International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 10, Issue 12 (December 2014), PP.01-06

A Study on Effect of Sizes of aggregates on Steel Fiber Reinforced Concrete

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Abstract:- Plain, unreinforced concrete is a brittle material, with a low tensile strength, limited ductility and little resistance to cracking. In order to improve the inherent tensile strength of concrete there is a need of multidirectional and closely spaced reinforcement, which can be provided in the form of randomly distributed fibers. Steel fiber is one of the most commonly used fibers The present experimental study considers the effect of aggregate size and steel fibers on the modulus of elasticity of concrete. Crimped steel fibers at volume fraction of 0%.0.5%, 1.0% and 1.5% were used. Study on effect of volume fraction of fibers and change of aggregate size on the modulus of elasticity of concrete was also deemed as an important part of present experimental investigation. This work aims in studying the mechanical behavior of concrete in terms of modulus of elasticity with the change of aggregate size reinforced with steel fibers of different series for M30 and M50 grade concretes. The results obtained show that the addition of steel fiber improves the modulus of elasticity of concrete. It was also analyzed that by increasing the fiber volume fraction from 0%, to 1.5% there was a healthy effect on modulus of elasticity of Steel Fiber Reinforced concrete.

Keywords:- tensile strength, steel fibers, fiber reinforced concrete, brittle material, cementitious material

I. INTRODUCTION

Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape. It also replaces old construction materials such as brick and stone masonry. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementitious material, aggregate and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of applications. The presence of micro cracks in the mortar-aggregate interface is responsible for the inherent weakness of plain concrete. The weakness can be removed by inclusion of fibers in the mixture. Different types of fibers, such as those used in traditional composite materials can be introduced into the concrete mixture to increase its toughness, or ability to resist crack growth. The fibers help to transfer loads at the internal micro cracks. Such a concrete is called fiber-reinforced concrete (FRC) Concrete is characterized by brittle failure, the nearly complete loss of loading capacity, once failure is initiated. This characteristic, which limits the application of the material, can be overcome by the inclusion of a small amount of short randomly distributed fibers (steel, glass, synthetic and natural) and can be practiced among others that remedy weaknesses of concrete, such as low growth resistance, high shrinkage cracking, low durability, etc. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementitious material, aggregate and water and by adding some special ingredients. Hence concrete is very well suited for a wide range of applications.. The contents of each section may be provided to understand easily about the paper.

II. LITERATURE REVIEW

Amin Abrishambaf, Joaquim A.O. Barros,**[2013]** have studied the Relation between fiber distribution and post-cracking behavior in steel fiber reinforced self-compacting concrete panels. In this research, the influence of the fiber distribution and orientation on the post-cracking behaviour of steel fiber reinforced self-compacting concrete (SFRSCC) panels was studied. To perform this evaluation, SFRSCC panels were cast from their centre point. For each SFRSCC panel, cylindrical specimens were extracted and notched either parallel or perpendicular to the concrete flow direction, in order to evaluate the influence of fiber dispersion and orientation on the tensile performance. The post-cracking behaviour was assessed by both splitting tensile tests and uniaxial tensile tests. To assess the fiber density and orientation through the panels, an image analysis technique was employed across cut planes on each tested specimen. It is found that the splitting tensile test overestimates the post-cracking parameters. Specimens with notched plane parallel to the concrete flow direction show considerable higher post-cracking strength than specimens with notched plane perpendicular to the flow direction.

Vikrant S Vairagade, Kavita S. Kene,[2012] have done the Experimental investigation for M-20 grade of concrete to study the compressive strength, and tensile strength of steel fiber reinforced concrete (SFRC) containing fibers of 0% and 0.5% volume fraction of hook end Steel fibers of 50 and 53.85 aspect ratio were used. A result data obtained has been analyzed and compared with a control specimen (0% fiber). A relationship between Compressive strength vs. days, and tensile strength vs. days represented graphically. Result data clearly shows percentage increase in7 and 28 days Compressive strength and Tensile strength for M-20 Grade of Concrete.

A.M. Shende, A.M. Pande [2012] have done the experimental study on Steel Fiber Reinforced Concrete. Critical investigation for M-40 grade of concrete having mix proportion 1:1.43:3.04 with water cement ratio 0.35 to study the compressive strength, flexural strength, Split tensile strength of steel fiber reinforced concrete (SFRC) containing fibers of 0%, 1%, 2% and 3% volume fraction of hook tain. Steel fibers of 50, 60 and 67 aspect ratio were used. A result data obtained has been analyzed and compared with a control specimen (0% fiber). A relationship between aspect ratio vs. Compressive strength, aspect ratio vs. flexural strength, aspect ratio vs. Split tensile strength represented graphically. Result data clearly shows percentage increase in 28 days Compressive strength, Flexural strength and Split Tensile strength for M-40 Grade of Concrete.

Osman Gencel et al. **[2011]** studied the Workability and Mechanical Performance of Steel Fiber-Reinforced Self-Compacting Concrete with Fly Ash. In this experimental investigation steel fiber having aspect ratio of 60 and geometry of cylindrical with hooked ends were used. The steel fibers were used at volume fractions of 0.2%, 0.4%, 0.6% and 0.8%. Water/Cement ratio (W/C), cement, fly ash and super plasticizer contents were kept constant at 0.40, 400, 120 and 6 kg/m3, respectively. It was concluded that mechanical properties of concrete can be improved by the addition of steel fibers. However, the improvement in compressive strength does not always increase with a larger content of fibers The modulus of elasticity was improved only slightly with increasing fiber content. A significant improvement in the energy absorption and ductility in compression was achieved by adding fibers to concrete.

Mohammed Alias Yusof et al. **[2011]** studied the mechanical properties of hybrid steel fiber reinforced concrete with different Aspect Ratio... The results indicate that the hybrid steel fiber reinforced concrete (at volume fraction of 1.5%, consisting of 70% long fiber and 30% short fiber) gave the highest value of flexural strength and split tensile strength. On the other hand, the concrete mix containing 30% long fibers and 70% short fibers at 1.5% volume fraction gave the highest compressive strength. The results reveal that longer fiber performs better in flexural and tensile strength. On the other hand, concrete with short steel fiber performs better in compression as compared to concrete with longer steel fiber. It was also observed that by increasing the percentage of fiber volume in the mix, the workability of the concrete mix was reduced.

V. Malarics & H.S. Muller [2010] have done the evaluation of the splitting tension test for concrete from a fracture mechanical point of view. They aimed at the derivation of a consistent conversion formula between the splitting tensile strength $f_{ct,sp}$ and the uniaxial tensile strength f_{ct} for the entire spectrum of structural concretes used in practice. First, the validity of the splitting tension test had to be verified. To achieve this, an extensive experimental programme was carried out. Furthermore, a testing method was developed to detect the cracking sequence in the specimen during the splitting tension tests. Based on fracture mechanical parameters obtained by the experiments, the splitting tension test was analyzed by means of numerical simulations as well. To investigate the interdependency of the compressive strength and the splitting and uniaxial tensile strength, concretes of different strength classes were tested. Both experimental and numerical test results show a complex failure mechanism in the specimen during the splitting tension test.

III. EXPERIMENTAL INVESTIGATION

3.1Materials

a) Cement

In the experimental investigations ordinary Portland cement (OPC) of 53 grade is used. The cements procured were tested for physical properties in accordance with IS: 4031-1988 and IS: 8112-1989.

b) Fine Aggregate

Fine aggregate (river sand) obtained from local market was used in this study.

c) Coarse Aggregate

The properties of coarse aggregate like size of aggregate, shape, grading, surface texture etc play an important role in workability and strength of concrete. These properties were determined as per IS: 2386-1963.

d) Water

Potable water confirming to IS: 456-2000 was used in the investigations for both mixing and curing.

e) Steel Fibers

The present study was carried out using Steel Fibers. The fibers are procured from Stewols India Pvt. Ltd., Nagpur.The type of fibers used were cripped end steel fibers and the diameter of fiber is 0.5 mm and 30 mm in length.

3.2 Experimental Programme

In this experimental work the concrete specimens were casted. The dimensions of specimens considered in this study are 150 × 300 mm cylinders which were tested to study the tensile nature and compressive nature of concrete. The mix design of concrete was done according to Indian standard guidelines.Based upon the quantities of ingredient of the mixes, details of materials for 1 cubic meter of concrete are as follows:

Table 1 : Details of materials for 1 cubic meter of concrete

Grade of concrete	Aggregate size	% of steel fiber	Mix proportions	Water wt.(kg)	Cement wt.(kg)	Fine aggregate wt.(kg)	Coarse aggregate wt.(kg)	Weight of steel fibers(kg)
M30	20mm	0	0.46:1:1.26:3.12	191.6	416.5	525.7	1300.3	0
		0.5						4.73
		1						9.46
		1.5						14.186
M30	16mm	0	0.46:1:1.28:2.88	197.35	429.021	548.3	1236.55	0
		0.5						4.73
		1						9.46
		1.5						14.186
M30	10mm	0	0.46:1:1.29:2.55	206	447.83	579.4	1143.53	0
		0.5						4.73
		1						9.46
		1.5						14.186
M50	20mm	0	0.39:1:0.74:3.08	28.85	73.92	54.7	227.7	0
		0.5						4.726
		1						9.462
		1.5						14.192
M50	16mm	0	0.4:1:0.79:2.98	29.55	73.87	58.36	220.14	0
		0.5						4.726
		1						9.462
		1.5						14.192
M50	10mm	0	0.42:1:0.84:2.84	31.05	73.87	62.05	209.81	0
		0.5						4.72 6
		1						9.462
		1.5						14.192

IV. RESULTS AND DISCUSSIONS

4.1 Mechanical Properties of Concrete after testing

After 28 days of curing, the specimens were tested so as to obtain compressive strength and tensile strength were as follows:

Table 2: Mechanical properties of concrete

Grade of concrete	Size of aggregate	% of steel fibers	Compressive Strength f_{ck}(N/mm²)	Tensile Strength f_t(N/mm²)
M30	20mm	0	37.3	3.4
		0.5	42.53	4.1
		1	53.03	4.4
		1.5	48.5	4.5
	16mm	0	33.92	3.5
M30		0.5	33.66	4.2
		1	42.37	4.4
		1.5	30.37	4.45
M30	10mm	0	30.66	3.5
		0.5	37.03	4
		1	48.22	4.3
		1.5	45.55	4.3
M50	20mm	0	57.55	4.3
		0.5	60.11	4.8
		1	64.34	5.2
		1.5	63.24	5.3
M50	16mm	0	56.22	4.1
		0.5	60.0	4.8
		1	64.20	5.2
		1.5	63	5.3
M50	10mm	0	56.20	4.2
		0.5	59.83	4.82
		1	64	5.32
		1.5	62.56	5.45

The following figures shows the effect of size of coarse aggregates on the strength characteristics of M30 and M50 grade concrete:

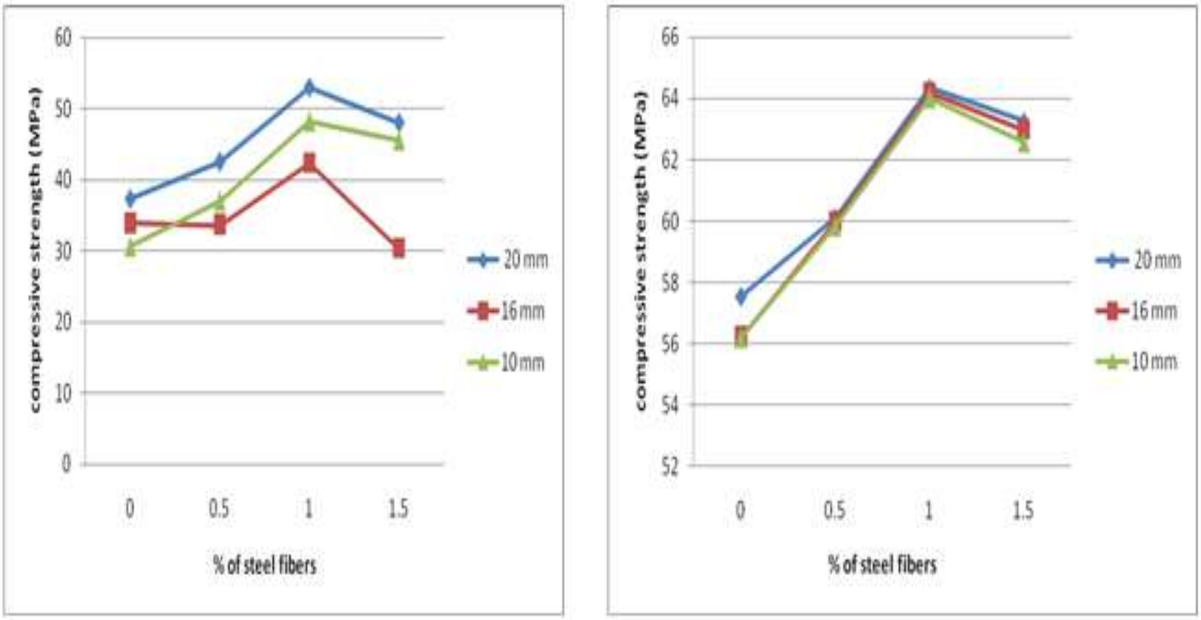

Fig.1 : Graph showing variations in Compressive strength of M30 & M50 grade concrete using 20mm,16mm & 10 mm aggregate at various replacement levels of steel fibers

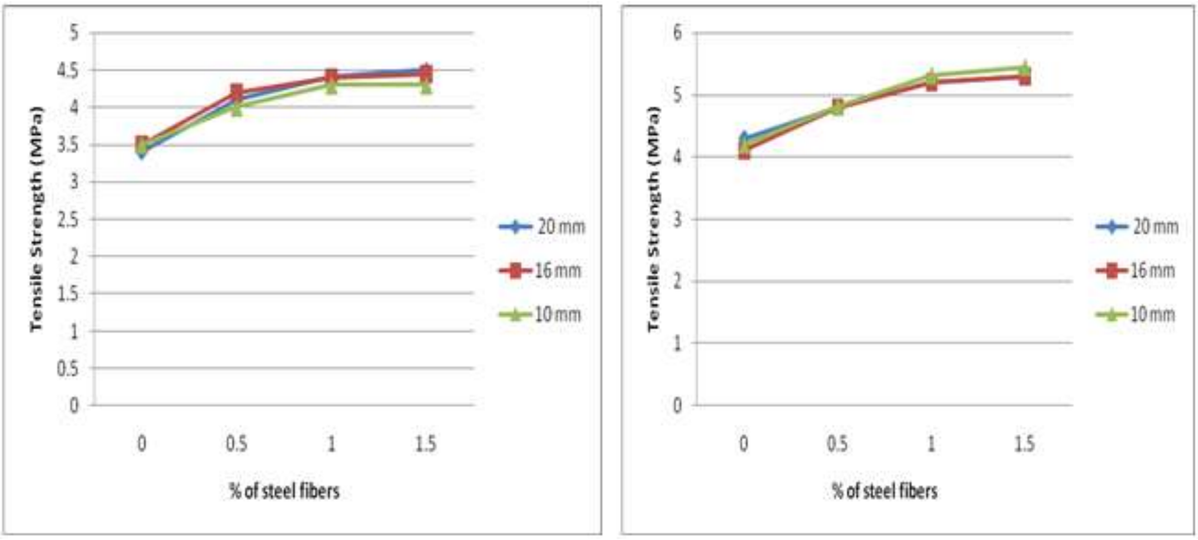

Fig.2: Graph showing variations in tensile strength of M30 & M50 grade concrete using 20mm, 16mm & 10 mm aggregate at various replacement levels of steel fibers

Fig.3 Cylindrical Specimens before testing

Fig.4 Cylinder under C.T.M during testing

Fig.5 Cylinder during Split-tensile Test

IV. CONCLUSIONS

1. The compressive strength is found to be maximum when the aggregate size is 20 mm.
2. The effect of steel fiber on compressive strength and tensile strength is predominant.
3. The compressive strength and tensile strength were found to be increased with the increase in the volume fraction of steel fiber.
4. The compressive strength and tensile strength were found to be maximum when the fiber volume is 1.5%.
5. Eventhough there is a reduction in compressive strength of concrete in M50 grade,it can be concluded that there was no significant effect of aggregate on the compressive strength property of concrete.
6. Similarly there is no significant effect of aggregate on the tensile strength property of concrete both in M30 and M50 grades of concrete.

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