STRENGTH STUDIES ON STEEL FIBRE REINFORCED CONCRETE WITH PARTIAL REPLACEMENT OF FLY ASH WITH DIFFERENT ASPECT RATIOS

Thata Girisha[1], Ms.Kola Sahithi[2]
PG Student (Structural Engg)[1], Assistant Professor[2]
Department of Civil Engineering, Universal College of Engineering &Technology,
Guntur (D.t), AP, India.

Abstract: It is now well established that one of the important properties of steel fibre reinforced concrete (SFRC) is its superior resistance to cracking and crack propagation. As a result of this ability to arrest cracks, fibre composites possess increased extensibility and tensile strength, both at first crack and at ultimate, particular under flexural loading; and the fibres are able to hold the matrix together even after extensive cracking.. The transformation from a brittle to a ductile type of material would increase substantially the energy absorption characteristics of the fibre composite and its ability to withstand repeatedly applied, shock or impact loading. In this paper, the mechanic properties, technologies, and applications of SFRC are discussed. Experimental investigation was done using M25 mix and tests were carried out as per recommended procedures by relevant codes. The results were compared with conventional concrete to study the compressive strength, flexural strength, tensile strength of steel fibre reinforced concrete (SFRC) containing fibres of 0%, 0.5%, 1%, and 1.5% volume fraction. Steel fibers of 75 and 90 aspect ratios are used. We have conducted totally 14 experimental trails i.e., 75 and 90aspect ratio (with 0.5%, 1%, 1.5% Fibers) and 75 and 90 aspect ratio with 10% replacement of cement with fly ash(with 0.5%, 1%, 1.5% Fibres). A result data obtained has been analyzed and compared with a control specimen (0% Fibre). A relationship between Compressive strength, Flexural strength, Tensile strength with Age i.e. 7days, 28 days and 90 days represented graphically.

INTRODUCTION

Concrete is the key material used in various types of construction, from the flooring of a hut to a multi storied high rise structure from pathway to an airport runway, from an underground tunnel and deep sea platform to high-rise chimneys and TV Towers. In the last millennium concrete has demanding requirements both in terms of technical performance and economy while greatly varying from architectural masterpieces to the simplest of utilities. It is the most widely used construction materials. It is difficult to point out another material of construction which is as versatile as concrete.

Concrete is one of the versatile heterogeneous materials, civil engineering has ever known. With the advent of concrete civil engineering has touched highest peak of technology. Concrete is a material with which any shape can be cast and with equal strength or rather more strength than the conventional building stones. It is the material of choice where strength, performance, durability, impermeability, fire resistance and abrasion resistance are required.

Cement concrete is one of the seemingly simple but actually complex materials. The properties of concrete mainly depend on the constituents used in concrete making. The main important material used in making concrete are cement ,sand, crushed stone and water .Even though the manufacturer guarantees the quality of cement it is difficult to produce a fault proof concrete. It is because of the fact that the building material is concrete and not only cement. The properties of sand, crushed stone and water, if not used as specified, cause considerable trouble in concrete.

MATERIALS AND ITS PROPERTIES

Cement:
Ordinary Portland cement 53 grade brand conforming to I.S.I standard is used in the present investigation. The cement is tested for its various properties as per IS code.

Fine aggregate: The locally available sand is used as fine aggregate in the present investigation. The sand is free from clayey matter, salt and organic impurities. The sand is tested for various properties like specific gravity, bulk density etc., in accordance with IS 2386-1963(28). Grain size distribution of sand shows that it is close to the zone-I of IS 383-1970(29).

Coarse aggregate: Machine crushed angular granite metal from local source is used as coarse aggregate. It is from impurities such as dust, clay particles and organic matter etc. The coarse aggregate is also tested for its various properties.

Fly ash: Traditionally, the composition of fly ash is expressed in terms of oxide composition, through the constituents are not strictly present in the form of oxides. The typical composition of Indian fly ash is shown in table**.** The temperature in a pulverized fuel boiler would be around 1400˚C and the fuel gas velocity is such that to remove the ash particles rapidly out of the boiler. Due to this reaction with $Ca(OH)_2$ and hence the pozzolonic activity of fly ash.

Table 1 Typical Composition Of Fly Ash And Cement

Constituents	Fly ash	Cement
SiO_2	49-67	17-25
Al_2O_3	16-33	3-8
Fe_2O_3	4-10	0.2-6
CaO	1-4	60-65

MgO	0.2-2.0	0.5-4
SO_3	0.1-2.0	1-2
Na_2O	0.1-0.2	0.5
K_2O	0.1-1.0	0.5
LOI	0.1-1.6	1-3

Fibres:

Fibres are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact–, abrasion–, and shatter–resistance in concrete. Generally fibres do not increase the flexural strength of concrete, and so cannot replace moment–resisting or structural steel reinforcement. Indeed, some fibres actually reduce the strength of concrete.

The amount of fibres added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibres), termed "volume fraction" (V_f). V_f typically ranges from 0.1 to 3%. The aspect ratio (l/d) is calculated by dividing fibre length (l) by its diameter (d). Fibres with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio. If the fibre's modulus of elasticity is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increasing the aspect ratio of the fibre usually segments the flexural strength and toughness of the matrix. However, fibres that are too long tend to "ball" in the mix and create workability problems. Some recent research indicated that using fibres in concrete has limited effect on the impact resistance of the materials. This finding is very important since traditionally, people think that ductility increases when concrete is reinforced with fibres. The results also indicated out that the use of micro fibres offers better impact resistance compared with the longer fibres. The High Speed 1 tunnel linings incorporated concrete containing 1 kg/m³ of polypropylene fibres, of diameter 18 & 32 μm.

An Experimental study is conducted to find out the compressive, Flexural strength and Split tensile strength of concrete at 7, 28 and 90 days.

M25 Grade Conventional Concrete

Conventional Concrete+10% Fly Ash
Conventional Concrete+75 Aspect Ratio
Conventional Concrete+0.5%Fibres
Conventional Concrete+1%Fibres
Conventional Concrete+1.5%Fibres
Conventional Concrete+90Aspect Ratio
Conventional Concrete+0.5%Fibres
Conventional Concrete+1%Fibres
Conventional Concrete+1.5%Fibres
Conventional Concrete+10%Fly Ash+75 Aspect Ratio
Conventional Concrete+10%Fly Ash+0.5%Fibres
Conventional Concrete+10%Fly Ash+1%Fibres
Conventional Concrete+10%Fly Ash+1.5%Fibres
Conventional Concrete+10%Fly Ash+90 Aspect Ratio
Conventional Concrete+10%Fly Ash+0.5%Fibres
Conventional Concrete+10%Fly Ash+1%Fibres
Conventional Concrete+10%Fly Ash+1.5%Fibres

RESULTS AND DISCURSIONS

10% of cement is replaced by a combination of Fly Ash and Silica Fume in different proportions. Compressive strength of cube specimens at 7days and 28 days, split tensile strength at 7 and 28 days & flexural strength at 28 days are noted down below.

Table: 2 Variation of compressive strength at 7 days with addition of fibres

S.no.	% Fibres	% fly ash	Compressive strength	Split tensile strength
1	0	0	20.63	4.27
2	0	10	18.57	3.72
	75 Aspect Ratio			
3	0.5	0	32.65	3.13
4	1.0	0	36.87	2.74
5	**1.5**	**0**	**37.21**	**2.41**
	90 Aspect Ratio			
6	0.5	0	30.30	2.90
7	1.0	0	34.27	2.55
8	1.5	0	34.58	2.24
	75 Aspect Ratio			
9	0.5	10	24.69	2.76
10	1.0	10	24.99	2.30
11	**1.5**	**10**	**27.94**	**1.98**
	90 Aspect Ratio			
12	0.5	10	22.95	2.66
13	1.0	10	23.22	2.14
14	1.5	10	25.97	1.84

Table:3 Variation of compressive strength at 28 days with addition of fibres

S.no	% Fibres	% fly ash	Compressive strength	Split tensile strength
1	0	0	32.50	5.77
2	0	10	30.91	5.71
	75 Aspect Ratio			
3	**0.5**	**0**	**38.98**	**7.10**
4	1.0	0	43.01	6.57
5	1.5	0	43.56	5.98
	90 Aspect Ratio			
6	0.5	0	36.23	6.59
7	1.0	0	39.97	6.12
8	1.5	0	40.49	5.56
	75 Aspect Ratio			
9	**0.5**	**10**	**29.15**	**6.54**
10	1.0	10	30.37	5.21
11	1.5	10	32.79	4.46
	90 Aspect Ratio			

12	0.5	10	27.10	6.07
13	1.0	10	28.23	4.14
14	1.5	10	30.48	3.84

Table:4 Variation of compressive strength at 90 days with addition of fibres

S.no	% Fibres	% fly ash	Compressive strength	Split tensile strength
1	0	0	35.1	6.0
2	0	10	32.23	5.9
	75 Aspect Ratio			
3	**0.5**	**0**	**40.99**	**7.8**
4	1.0	0	46.01	6.98
5	1.5	0	46.89	6.12
	90 Aspect Ratio			
6	0.5	0	38.25	6.92
7	1.0	0	40.23	6.75
8	1.5	0	42.64	6.01
	75 Aspect Ratio			
9	**0.5**	**10**	**30.11**	**6.96**
10	1.0	10	32.14	6.23
11	1.5	10	34.26	5.56
	90 Aspect Ratio			
12	0.5	10	29.03	6.97
13	1.0	10	30.21	5.87
14	1.5	10	31.23	4.65

Table:5 Variation of flexural strength at 28 days with addition of fibres

S.no.	% fibres	%fly ash	Flexural strength
1	0	0	5.12
2	0	10	4.98
	75 Aspect Ratio		
3	0.5	0	6.45
4	1.0	0	7.08
5	**1.5**	**0**	**8.34**
	90 Aspect Ratio		
6	0.5	0	5.99
7	1.0	0	6.58
8	1.5	0	7.75
	75 Aspect Ratio		
9	0.5	10	5.84
10	1.0	10	6.51
11	**1.5**	**10**	**7.87**
	90 Aspect Ratio		
12	0.5	10	5.42
13	1.0	10	6.05
14	1.5	10	7.31

Table:6 Percentage Variation of Fiber Reinforced Concrete Compared To Conventional Concrete for 7 Days

Aspect ratio	% fibres	Strength comparing with conventional concrete (N/mm^2)	
		Compressive	Split
75	0.5	58.26	23.70
75	1.0	78.72	35.83
75	**1.5**	**80.37**	**43.56**
90	0.5	46.87	32.10
90	1.0	66.12	40.28
90	1.5	67.62	47.54
75(10%fl	0.5	32.96	25.81
75(10%fl	1.0	34.57	31.45
75(10%fl	**1.5**	**50.96**	**46.77**
90(10%fl	0.5	23.54	28.49
90(10%fl	1.0	25.05	42.97
90(10%fl	1.5	39.85	50.54

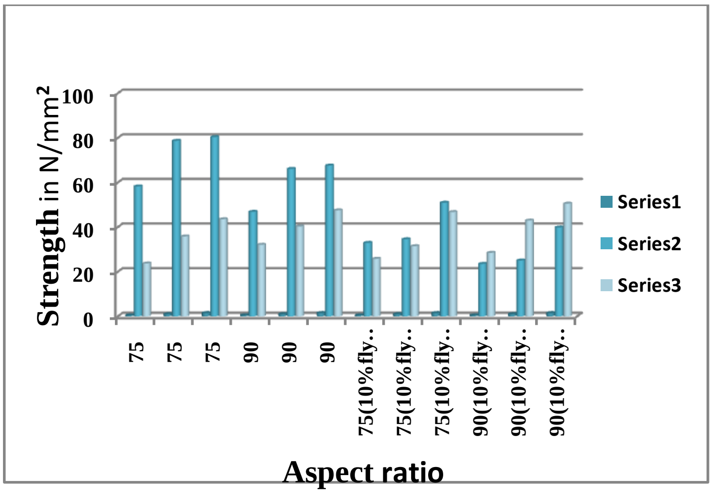
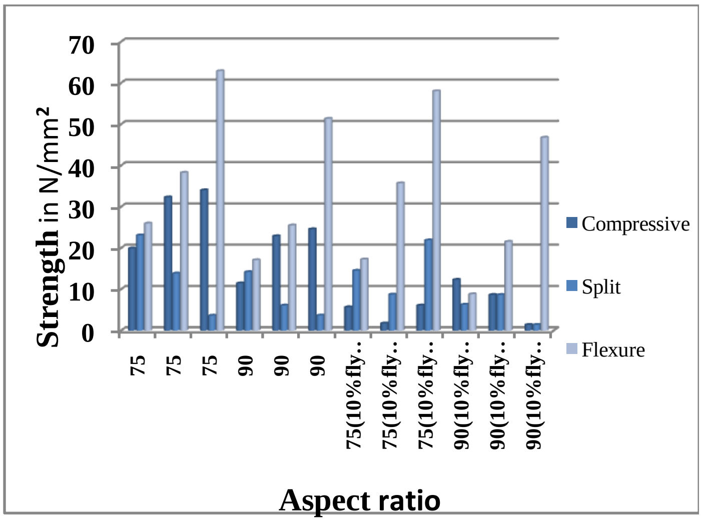


Table:7 Percentage Variation Of Fiber Reinforced Concrete Compared To Conventional Concrete For 28 Days

Aspect ratio	% fibres	Strength comparing with conventional concrete		
		Compressive	Split	Flexure
75	**0.5**	19.94	**23.1**	25.98
75	1.0	32.32	13.86	38.28
75	**1.5**	**34.03**	3.64	**62.90**
90	0.5	11.48	14.2	17.1
90	1.0	22.90	6.1	25.51
90	1.5	24.58	3.68	51.37
75(10%fly	0.5	5.69	14.54	17.27
75(10%fly	1.0	1.75	8.76	35.72

75(10%fly	**1.5**	**6.1**	21.90	**58.03**
90(10%fly	0.5	12.33	6.30	8.84
90(10%fly	1.0	8.67	8.67	21.55
90(10%fly	1.5	1.4	1.4	46.79



CONCLUSIONS

For 75 aspect ratio with 1.5% of fibers (with and without fly ash) we got maximum compressive strength when compared with conventional concrete. This proportion is more suitable for compressive members. For 75 aspect ratio with 0.5% of fibers (with and without fly ash) we got maximum spilt tensile strength when compared with conventional concrete. For 75 aspect ratio with 1.5% fibers (with and without fly ash) we got maximum flexure strength when compared with conventional concrete. This proportion is more suitable for compressive members. Higher percentage of steel fibers workability was losing. Workability increases as the steel fiber percentage decreases.

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