Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 1; August, 2014 pp. 5-9

http://www.krishisanskriti.org/jceet.html

Effect of Strength of Concrete by Partial Replacement of Cement with Flyash and addition of Steel Fibres

Tarun Sama[1], Dilip Lalwani[2], Ayush Shukla[3], Sofi A.[4]

[4]*Vellore Institute of Technology, Vellore, Tamil Nadu-632014.*
[1,2,3]*Graduate Student, Civil Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu-632014*

Abstract: **The aim of this paper is to study the behavior of M-40 grade of concrete having mix proportion of 1:1.62:2.83 with w/c of 0.45 and to determine the compressive, split tensile and flexural strength of concrete reinforced with steel fibres. Four percentages of steel fibres (0%, 1%, 1.5% & 2%) having aspect ratio 50 were used. Cement was replaced with two percentages (40%, 60%) of Class F fly ash.All the tests were performed according to bureau of Indian standards. The results obtained were compared and examined with respect to the control specimen. The advantage of adding steel fibre in concrete is that it enhances its overall strength especially the flexural and split tensile strength. The optimum percentage of adding flyash and steel fibres was determined to be 40% and 2% which showed the maximum improvement in tensile and flexural strength.**

Keywords: **fibre reinforced concrete, flyash, steel fibre, strength, flexure, compression**

1. INTRODUCTION

In today's world the main emphasis is on green and sustainable development. Cement industry is one of the major contributors to pollution by releasing carbon dioxide. One ton of OPC production produces approximately one ton of Carbon dioxide. So by partially replacing cement with pozzolanic material such as fly ash, the cement industry can serve both the purposes of meeting the demands of construction industry and at the same time providing a green and clean environment. Fly ash is difficult to decompose so using flyash is a major step towards sustainable development. Also the concrete is weak in tension, so with the addition of steel fibres it's flexural and tensile strength is also enhanced. Flyash is obtained from thermal power plants as a waste material. Flyash does not have cementitious property by itself which is responsible for strength generation. But in presence of water it reacts with free lime obtained from cement and form hydrated products (C_2S and C_3S) which helps in attaining the strength and also improving the durability. As the flyash is very fine in structure, it fills more voids and provides superior pore structure and thereby improves its strength at later stages due to reduced permeability.

The advantage of adding steel fibres is that it prevents crack from proceeding by applying tweaking forces at the tips of the crack, thus delaying their advancement across the concrete and helps in attaining a gradual failure. And,0 increasing the tensile and flexural strength to many folds.

2. METHODS AND MATERIALS

2.1 Cement

The cement used was ordinary Portland cement 53 (OPC 53).All properties of cement were determined by referring IS 12269 - 1987. The specific gravity of cement is 3.15. The initial and final setting times were found as 55 minutes and 258 minutes respectively. Standard consistency of cement was 30%.

2.2 Coarse Aggregate

20mm size aggregates-The coarse aggregates with size of 20mm were tested and the specific gravity value of 2.78 and fineness modulus of 7 was found out.

12.5mm size aggregates-.The coarse aggregates size of 12.5mm was tested and the specific gravity value of 3.02 and fineness modulus of 5.9 was found out. Both types of aggregates were available from local sources and were taken in equal proportions.

2.3 Fine Aggregate

The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.60.

2.4 Water

The water used for experiments was potable water.

2.5 Steel Fibres

The steel fibre used in the experiments is having aspect ratio 50. Their quantity was increased from 0.5% to 2% by total weight of concrete. The length of fibre was 50mm and the diameter of fibre is 1mm.

2.6 Flyash

Class F flyash was used with specific gravity of 1.983.

2.7 Mixing and Casting

Mix design is a term used for determining quantities of different constituents, which in our experiment was done with Indian standard method. The quantities of cement, coarse aggregate, fine aggregate, flyash were found out with help of this method. The proportions for normal mix of M40 Normal Mix were: - Cement: Sand: Coarse Aggregate: Water 1: 1.62: 2.83: 0.45.

After calculating the quantity, all constituents were weighed using electronic weighing machine. First of all cement and flyash were thoroughly mixed in dry state, and sand was later added to the mixture. To the above mixture coarse aggregate was added. Now the whole mixture was fed into the mixing machine for thorough mixing. Steel fibres were added during mixing according to the weight of concrete (0.5% to 2%). Water was finally added to the dry mixture. Plasticizers were added to improve workability of the mix. After mixing operation, moulding was done and as the moulds were filled tamping was done simultaneously for compaction. Then moulds were transferred to vibrators where they were vibrated for 1-2 minutes to provide uniform compaction .After 24 hours demoulding was done and the specimen were placed in curing tank for 7 and 28 days.

2.8 Tests Performed

2.8.1 Compressive Strength

Compression is a major characteristic property of concrete. To test the compressive strength, cube specimens of dimensions 100 x 100 x 100 mm were casted for M40 grade of concrete. After curing of specimen for 7 and 28 days, their testing was done with the help of Compressive Testing Machine. The load was applied on the specimen till the specimen failed. The failure load was noted. For each test 2 specimens were prepared and tested and their average value is taken as final value. The compressive strength was calculated according to following formulae, Compressive strength (MPa) = Failure load / cross sectional area.

2.8.2 Split Tensile Strength

Concrete is usually weak in tension, so to enhance this property of concrete steel fibres were added. For split tensile test, cylinder specimens of dimensions 100mm diameter and 200mm length were used. After curing the cylinder were tested with the help of compressive testing machine. The failure load was noted. In each category two cylinders were tested and their average value is found out.

Split tensile strength= 2P/3.14*d*L where P= failure load, d= diameter, L=length of cylinder.

2.8.3 Flexural Strength

The specimens used for flexural test are beams with dimension of 100x100x500mm.After the curing of the specimen is completed, these specimens were tested under two point loading test. First of all effective span is found out by dividing the span into 3 equal parts and it came out to be 400mm. The load is gradually increased till the specimen fails and at point of failure load is noted down. For every class of test 2 specimens were prepared and their mean value is taken as final value. The flexural strength was calculated according to following formulae.

Flexural strength (MPa) = (P x L) / (b x d2), where, P = Failure load, L = Centre to centre distance between the support = 400 mm, b = width of specimen=150 mm, d = depth of specimen= 150 mm.
The entire specimens were tested in the Structural Engineering laboratory of VIT VELLORE.

3. EXPERIMENTAL RESULTS

Table 1: Compressive strength of the specimens (cubes) in N/mm^2 for 7 & 28 Days

Fly ash	Steel fibers	σ_{avg} (N/mm^2) 7 Days	σ_{avg}(N/mm^2) 28 Days
0%	0%	29.50	40.30
	1%	34.85	40.70
	1.50%	36.25	42.55
	2%	38.95	46.85
40%	0%	23.60	26.05
	1%	26.55	38.20
	1.50%	28.50	40.05
	2%	34.60	45.55
60%	0%	16.75	24.85
	1%	19.50	27.35
	1.50%	22.00	31.65
	2%	26.25	39.40

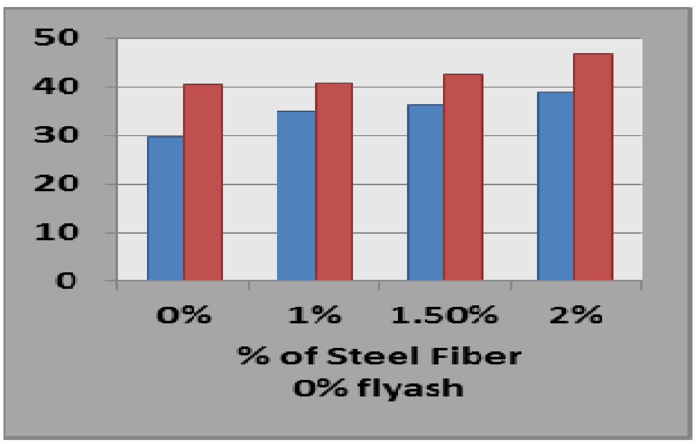
Table 2: Split Tensile Strength of the specimens (cylinders) in N/mm^2 for 7 & 28 Days

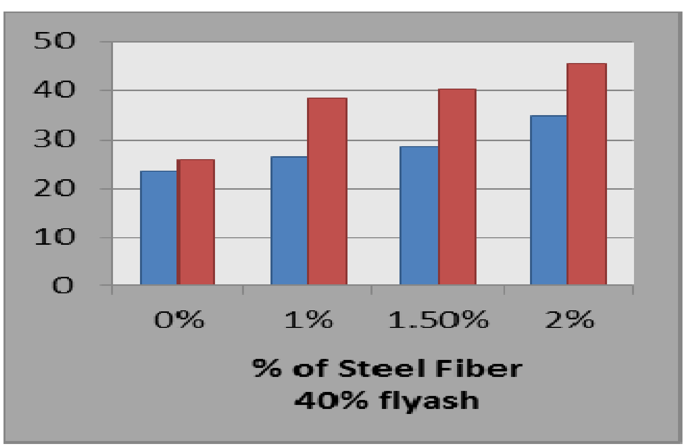
Fly ash	Steel fibers	T_{avg} (N/mm^2) 7 Days	T_{avg} (N/mm^2) 28 Days
0%	0%	1.81	2.53
	1%	2.66	3.12
	1.50%	2.85	3.58
	2%	2.88	4.38
40%	0%	1.81	2.24
	1%	2.34	2.91
	1.50%	2.55	3.45
	2%	2.79	3.92
60%	0%	1.32	2.13
	1%	1.56	2.45
	1.50%	1.78	2.55
	2%	1.88	2.88

Table 3: Split Tensile Strength of the specimens (beams) in N/mm^2 for 7 & 28 Days

Fly ash	Steel fibers	σf_{avg} (N/mm^2) 7 Days	σf_{avg}(N/mm^2) 28 Days
0%	0%	4.0	5.5
	1%	4.5	6.3
	1.50%	4.6	6.24
	2%	5.4	6.8
40%	0%	3.4	5.4
	1%	5.3	7.7
	1.50%	5.3	9.2
	2%	5.9	11.96
60%	0%	3.3	6.6
	1%	3.7	5.1
	1.50%	3.9	5.1
	2%	4.2	6.6

Table 4: Comparision of Compressive Strength of Cubes on 7 and 28 Days





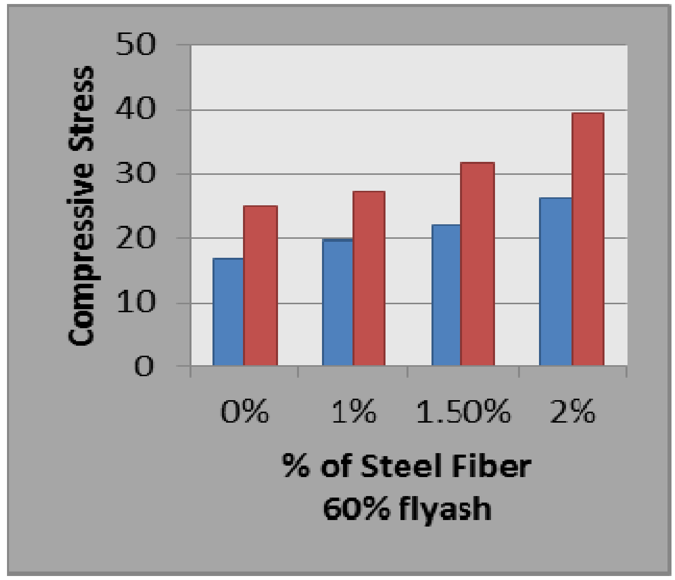
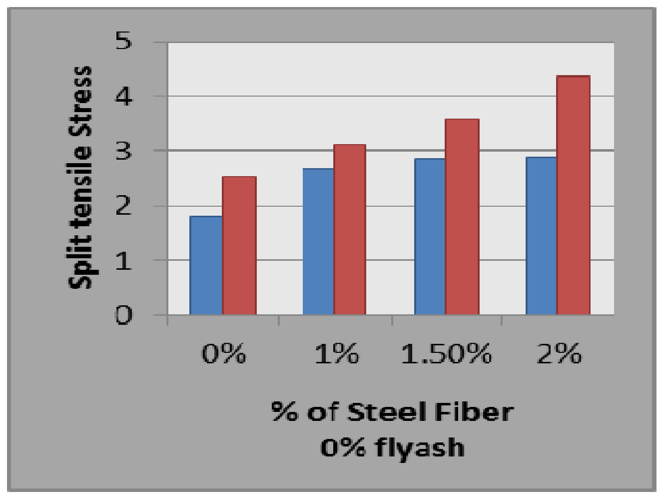
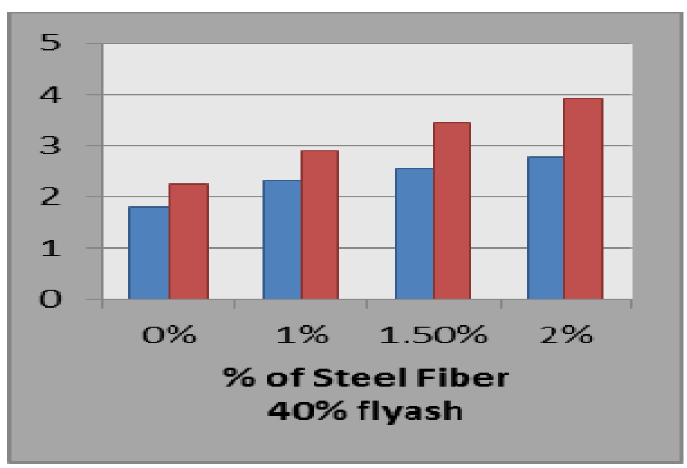


Table 5: Comparision of Split Tensile Strength of Cylinders with 40% Flyash on 7 and 28 Days





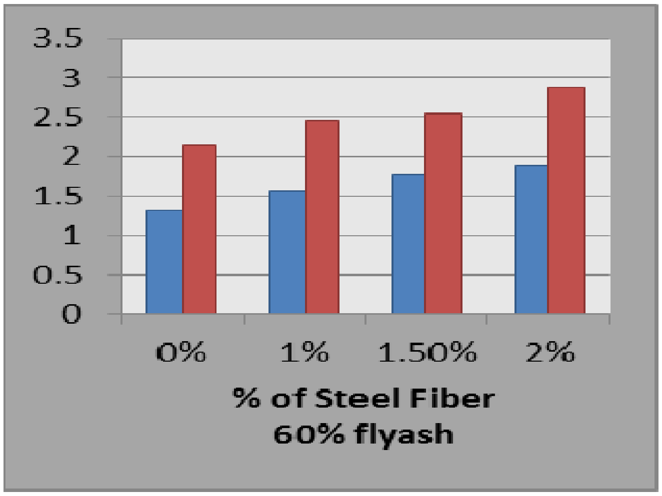
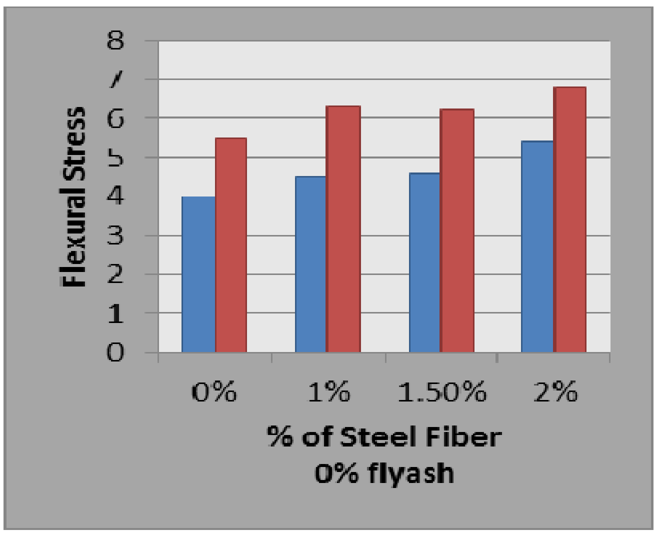
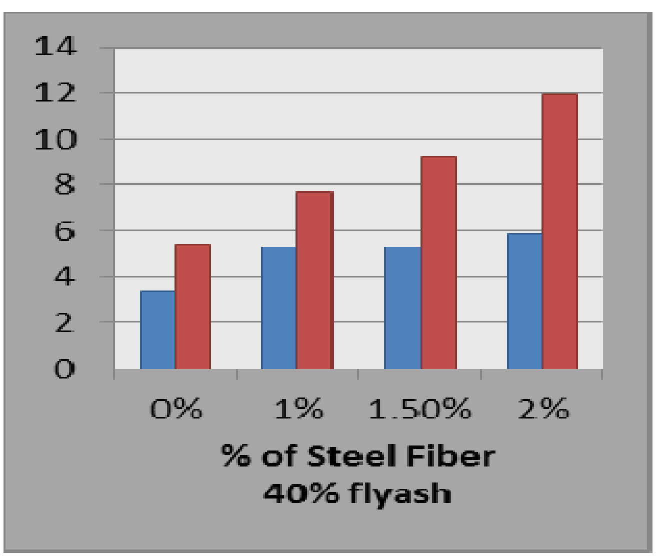
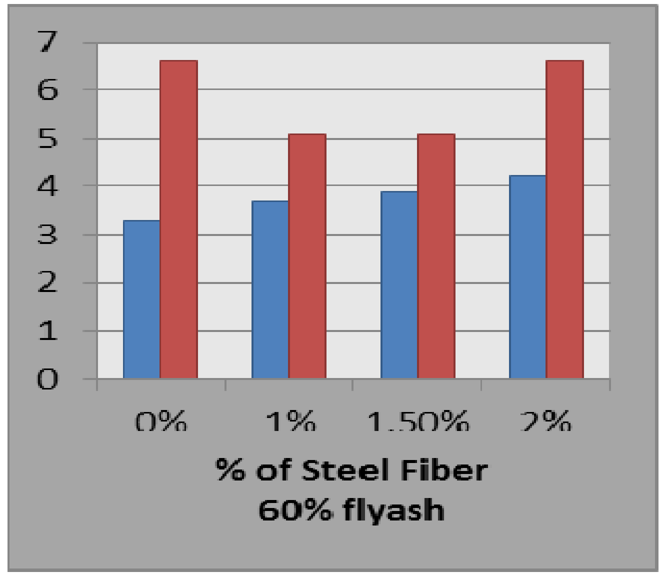


Table 6: Comparision of Flexural Strength of Beams on 7 and 28 days







4. DISCUSSIONS

Concrete reinforced with steel fibres has shown considerable improvement in flexural and split tensile strength as compared to plain concrete. At 0% fly-ash and 2% steel fibers maximum compressive stress is obtained[Table 1]. Also stress of 40% fly-ash with 2% steel fibers is almost same as desired. The split tensile stress at 40% fly-ash and 2% steel fibers is almost same as 0% fly-ash and 2% steel fibers. In case of Flexural Stress, as the percentage of steel fibers increases the optimum stress was obtained at 40% fly-ash with 2% addition of steel fibers.[Table 3]. As the cement is reduced by 40% the concrete prepared is cost effective and environmental friendly.

5. CONCLUSION

Due to addition of flyash there is considerable improvement in compressive strength of the concrete and not much improvement in tensile strength. With the replacement of cement in concrete by flyash the concrete prepared is environment friendly and cost effective. The workability of concrete is improved considerably by addition of flyash. With the addition of steel fibres and flyash in concrete ductility is improved considerably. The ratio of tensile strength to compressive strength can be enhanced by reduction of flyash and the reduction of steel fibres.

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