Global Scientific JOURNALS

GSJ: Volume 9, Issue 9, September 2021, Online: ISSN 2320-9186
www.globalscientificjournal.com

MICROSCOPIC AND MECHANICAL ANALYSIS OF HYBRID FIBER REINFORCED CONCRETE

Arqam habib[1], Fawad Ahmad[2], Shahfahad[3], Amar Ghafoor[4], Muhammad Ibrahim[5], Mansoor Kamal[6]

[1, 3,4,5,6] Research Students, Department of Civil Engineering Iqra National University Peshawar
[2] Research Supervisor, Department of Civil Engineering Iqra National University Peshawar

Corresponding Email Id: arqamhabib1212@gmail.com

Abstract

Concrete, the most significant and commonly utilized element, is expected to have very high strength and adequate workability properties and efforts in the field of concrete technology are made to improve the properties of concrete utilizing up to some amounts of fibers. The term hybrid generally refers to the combination of composites, and consists of multi-property material. Therefore, the matrix is named with hybrid fiber reinforced concretes. The aim of this research work was to test the viability of concrete on the Hybrid fiber by testing the concrete behavior at fresh and hardened state, i.e. workability, compressive, split tensile, flexural strength by varying proportions of steel and polypropylene fibers respectively and to compare with control concrete specimen with no addition. All the tests were carried out in accordance with the guidelines set by ASTM standards. It was observed that the workability of the mixtures decreased by increasing the percentage of hybrid fibers more bonding effect thus decreases the workability. Compressive, flexure and split tensile strength increases as the Steel fiber content in hybrid fiber increases to a certain extent and then decreases as the fiber content increases further. It is recommended that for strength enhancement, the Hybrid fiber can be used as steel fiber reinforcement up to Steel 0.85 and Polypropylene 0.15 respectively.

Introduction

With global innovations in sustainability, it is critical that Fiber Reinforced Concrete (FRC) boost tensile strength, hardness, ductility, post-cracking resistance, fatigue characteristics, longevity, shrinking properties, effects, cavitation, erosion tolerance, and concrete serviceability [1]. Beton's shear, bending and serviceability properties improve if the RCC beam is reinforced with textile besides this the crack width also reduces Concrete reinforced with cellulose has shown that the crack width is less than that of plain concrete besides having less crack width, Reinforced concrete with cellulose was found to 40 percent tougher than unreinforced concrete [2]. Analogous to that of steel, it has been found that fiber like armed enhances concrete strength. The use of FRC has increased over the past two decades [3]. In each lathe industry, waste is accessible in the form of steel scraps created by the lathe machines in the process of finishing various sections of the machine and dumping this waste into the barren soil which contaminates the soil and groundwater and creates an unhealthy environment. Such steel scraps are once a day used by creative manufacturing companies as well as in the road and highway sectors as surplus materials [4].

Literature Review

Hybrid Fiber reinforced concrete use increases the overall properties and optimizes the performance of composites [5]. Polypropylene fibers are manufactured in varying sizes and forms, and with various hair-like or plastic-made properties. Using small isolated polypropylene fibers spread at random has different effects on the concrete property [6]. The effectiveness of polypropylene fiber on concrete's compressive strength depends on the percentage of its thickness [7]. The effect of steel fibers on the compressive strength of concrete is discussed extensively in literature. Many studies have observed that the use of steel fiber in concrete improves the importance of compressive strength. Increases in compressive strength vary from small to major [8]. Two stabilizing measures attribute the effect of fibers on the compressive force. First, the fiber bridging effect across the micro cracks would be a larger number of pores in the concrete admixture which decreases the compressive strength and second factor, resulting in increased compressive strength [9].

Experimental Work

The aim of this research work was to test the viability of concrete centered on the Hybrid fiber by testing the following physical properties, i.e. compressive strength, tensile strength fracturing, flexural strength. All these physical properties were found out by varying proportions of steel and polypropylene fibers respectively will casted and compare with control concrete specimen with no addition. All the tests were carried out in accordance with the guidelines set by ASTM standards. Following tests were conducted in this research work.

Workability Tests of Fresh Concrete ASTM 143/C 143M-05a

Before the check the interior surface of the mold was washed and moistened with a wet rag. The mould was installed on a smooth, horizontal, vibration-free surface. As the mold was being packed, it kept tightly on the bits of the foot. The mould was filled in on three layers. Each coating was around one – a third of the height of the mould. Each layer was roded with 25 rounded rod ends. Each stroke has a uniform rod that extends over the mould cross section. The surface concrete was taken off until the top coat was rodded. Remove the mould immediately by raising it slowly and carefully in the vertical direction. The height of the recession was assessed immediately. The mould height and average height of the upper surface of the concrete are determined.

Figure 1: Slump Test for fresh concrete

Compression test ASTM C-39/39M

The compressive strength is calculated using formula;

GSJ: Volume 9, Issue 9, September 2021
ISSN 2320-9186

$$\text{Compressive strength} = \frac{\text{Maximum load}}{\text{cross sectional area}}$$

Figure 2: Compression Test

Splitting Tensile Strength of Cylindrical Concrete Specimens ASTM 496/C 496M

Following formula is used to calculate the splitting tensile strength of the specimen:

$$T=2P/\boldsymbol{\pi}ld$$

Where:
T = splitting tensile strength, psi [MPa].
P = maximum applied load indicated by the testing machine, lb f [N].
l = length, in. [mm].
d = diameter, in. [mm].

Figure 3: Splitting tensile test

Flexural strength test ASTM C-293/C293M-10

Following formula is used to calculate the modulus of rupture as follows:

$$R= \frac{\mathbf{3PL}}{\mathbf{2bd^2}}$$

Where
R = modulus of rupture, MPa [psi]
P = maximum applied load indicated by the testing machine, N [lb f],

L = span length, mm [in.]
b = average width of specimen, at the fracture, mm [in.]
d = average depth of specimen, at the fracture, mm [in.]

Figure 4: Flexure Test

Number of Concrete specimens

In order to test the mechanical properties of control concrete and concrete including partial substitution of steel and polypropylene fiber as fiber reinforcement in concrete, 24 concrete cylindrical and 12 beam specimens were casted. Detail number of concrete samples is shown.

Table 1: Number of concrete specimen

Concrete Mix	**Hybrid Fiber**		**Compressive Test**	**Split Tensile Test**	**Flexural Test**
	Steel (%)	Polypropylene (%)	28 Days	28 Days	28 Days
M0	`0	0	2	2	2
M1	0.5	0	2	2	2
M2	0	0.3	2	2	2
M3	0.85	0.15	2	2	2
M4	0.7	0.3	2	2	2
M5	0.55	0.45	2	2	2

Results and Discussion

Workability Tests of Fresh Concrete ASTM 143/C 143M-05a

To check the workability, fresh concrete slump test was carried out. A slump check was conducted for each batch of concrete. As a partial addition to concrete fiber reinforcement each batch of concrete had percent of the hybrid fiber. The addition of (Steel, Polypropylene) was (0.5,0), (0,0.30), (0.85,0.15), (0.70,0.30), (0.55,0.45) respectfully. Slump test was also carried out for concrete control.

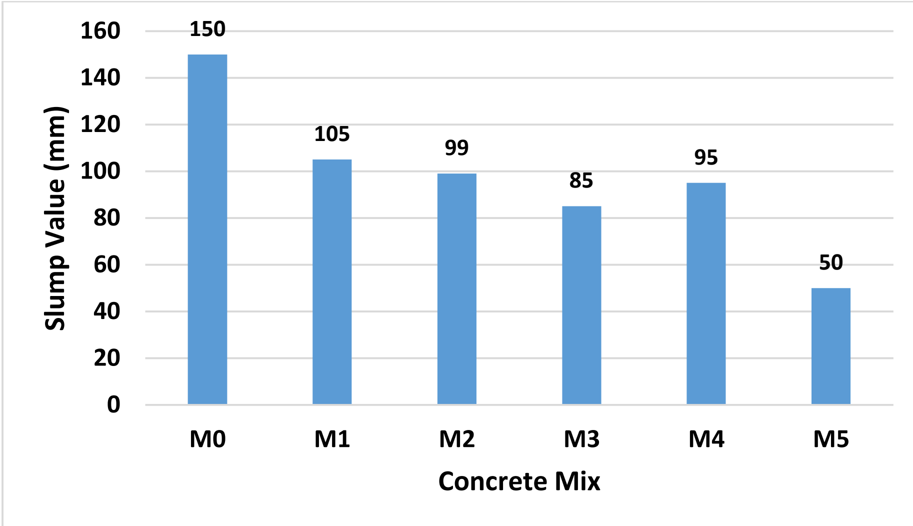

Figure 5: Slump test result

The result of slump test indicates that the ordinary concrete achieved the slump value up to 150 mm. while the slump value of concrete mix i.e. M1 to M5 indicates that by adding steel fiber as well as Polypropylene gradually decreasing the workability. The Composite Concrete blend has strong fresh bonding. By increasing the percentage of hybrid fibers more bonding effect thus decreases the blend's slump value when using the hybrid fibers in concrete.

Compressive, split tensile and flexure strength

The compression, split tensile and flexural test was performed on cylindrical and beam concrete samples with partial addition of Hybrid Fiber as fiber reinforcement.

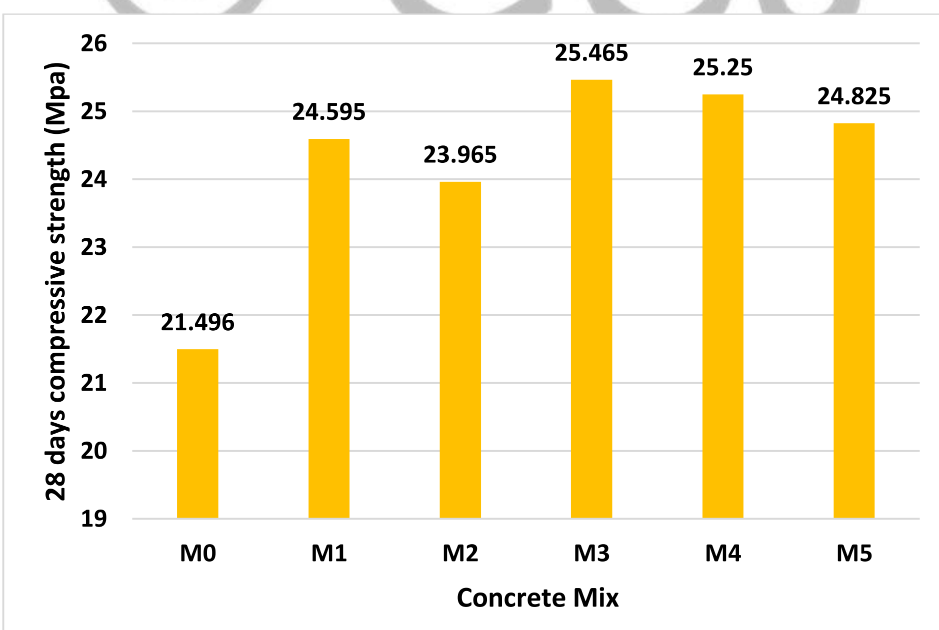

Figure 6: Compressive strength 28 Days

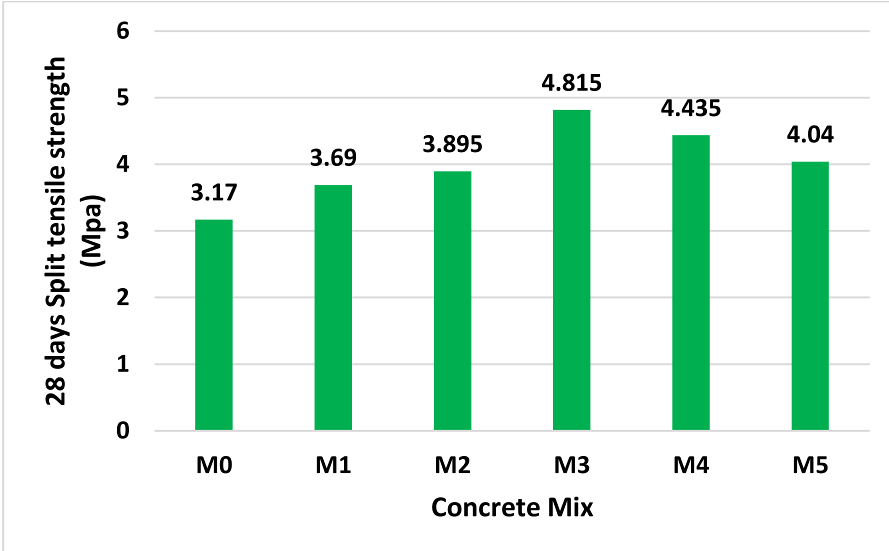

Figure 7: Splitting tensile strength (28 days age)

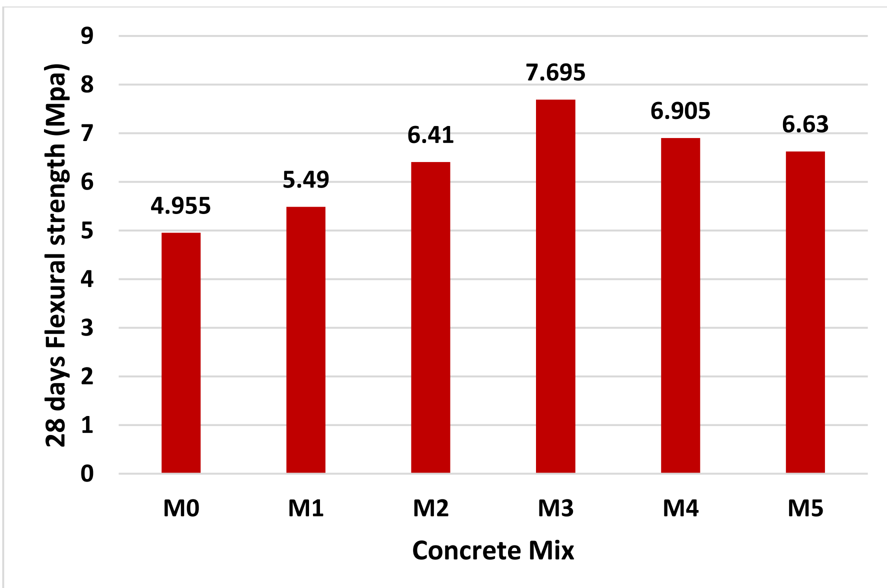

Figure 8: Flexural strength (28 days age)

Scanning Electron Microscopy

The addition of steel and Polypropylene fibers into concrete will minimize micro-cracks and avoid the expansion of macro-cracks, thus enhancing the internal stability of the concrete. The transverse deformation of concrete under stress is limited and the fibers may be tightly bound to the matrix. When stress is transferred from the matrix to the fibers, the fibers absorb energy due to deformation, which in effect slows the concrete's degradation process; as a result, the concrete's mechanical strength increases.

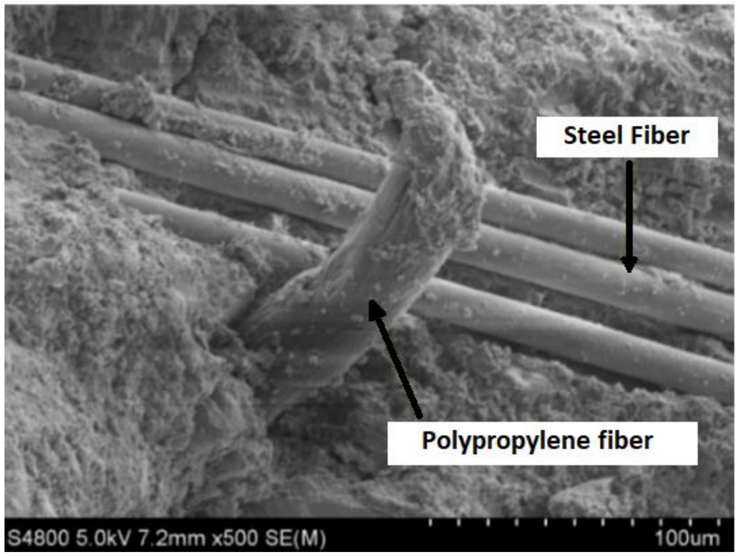

Figure 9: Distribution of steel and polypropylene fibers in hybrid fiber reinforced concrete.

Conclusions

It was observed that the workability of the mixtures decreased by increasing the percentage of hybrid fibers more bonding effect thus decreases the workability. Compressive, flexure and split tensile strength increases as the Steel fiber content in hybrid fiber increases to a certain extent and then decreases as the fiber content increases further.

Recommendation

It is recommended that for strength enhancement, the Hybrid fiber can be used as steel fiber reinforcement up to (Steel=0.85, Polypropylene=0.15).

References

1. Paul, S.C., van Zijl, G.P. and Šavija, B., 2020. Effect of fibers on durability of concrete: A practical review. Materials, 13(20), p.4562.
2. Raj, V., 1991. Treatise on utilization of bamboo as reinforcement in ferrocement. Journal of Ferrrocement, 21(4), pp.371-381.
3. Behfarnia, K. and Behravan, A., 2014. Application of high performance polypropylene fibers in concrete lining of water tunnels. Materials & Design, 55, pp.274-279.
4. Singh, S., Ramakrishna, S. and Gupta, M.K., 2017. Towards zero waste manufacturing: A multidisciplinary review. Journal of cleaner production, 168, pp.1230-1243.
5. Banyhussan, Q.S., Yıldırım, G., Bayraktar, E., Demirhan, S. and Şahmaran, M., 2016. Deflection-hardening hybrid fiber reinforced concrete: The effect of aggregate content. Construction and building materials, 125, pp.41-52.
6. Papadaki Anastasopoulou, A.A., 2019. Plastic matters-material politics of plastic at the Environment Agency Austria (Doctoral dissertation, uniwien).
7. Qin, Y., Zhang, X., Chai, J., Xu, Z. and Li, S., 2019. Experimental study of compressive behavior of polypropylene-fiber-reinforced and polypropylene-fiber-fabric-reinforced concrete. Construction and Building Materials, 194, pp.216-225.

8. Williamson, G.R., 1974. The effect of steel fibers on the compressive strength of concrete. Special Publication, 44, pp.195-208.
9. Afroughsabet, V., Geng, G., Lin, A., Biolzi, L., Ostertag, C.P. and Monteiro, P.J., 2019. The influence of expansive cement on the mechanical, physical, and microstructural properties of hybrid-fiber-reinforced concrete. Cement and Concrete Composites, 96, pp.21-32.