INVESTIGATION ON THE STRENGTH PROPERTIES OF HYBRID FIBRE REINFORCED CONCRETE CONTAINING BASALT AND GLASS FIBRES

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Abstract: Fibre reinforced concrete is made by the inclusion of discrete amount of fibres with fine and coarse aggregates. The fibres utilized for FRC can be a regular material (eg: cellulose, asbestos, banana etc) or are simulated fibres for eg: glass, steel, carbon etc. A Hybrid fibre reinforced concrete is a composite of two or more fibres in concrete. The word fibre reinforced concrete (FRC) can be explained as a concrete that contains spread at random oriented materials. Blend of both metallic and non-metallic kind of fibres help in improving the solid properties widely. Fibres are spread uniformly in the blend, which prevents or delays initiation and propagation of mix cracking. The prime objective of this study is to investigate the fresh properties of HFRC containing basalt and glass fibres like slump test and and hardened properties of HFRC such as compressive strength, flexural strength and ultrasonic pulse velocity at a period of 7 and 28 days.

Keywords: *Basalt fibres, Glass fibres, Hybrid fibre Reinforced Concrete*

INTRODUCTION

Fibres are commonly utilized in reinforcing it with concrete. Concrete has an extremely low rigidity and little protection from cracking. The effectiveness of fibre reinforced concrete (FRC) in different structural building applications is unquestionable. Fibre reinforced concrete has so far been effectively utilized in sections on grade, building boards, precast items, seaward structures, structures in seismic locales, slight and thick fixes, crash obstructions, footings, water powered structures and numerous other applications. Fibre-strengthened concrete is concrete containing fibres which have their own reliability. It contains short discrete fibres that are consistently circulated and arbitrarily situated. Fibres include steel fibres, glass fibres, mixed fibres and normal fibres – all of them provide fluctuating properties to the concrete. Likewise, the character of fibre-reinforced concrete changes with fibre’s materials, orientation and densities.

Hybrid fibre reinforced concrete (HFRC) utilizes diverse sort of fibres whose result depends on the kind of orientation chosen for the fibres in the concrete. This is a key factor that controls the utilization of HFRC. The behavior of HFRC containing basalt fibres and polyolefin fibres were studied by *Nasar and Hameed* (2017). 12 mm length of basalt fibres was used. The percentage of basalt fibres was varied from 0.25 to 0.75 and polyolefin fibres was varied from 0.15 to 0.35. The optimum combination of hybrid fire reinforced concrete was 0.75 % basalt and 0.25 % polyolefin fibres. The average compressive stress first increases from 0.15 to 0.25% of polyolefin fibres and then decreases from 0.25 to 0.35% *(Nasar and Hameed (2017).*

It is observed that there is no significant effect of glass fibres inclusion on compressive strength. In comparison to basalt fibres the tensile strength at 28 days due to glass fibres addition is less. There is no such change is observed due to glass fibres in flexural strength *(Fadil et al.2018).*

Konapure and Kalyankar (2015) studied that lower compaction factor and lower slump is obtained at 0.8% basalt fibres and 0.2% polypropylene fibres. Maximum compaction factor and maximum slump is obtained at 0.4% basalt fibres and 0.1% polypropylene fibres. There is a marginal increase in compressive and flexural strength of concrete on addition of 0.5% fibres(basalt and polypropylene).At 1% addition of fibres (basalt and polypropylene), the flexural strength is observed to be decreasing.

Cement in concrete can be replaced up to 50% by class F flyash. The parameters investigated increases by the addition of steel fibres, polypropylene fibres and basalt fibres. Favorable effects on mechanical characteristics were also observed. Hybrid combination of 1% steel fibres, 0.75% polypropylene fibres and 0.75% basalt fibres provides best overall results *(Shubhra and Parihar 2017).*

There were studies made on high elastic modulus fibres such as steel fibres, basalt fibres, polyvinyl alcohol fibres and low elastic modulus fibres like polypropylene fibres. The mechanical properties of concrete are very less affected by the single basalt fibres, polypropylene fibres and hybrids of basalt fibres. When polyvinyl alcohol and polypropylene fibres are used, the splitting tensile strength and flexural strength are found to be decreased by 17.8%, 12.9% when compared with the single-doped polyvinyl alcohol fibre concrete *(He et al. 2017).* The workability of concrete increments at 1% with the addition of glass fibres *(Kumar et al 2018).* Increase in compressive, flexural and split tensile strength for M-20 mix of concrete at 7 and 28 days are seen to be more at 1%. By using the waste product of glass as fibres, it has been seen that there is a continuous increment in compressive value when it is compared to the normal concrete i.e. while glass fibres is 0% in the overall mix.

EXPERIMENTAL INVESTIGATION

In this paper, the fresh and hardened properties of the HFRC of M40 grade prepared with basalt and glass fibres were studied. For each mix, six numbers of cube (150x150x150)mm, six numbers of beam (100x100x500)mm were cast and investigation were conducted to study the workability of hybrid fibre reinforced concrete (HFRC). The properties of hardened HFRC such as compressive strength, flexural strength and ultrasonic pulse velocity at a period of 7 and 28 days were also studied. The results of HFRC with normal concrete without the addition of fibres in it were compared to negotiate between the properties of the two concretes. Also, the optimum proportion of the glass and basalt fibres was found out in HFRC.

Table 1 Experimental Programme

Sr. No.	Mix	Fibre Proportion (%)	
		Basalt fibres	Glass fibres
1	M-B0-G0	0	0
2	M-B0.15-G0.15	0.15	0.15
3	M-B0.20-G0.20	0.20	0.20

Table 2 Mix Proportions of HFRC

Cement (kg/m^3)	Fine aggregates (kg/m^3)	Coarse aggregates (kg/m^3)	Water (litres)	Super plasticizer (litres)
388	850	1168	148	4.65

MATERIALS USED

Ordinary Portland Cement (OPC) of 43 grade was used in the study. Table 3 represents the specification of OPC. Potable tap water was used to prepare all the mixes. Natural river sand were used as fine aggregates. The super-plasticizer used was Master Genellium 8765. In this paper, the hybrid blend consists of basalt fibres and glass fibres. The complete properties of basalt fibres and glass fibres are given in Table 4.

Table 3 Characteristics of OPC-43 Grade

Characteristic	Units	Result Obtained	Permissible range specified (IS: 8112-1989)
Specific gravity	-	3.15	3.10- 3.15
Soundness (expansion by Le-Chatelier test)	mm	3	10 (max)

Normal Consistency (percentage cement by weight)	%	32	30-35
Setting time (i) Initial (ii) Final	minutes	65 410	30 (min) 600 (max)
Compressive Strength (i) 3-days (ii) 7-days (iii) 28-days	MPa	23.00 35.50 45.10	23.00 (min) 33.00 (min) 43.00 (min)

Table 4 Properties of basalt and glass fibres

Parameters	Basalt fibres	Glass fibres
Length (mm)	12	12
Density (g/cm^3)	2.65	2.6
Elastic modulus (GPa)	93.1	72.85
Tensile strength (MPa)	4500	2050
Daimeter (mm)	12	14
Appearance	Gloden brown	White

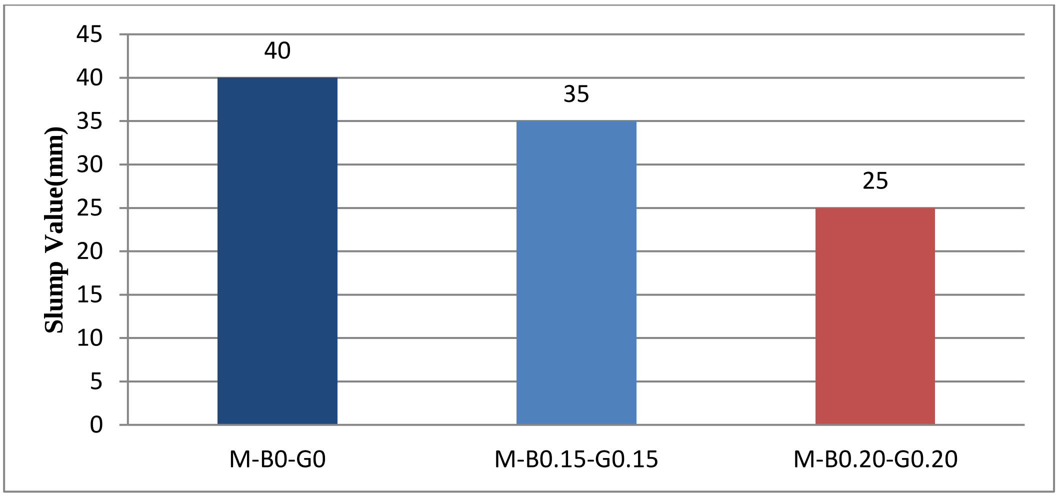
Figure 1 Chopped basalt fibres

Figure 2 Glass fibres

RESULT AND DISCUSSIONS

Table 5 Results of Fresh Properties of Mixes

Sr. No.	Mix	Fibres (% by weight of cement)	Slump values (mm)
1.	M-B0-G0	0	40
2.	M-B0.15-G0.15	0.30	35
3.	M-B0.20-G0.20	0.40	25

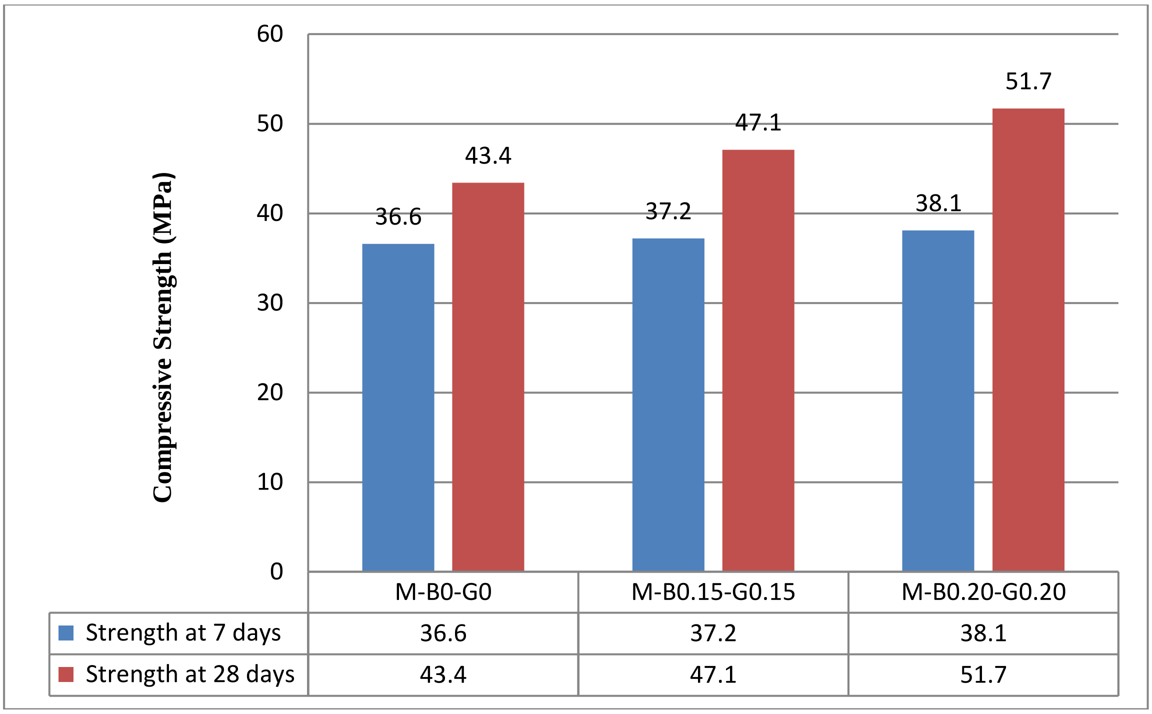


Graph 1 Results of slump value

Table 5 and graph 1 demonstrates the value of slump of mixes decrease due to addition of fibres. It happens because the scattered fibres in the concrete may form a network structure, which will limit blend from segregation and flow. When the control mix (M-B0-G0) was compared with the M-B0.20-G0.20 mix, the maximum decline in the slump was observed as 37.5 percent.

Table 6 Result of Compressive Strength

S.No.	Mix	Avg. Compressive Strength at 7 days (MPa)	Avg. Compressive Strength at 28 days (MPa)
1.	M-B0-G0	36.6	43.4
2.	M-B0.15-G0.15	37.2	47.1
3.	M-B0.20-G0.20	38.1	51.7

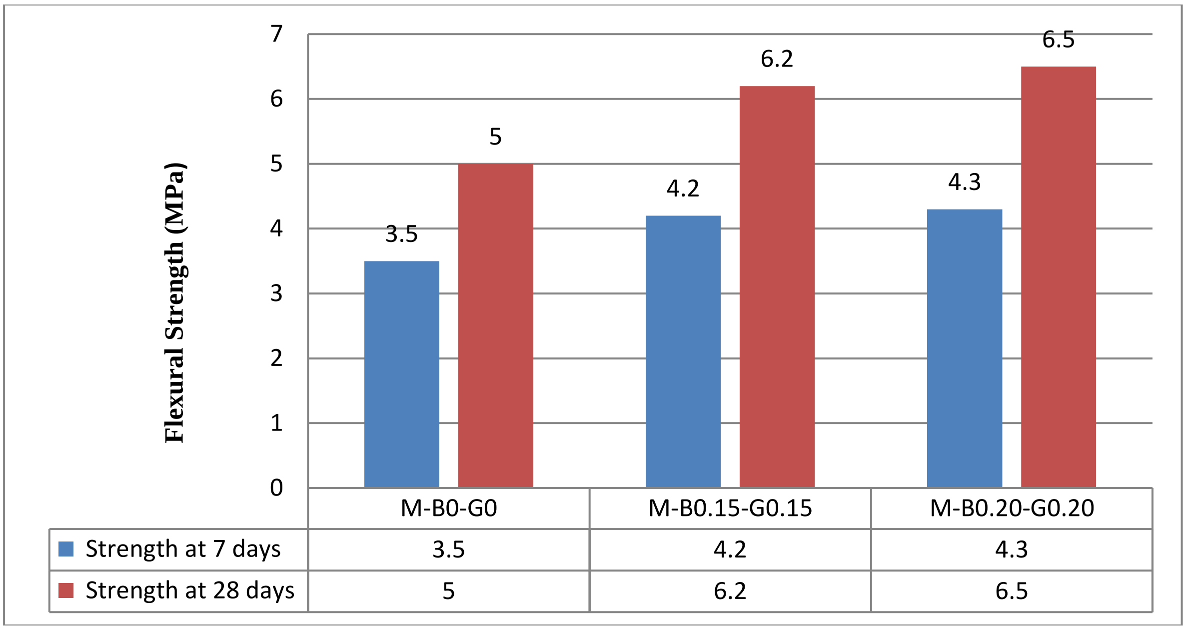


Graph 2 Results of Compressive Strength

Table 6 and graph 2 demonstrates the compressive strength of mixes. When the control mix (M-B0-G0) was compared to all the other mixes, the compressive strength was increased for all the blends. However, for M-B0.20-G0.20 mix with the mixture of 0.20% basalt fibres and 0.20% glass fibres, the ideal compressive strength was achieved. When (M-B0.20-G0.20) mix was compared with the control blend (M-BF0-GF0), the compressive strength was seen to be improved by 4.09% at 7 days and 19.12% at 28 days. It clearly shows that the enhancement in the fibre content results in the increase of compressive strength of the mix.

Table 7 Results of Flexural Strength

S.No.	Mix	Avg. Flexural Strength at 7 days (MPa)	Avg. Flexural Strength at 28 days (MPa)
1.	M-B0-G0	3.5	5
2.	M-B0.15-G0.15	4.2	6.2
3.	M-B0.20-G0.20	4.3	6.5

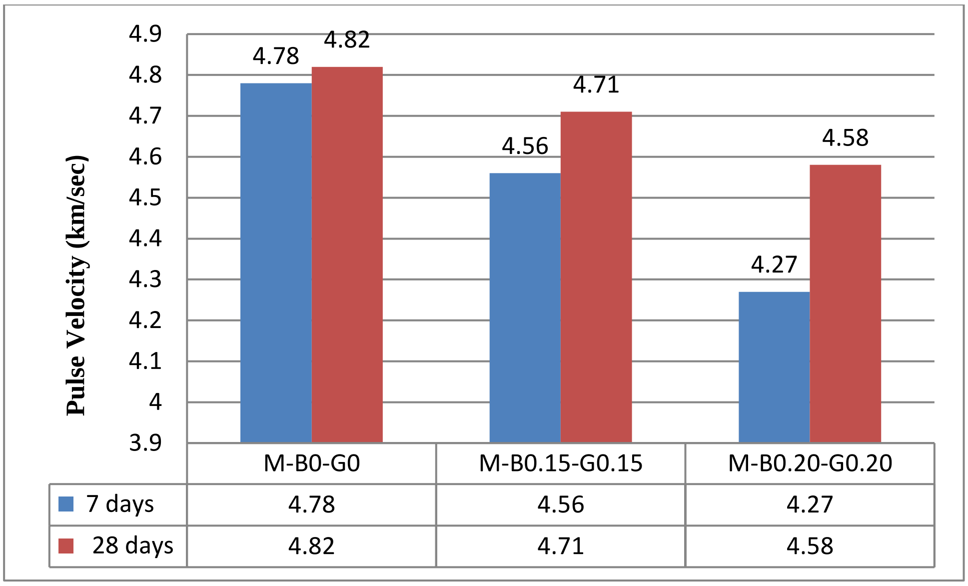


Graph 3 Results of Flexural Strength

Now, the table 7 and graph 3 demonstrates the flexural strength of the mixes. In contrast to the control mix (M-B0-G0), flexural strength increased comprehensively for all blends. Although, for M-B0.20-G0.20 mix with the composition of basalt fibres 0.20% and glass fibres 0.20%, the maximum flexural strength was procured. In comparison with the control mix (M-B0-G0), flexural strength of the mix (M-B0.20-G0.20) improved by 24% at 7 days and 30% at 28 days. The inference which can be taken out from this variation is that by adding more fibre we get more flexural strength.

Table 8 Results of Ultrasonic Pulse Velocity (UPV)

S. No.	Mix	Ultra pulse velocity (UPV) (km/sec) at 7days	Ultra pulse velocity (UPV) (km/sec) at 28 days
1.	M-B0-G0	4.78	4.82 (Excellent)
2.	M-B0.15-G0.15	4.56	4.71 (Excellent)
3.	M-B0.20-G0.20	4.27	4.58 (Excellent)



Graph 4 Results of Ultrasonic Pulse Velocity (UPV)

UPV test is one of the non-destructive tests which is very useful for the examination of the sub-surface of the concrete without harming the integrity of the structure. The values obtained for the UPV test is excellent in all cases which means that the material used is of good quality and is continuous throughout.

CONCLUSIONS

The trends of variation of fresh and hardened properties of the HFRC can be seen from the above results. On the basis of trends seen from the above results, the following conclusions can be drawn-

1. As the percentage of fibres added increases, fresh properties of HFRC decreases.
2. The slump value decreased on addition of fibres and it was found to be minimum for the mix M-B0.20-G0.20.
3. For M-B0.20-G0.20 mix, the optimum compressive strength was acquired.
4. Optimum flexural strength was found for M-B0.20-GF0.20.
5. All the mixes have shown excellent in quality. .

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