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Studies On Harden Properties Of Mortar Using Steel Fibre

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Abstract

An experimental program was carried out to evaluate the mechanical properties of cement-based composites. Compressive strength test and splitting tensile strength test were performed and the results were analyzed statistically. According to the results of this study, the designed direct tensile testing method was a suitable method to estimate the tensile strength of fibre cement- based composites. Steel fibres can greatly increase the mechanical properties of cement-based composites. Specimens containing fibre of 0.0, 0.3, 0.4, 0.5, 0.6, 0.8 and 1.0 % are prepared and tested in this work. It is demonstrated that certain amount of fibres enhances the compressive and split tensile capacity of the fibre reinforced cement mortar. The Compressive strength of mortar was increased to 43.62 % at 3 days, 62.29 % at 7 days & 22.62 % at 28days and Split tensile strength was increased by 105.26 % at 7 days & 29.17 % at 28 days.

"1. Introduction"

Cement-based composites have long been used for civil structures such as highways, bridges and buildings. However, unexpected deterioration of reinforced or pre-stressed concrete structures has led to the improvement of durability of concrete. Traditionally, the constituents of cement-based composites include cementitious material, water, aggregate and/or admixtures. Fibre has been added in cement-based composites since 1960's to enhance concrete properties, particularly tensile strength, abrasion resistance and energy absorbing capacity. The presence of fibre would refrain the growth or propagation of internal cracks and helps to transfer load. The specimen with fibre has much higher ductility than the specimen without fibre, for which fibre reinforced composites (FRC) also demonstrates a significant increase in energy absorption or toughness. However, the properties of FRC would be affected by the type, volume fraction and aspect ratio of fibre. Lower fibre volume fraction is usually preferred as far as material cost and workability are concerned. [1-6]

It was also reported that the combination of silica fume with steel fibre would effectively enhance the compressive strength, splitting tensile strength, abrasion resistance and impact resistance and be beneficial for fibre dispersion in cement-based composites. Silica fume would increase the bonding between fibre and mortar by strengthening the interfacial zone. [8-12] This study was aimed to evaluate the effect of steel fibre on the mechanical properties of cement-based composites with silica fume. A multiple regression analysis was also performed on the experimental results to quantify the influence of material variables on the mechanical properties.

This investigation is aimed at generating information on the overall response of Compressive as well as tensile behavior of cement composite reinforced with different fibre percentage of steel 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 were 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 steel fibre cement mortar in structural applications.

“2. Research significance”

Dimensional hybrid and amount of steel 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 steel 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.

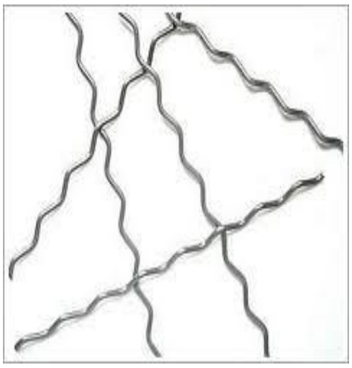
“3. Experimental programm”

In order to study the effects of steel fibres on the behavior of cement composites in terms of compressive strength and split tensile strength, tests were carried out on specimens with steel fibres and without steel 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.

“4. Materials and methods”

4.1. Steel fibres

The steel fibres used in this research work are commercially available in India. The fibres are generally sized by either cutting or by chopping, and therefore it is also known as chopped steel fibre. Common length of chopped steel fibre is 10 mm. The properties of steel fibres are given in Table 1. The physical appearance of the steel fibre used in this investigation is shown in Fig. 1.



“Fig. 1 Physical appearance of short steel fibres”

“Table 1 Properties of polyester fibre”

Property	Steel Fibre
Length (mm)	25
Diameter (mm)	0.5
Density	7.95
Tensile Strength (GPa)	1.1
Elastic Modulus	193
Softening Point (°C)	1350
Elongation (%)	40

4.2. 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 steel 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 min was required to obtain a homogeneous mortar–fibre mixer.

"Table 2 Proportion of mortar mix"

Index	Cement (gm)	Sand (gm)	Water (ml)	Steel 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

4.3. 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 25°C with relative humidity of about 60%.

4.4. 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 failure patterns of some tested elements in flexure are shown in Fig. 2.

"Fig. 2(a) Compression test"

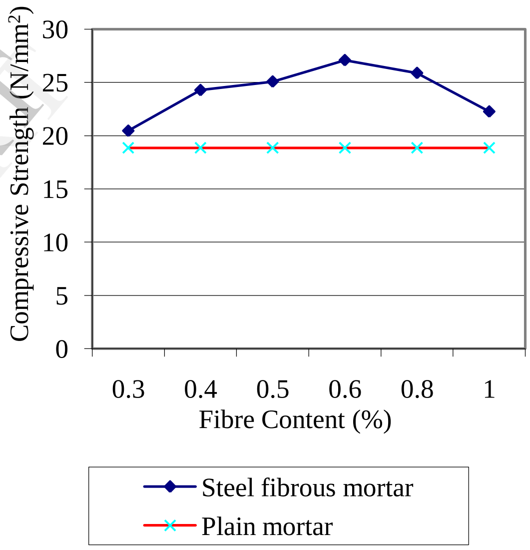
"Fig. 2(b) Split tensile test"

4.5. Crack-stress of cement composites [7]

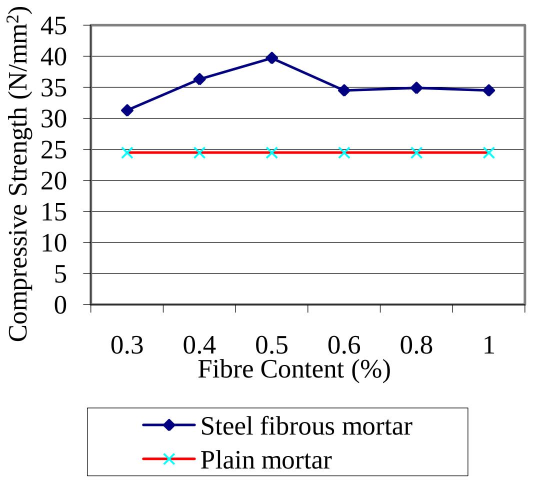
Considering the homogeneous nature of the cement composite, the split tensile strength is given by

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

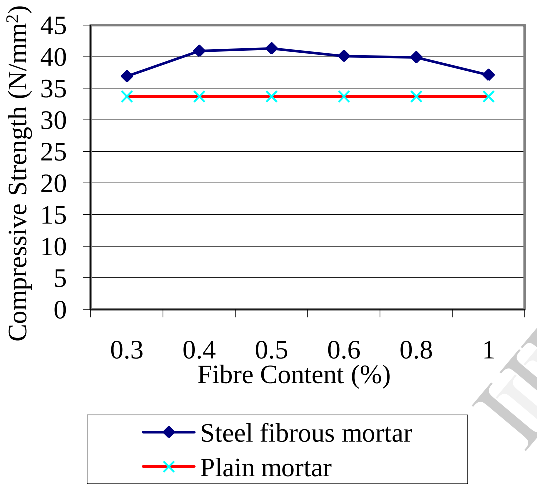
Where P is load at failure and S is side of cube.



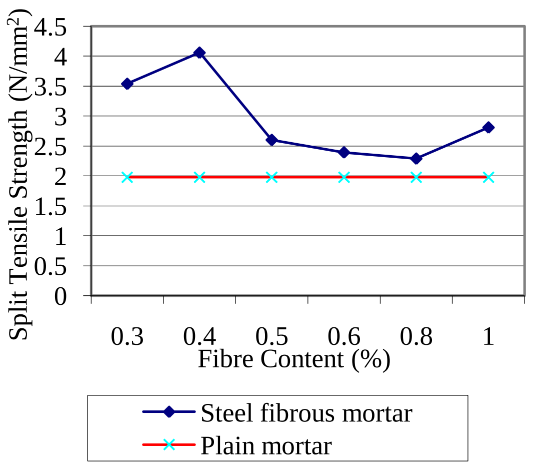
"Fig.3 Compressive strength with various fibre dosages for 3 days curing"



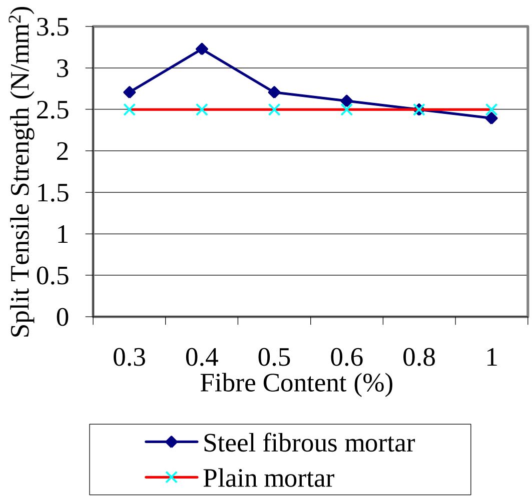
"Fig. 4 Compressive strength with various fibre dosages for 7 days curing"



"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"

"5. Results and discussion"

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 steel fibre mortar, the maximum compressive strength increased 43.62 % at 3 days, 62.29 % at 7 days & 22.62 % at 28days without any chemical agents or any other additives.
b) For steel fibre mortar, the maximum split tensile strength increased at 105.26 % at 7 days & 29.17 % respectively.

From the above results it is observed that addition of steel fibres in mortar giving good compressive strength compare to plain mortar at early stages. And in split tensile test, tensile strength of steel 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 as well as good compressive strength to the mortar.

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