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Experimental Study on Steel Fibre Reinforced Concrete for M-40 Grade

Abstract

Fibre reinforced concrete is a composite material containing concrete and fibrous material, which increases its strength properties. The mixture contains short discrete fibres that are uniformly distributed and randomly oriented. There are many different kinds of fibres, e.g., steel fibres, glass fibres, synthetic fibres and natural fibres, which differ from each other in shape, each shape also varies in dimensions, geometry, distribution and orientation, which results in different strength characteristics when being used as a reinforcement in concrete.[1]

History and usage of fibres as a reinforcement goes back to more than 3500 years, when straw was used as a reinforcement in sun-baked bricks and horse hair was used in mortar bricks. In early 1900s a new development was made in the field of fibre reinforced concrete, when asbestos fibres were used to reinforce concrete.[2] For the past 30 to 40 years steel, glass and synthetic fibres have been increasingly used to improve the properties of concrete and researches into new fibre reinforced concretes continue even today.

Concrete is most widely used construction material in the world. That is because it is a relatively cheap construction material, it has an ability to cast in any form and shape and also it is used as a replacement of old construction materials such as bricks and stone masonry. At the same time concrete has a lot of weaknesses. Its tensile strength is typically only one tenth of its compressive strength. It is also relatively brittle material with low ductility. Its other deficiencies are low post cracking capacity, limited fatigue life, incapability of accommodating large deformations and low impact strength. To reduce these weaknesses, the reinforcement has been used and one way to reinforce concrete is to use steel fibres. That is the reason behind the growing interests in improving fibre reinforced concrete.[3]

In recent years different types of steel fibres and their characteristics, also new types of concrete have gotten a lot of attention by researchers all over the world, and that is because steel fibres have multiple positive effects on concrete structures. The main reason why fibres are used is that they improve the structural strength, they bridge the cracks that develop in concrete and increase the ductility of concrete elements. Fibres also reduce and control the crack widths caused by the plastic shrinkage and drying shrinkage, and therefore improve durability. They also improve the impact and abrasion and the freeze-thaw resistances and lastly reduce the steel reinforcement requirements. These are some of the many reasons, why steel fibre reinforced concrete is more and more widely used and has gotten an eye of many researchers.[3]

The purpose of the article “Experimental Study on Steel Fibre Reinforced Concrete for M-40 Grade” was to study the compressive strength, flexural strength and split tensile strength of steel fibre reinforced concrete. Multiple tests were carried out with the specimens containing 0%, 1%, 2% and 3% of hook ended steel fibres of the total volume of the composite volume fraction, and using steel fibres with the aspect ratio of 50, 60 and 67, where the parameter aspect ratio of the fibre is the ratio of its length to its diameter. The experiments were used to prove or disprove that aspect ratio of 50 gives higher strength properties and that the strength characteristics increase with addition of steel fibres.[3]

During the study, 90 specimens were tested in order to examine the relation between fibre volume fraction in the concrete mixture and aspect ratio of the steel fibres. Mix proportion of 1:1.43:3.04 with water cement ratio 0.35 was used in the experiment and in all specimens ordinary Portland cement of 53 grade, locally available sand with specific gravity 2.65 and water absorption 2%, crushed granite stones of 10 mm size having specific gravity of 2.70 and potable water were used. Also superplasticizer of 0.6% to 0.8% by weight of cement was used to impart additional workability.[3]

In order to carry out the compressive strength, flexural strength and split tensile strength tests, three different types of specimens were used. For compressive strength tests cube specimens of dimensions 150 x 150 x 150 mm were used, for

flexural strength tests beam specimens of dimensions 100 x 100 x 150 mm and for split tensile strength test cylinder specimens of diameter 150 mm and length 300 mm were used. For each strength test 30 specimens were used and separated into 10 different categories, all varying in fibre volume fraction and aspect ratio, e.g. category no.1 - 0% of fibres in the mixture; category no. 2 - 1% of fibres in the mixture with aspect ratio of 50; category no. 3 - 2% of fibres in the mixture with aspect ratio of 60 etc. In each category three specimens were tested and the average value of these three was noted.

The experimental results showed that compared to the specimens with fibre volume fraction of 1% or 2%, the specimens with fibre volume fraction of 3% gave always better strength test results. As well as the aspect ratio of 50 gave better results than the aspect ratios 60 and 67. The compressive strength test result grew from 45.19 MPa to 56.30 MPa when comparing to each other the specimen with 0% of fibres in it and the specimen giving the best strength characteristics, which is the specimen with 3% of fibres in it with aspect ratio of 50. Similar results can also be obtained from flexural and split tensile strength tests where the strength characteristics increased from 7.47 MPa to 10.40 and from 3.07 MPa to 4.34 MPa, respectively. In general, it is observed that compressive strength increases from 11 to 24%, flexural strength from 12 to 49% and split tensile strength increases from 3 to 41% with addition of steel fibres.[3] Below the graphical representation of the three tests performed on 1%,2% and 3% of fibre steel and aspect ratios of 50, 60 and 67 are shown.

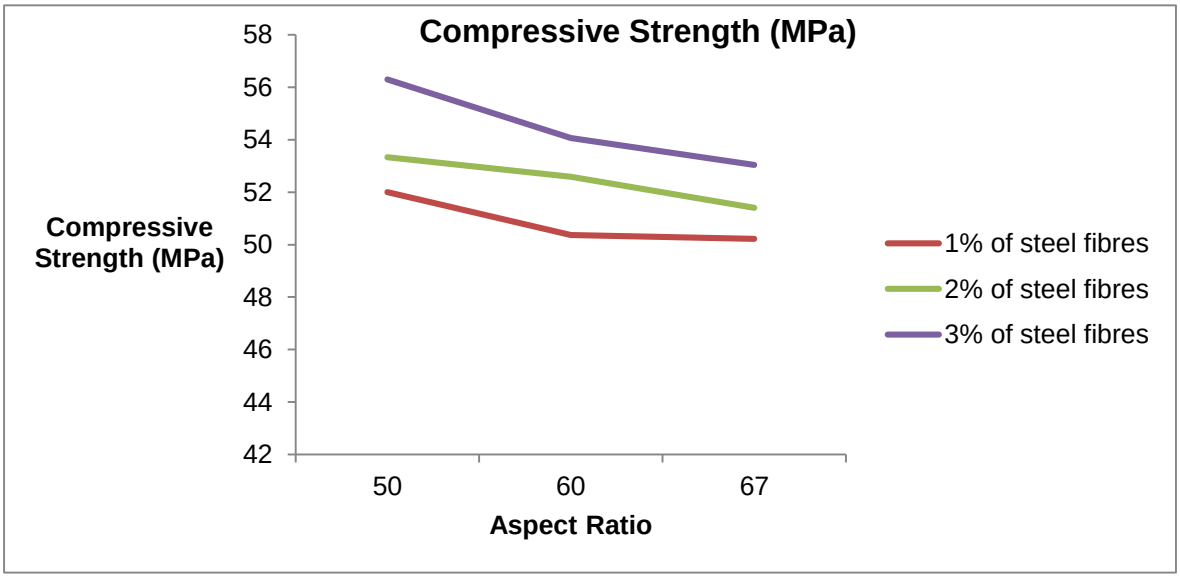

Figure 1 Graphical representation of compressive strength vs. aspect ratio of 1%,2% and 3% fibre

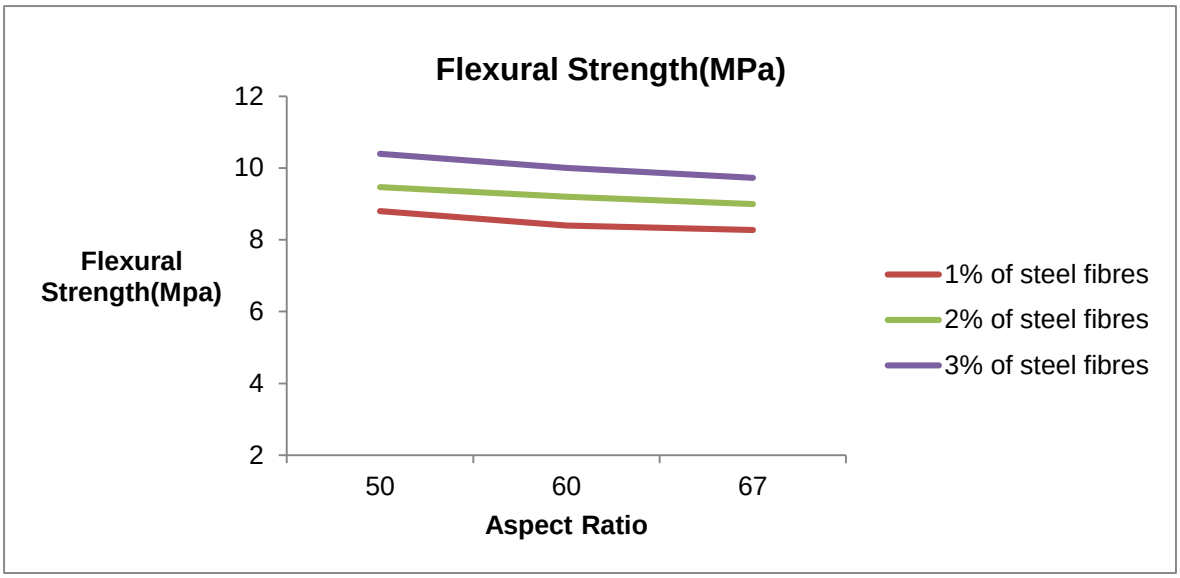

Figure 2 Graphical representation of flexural strength vs. aspect ratio of 1%,2% and 3% fibre

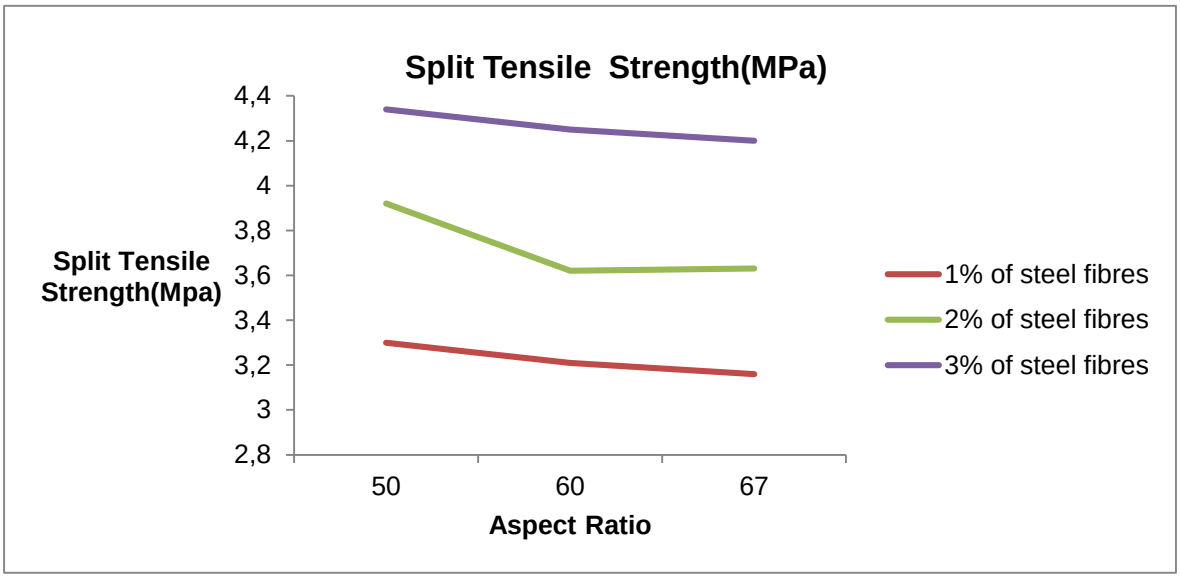

Figure 3 Graphical representation of split tensile strength vs. aspect ratio of 1%,2% and 3% fibre

In conclusion, during the experimental study it was proven that when adding steel fibres to the mixture, it gives better strength characteristic values when compared to the control specimens with 0% of steel fibres in it. It was also proven that the increase in the percentage of steel fibres in the mixture gives the higher strength characteristic value in each experiment carried out, as well as the aspect ratio of 50 gives always better results when being compared to the aspect ratios of 60 and 67. It can also be said that besides improving the structural strength, it also reduces the internal cracks and controls crack widths, thus improving the durability of the structure.

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