A Study on rhe Mechanical Properties of Concrete Containing Waste Tire Rubber Aggregates

Blessen Skariah Thomas[1], Jian Yang[2,3]

[1] *Providence College of Engineering, Chengannur, Kerala, India*
[2] *School of Naval Architecture, Ocean and Civil Engineering, Shanghai Jiao Tong University, Shanghai, China*
[3] *School of Civil Engineering, University of Birmingham, Birmingham, UK*

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INTRODUCTION

The invention of concrete has been one of the key events in evolution because of its simplicity, strength, durability and affordability for society. It is the third most widely used substance in the world after air and water. As it is a versatile construction material, it is also known as 'liquid stone' because of its ability to be moulded in to any shape allowing people to realise their dream of construction. The ingredients of concrete are cement, aggregates, water and admixtures. The most important ingredient in concrete is the ordinary looking grey powder known as cement, which is also the costliest. Aggregates constitute 60 to 75 percentage of the total volume of concrete

Due to the huge increase in population and the uplift in living standards of people, there was a big growth in the number of vehicles. As a result of this, lots of tires are ending as waste every day. One of the possible solutions for the use of waste tire rubber is to incorporate it into cement concrete, replacing some of the natural aggregates. In this study, M30 grade of concrete was studied with a water-cement ratio of 0.4. Crumb rubber (waste tire rubber mechanically grinded into rubber crumbs) was partially substituted for fine aggregate from 0% to 20% in multiples of 2.5%.

RESULTS

From the compressive strength test in Figure 2, gradual decrease in the compressive strength of concrete was noticed as the amount of crumb rubber (Figure 1) was increased from 0% to 20%. When the water-cement ratio was 0.4, maximum value for compressive strength (48.8 N/mm^2) was obtained in the case of control mix concrete and the minimum value (23.5 N/mm^2) was obtained for the concrete mix with 20% crumb rubber. Although there was a decreasing trend in the compressive strength for the increase of crumb rubber, a value above 30 N/mm^2 was obtained for all the 6 mixes in which crumb rubber was substituted from 0% to 12.5% of fine aggregate. Substantial gain in compressive strength was observed after 90 days of curing. As sufficient amount of water was available for full hydration of concrete, the pore spaces in the concrete were filled by the products of hydration.

Figure 1: Rubber Powder and Crumb Rubber of size 0.8-2 mm

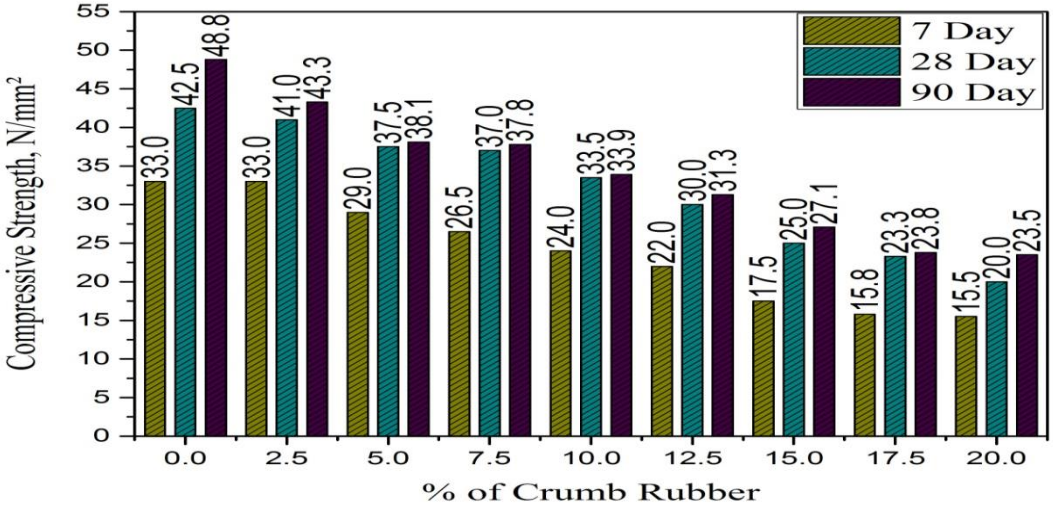

Figure 2: Compressive Strength of Specimens with w/c 0.4

Figure 3: Failure pattern of control specimen and rubberized specimen after compressive loading

The control specimens exhibited brittle failure while the rubberized concrete did not show brittle failure under compression loading (given in Figure 3). Horizontal cracks were observed for the specimens with rubber and inclined cracks were observed in the control specimens.

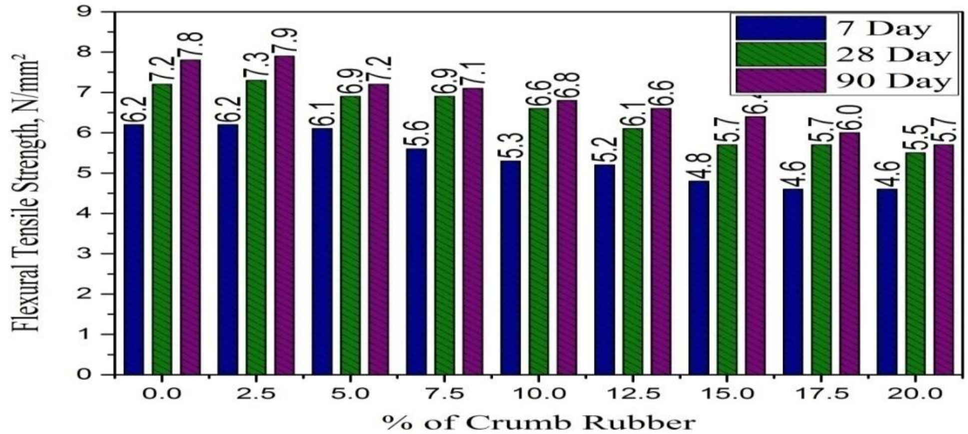

Figure 4: Flexural Tensile Strength of Specimens

In the case of Flexural tensile strength of concrete (Figure 4), gradual reduction in flexural tensile strength was observed when the percentage of crumb rubber was increased. When we observe the 7 days flexural tensile strength of the high strength concrete mixes with water-cement ratio 0.3, the maximum value (6.2 N/mm^2) was observed for the mixes with 0% and 2.5% crumb rubber and minimum value (4.6 N/mm^2) observed for the mixes with 17.5% and 20% crumb rubber. At 28 days, the maximum value (7.3 N/mm^2) was obtained in the mix with 2.5% crumb rubber and minimum value (5.5 N/mm^2) was obtained for the mix with 20% crumb rubber. The flexural tensile strength was expected to decrease if the percentage of crumb rubber is increased further. At 90 days a trend similar to that of 28 days was observed, where the maximum and minimum values were 7.9 N/mm^2 and 5.7 N/mm^2 respectively. When the 90 days strength was considered, the reduction in compressive strength of the mix with 20% crumb rubber was 26% than that of the control mix. Figure 5 shows the pattern of failure of specimens under flexural loading are displayed in. It was observed that the control specimens exhibited brittle failure and was broken to two pieces under loading while the rubberized concrete did not show brittle failure under flexural tensile loading.

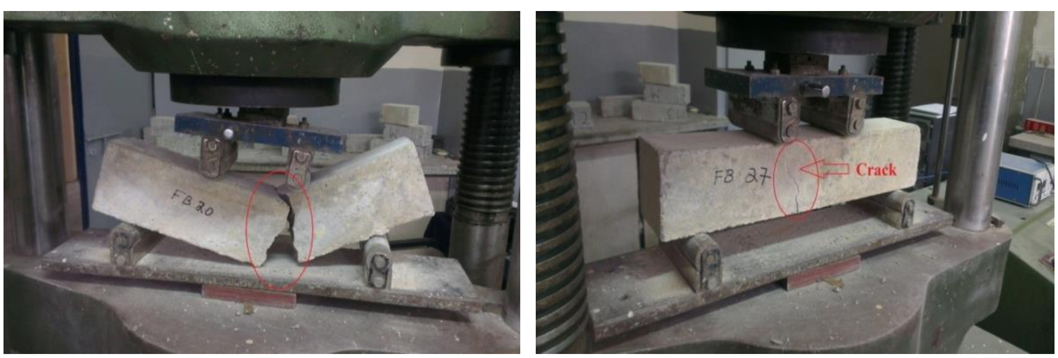

Figure 5 : Failure of control mix specimen under flexural loading

The pull-off strength test for the entire series of concrete mix was performed on the concrete specimens after 28 days curing. The highest strength (2.63 N/mm^2) was obtained for the control mix concrete with water-cement ratio 0.4. Gradual decrease in the pull-off strength was observed as the percentage of crumb rubber substitution was increased. Similar trend was observed for the mixes with water-cement ratios 0.45 and 0.5. In M60 grade series, the highest strength (3.18

N/mm²) was obtained for the control mix and lowest value (2.15 N/mm²) was observed for the mix with 20% crumb rubber. It was clear from the results that the variation in pull-off strength closely follows the trends of the corresponding compressive strength results of the mixes as reported by Pereira and Medeiros (2012). They have mentioned that the results of the compressive strength and pull off strength exhibit the same pattern.

From the abrasion test, it was observed that the rubberized concrete specimens showed better resistance to abrasion when compared to the control mix specimens. During the abrasion test, the crumb rubber particles present in the rubberized concrete had projected beyond the smooth surface of the concrete and acted like a brush limiting the grinding/rubbing. This minimized the action of abrasive powder on the surface of concrete and hence the rubberized concrete was more resistant to abrasion compared to the control mix.

CONCLUSIONS

From the results it was observed that the compressive, flexural tensile and pull-off strength tests, gradual decrease in strength was noticed as the amount of crumb rubber was increased in concrete. On the other hand, they showed better resistance to abrasion when compared to the control mix. In the compressive, flexural tensile and pull-off strength tests, gradual decrease in strength was noticed as the amount of crumb rubber was increased in concrete. The compressive and pull-off strength of the mix with 20% crumb rubber reduced by more than 50% compared to the control mix. The reduction in flexural strength for the same mix was only 25-27% when compared to the control mix. The tire rubber particles can improve the abrasion resistance of concrete, and this can help its application in pavements, floors and concrete highways, or in places where there are abrasive forces between surfaces and moving objects.

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