

Mechanical Properties of Glass Fiber Reinforced Concrete Using Recycled Concrete

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ABSTRACT: Now a days in the construction sector, the possibility of substituting coarse aggregate with recycled concrete originated from wastes of demolished or renovated structures offers technical, economic and environmental advantages. The study investigated the changes in concrete properties on partial replacement of coarse aggregate by recycled concrete aggregate in various percentages (20-100%). The changes in many properties of concrete such as, workability, compressive strength, tensile strength and flexural strength can be studied by the addition of fibers into concrete mass. The laboratory experiments on cube, cylinder and beam specimens designed with recycled concrete-glass fiber reinforced concrete (GFRC) containing fibers of 0.01, 0.02 and 0.03% of volume with aspect ratio of 100 have found many applications of FRC in civil engineering filed. Comparing the result of GFRC with plain M20 grade concrete, this paper validated the positive effect of recycled concrete and fibers on the compressive strength, split tensile strength and flexural strength of the specimen at 7 and 28 days.

KEYWORDS: Recycled concrete aggregate, Glass fibers, Compressive strength, Split tensile strength, Flexural strength.

I. INTRODUCTION

Concrete is the major construction material commonly used all over the world. By reducing the use of energy materials we can make increment in resource efficiency. Thus for the production of concrete the waste materials obtained from the demolished or renovated structures are utilized. The reuse of this demolition waste in the form of recycled concrete - coarse aggregate considered as an effective attempt to make economic and environmental advantages. The concrete containing short discrete fibers which increases its structural integrity is called fiber reinforced concrete. The cracking in concrete due to plastic shrinkage and drying shrinkage can be controlled by using fibers. The factors mainly depends the characteristic performance of fiber reinforced concrete (FRC) are fiber orientation, fiber concentration, fiber material and fiber geometry. The mechanical properties of concrete such as compressive strength, flexural strength and tensile strength can be improved by the addition of glass fibers in to it. This study examine the possibility of use of glass fibers with recycled concrete as coarse aggregate for a M20 grade of concrete with a W/C ratio of 0.6. The effect of recycled coarse aggregate on the compressive strength, split tensile strength, flexural strength and workability of FRC is studied in this paper. The workability of concrete was measured in terms of slump value.

II. MATERIALS USED

A. Cement

Ordinary Portland cement of 53 grade was used in this study. Various tests on cement are conducted as per IS:4031-1988 and found as it conforms to the specifications of IS:12269-1987.

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B. Fine Aggregate

In this study the locally available manufactured sand passing through 4.75 mm IS sieve was used as fine aggregate. As per IS: 383-1970 it conforms to zone II. The fineness modulus and specific gravity were found to be 2.898 and 2.63 respectively.

C. Natural Coarse Aggregate

Locally available crushed stone metal which is passing through 20 mm IS sieve was used as natural coarse aggregate in this study. The aggregate conforming to IS: 383-1970 was used. The specific gravity and fineness modulus were found to be 2.67 and 3.10 respectively.

D. Recycled Concrete Aggregate

The recycled concrete aggregate was obtained from the construction demolition waste. Nominal size of aggregate of less than 20 mm were used in the present study. The specific gravity of RCA is 2.69 and the water absorption is 3.12%. The specific gravity and fineness modulus of recycled concrete aggregate (RCA) were found to be 2.29 and 3.23.

E. Water

Water available from local sources which is fit for drinking purpose was used in this study for mixing and curing of all the concrete mixes.

F. Glass Fibers

Glass fibers having aspect ratio of 100 were used in this study. Glass fibers were uniformly distributed in the matrix of concrete to improve its properties.

III. MIX COMPOSITION

This experimental study was carried out to investigate the properties of M20 grade concrete. The percentage of glass fibers was varied from 0.01 to 0.03% by total volume of concrete to study the effect of glass fibers on the mechanical properties of recycled coarse aggregate concrete. The quantity of materials obtained based on the design mix is shown in Table 1.

Table 1: Quantity of materials for design mix

Component	Quantity
Cement	363.63kg/m ³
Fine aggregate	607.27kg/m ³
Coarse aggregate	1210.90kg/m ³
Water	218.18kg/m ³

IV. EXPERIMENTAL PROGRAM

A. General

Concrete is tested in both fresh and hardened states to determine the different properties of concrete. Fresh concrete is tested to determine the properties such as workability and hardened concrete is tested to determine various mechanical properties such as compressive strength, split tensile strength and flexural strength. Hardened concrete is tested after casting and curing of specimen while fresh concrete is tested immediately after mixing the concrete.

B. Workability

The slump test is conducted to study the workability of prepared concrete. This tests were performed using slump moulds as per IS:1199-1999 to determine the workability of the Recycled concrete-Glass fiber reinforced concrete.

C. Compressive strength test

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Compressive strength is one of the most important property of hardened concrete. The compression test was conducted on cube specimens of size 150mmx150mmx150mm which is cured for 7 & 28 days. Place the specimen with flat face horizontal and mortar filled face facing upwards between plates of the testing machine. The cubes were removed from the storage of water 24 hours before testing. Apply load axially at a uniform rate of 14 N/mm² per minute till failure occurs and note the ultimate load value

D. Split tensile strength test

The splitting tests are indirect tests used for determining the tensile strength of concrete, which is necessary to determine the load at which the concrete members may crack. The split tensile strength test was conducted on cylinder specimens of size 150mmx300mm which is cured for 7 & 28 days. Draw diametrical line on the two ends of the specimen to ensure that they are on the same axial plane. Align the specimen so that lies marked on the ends are vertical and centered over the bottom plate. Load is applied continuously without shock until the concrete specimen failed and note the maximum load at failure.

E. Flexural strength test

In the flexural strength test the concrete beam was subjected to flexure by using two point loading until failure occurs. The specimen placed in the machine in such a manner that the axis of the specimen is aligned with the axis of the loading device. The flexural strength test was conducted on the beam specimens of size 500mmx100mmx100mm. The load are applied without shock and the ultimate load at failure is noted.

V. RESULTS AND DISCUSSIONS

A. Effect of glass fibers on workability

The workability for concrete with fiber glass percentages of 0.01, 0.02 and 0.03% by volume is determined by slump value test. As the percentage of glass fiber increased the workability reduced due to balling.

B. Compressive strength

The result obtained from the compressive strength is shown in Figure 1 and Figure 2. The maximum compressive strength at the age of 28 days is obtained for concrete with 60 % of RCA. Hence the glass fiber reinforced concrete is prepared with 60% of RCA.

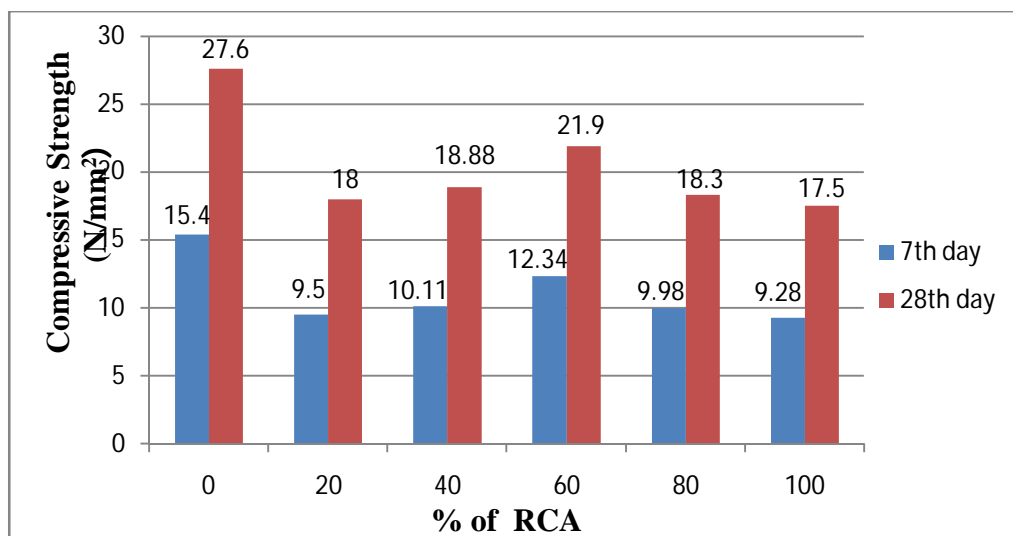


Fig.1 Compressive strength of specimen at different percentage of RCA

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In the case of concrete mixes with recycled concrete aggregate, the maximum compressive strength at the age of 28 days is obtained for concrete with 60% of RCA. Also the strength value obtained for 60% of RCA is less than the corresponding value of conventional concrete. The value obtained for concrete with 60% of RCA is 21.9 N/mm².

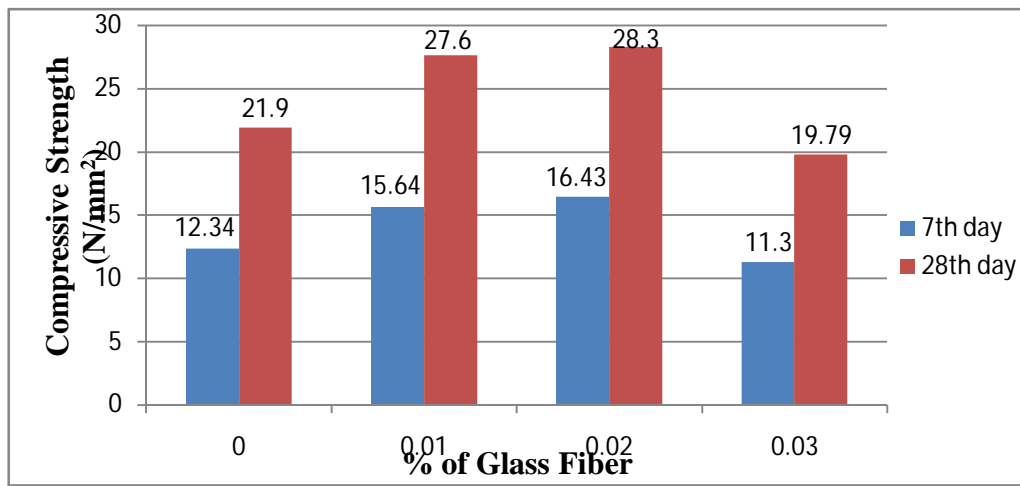


Fig.2 Compressive strength of RCA-Glass fiber concrete

From the results it is observed that the compressive strength increases with increase in fiber percentage upto a limit and then decreases with further increase in fiber percentage. It also increases with age of concrete. From the results of compressive strength of RCA-Glass fiber concrete, it is observed that the maximum value of compressive strength is obtained for concrete mix with 0.02% of glass fiber. The maximum value of compressive strength for 28 days is obtained as 28.3 N/mm².

C. Split tensile strength

The Figure 3 and Figure 4 shows the results obtained from split tensile strength test.

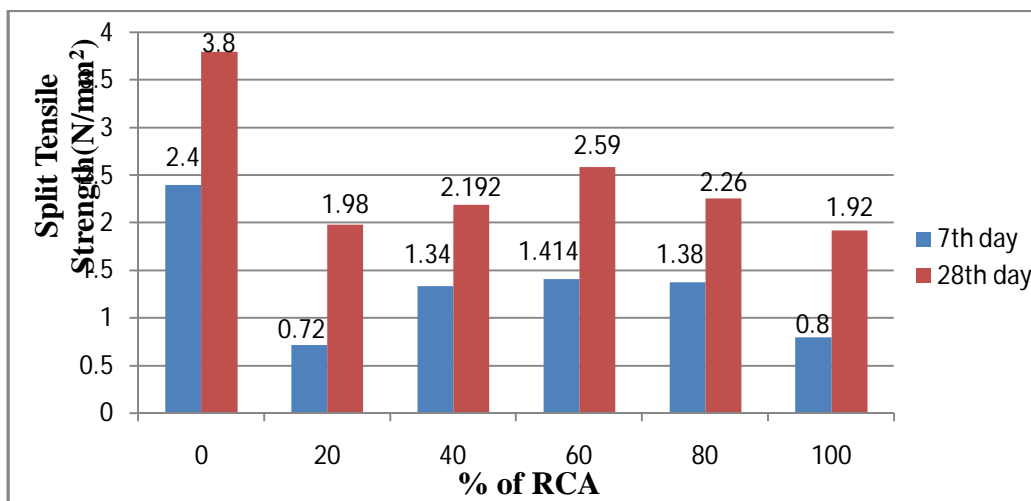


Fig.3 Split tensile strength of specimen at different percentage of RCA

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In the case of concrete mixes with recycled concrete aggregate, the maximum split tensile strength at the age of 28 days is obtained for concrete with 60% of RCA. Also the strength value obtained for 60% of RCA is less than the corresponding value of conventional concrete. The value obtained for concrete with 60% of RCA is 2.59 N/mm² which is less than 3.8 N/mm² of conventional concrete.

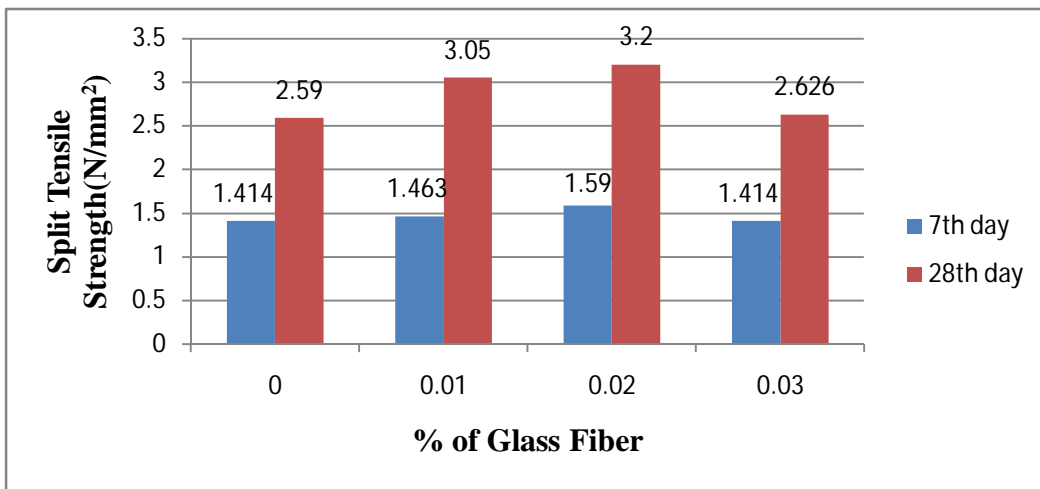


Fig.4 Split tensile strength of RCA-Glass fiber concrete

From the results it is observed that the split tensile strength increases with increase in fiber percentage upto a limit and then decreases with further increase in fiber percentage. It also increases with age of concrete. From the results of split tensile strength of RCA-Glass fiber concrete, it is observed that the maximum value of split tensile strength is obtained for concrete mix with 0.02% of glass fiber. The maximum value of split tensile strength for 28 days is obtained as 3.2 N/mm².

C. Flexural strength

The Figure 5 and Figure 6 shows the results obtained from Flexural strength test. From the results it is observed that the compressive strength increases with increase in fiber percentage and it also increases with age of concrete. At the age of 28 days the maximum value of flexural strength for RCA-Glass fiber reinforced concrete obtained in the concrete with 0.02% of glass fiber. The maximum value of flexural strength obtained is 4.03 N/mm².

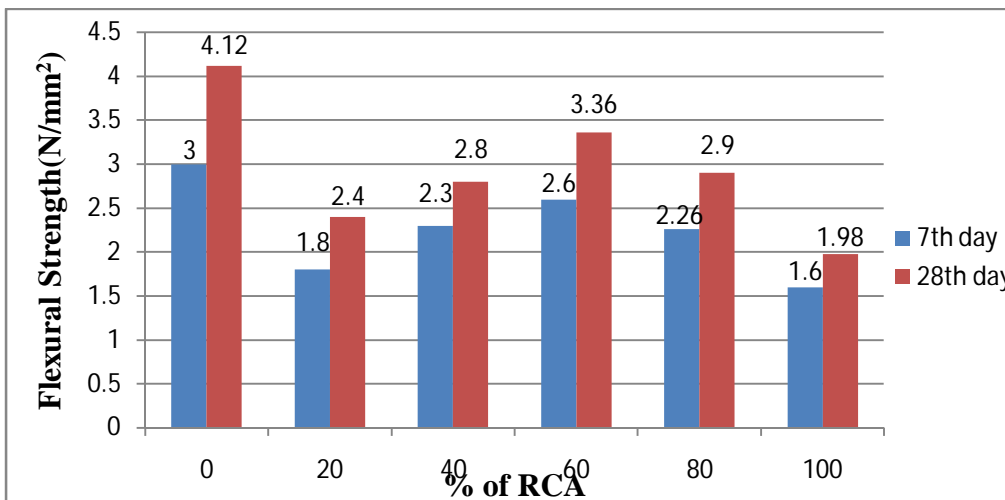


Fig.5 Flexural strength of specimen at different percentage of RCA

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In the case of concrete mixes with recycled concrete aggregate, the maximum flexural strength at the age of 28 days is obtained for concrete with 60% of RCA. Also the strength value obtained for 60% of RCA is less than the corresponding value of conventional concrete. The value obtained for concrete with 60% of RCA is 3.36 N/mm^2 which is less than 4.12 N/mm^2 of conventional concrete.

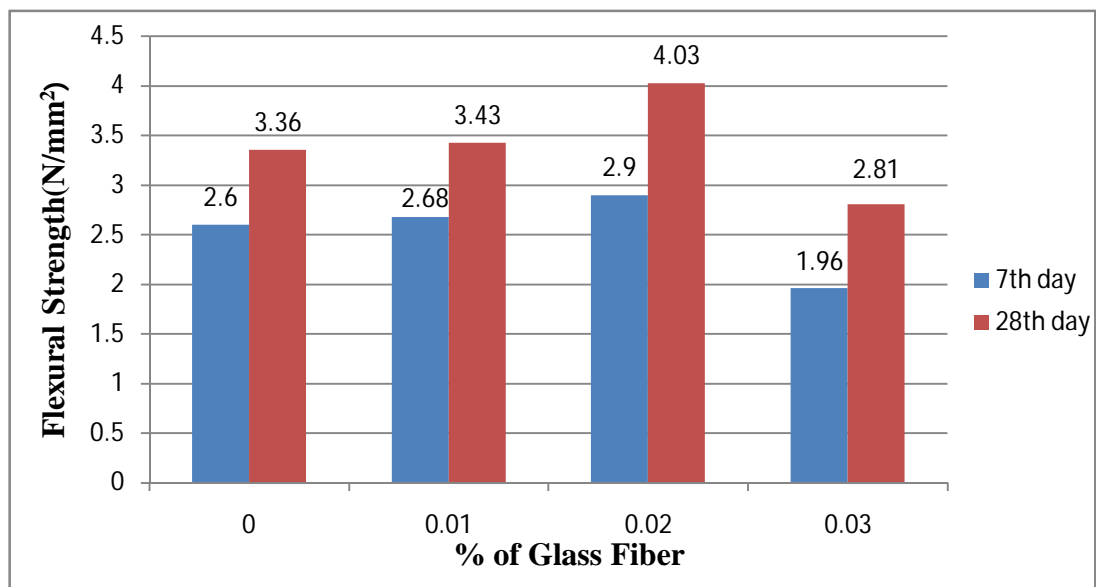


Fig.6 Flexural strength of RCA-Glass fiber concrete

From the results it is observed that the flexural strength increases with increase in fiber percentage upto a limit and then decreases with further increase in fiber percentage. It also increases with age of concrete. From the results of flexural strength of RCA-Glass fiber concrete, it is observed that the maximum value of flexural strength is obtained for concrete mix with 0.02% of glass fiber. The maximum value of flexural strength for 28 days is obtained as 4.03 N/mm^2 .

VI. CONCLUSIONS

Based on the experiments conducted and the analysis of results obtained, the following conclusions are drawn.

- As the percentage of glass fiber increases in the concrete from 0.01% - 0.02%, the value of compressive strength also increases from 27.6 MPa to 28.3 MPa at 28 days.
- As percentage of glass fibers increases from 0.01% - 0.02% in the concrete the flexural as well as split tensile strength increases considerably.
- The flexural strength and split tensile strength of concrete are almost same as conventional concrete with 60% of RCA used as replacing material.
- It was observed from the failure pattern of the specimens, that the crack formation is more in the concrete without fibers than the concrete reinforced with glass fiber.

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