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Influence of Fibers on Strength Characteristics of Cement Mortar

Shrungi Mohan Naik[1*], K. G. Guptha[2]
[1]Student, Department of Civil Engineering, Goa College of Engineering, Farmagudi, Goa, India
[2]Head of the Department, Department of Civil Engineering, Goa College of Engineering, Farmagudi, Goa, India

***Abstract*: Cement mortar, being a bonding material has extensive application in plastering, masonry work, repairing damaged concrete and the development of precast products. Portland cement gives a mortar high early strength, a consistent hardening rate, and higher bond strengths. However, Portland cement mortar is found to be a relatively brittle material. Cracks are prone to happen in plastic as well as the hardened stage. Hence, there is an increase in the demand for blast-resisting materials. The blast may cause concrete to spall, and disintegrate. Introduction of Fibers in cement mortar to increase the strength characteristics and develop a better bonding in cement sand mixture which will delay the failure of concrete. This study aims at determining and understanding the compressive and flexural strength characteristics of fiber reinforced mortar with the addition of different percentages of fibers in mortar. Two types of polypropylene fibers were used namely, plain and crimped polypropylene fibers in percentages of 0.5,1,2 of length 55mm, 27.5mm, 13.75mm.**

***Keywords*: Fiber-reinforced, Polypropylene, Mechanical properties, Compressive.**

1. Introduction

Cement mortar is a bonding material and is produced by mixing cement, and fine aggregate with water. Cement mortar has extensive application in masonry work, plastering, repairing damaged concrete, patching or filling, rendering, floor leveling, and the development of precast products.

Portland cement gives a mortar high early strength, a consistent hardening rate, and higher bond strengths. However, Portland cement mortar is found to be a relatively brittle material. Cracks are prone to happen in plastic as well as the hardened stage. Mortar with high cement have greater shrinkage and hence shrinkage cracks are more. The micro-cracks get developed from the outside to the inside, hence there is an increase in the permeability of the mortar. Mortar has a large contact area with the surrounding environment and hence, a good mortar should resist the penetration of water and should possess high durability.

There is an increase in the demand for blast-resisting materials. The blast may cause concrete to spall, and disintegrate. Fibers are introduced in cement mortar to increase the strength characteristics and develop a better bonding which will delay the failure of concrete. This study aims at determining and understanding the strength characteristics of fiber reinforced mortar with the addition of different percentages of fibers in mortar.

Fiber is a small strand used to reinforce cement mortar and concrete. Different fibers possess unique structural and chemical properties. Fibers can be circular or flat in cross-section. The aspect ratio i.e., the ratio of length to the diameter of fibers is usually between 30 to 150.

2. Materials

Material used in this research are listed below.

A. Cement

Ordinary Portland Cement (OPC) of 53 grade is used in preparation of mortar. Physical aspects such as specific gravity and normal consistency were found and tabulated below in table 1. Potable water, free of dissolved contaminants is ideal for use in the manufacture of Mortar mix. The water used in preparation of cement mortar mix complied with the requirements of IS 456:2000.

Table 1
Physical properties of cement

S. No.	Physical Properties	Findings
1	Standard consistency	31%
2	Specific Gravity	3.1

B. Standard Sand

The standard stand is used as fine aggregate in this study. Standard sand as per IS 650 is made of local natural silica sand (silica content 99%) and has a water content lower than 0.1%. It contains uncrushed and angular grains with a very small percentage of rounded/flaky particles. The standard sand is obtained from TAMIN.

C. Fibers

The Two different types of fibers are used in this study namely, plain polypropylene fibers and crimped polypropylene fiber of 55mm length to find the percentage of fibers to be added to improve the strength and also take care of the workability. Fibers used in this study are manufactured by MAPEI, namely MAPEFIBRE IT NV 39 and ST 55.

Polypropylene fiber (PPF) is a kind of linear polymer

*Corresponding author: shrunginaik@gmail.com

synthetic fiber obtained from the polymerization of propylene. It has some advantages which include lightweight, high strength, durability, high toughness, and corrosion resistance. The hydrophobic surface which does not get wet by cement paste helps to prevent fibers from balling effect while mixing like other fibers.

Plain polypropylene fibers are flat and straight, having some surface texture for better bonding with the mortar mixture. Crimped polypropylene fibers are another type of polypropylene fibers, which have undulations or succession of waves. Crimped polypropylene fibers are relatively stronger than plain polypropylene fibers due to their cross-section. Also, these fibers have a very good bond strength with the mortar. Figure 2 shows the polypropylene fibers.

(a) Plain

(b) Crimped

Fig. 1. Polypropylene fibers

1) Aspect Ratio of Fibers

An aspect ratio of fibers is the ratio of the length of the fibers to the diameter of the fiber. Aspects ratio of fibers used in the study is as given in the table 2.

Table 2
Aspect ratio of fibers

Type	Length	Effective diameter	Aspect ratio
Plain	L- 55mm	0.8	68.75
	L/2- 27.5mm	0.8	34.37
	L/4- 13.75 mm	0.8	17.18
Crimped	L- 55mm	0.91	60.44
	L/2- 27.5mm	0.91	30.22
	L/4- 13.75 mm	0.91	15.11

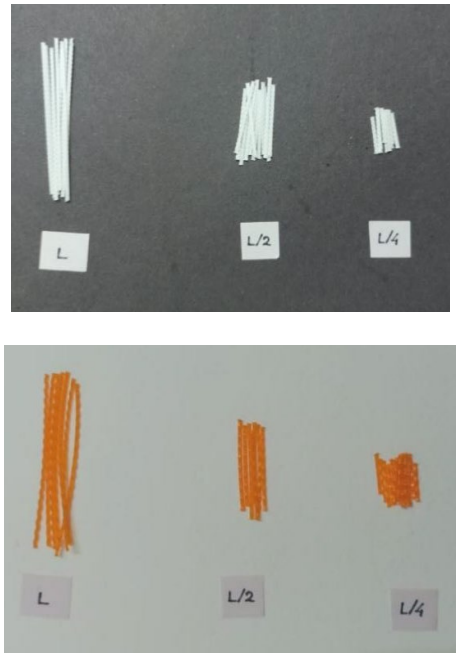


Fig. 2. Various lengths of fibers used

3. Methodology Adopted

Plain and crimped polypropylene fibers are added to cement mortar of cement-sand content of 1:3. Percentage of water added is (.25 NC+3) % as per IS: 4031. In addition to that, fibers

Table 3
Dosage of fibers

Type of fibers	Percentage of fibers	Length of fibers	Weight of fibers (gms)	Cube names
Plain polypropylene fibers	0.5	L	1	W-0.5% L
		L/2	1	W-0.5% L/2
		L/4	1	W-0.5% L/4
	1	L	2	W-1% L
		L/2	2	W-1% L/2
		L/4	2	W-1% L/4
	2	L	4	W-2% L
		L/2	4	W-2% L/2
		L/4	4	W-2% L/4
Crimped polypropylene fibers	0.5	L	1	O-0.5% L
		L/2	1	O-0.5% L/2
		L/4	1	O-0.5% L/4
	1	L	2	O-1% L
		L/2	2	O-1% L/2
		L/4	2	O-1% L/4
	2	L	4	O-2% L
		L/2	4	O-2% L/2
		L/4	4	O-2% L/4

of various lengths, L, L/2, L/4 i.e., 55mm, 27.5mm, 13.75mm are added in various percentages of 0.5%, 1%, 2% to the weight of cement and cubes of 7cm x 7cm x 7cm were casted and cured at 27ºC.

The cement, sand, fibers, and water were mixed in a mortar mixer to achieve a better homogenous mix. The proportions used and cube naming are shown in the table. Flow was found using flow table test to determine the workability of various mortar mixes with fibers. 1-day, 3-day, 7-day and 28-day compressive strength and Stress-strain behavior of these cubes were found and compared to arrive at optimum dosage.

Fig. 3. Mortar mixer

Fig. 4. Flow table test

4. Results

Flow values of cement mortar reduce as the percentage of fibers increases. The fibers of length 55mm i.e., full length fibers for and above 2 % make a very harsh mix with a very low value of flowability.

For the plain polypropylene fibers, the 7-day compressive strength is observed to have increased with the percentage of fibers. For fibers of full-length, there is a considerable increase in strength between 0.5-1% of fiber dosage (15% increase between 0.5% to 1%) and a steady increase above that dosage. For the fibers of other lengths, there is a slow increase in the strength of about 8% for every 0.5% increment in fiber dosage.

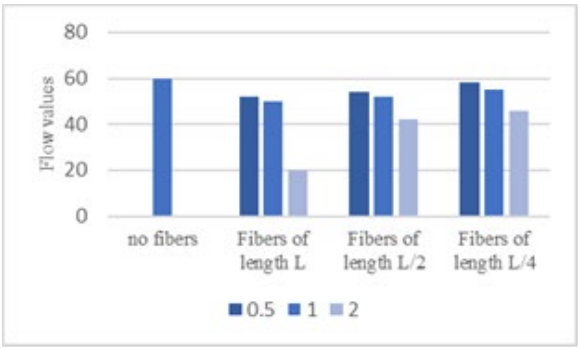


Fig. 5. Flow values for plain fibers

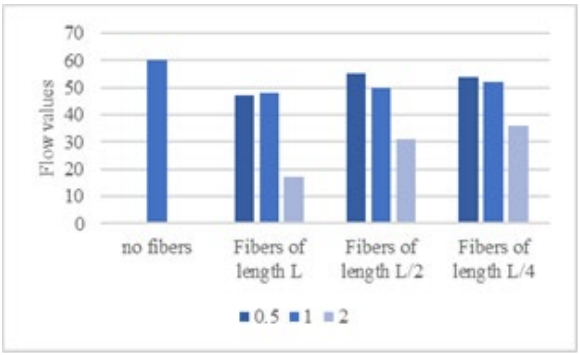
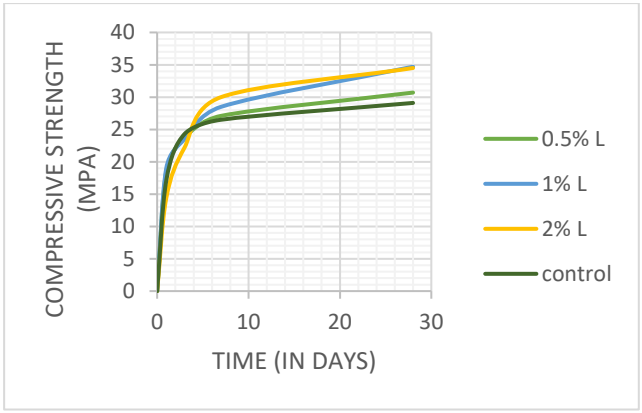
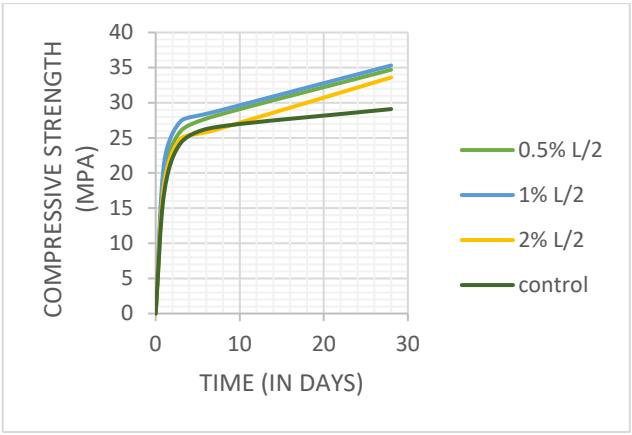


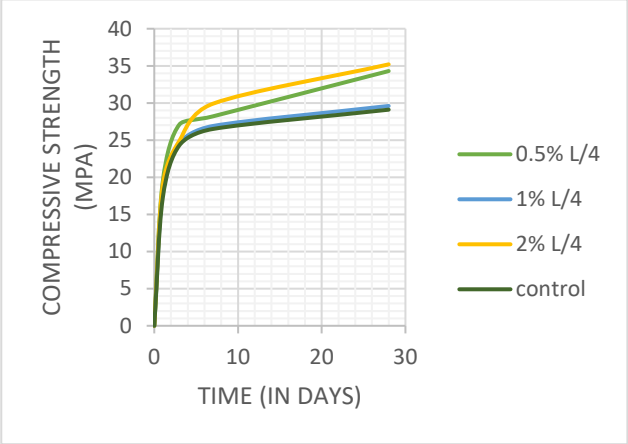
Fig. 6. Flow values for crimped fibers



Length L



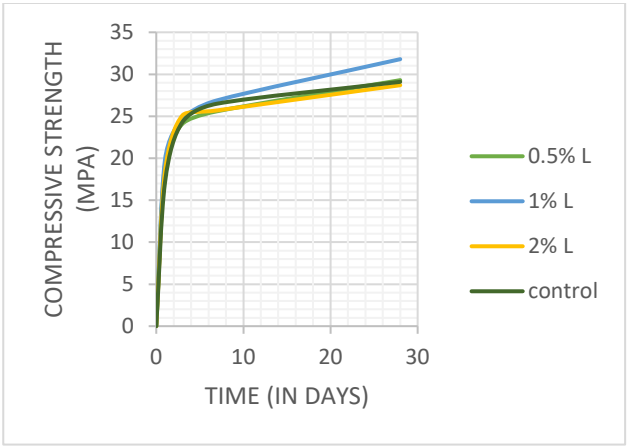
Length L/2



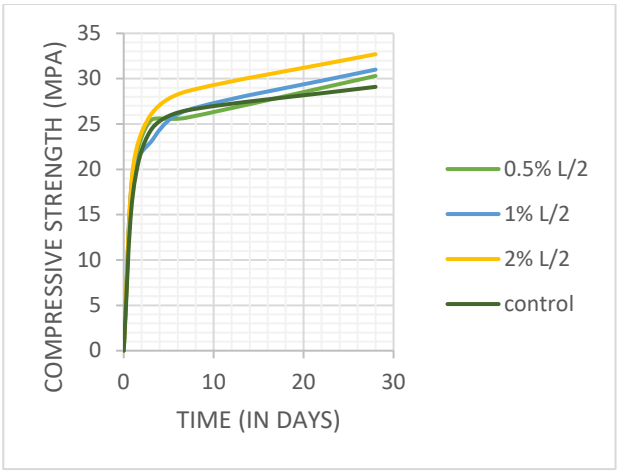
Length L/4

Fig. 7. Variation of compressive strength with the percentage of plain fibers

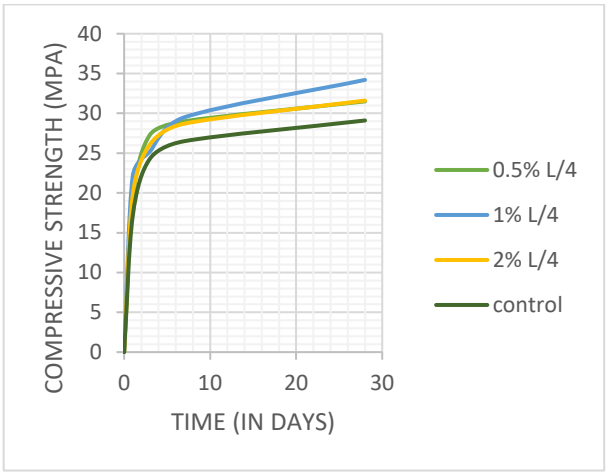
For the crimped polypropylene fibers, the 7-day compressive strength of full-length fibers reached a peak between 0.5-1% dosage of fibers. Half-length fibers and quarter length fibers have the best results for 0.5% fibers. With a decrease in the length of crimped fibers, a reduction is observed in strength for the same percentage of fibers. For the percentage of quarter length fibers more than 1%, the strength is almost similar to the control mix.



Length L



Length L/2



Length L/4

Fig. 8. Variation of compressive strength with the percentage of crimped fibers

The optimum percentage of fibers is 1 % for plain polypropylene fibers and the optimum length is full length i.e., 55mm for achieving desirable strength of about 24Mpa.

The optimum percentage of fibers is 0.5-1% for crimped polypropylene fibers of length 55mm (full-length) giving the strength of about 27 MPa and 0.5% for fibers of other lengths.

5. Conclusion

This paper presented a study on the influence of fibers on strength characteristics of cement mortar.

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References

[1] Borinaga-Treviño, R., Orbe, A., Canales, J. & Norambuena-Contreras, J., 2021. Thermal and mechanical properties of mortars reinforced with recycled brass fibres. Construction and Building Materials, Issue 284.

[2] Sevil, T., Baran, M., Bilir, T. & Canbay, E., 2011. Use of steel fiber reinforced mortar for seismic strengthening. Construction and Building Materials, Issue 25, pp. 892-899.

[3] Pereira de Oliveira, L. A. & Castro-Gomes, J. P., 2011. Physical and mechanical behaviour of recycled PET fibre reinforced mortar. Construction and Building Materials, Issue 25, pp. 1712-1717.

[4] Graham, R. K., Huang, B., Shu, X. & Burdette, E. G., 2013. Laboratory evaluation of tensile strength and energy absorbing properties of cement mortar reinforced with micro- and meso-sized carbon fibers. Construction and Building Materials, Issue 44, pp. 751-756.

[5] Zhang, H., Liu, Y., Sun, H. & Wu, S., 2016. Transient dynamic behavior of polypropylene fiber reinforced mortar under compressive impact loading. Construction and Building Materials, Issue 11, pp. 30-42.