. time of curing for design mix No. 4

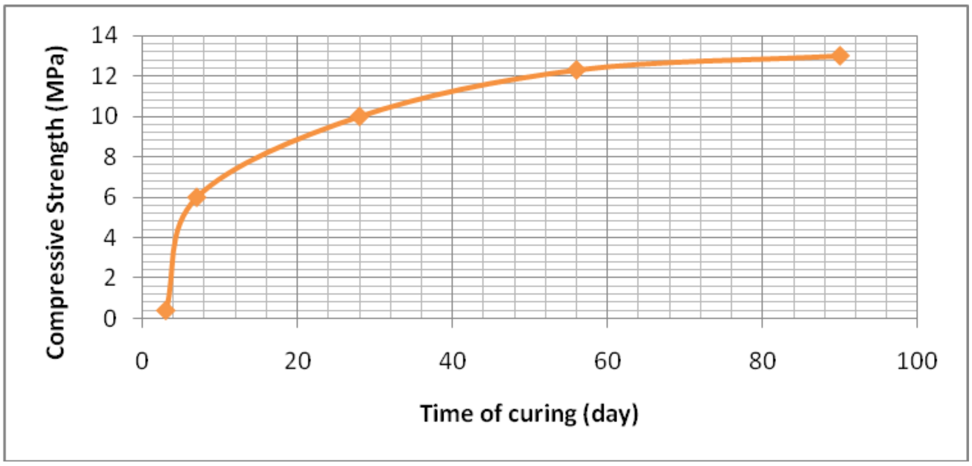

Figure 9: Compressive strength vs. time of curing for design mix No. 5

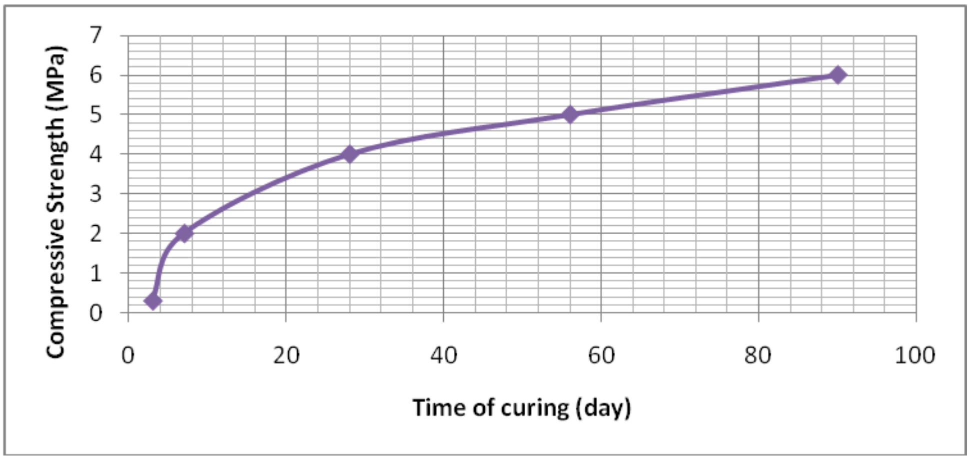

Figure 10: Compressive strength vs. time of curing for design mix No. 6

Figure 12: Concrete specimen for mix No. 2

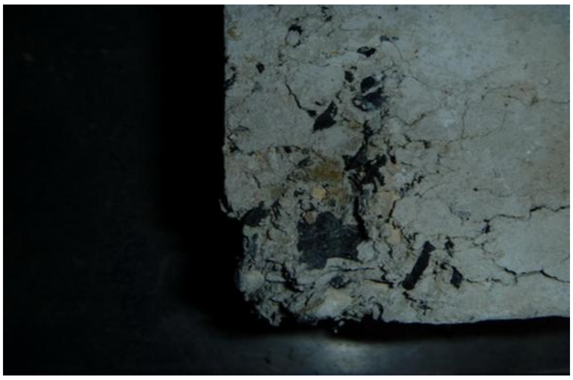

Figure 13: Concrete specimen for mix No. 3

Figure 14: Concrete specimen for mix No. 4

Figure 15: Concrete specimen for mix No. 5

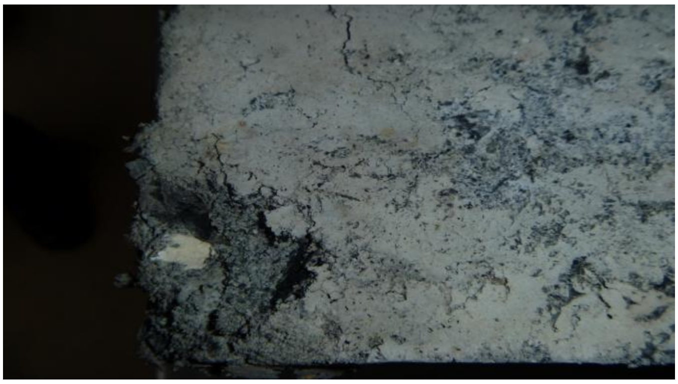

Figure 16: Concrete specimen for mix No. 6

3. Conclusion

Based on the results of tests, concrete containing shredded tire particles as aggregates is still not recommended for structural uses because of the low compressive strength comparing with the normal concrete containing natural rock aggregates.

During the tests it was noted that as the percentage amount of shredded tires increased, the amount of energy required for casting specimens increased substantially, because of the reduction of workability in the concrete.

In another hand, it was observed that the pieces of concrete cubes tested tend to stay together linked through the rubber particles, which means that the usage of shredded tires as aggregates in concrete may produce a much more tough concrete and may reduce the cracks in the aging concrete.

Although synthetic lightweight aggregates specially shredded tires are more expensive than normal-weight or natural rock aggregates, the increased strength-to-weight ratio offers sufficient overall saving in materials, through the reduction of dead load to more than offset the higher aggregate cost per cubic meter of the concrete. Lower total loads mean reduced supporting sections and foundations, and less reinforcement.

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