# COMPARISON OF CONCRETE BEHAVIOR WITH AND WITHOUT FIBERS

Salem Alsamusi[1]

## Abstract:

Typically concrete main constituent elements are cement, aggregate (coarse and fine), and water. Admixtures are also added to improve some properties in concrete either in fresh or hardened sate. Nowadays Concrete fibers are new frontier in the reinforced concrete structures in different aspects such as weight, strength, and durability. In this paper we conducted a comprehensive experimental study on the effects of utilizing selected types of fibers on concrete properties. Concrete constituents such as cement, aggregates and fibers provided from local sources. Two types of fibers were used in the experimental program. These types are glass fiber and polypropylene fiber. Effects of these fibers on fresh concrete properties such as workability and on hardened concrete properties such as strength and unit weight were studied. The results of the experimental work on more than 300 samples were presented. A conclusion based on this study did indicate that major effects of selected percentage on the behavior of concrete both in fresh and hardened state have been observed.

**Keywords**: concrete, fibers, workability, strength, deflection.

## 1 Introduction

Concrete, whether containing natural or waste glass aggregate, is relatively brittle, and its tensile strength is only about one tenths of its compressive strength, largely because of the ease with which cracks can propagate under tensile loads. For many applications, it is becoming increasingly popular to reinforce the concrete with small, randomly distributed fibers. The main purposes are to increase the tensile, flexural strengths and energy absorption capacity. While steel fibers are probably the most widely used and effective fibers for many applications, other types of fibers are more appropriate for special applications. Fiber reinforced concrete has started to find its place in many areas of civil infrastructure applications where the need for repairing and increasing durability arises. Fiber reinforced concrete is better suited to minimize cavitations and erosion damage in structures such as bridge piers where high velocity flows are encountered. A substantial weight saving can be produced using relatively thin FRC sections having the equivalent strength of thicker plain concrete sections.

[1] Salem Alsamusi, Civil Engineering Department, School of Engineering, Garyounis University, Benghazi, POB 17077 Al-Silmani, LIBYA, e-mail: Alsanusi@garyounis.edu

## 2 Experimental program

In this program the following variables were investigated to establish the effects of fibers on concrete. Amount of fiber (percentage by volume of mix); 0, 0.5, 1 and 1.5%. Fiber type; glass, polypropylene and hybrid (composite of glass and polypropylene fibers). Water cement ratio; 0.5, 0.6 and 0.7. A total of three concrete series at different water cement ratio have been studied. Each series consist nine concrete mixes at different fiber types and different volume fractions. Out of the nine concrete mixes one is plain concrete mix acting as a control mix. The mix proportions are summarized in table

**Tab. 1** mix proportions

| Parameter | Mix Designation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plain concrete (control mix) | | | Glass Fiber | | | Polypropylene Fiber | | | Combination of Glass and Polypropylene fibers | | |
| | CI | CII | CIII | GFRCI | GFRCII | GFRCIII | PFRCI | PFRCII | PFRCIII | FRCI | FRCII | FRCIII |
| Series -A- | | | | | | | | | | | | |
| Fiber % | 0 | 0 | 0 | 0.5 | 1 | 1.5 | 0.5 | 1 | 1.5 | 0.5 | 1 | 1.5 |
| Series -B- | | | | | | | | | | | | |
| Fiber % | 0 | 0 | 0 | 0.5 | 1 | 1.5 | 0.5 | 1 | 1.5 | 0.5 | 1 | 1.5 |
| Series -C- | | | | | | | | | | | | |
| Fiber % | 0 | 0 | 0 | 0.5 | 1 | 1.5 | 0.5 | 1 | 1.5 | 0.5 | 1 | 1.5 |

## 3 Test results:

The results of the experimental works are shown in table 2. Only the average strength of at least three specimens for each mix is presented. The results are well explained in form of graphs as shown in figures 1 through 13. These figures do show the effect of w/c, unit weight, strength( compressive, flexure, split), workability with changing percentage of fibers content.

**Tab. 2** Test Results

| *Mix Designation* | *w/c* | *Fiber content* (% by vol.) | *Slump* (cm) | *Vebe time* sec. | *Unit weight* (kN/m$^3$) | *Concrete strength* (MPa) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | $f'_c$ | $f'_t$ | $f'_r$ |
| Ca | 0.5 | 0 | 2.25 | 3.00 | 23.15 | 27.53 | 3.29 | 7.21 |
| GFRC1a | 0.5 | 0.5 | 0 | 5.60 | 22.86 | 18.10 | 4.22 | 8.26 |
| GFRC2a | 0.5 | 1 | 0 | 7.40 | 22.12 | 20.46 | 3.25 | 7.71 |
| GFRC3a | 0.5 | 1.5 | 0 | 15.29 | 21.84 | 14.05 | 3.20 | 5.70 |
| PFRC1a | 0.5 | 0.5 | 0 | 7.70 | 23.11 | 16.12 | 2.58 | 5.83 |
| PFRC2a | 0.5 | 1 | 0 | 16.90 | 22.75 | 16.03 | 2.98 | 7.48 |
| PFRC3a | 0.5 | 1.5 | 0.5 | 16.00 | 21.58 | 8.48 | 2.66 | 5.42 |
| Cb | 0.6 | 0 | 20.5 | 0.00 | 23.31 | 22.91 | 3.04 | 7.07 |
| GFRC1b | 0.6 | 0.5 | 0 | 4.30 | 22.05 | 19.04 | 2.96 | 7.32 |
| GFRC2b | 0.6 | 1 | 0 | 7.30 | 21.65 | 10.65 | 2.43 | 7.18 |
| GFRC3b | 0.6 | 1.5 | 0 | 5.71 | 21.28 | 12.63 | 2.58 | 6.66 |
| PFRC1b | 0.6 | 0.5 | 1.5 | 4.81 | 22.11 | 20.27 | 2.62 | 6.58 |
| PFRC2b | 0.6 | 1 | 0.7 | 4.93 | 21.83 | 15.65 | 2.51 | 6.06 |
| PFRC3b | 0.6 | 1.5 | 0 | 6.80 | 22.15 | 15.37 | 2.57 | 6.58 |
| FRC1b | 0.6 | 0.5 | 0 | 5.1 | 22.33 | 22.81 | 3.05 | 7.31 |
| FRC2b | 0.6 | 1 | 0 | 5.97 | 21.94 | 18.53 | 2.89 | 6.67 |
| FRC3b | 0.6 | 1.5 | 0 | 7.8 | 22.42 | 15.84 | 2.59 | 7.59 |
| Cc | 0.7 | 0 | 24 | 0.00 | 22.82 | 18.01 | 2.52 | 5.63 |
| GFRC1c | 0.7 | 0.5 | 1.5 | 4.11 | 21.31 | 15.37 | 2.49 | 5.95 |
| GFRC2c | 0.7 | 1 | 0 | 4.23 | 20.81 | 12.30 | 2.29 | 5.56 |
| GFRC3c | 0.7 | 1.5 | 0 | 4.41 | 19.11 | 10.68 | 2.26 | 5.12 |
| PFRC1c | 0.7 | 0.5 | 1.8 | 3.00 | 22.33 | 17.54 | 2.47 | 4.63 |
| PFRC2c | 0.7 | 1 | 0.5 | 5.26 | 21.68 | 12.92 | 2.73 | 5.14 |
| PFRC3c | 0.7 | 1.5 | 1.25 | 5.33 | 20.82 | 10.09 | 2.21 | 4.29 |
| FRC1c | 0.7 | 0.5 | 2.2 | 3.4 | 21.63 | 13.79 | 2.56 | 5.70 |
| FRC2c | 0.7 | 1 | 1 | 4.91 | 21.76 | 15.98 | 2.65 | 5.64 |
| FRC3c | 0.7 | 1.5 | 0 | 6.48 | 21.78 | 14.47 | 2.57 | 5.83 |

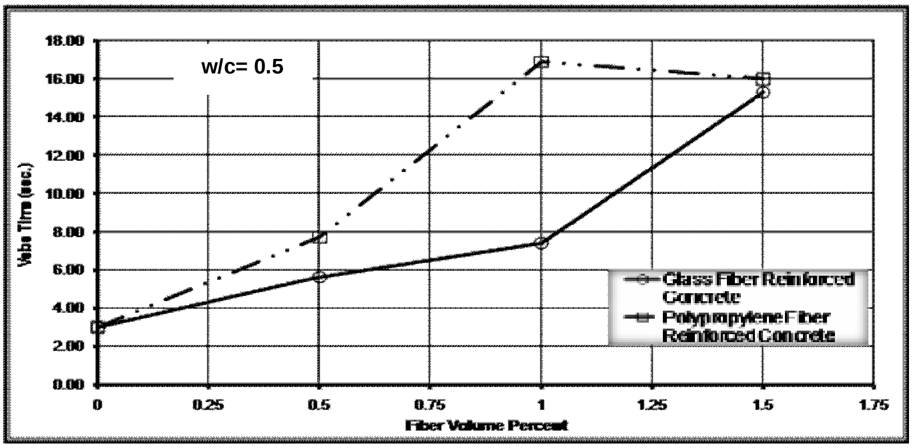


**Fig. 1** Fiber content-vebe time

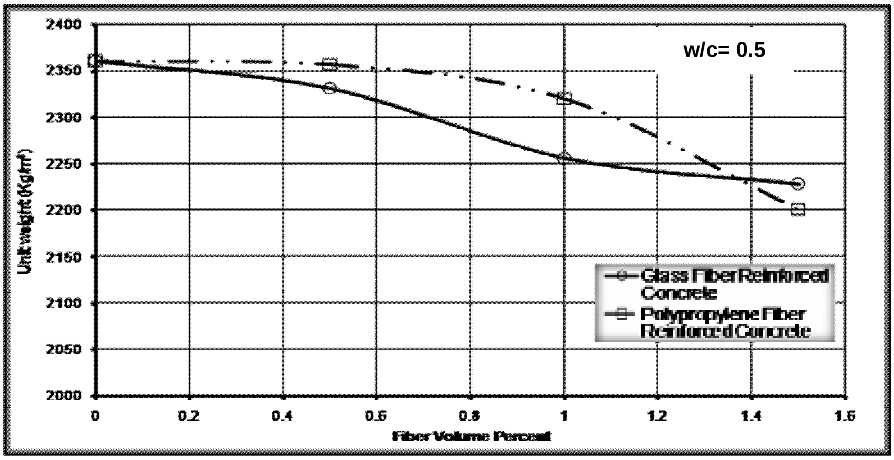


**Fig. 2** Fiber content - unit weight

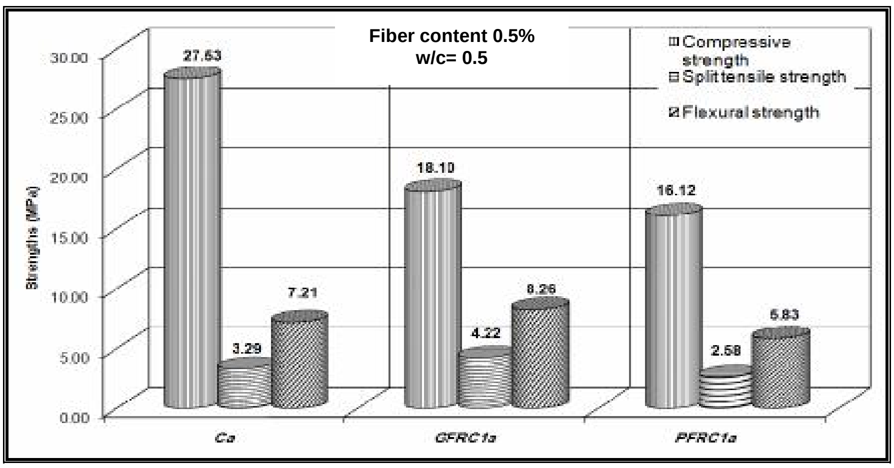


**Fig. 3** Strength comparison between mixes

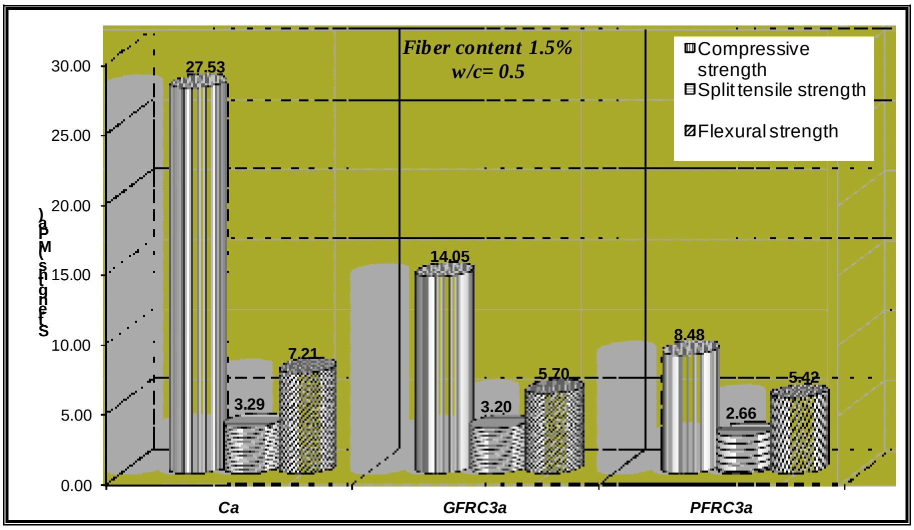


**Fig. 4** Strength comparison between mixes

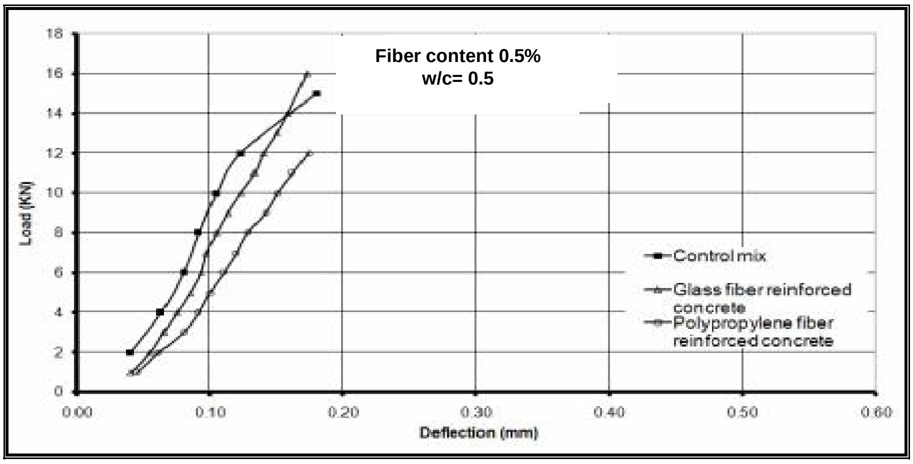


**Fig. 5** ductility comparison between mixes

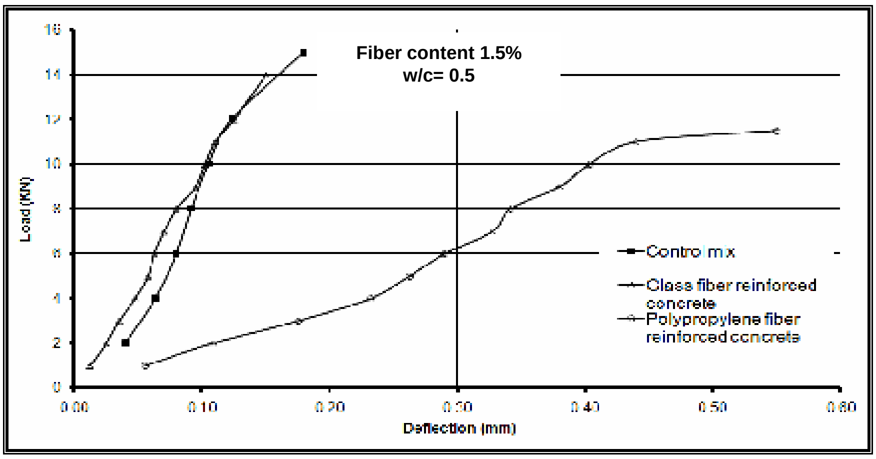


**Fig. 6** ductility comparison between mixes

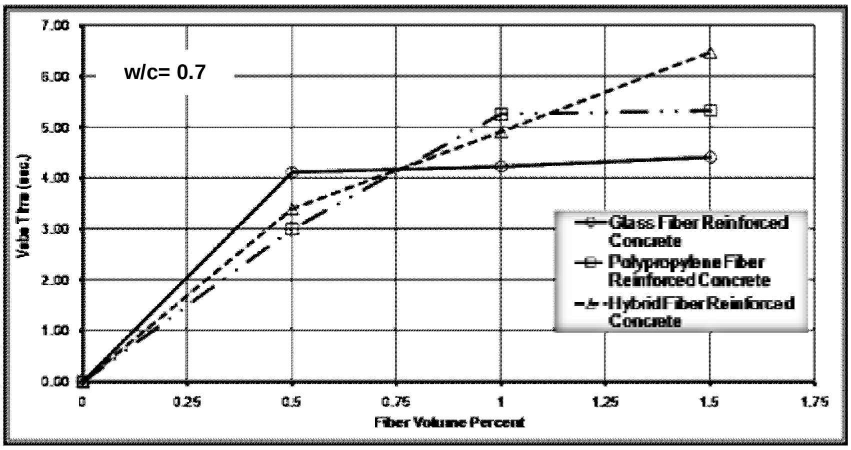


**Fig. 7** Fiber content-vebe time

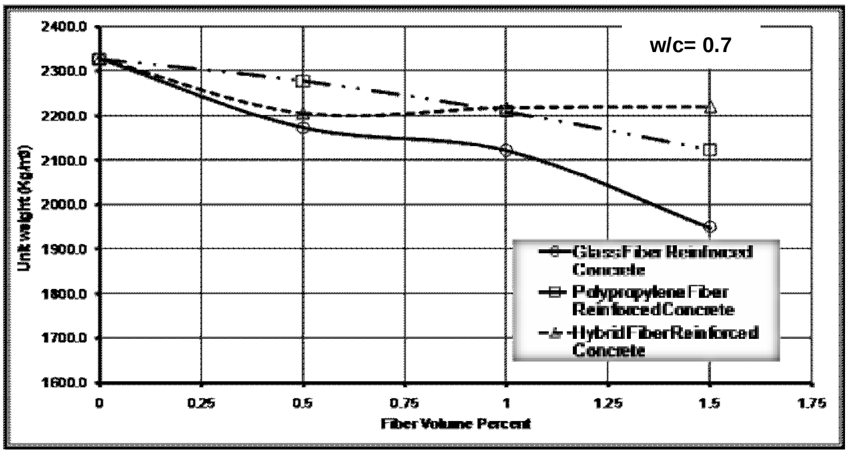


**Fig. 8** Fiber content - unit weight

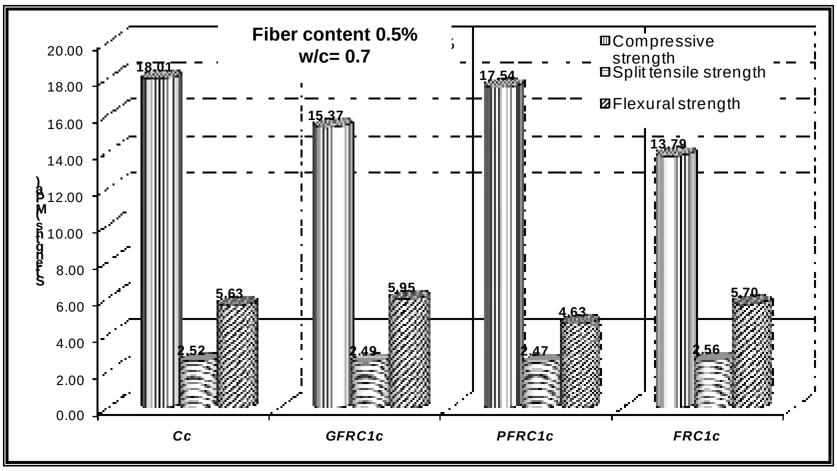


**Fig. 9** Strength comparison between mixes

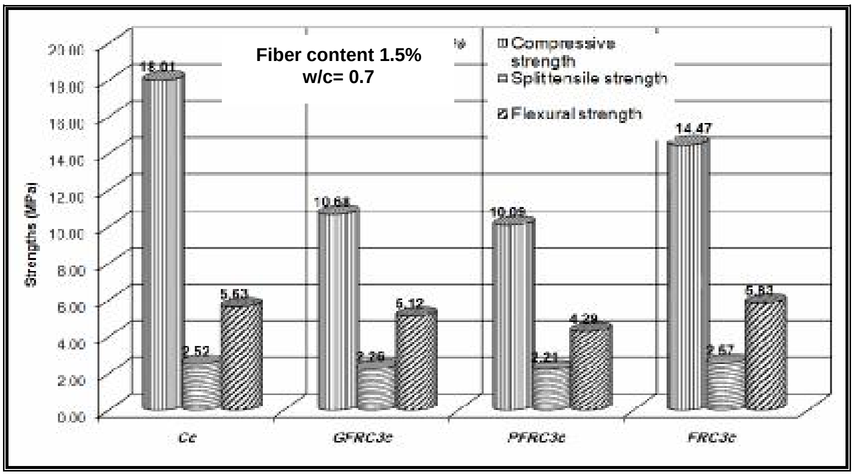


**Fig. 10** Strength comparison between mixes

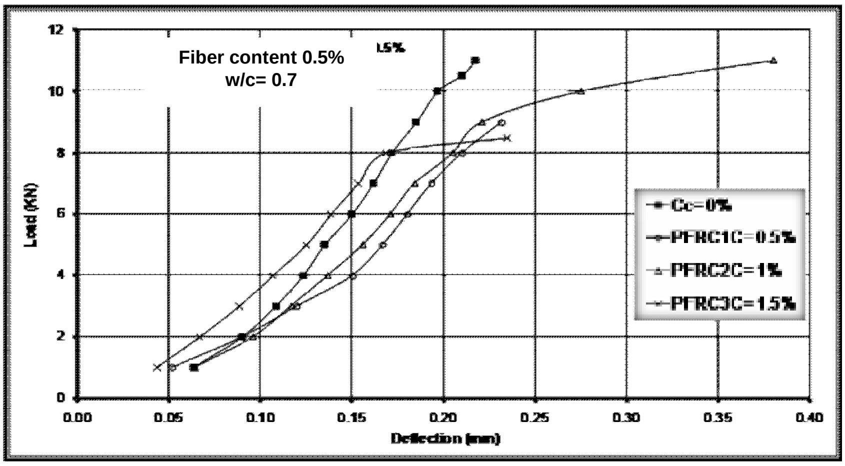


**Fig. 11** ductility comparison between mixes

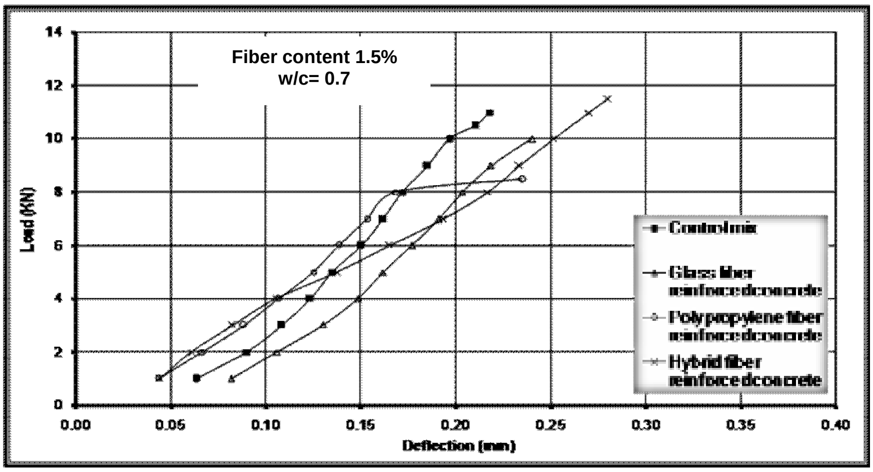


**Fig. 12** ductility comparison between mixes

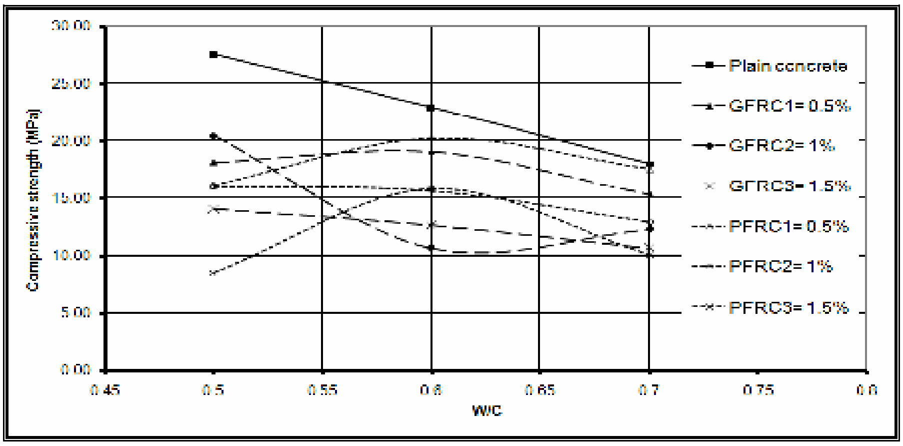


**Fig. 13** Effect of w/c on compressive strength

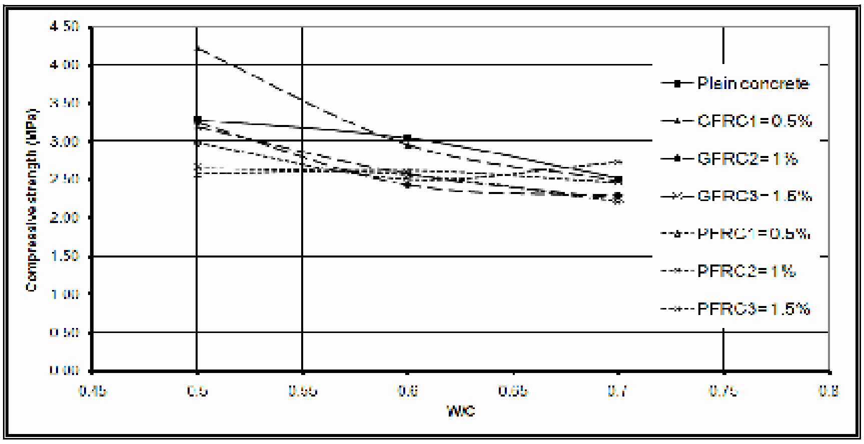


**Fig. 14** Effect of w/c on split tensile strength

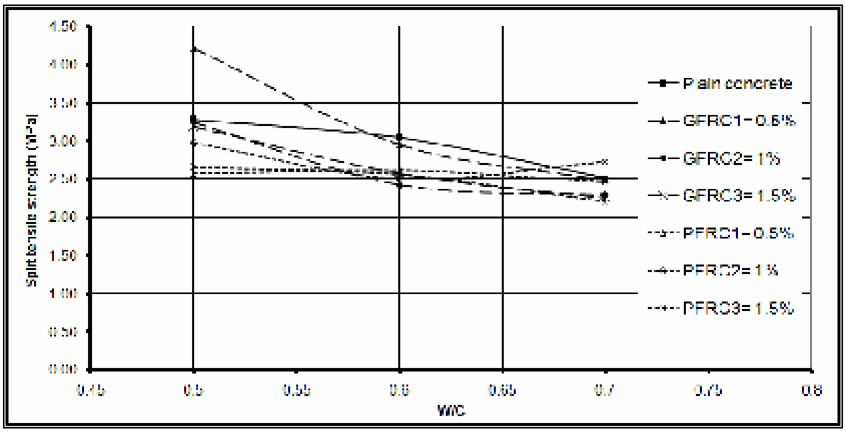


**Fig.15** Effect of w/c on flexural strength

# 4 Conclusions:

From our comprehensive investigation of applying two types of fibers to concrete mix we extract the following main points:

a) Slump decreases rapidly as fiber volume percent is increased going from few centimeters at non reinforced concrete to zero slump at 1.5 volume percent. But it should emphasized that all mixes, even those exhibiting zero slump, were mixed, placed, finished and consolidated in the laboratory without great difficulty. Vebe test has been shown that the initial resistance of the basic mix increased with increase in fiber concentration. Reduction in workability caused by polypropylene fiber was greater than that caused by glass fiber.

b) The unit weights of fiber reinforced concrete mixes are somewhat lower than conventional concrete because of the entrapped air in the matrix. The reduction in unit weight caused by glass fiber was grater than that caused by polypropylene fiber.

c) Fibers tend to decrease the ultimate compressive strength rather than increase it. Decrease in ultimate strength is not uniform due to varying in degree of process of mixing and compaction.

d) Deflection load measurements do indicate that the fibers increased the ductility of the concrete. Also, it was observed that the samples tend to fail more gradually with the addition of fibers.

e) The tensile and flexural strengths results did not show clear variation between the mixtures, Also, compressive strengths were lower for glass, polypropylene and hybrid.

f) Comparison of polypropylene fiber to the glass fiber do indicate that the glass fiber has considerable ductility for beams under flexure. This is possible due to the fact that the modulus of elasticity of glass fiber is higher than that of the polypropylene fiber.

## References

[1] ACI Committee 544, "State-of-the-Art Report on Fiber Reinforced concrete54", American Concrete Institute, United States of America, 2001.

[2] Brown, R., Shukla, A. and Natarajan, K., "Fiber Reinforcement of Concrete Structures", University of Rhode Island, Final Report, No. URITC FY99-02, 2002.