STUDIES ON HARDEN PROPERTIES OF MORTAR USING POLYESTER FIBRE

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ABSTRACT

Polyester Fibre Reinforced mortar hava been evaluated for use as a cement concrete pavement material. The study focused on laboratory evaluation of various mechanical properties of cement mortar, with and without Polyester Fibre. Split Tensile test was done on specimens as concrete and mortar are weak in tension so tensile strength can be increased by using polyester fibres. The Polyester Fibre Reinforced mortar exhibited improved split tensile strength and compressive strength over that of plain cement mortar. Due to their non-biodegradability, the use of polyester fibres in cement mortar in road works can also help in conservation of environment. Behavior of cement-based matrices carrying Polyester fibres reinforcement of different percentage is studied in this paper. Specimens containing fibre of 0.0, 0.3, 0.4, 0.5, 0.6, 0.8 and 1.0 % are prepared and tested. It is demonstrated that certain amount of fibres enhances the compressive as well as split tensile capacity of the fibre reinforced cement mortar. The Compressive strength of mortar was increased to 17.68 % at 7 days and Split tensile strength was increased by 32.58 % at 7 days & 70.37 % at 28 days.

KEYWORDS: *Mortar, Polyester fibre, compressive strength, split tensile strength*

I. INTRODUCTION

It is well known that one of the problems of a cement-based material is the intrinsically brittle type of failure owing to low tensile strength and poor fracture toughness that impose constraints in structural design and long-term durability of structures. In order to satisfy the performance of cement-based matrices, incorporation of fibres is getting growing interest to increase the toughness, impact resistance, fatigue endurance, energy absorption capacity as well as tensile properties of the basic matrix. Both the development and propagation of cracks of cement-based composite are resisted through stress-transfer bridges and crack tip plasticity mechanisms due to the presence of fibres. As a result of the above advantages, fibre reinforced cement-based composites are steadily used in hydraulic structures, tunnel linings, highway and airfield pavements and tensile skin in concrete beams and slabs. [1]

Extensive literature review indicates that several types of fibres such as steel, asbestos, glass, metallic glass ribbons, polymeric, Polyester, natural fibres and textile reinforcements were being used to reinforce cement matrix and considerable works have been done on the mechanical properties of these types of cement-based materials. Among the different types of fibres used in cement-based composites, Polyester fibres offer distinct advantages. The non-corrodible characteristics of Polyester fibre, high strength-to-weight ratio, good fatigue strength and low relaxation losses are properties that motivate structural engineers to use Polyester fibre cement composites in many structures and structural components that are exposed to increased temperature and mechanical wear. Their potential use in machine foundations, earthquake resistance structures, blasts shelters, electrical and electronics industries, in thin pre-cast products like roofing elements, tiles, curtain walls, cladding panels, I- and L-shaped beams, repairing and retrofitting material are some of the examples.

No attempt has so far been made to study the effect of fibre hybridization in size and quantities of Polyester fibre on flexural properties of cement-composites except for the incomplete research works that can be found in the technical literatures. Although dimensional and modular hybrids using steel fibre and polystyrene fibre on crack growth resistance of hybrid fibre reinforced cement composites have been studied earlier, it is necessary to assess and optimize the characteristics of the optimal fibre system. [3-6]

This investigation is aimed at generating information on the overall response of Compressive as well as tensile behaviour of cement composite reinforced with different fibre percentage of Polyester fibres. Compression and split tensile tests on cement mortar cubes of size 70.6 x 70.6 x 70.6 mm containing fibre of 0.0, 0.3, 0.4, 0.5, 0.6, 0.8 and 1.0 % by weight were carried out. Effect of fibre content was demonstrated by the stress–fibre content curves. Results of compression and split tensile strenth were studied and depicted in tabular and graphical form for the sake of convenient design of Polyester fibre cement mortar in structural applications.

II. RESEARCH SIGNIFICANCE

Dimensional hybrid and amount of Polyester fibres in cementitious composites can be effective in arresting cracks at both macro and micro levels. The problem of failure mechanism and bearing capacity of fibre reinforced concrete (FRC) under various loading conditions has been studied quite extensively in the past. In spite of the volume of information available, relatively very little or no research work is reported in the technical literature on the split tensile strength of thin cementitious composites containing Polyester fibres with varying quantities although it presents considerable versatility towards the development of cementitious composites for structural applications. The purpose of this research is to investigate the split tensile and compressive behaviour of fibre-reinforced cementitious composites and to identify synergistic effects of quantities, if present.

III. EXPERIMENTAL PROGRAM

In order to study the effects of Polyester fibres on the behavior of cement composites in terms of compressive strength and split tensile strength, tests were carried out on specimens with Polyester fibres and without Polyester fibres. For the case of cement composite with fibre, it was reinforced by 10 mm fibres. The variable percentage of fibre content, chosen for this investigation were 0.3, 0.4, 0.5, 0.6, 0.8 and 1.0 % whereas the size of the test cubes was kept constant to 70.6 x 70.6 x 70.6 mm for all the specimens to investigate the effectiveness of amount of fibres in cement composites.

IV. MATERIALS AND METHODS

A. Polyester Fibres

The Polyester fibres used in this research work are commercially available in India. Its diameter varies from 20 µm to 40 µm. The fibres are generally sized by cutting. Common length of Polyester fibre is 3, 4.8, 6, 12, 18 and 24 mm. here we have used 18 mm long polyester fibre. The properties of Polyester fibres are given in Table 1. The physical appearance of the Polyester fibre used in this investigation is shown in Fig. 1.

Table 1 Properties of polyester fibre

Diameter (µm)	Density	Tensile Strength (GPa)	Elastic Modulus	Softening Point (°C)	Elongation (%)
20 - 40	1.3 – 1.6	4 - 6	>5000	250 - 265	20 - 60

Fig. 1 Physical appearance of short Polyester fibres

B. Mortar–Fibre Mixture

In this study, ordinary Portland cement and river sand with fineness modulus of 3.05 were used. The water to cement ratio and cement to sand ratio were kept as 0.405 and 0.33 by weight in all the mixes.

In each casting, three cubes of plain mortar of size 70.6 x 70.6 x 70.6 mm were cast and tested to find out the compressive strength and split tensile strength of the mortar. The details of the Proportion of mortar mix are given in Table 2. The required amount of sand, cement and Polyester fibre were dry mixed manually on a glass plate in such a way that the procedure involves several passes of scoop through the dry mix to ensure an even distribution of cement and fibre in the mixture. The calculated amount of water to be necessary to obtain a water-cement ratio of 0.405 was added gently to the dry mix and finally, the components were mixed thoroughly. Nearly 3–5 minutes was required to obtain a homogeneous mortar–fibre mixer.

Table 2 Proportion of mortar mix

Index	Cement (gm)	Sand (gm)	Water (ml)	Polyester Fibre (% weight of cement)
M0	200	600	81	-
M1	200	600	81	0.3
M2	200	600	81	0.4
M3	200	600	81	0.5
M4	200	600	81	0.6
M5	200	600	81	0.8
M6	200	600	81	1.0

C. Casting Of Cubes

The test cubes were cast in steel moulds with open tops. Each of the four side-walls and the base of the mould were detachable to facilitate the demoulding process after its initial setting. The specimens were air-dried for 1 day for initial setting and then immersed in water for curing. After 28 days of curing the specimens were air-dried in room temperature at about 25ºC with relative humidity of about 60%.

D. Testing Of Cubes

Cubes were tested under compression and split tension. The tests were performed with a loading speed of 10.0 mm per minute and the readings were taken at an interval of 1 KN. The photographs of compression test and split tensile strength test and test setup are shown in Fig. 2. In split tensile test a compressive load is given diagonally to the specimen. And stress is calculated for equation given in IV-E.

Fig. 2 (a) Compression Test setup and actual practice

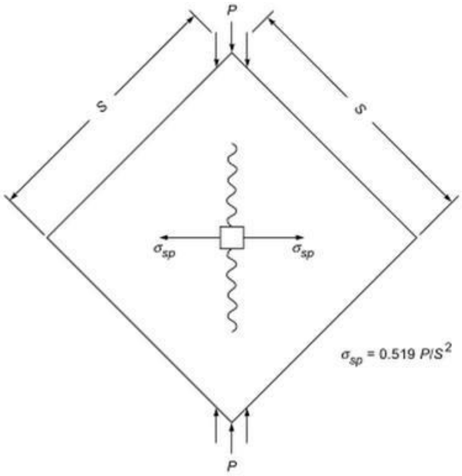

Fig 2(b) Split tensile test actual practice

E. Crack-Stress Of Cement Composites[2]

Considering the homogeneous nature of the cement composite, the split tensile strength is given by

$$\sigma_{sp} = 0.519\, P/S^2$$

Where P is load at failure and S is side of cube.

V. RESULTS AND DISCUSSION

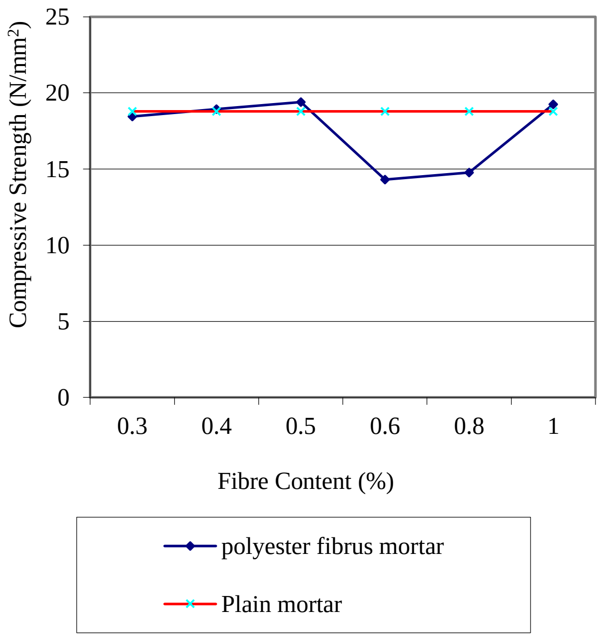

Fig.3 Compressive strength with various fibre dosages for 3 days curing

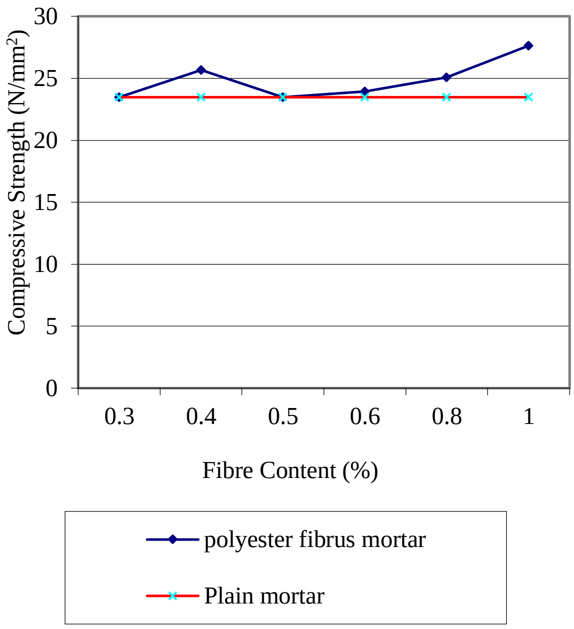

Fig. 4 Compressive strength with various fibre dosages for 7 days curing

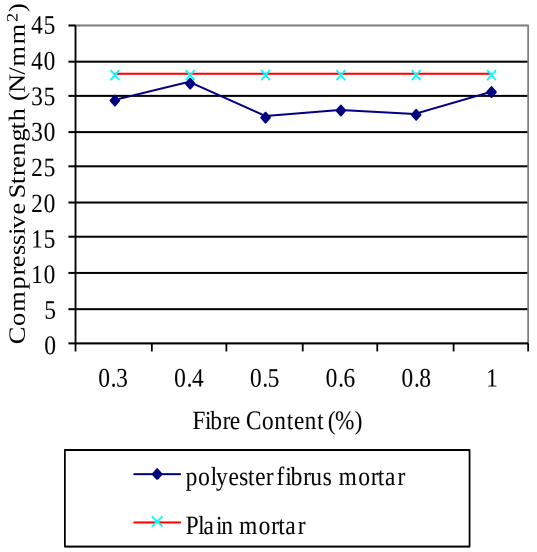

Fig. 5 Compressive strength with various fibre dosages for 28 days curing

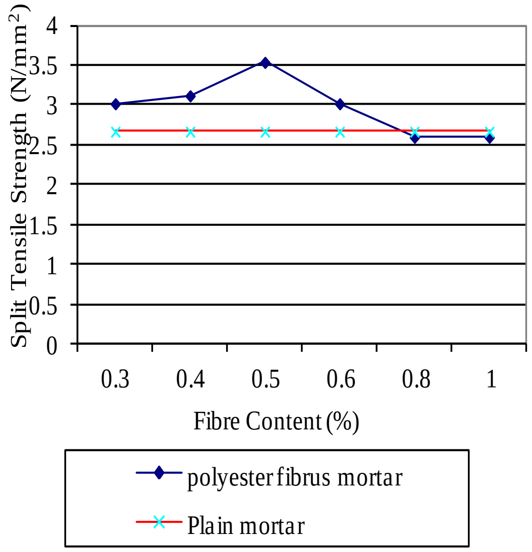

Fig. 6 Split Tensile strength with various fibre dosages for 7 days curing

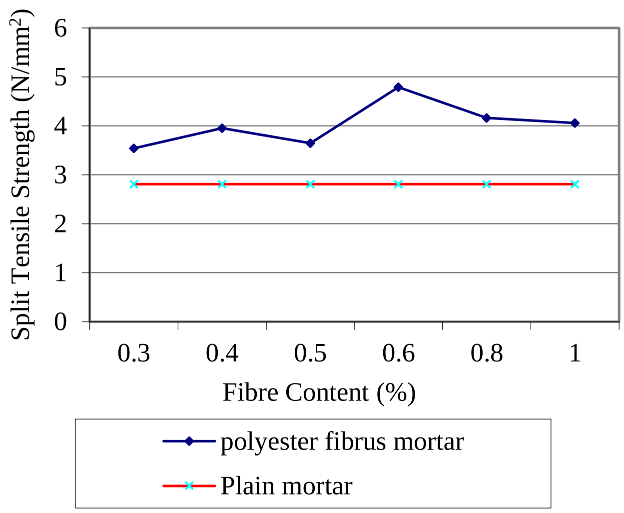

Fig. 7 Split Tensile strength with various fibre dosages for 28 days curing

The control cement mortar cubes were tested and the strength – fibre content curves are illustrated in Fig. 3-7. It is clear that the cement mortar exhibited its pure brittle nature without showing any softening or ductility. The following critical remarks are drawn:

a) In Polyester fibre mortar, the maximum compressive strength increased at 7 days 17.68 % without any chemical agents or any other additives.
b) For Polyester fibre mortar, the maximum split tensile strength increased at 7 days 32.58 % at 7 days & 70.37 % at 28 days respectively.

VI. CONCLUSION

From the above results it is observed that addition of Polyester fibres in mortar giving good compressive strength compare to plain mortar at initial stages. And in split tensile test, tensile strength of Polyester fibre in some certain quantity in mortar mix gives high tensile strength compare to plain mortar. From the above results, it is clear that fibre addition in mortar gives high tensile strength which prevents the cracks. As mortar is weak in tension fibre in certain quantity gives high tensile strength and good compressive strength to the mortar at early age.

REFERENCES

[1] Dave U. V. and Desai Y. M. "Effect of Polypropylene, Polyester and Glass fibres on various strength of ordinary and standard concrete" the first international conference on recent advance in concrete technology, Sep. 2007,Washington D.C. U.S.A.
[2] Gambhir M. L. (2010), "Concrete Technology, Theory and Practice", Tata McGraw Hill Education Private Limited. New Delhi.
[3] Li V. C.: "On Engineered Cementitious Composites (ECC) - A Review of the Material and its Applications", Journal of Advanced Concrete Technology, Vol. 1, No. 3, pp. 215-230, Nov. 2003.
[4] Li V. C.: "Engineered Cementitious Composites (ECC) – Tailored Composites through Micromechanical Modeling", Proceedings of Fibre Reinforced Concrete: Present and the Future, Canadian Society of Civil Engineers, 1997.
[5] Rathod J. D., Patodi S. C., Parikh B. K. and Patel K. H.: "Study of Recron 3S Fibre Reinforced Cementitious Composites", Proceedings of a National Conference on "Emerging Technology and Developments in Civil Engineering", Amaravati, pp. I-88 to I-95, March 2007.
[6] Rafat Siddique, Kushal Kapoor, El-Hadj Kadri, Rachid Bennacer "Effect of polyester fibres on the compressive strength and abrasion resistance of HVFA concrete" *Construction and Building Materials, Volume 29, April 2012, Pages 270-278.*
[7] Silva FA, Butler M, Mechtcherine V, Zhu D, Mobasher B. Strain rate effect on the tensile behaviour of textile-reinforced concrete under static and dynamic loading. Mater Sci Engng, A 2011;528:1727–34.

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