**Effects of steel fibres on compressive and flexural strength of steel fibre reinforced concrete**

Olubisi A. Ige, Stephanie Barnett, Ayman Y. Nassif, John B. Williams

School of Civil Engineering and Surveying, University of Portsmouth, Portsmouth, PO1 3AH, UK

**ABSTRACT**

This work investigated the effects of fibre type, dosage and maximum aggregate size on the flexural performance of steel fibre reinforced concrete (SFRC). Hooked-end steel fibres with 50 mm and 60 mm length, aspect ratio of 45, 65 and 80, and dosages of 0 kg/m³, 25 kg/m³, 40 kg/m³, 50 kg/m³ and 60 kg/m³ were used with maximum sizes of coarse aggregate of 10mm and 20mm. The same mix proportion of concrete was used in the investigation. The experimental results show that the strength performance of SFRC improved drastically when compared to plain concrete without fibres. Remarkable improvements were observed at larger dosages of steel fibres, particularly at 50 kg/m³ dosage and with fibres with aspect ratio 80 noted to give the best results.

**Keywords**: Concrete, Steel fibres, Compressive strength, Flexural strength

**1. INTRODUCTION**

Concrete remains the most widely used man-made material in the world. However, its brittle nature mode of failure is undesirable. Short discrete fibres are therefore introduced into the matrix which substantially improves many of its engineering properties. The usage of fibres (local) as reinforcement for brittle matrix materials is not new; it has been since time immemorial such as horsehair in mortar and straw in bricks. In some recent times, asbestos, cellulose, glass, steel and polypropylene fibres have been used to reinforce cement products.

This is achieved by the ability of steel fibres to bear some of the stress that occur in the matrix themselves and transfer the other portion of stress to the stable components of the concrete matrix ([Aydın & Baradan, 2013](#_ENREF_1)). Most researchers agreed that the main objective of inclusion of fibres is to attempt to modify the properties of concrete by improving the tensile or flexural strength, improving the impact strength and toughness, controlling cracking and the mode of failure by means of post-cracking ductility and improving durability ([Bencardino, Rizzuti, Spadea, & Swamy, 2013](#_ENREF_3); [Hannant, 2003](#_ENREF_4); [Michels, Christen, & Waldmann, 2013](#_ENREF_5)).

There have been investigations carried out in the past where the effects of different types and geometry of steel fibres on the post-cracking strength of sfrc were studied. [Soulioti, Barkoula, Paipetis, and Matikas (2011](#_ENREF_6)) have worked on waved or wavy profile and hooked end steel fibres, [Soutsos, Le, and Lampropoulos (2012](#_ENREF_7)) did not only investigate the hooked end, wavy profile, flattened ends types of steel fibres but also worked on the synthetic type of fibres. In all these researches, hooked end type of steel fibres were found to show the best result in post cracking strength and ductility of sfrc. [Barnett, Lataste, Parry, Millard, and Soutsos (2010](#_ENREF_2)) investigated the effect of fibre distribution and orientation on flexural strength of ultra-high performance fibre reinforced concrete (UHPFRC) and concluded that fibre orientation has a very significant effect on the flexural strength and other mechanical properties of UHPFRC in particular and fibre reinforced concrete in general. However, the experimental results on monitor of distribution and orientation of steel fibres in sfrc and the effects on maximum output of the resulting concrete are considered few.

**2. EXPERIMENTAL WORK**

Variables selected for this study are fibre length of 50, 60, and 60mm, aspect ratio (ratio of length to diameter of fibre) of 45, 65 and 80, and dosages of 0 kg/m³, 25 kg/m³, 40 kg/m³, 50 kg/m³ and 60 kg/m³ by mass were used with maximum sizes of coarse aggregate of 10mm and 20mm. Hooked end type of steel fibres, Portland cement, CEM 1 52.5R, tap water, polycarboxylate polymer-based superplasticizer and natural sand were used in the mixes. Water/cement ratio of 0.5 was used for this study. Mixing of the concrete was accomplished by pan mixer, adopting a particular procedure for all mixes so as to achieve a uniform and also to avoid balling effect.

**3. RESULTS AND DISCUSSION**

The 28-day compressive strength results conducted on 100 mm cubes, as given in Figure 1, show a slight improvement in the compressive strength by the addition of steel fibres to concrete. The mean strength of sfrc varies between 58 to 70 MPa and 58 to 68 MPa for 10 and 20 mm aggregate sizes respectively while plain concrete had 53 MPa for 10 mm maximum aggregate size and 61 MPa for 20 mm maximum aggregate size. The compressive strength of sfrc increases with increase in fibre dosage until optimum compressive was however achieved at 50 Kg/m³ dosages of steel fibre for both aggregate sizes after which it declined. The steel fibre 80 l/d and 65 l/d gave the optimum strength at this dosage at 20 mm and 10 mm coarse aggregate sizes respectively.

The flexural strength of a notched beam (150 x 150 x 600mm prismatic specimens) determined by three-point bending tests shows that addition of steel fibres to concrete remarkably improves the flexural strength when compared to plain concrete as there were up to 83% and 54% increase in maximum strength reached for concrete with maximum course aggregate sizes of 20 and 10 mm respectively. Figure 2, (a) and (b) show the flexural strength of plain concrete and that of dosages of sfrc with particular steel fibre, 65/60, aspect ratio (length/diameter) of 65 and length of 60. It can be deduced that the higher the dosage, the better the flexural strength. Also, high flexural strength is seen as depending on good selection of fibre geometry, dosage and mixture combination of aggregates within the concrete. Visual inspection of the tested specimens showed that distribution and orientation of fibres for different length/aggregate size combination was notably different.

**4. CONCLUSIONS AND FUTURE WORKS**

The inclusion of steel fibres in concrete has significantly improved the mechanical properties of concrete turning it from being a brittle to a ductile material. The influence and effectiveness of steel fibres in concrete are distinctively noticed at higher dosages, this is attributed to a better distribution and orientation of steel fibres within the concrete matrix as a result of adequate contents of fibres. Fibre effects on compressive strength is slightly pronounced, with optimum compressive noticed at fibre dosage of 50 kg/m³ and with fibre of 80 l/d ratio. Distribution of fibre is also dependent on length and aspect ratio with adequate aggregate size combination; this in turn affects the orientation of fibres within the matrix for enhanced post-cracking strength.

On-going research work involves the manufacture of concrete slabs specimen of 600 by 600 by 100 mm with all the same variables apart from the fibre dosage being fixed at 50 kg/m³ for flexural testing. Once tested, cores will be taken and analysed by X-ray CT for detailed investigation of the effects of the chosen variables on fibre distribution and orientation and the subsequent effects on mechanical performance of the material.

**5. REFERENCES**

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(b)

(a)

Fig 1: Relationship between compressive strength and dosages of different fibres with (a) 10 mm maximum aggregate size and (b) 20 mm maximum aggregate size.

(b)

(a)

Fig 2: Flexural strength of SFRC with varying fibre dosages of 65/60 steel fibres with (a) 10 mm aggregate size and (b) 20 mm aggregate size