International Journal of Advance Engineering and Research Development
Scientific Journal of Impact Factor (SJIF): 4.72
Special Issue SIEICON-2017,April -2017
e-ISSN : 2348-4470 p-ISSN : 2348-6406

Performance Evaluation of ordinary concrete reinforced with Polypropylene (P), Polyethylene (E) and Woven rowing (O) glass fibers for different water-cement ratios.

Maulik kansagra[1], Vikrant Prajapati[2], Darshak Chauhan[3]

[1] *Assstant Professor, Civil Engineering Department, Sigma Institute of Engineering, Bakrol, Vadodara*
[2] *Assistant Professor, Civil Engineering Department, Sigma Institute of Engineering, Bakrol, Vadodara*
[3] *Assistant Professor, Civil Engineering Department, Sigma Institute of Engineering, Bakrol, Vadodara*

Abstract *- Fibre is a material which could be added in concrete to change its properties and strength. Presented in this paper is the performance evaluation of ordinary M25 grade of concrete when reinforced with different volumes of Polypropylene (P), Polyethylene (E) and Woven rowing (O) glass fibers. The laboratory tests for workability, compressive strength, tensile strength and flexural strength were carried out for the above mentioned glass fibre reinforced concrete specimen prepared with different water cement ratios. The results show that use of any of these glass fibres proves to be beneficiary in terms of increase in overall strength of concrete. The optimum strength was observed in E-glass fiber at 0.07% by volume with 0.4 w/c ratio without compromising the workability.*

Keywords *- Fiber reinforced concrete (FRC), Polypropylene glass fiber (P), Polyethylene glass fiber (E), woven rowing glass fiber (O).*

I. INTRODUCTION

Plain cement concrete has relatively high compressive strength but possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to the brittle fracture of the concrete. It has been recognized that the addition of small closely spaced and uniform dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as Fiber Reinforced Concrete (FRC).

FRC contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers. Within these different fibers that character of fiber-reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation and densities.
Fibers are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete. Generally fibers do not increase the flexural strength of concrete, and so cannot replace moment resisting or structural steel reinforcement. Different types of fibers like steel fiber, mineral fiber, glass fiber etc plays different role in the strength and properties according to their nature.

Table 1 shows the brief review of literature of the relevant research. It reveals the fact that the performance of concrete always improves when it is reinforced by glass fibres. Experiments were carried out to check the performance of glass FRC along with the workability for the most commonly used M25 grade of concrete. The details of the materials used are as follows:

I.A Cement

Grade of cement used: M53
Name of company: Binani
Rate of cement: 300 Rs/ bag

I.B Fine aggregate

Size of fine aggregate: Smaller than 4.75mm and retained on 0.15mm sieve.
Fineness Modulus: 2 to 3
Rate of fine aggregate: 900 Rs/ Ton

I.C Coarse aggregate

Size of coarse aggregate: Smaller than 7.5mm and retained on 4.75mm sieve.
Fineness Modulus: 5.5 to 8
Rate of fine aggregate: 1700 Rs/ Ton

I.D Glass Fibers

1. Polyethylene glass fiber of mesh 450 costing 95 Rs/kg.
2. Polypropylene glass fiber of mesh 450 costing 100 Rs/kg.
3. Woven rowing glass fiber of mesh 600 costing 98 Rs/kg.

P-GLASS

E-GLASS

O-GLASS

Figure 1 - Types of Glass Fibers

Table 1 - Literature review of glass fiber

Sr. No	Name	Details	Properties calculated	Remarks
[1]	Ruhul A. Khan et al, 2011	50% weight fiber of jute fiber reinforced polyvinyl chloride (PVC) matrix and E-glass fiber reinforced PVC matrix	tensile strength, tensile modulus, bending strength, bending modulus and impact strength	E-glass fiber/PVC composites was found to be increased
[2]	Varga,2010	polyalkenyl-poly-maleic-anhydride-ester-amide type additives was added on glass-fiber surface	tensile properties, flexure properties	Both properties were seen to be improved.
[3]	Rabea Barhum, 2012	short, dispersed AR (alkali resistant) glass and carbon fibres are added in concrete	Crack and bond strength and tensile strength in particular binder ratio.	increase of 40 % in tensile strength when water binder ratio was 0.30
[4]	RuhulA. Khan et al, 2011	when Phosphate glass fiber of the composition 20Na2O–24MgO–16CaO–40P2O5 was produced	Interfacial shear strength	–
[5]	Yu Liu et al,2012	0.5 wt.% Multi-walled carbon nanotubes(MWCNTs) and 10 phr reactive aliphatic diluent named n-butyl glycidyl ether(BGE)	interlaminar shear strength (ILSS)	25.4% increase in ILSS
[6]	Yan Lv, 2012	glass fiber reinforced concrete beam	flexure fatigue loading	with different fiber volume fraction
[7]	HoussamToutanji, 2003	Concrete beams reinforced with different GFRP reinforcement ratios	deflections and crack widths and compared to ACI 440.1R-01 equations	–
[8]	Dong-Uk Choi et al, 2012	specimens with GFRP bars	bond strengths	compared with conventional steel rebar's

II. PREPARATION OF SPECIMENS AND TESTS SETUP

II.AMix design

As shown in table 2, Mix designs have been formulated as per code 10262:1982 (recommended guidelines for Concrete mix design). Three designs have been selected with respect to water cement ratios which are 0.5, 0.45 and 0.4. The different percentages of glass fibers are taken with respect of volume of the total casting by trial and error method. The volume to be added in the concrete is 0.076, 0.152 and 0.227% respectively.

Water	Cement	Fine aggregate	Coarse aggregate	Glass fiber in volume		
0.5	1	1.08	2.35	0.076	0.152	0.227
0.45	0.9	0.972	2.115	0.076	0.152	0.227
0.4	0.8	0.864	1.88	0.076	0.152	0.227

Table 2 - Mix design

II.B Tests performed

Workability is measured with sump test. Generally concrete giving shear or collapse slump are considered unsatisfactory for placing. Rich mixes normally behave than lean dry and very wet mixes. Cubes are casted for 7 days and 28 days to obtain compressive strength. Cylinders for 7 days and 28 days are casted for tensile strength. Beams for flexure strength are casted for 7 days and 28 days.

III. Experimental results

Workability observed during concreting shows that workability decreases as we reduce the water-cement ratio. But because of the length characteristic of O-glass fiber, the workability is seen to be more than other glass fibers because more water is needed to add in concrete for proper mix otherwise concrete would be poorly mixed.

Table 3 shows the result of strength of concrete reinforced with glass fiber at 0.5 water-cement ratio for 7 days and 28 days.

Table 4 shows the result of strength of concrete reinforced with glass fiber at 0.45 water-cement ratio for 7 days and 28 days.

Table 5 shows the result of strength of concrete reinforced with glass fiber at 0.4 water-cement ratio for 7 days and 28 days.

From graph 1, for E-glass fiber, maximum 7 days compressive strength is seen for 0.22% at 0.45 w/c ratio. Similarly, for P-glass fiber with 0.14% at 0.4 w/c ratio and O-glass fiber with 0.14% at 0.4 w/c ratio.

From graph 2, for E-glass fiber, maximum 28 days compressive strength is seen for 0.07% at 0.5 w/c ratio. Similarly, for P-glass fiber with 0.07% at 0.45 w/c ratio and O-glass fiber with 0.07% at 0.4 w/c ratio.

From graph 3, for E-glass fiber, maximum 7 days flexure strength is seen for 0.14% at 0.4 w/c ratio. Similarly, for P-glass fiber with 0.07% at 0.4 w/c ratio and O-glass fiber with 0.07% at 0.4 w/c ratio.

Type of fiber	Volume of fibre by %	Compressive strength (N/mm^2)		Tensile strength (N/mm^2)		Flexure strength (N/mm^2)	
		7 days	28 days	7 days	28 days	7 days	28 days
Ordinary M25		18.21	26.72	1.64	2.40	2.99	3.62
M25 Reinforced with E-glass	0.076	24.55	52.74	4.39	3.18	3.09	3.67
	0.152	25.07	49.93	4.18	3.3	4.43	4.76
	0.227	29.69	35.26	1.48	2.74	3.95	4.09
M25 Reinforced with P-glass	0.076	28.22	44	1.37	2.78	4.05	5.01
	0.152	32.15	43.41	1.47	3.11	3.64	3.90
	0.227	25.93	38.07	2.29	2.64	2.87	2.94
M25 Reinforced with O-glass	0.076	34.37	42.37	1.24	2.97	3.27	4.08
	0.152	34.37	38.81	2.45	3.11	3.40	3.77
	0.227	33.09	37.19	2.5	2.9	3.30	4.01

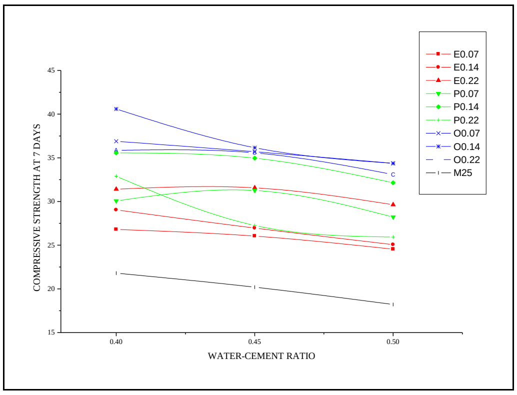
Table 3 – Strengths of glass fiber observed at w/c=0.5 for 7 days and 28 days

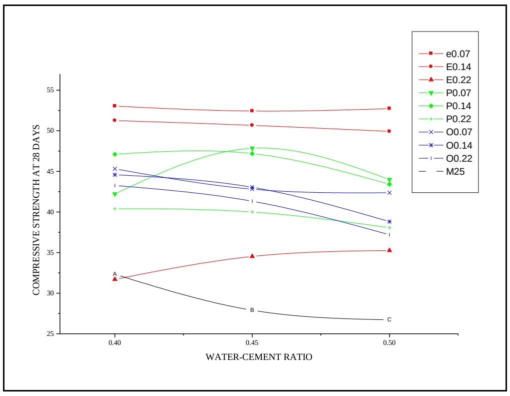
Type of fiber	Volume by %	Compressive strength (N/mm^2)		Tensile strength (N/mm^2)		Flexure strength (N/mm^2)	
		7 days	28 days	7 days	28 days	7 days	28 days
Ordinary M25		20.2	27.90	1.82	2.51	3.15	3.70
M25 Reinforced with E-glass	0.076	26.04	52.44	4.53	3.35	3.32	3.96
	0.152	26.96	50.67	4.65	3.63	4.66	4.91
	0.227	31.56	34.52	1.79	2.95	4.31	4.48
M25 Reinforced with P-glass	0.076	31.26	47.52	1.27	2.43	4.08	5.13
	0.152	34.96	47.19	1.39	3.26	3.82	4.31
	0.227	27.26	40	2.36	2.78	3.00	3.37
M25 Reinforced with O-glass	0.076	35.7	42.81	1.58	3.21	3.67	4.31
	0.152	36.15	43.04	2.78	3.3	3.44	3.81
	0.227	35.56	41.33	2.78	3.3	3.73	4.31

Table 4 - Strengths of glass fiber observed at w/c=0.45 for 7 days and 28 days

Type of fiber	Volume by %	Compressive strength (N/mm^2)		Tensile strength (N/mm^2)		Flexure strength (N/mm^2)	
		7 days	28 days	7 days	28 days	7 days	28 days
Ordinary M25		21.8	32.33	1.96	2.91	3.27	3.98
M25 Reinforced with E-glass	0.076	26.81	53.04	4.58	3.59	3.15	3.9
	0.152	29.04	51.26	4.72	3.54	4.89	5.02
	0.227	31.41	31.7	1.84	2.64	4.49	4.9
M25 Reinforced with P-glass	0.076	30.07	42.22	1.2	2.48	4.2	5.19
	0.152	35.56	47.11	1.3	3.09	3.9	4.89
	0.227	32.89	40.4	2.48	2.97	3.09	3.55
M25 Reinforced with O-glass	0.076	36.89	45.33	1.44	3.07	4.02	4.10
	0.152	40.59	44.59	3.16	3.4	3.93	4.31
	0.227	35.85	43.26	2.74	3.35	3.90	4.49

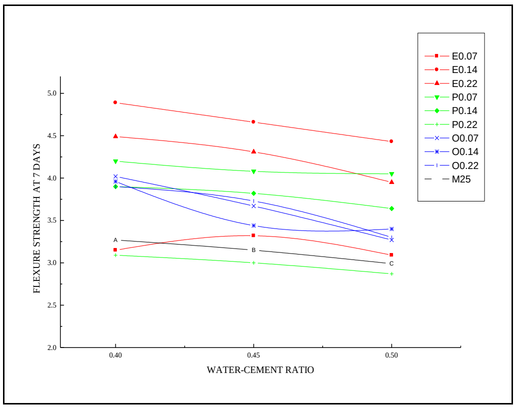
Table 5 - Strengths of glass fiber observed at w/c=0.4 for 7 days and 28 days



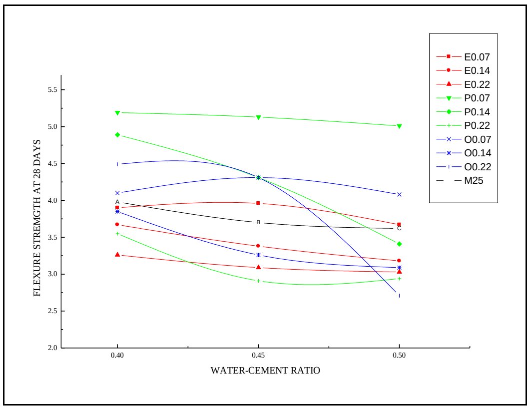


Graph 2 - Relation showing compressive strength at 28 days and water-cement ratio for different glass fiber at different percentages

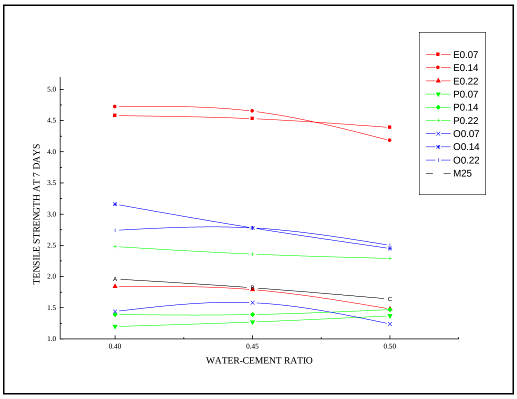
Graph 1 - Relation showing compressive strength at 7 days and water-cement ratio for different glass fiber at different percentages



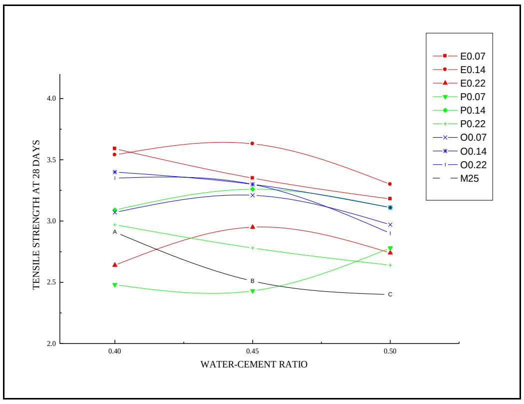
Graph 3 - Relation showing flexure strength at 7 days and water-cement ratio for different glass fiber at different percentages



Graph 4 - Relation showing flexure strength at 28 days and water-cement ratio for different glass fiber at different percentages



Graph 5 - Relation showing tensile strength at 7 days and water-cement ratio for different glass fiber at different percentages



Graph 6 - Relation showing tensile strength at 28 days and water-cement ratio for different glass fiber at different percentages

From graph 4, for E-glass fiber, maximum 28 days flexure strength is seen for 0.07% at 0.45 w/c ratio. Similarly, for P-glass fiber with 0.07% at 0.4 w/c ratio and O-glass fiber with 0.22% at 0.4 w/c ratio. It is also observed that the performance of concrete is poor when w/c ratio is increased.
From graph 5, for E-glass fiber, maximum 7 days tensile strength is seen for 0.14% at 0.4 w/c ratio. Similarly, for P-glass fiber with 0.22% at 0.4 w/c ratio and O-glass fiber with 0.14% at 0.4 w/c ratio.
From graph 6, for E-glass fiber, maximum 28 days tensile strength is seen for 0.14% at 0.45 w/c ratio. Similarly, for P-glass fiber with 0.14% at 0.45 w/c ratio and O-glass fiber with 0.14% at 0.4 w/c ratio.

IV. SUMMARY AND CONCLUSION

In this research project, the effects of adding glass fibers on the different strength were investigated. Different graphs have been plotted to show the behavior of different glass fibers in ordinary concrete. From the findings the following conclusions could be drawn:

1. Based on this experimental research, it can be concluded that use of E, P and O glass fiber in concrete is always beneficiary in one way or other.
2. E-glass fiber improves compressive strength, flexure strength and tensile strength at 0.45 w/c ratio.
3. P-glass fiber improves compressive and flexure strength at 0.45 and 0.4 w/c ratio respectively.

4. O-glass fiber improves compressive strength at 0.4 w/c ratio.
5. The average cost of E-glass fiber is 100 Rs/kg. Hence, it is feasible also. By spending a very nominal amount, one can increase the overall strength upto 60%.
6. Use of E-glass fiber at 0.07% by volume with 0.4 w/c ratio gives the best overall improvement in the strength of concrete (compressive and flexure strength). At the same time, it is workable also.

REFERENCES

[1] Dong-Uk Choi , Sung-Chul Chun , Sang-Su Ha,2012, “Bond strength of glass fibre-reinforced polymer bars in unconfined concrete” Engineering Structures, Volume 34, January 2012, Pages 303–313.
[2] HoussamT outanji, Yong Deng, 2003, “Deflection and crack-width prediction of concrete beams reinforced with glass FRP rods”, Construction and Building Materials, volume 17, (2003) pages 69–74.
[3] Rabea Barhum, Viktor Mechtcherine,2012, “Effect of short, dispersed glass and carbon fibres on the behavior of textile-reinforced concrete under tensile loading” Engineering Fracture Mechanics, volume 92 (2012), pages 56–71.
[4] Ruhul A. Khan, Nusrat Sharmin M. A. Khan, A. K. Das, Kamol Dey, Suvasree Saha, Towhidul Islam, Rafiqul Islam, Farah Nigar, Bapi Sarker, Kajal K. Debnath & M. Saha ;2011, “Comparative Studies of Mechanical and Interfacial Properties Between Jute Fiber/PVC and E-Glass Fiber/PVC Composites” Polymer-Plastics Technology and Engineering, Polymer-Plastics Technology and Engineering, Volume 50, Issue 2, 2011,Pages 153-159.
[5] Ruhul A. Khan, A. J. Parsons, I. A. Jones, G. S. Walker & C. D. Rudd ;“Interfacial Properties of Phosphate Glass Fiber/Poly(caprolactone) System Measured Using the Single Fiber Fragmentation Test”, Composite Interfaces, Volume 18, Issue 1, 2011, pages 77-90.
[6] Varga, N. Miskolczi,L. Bartha,G. Lipóczi;2010 “Improving the mechanical properties of glass-fibre-reinforced polyester composites by modification of fibre surface”, Materials & Design, Volume 31, Issue 1, January 2010, Pages 185–193.
[7] Yan Lva, He-ming Chenga, Zhi-guang Ma, 2012, “Fatigue performances of glass fiber reinforced concrete in flexure”,Procedia Engineering ,volume 31 (2012), pages 550 – 556.
[8] Yu Liu, Jiao-Ping Yang, Hong-Mei Xiao, Cheng-Bing Qu, Qing-Ping Feng Shao-Yun Fu ,Yasuhide Shindo ; 2012, “Role of matrix modification on interlaminar shear strength of glass fibre/epoxy composites”, Composites Part B: Engineering, Volume 43, Issue 1, January 2012, Pages 95–98.

