Experimental Study on Hybrid Concrete Using Steel Fiber Polypropylene Fiber and Silica Fume

N.Mohanraj, E.Arundhava Priya, A.Gopalan

Abstract: ***In this project modified hybrid concrete- a novel construction material is manufactured with fibers (steel fibers, polypropylene fibers) and silica fume by drilling through the cement and mortar in order to develop a high strength concrete. The primary purpose is always to develop a cement with increased.physical and mechanical properties. Experiments to study the mechanical properties of the hybrid concrete were carried out. The present study aims at producing the concrete specimen by reinforcing constant level of fibers (steel fibers of 0.7%, and polypropylene fibers of 0.3%) with the different percentage (5%, 10%, 15% and 20%) of silica fume and then comparing it with normal and fiber reinforced concrete. Different tests were carried out on the hybrid concrete specimen like compressive strength test, flexural strength test, and durability tests on normal concrete. The result obtained from the above tests were supreme than the normal concrete, the hybrid concrete exhibits series of crevice while loading and also has higher flexural and compressive strength than the normal concrete.***

Keywords: Ordinary Portland cement, Silica fume, Steel fibers, Polypropylene fibers, Compressive strength, Flexural strength, Durability.

I. INTRODUCTION

Cement structures possess emerged worldwide from historic period and are still emerging as modern structures with new advancements in construction industry. Hence, it is ought to improve the properties of concrete to produce modified concrete with high performance. Admixtures are used to improve both the fresh and hardened concrete properties of concrete. Some of them are fly ash, alccofine, silica fume, ground granulated blast furnace slag etc.,

Generally concrete is composed of cement, fine aggregate, coarse aggregate and water. Based on the usage different types of cement namely Ordinary Portland cement, Acid-resistant cement, High alumina cement, Low heat cement, Sulphate resisting cement, Rapid hardening cement etc., are utilized now a day's as the binding materials. In this paper with the view of improving compressive strength and flexural strength silica fume and fibers are added to the concrete in appropriate proportions.

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II. LITERATURE REVIEW

Many researchers have conducted experiments with steel fibers, polypropylene fibers and silica fume. Some of the journals from which we inferred knowledge just for this study receive below:

From the research work done by Ahsana Fathima, it is concluded that 0.75% of steel fiber and 0.25% of polypropylene fiber (of total volume of concrete) yields better compressive strength than other proportions of fibers. Hence from this we have chosen the percentage of steel and polypropylene fibers for our study as 0.7% and 0.3% (of total volume of concrete) respectively.

Vishal S.Gutke observed that optimum percentage of replacement of cement with SF is 10% and on further increase in SF percentage, the compressive strength of concrete reduces. From his work we have observed that for increase in water cement ratio, workability gets increased but in a same way strength gets decreased.

Faseyemi Victor Ajileye found that the increase in the level of micro silica fume replacement between 15% to 25% led to a lowering in the compressive strength of hardened concrete. Coming from his research it has demonstrated that among 5 to 10% alternative levels, silica fume cement will develop power sufficient intended for construction reasons.

During the investigation program done by Milind V.Mohod, the result of Polypropylene (pp) fiber combine by changing content just like 0%, 0.5%, 1%, 1.5% & 2%, he identified that the Polypropylene (pp) fibre articles upto 0.5% is definitely optimum. Hence from his investigation we certainly have observed the fact that concrete with higher ratio of polypropylene (pp) fiber turns into more firm and difficult to compact.

A.M. Shande created steel fibre strengthened concrete and concentrated that as the fibre rate increments correspondingly the compressive, pliable and flexural quality of concrete also gets raised. From his work we have discovered that the viewpoint proportion assumes a vital job in quality parameters.

III. MATERIALS USED

A. Cement

The concrete proposed for this task is Dalmia, OPC 53 grade. The properties of bond are resolved to meet the prerequisites of IS 12269-1987: Specification for 53 grade Ordinary Portland concrete.

Fig. 1 Cement

Table. 1 Properties of Cement

S.No	Property	Result
1.	Fineness	98%
2.	Specific gravity	3.07
3.	Consistency	26%
4.	Initial setting time	65 minutes
5.	Final setting time	210 minutes

B. Fine aggregate

The fabrics which is passed through 4.75mm IS sieve is termed as Fine aggregate. Here, natural sand is used as fine aggregate; in some instances crushed stone may also be used.

Fig. 2 Fine aggregate

Table. 2 Properties of Fine Aggregate

S.No	Property	Result
1.	Fineness modulus	3.718%
2.	Specific gravity	2.7
3.	Water absorption	0.84%
4.	Unit weight	1537.7 kg/m³

C. Coarse aggregate

The fabrics which is retained on 4.75mm IS sieve is termed as Coarse aggregate. Locally available crushed angular aggregate of size less than 20mm contouring to IS 383-1970 was utilized.

Fig. 3 Coarse aggregate

Table. 3 Properties of Coarse Aggregate

S.No	Property	Result
1.	Fineness modulus	5.26%
2.	Specific gravity	2.64
3.	Water absorption	0.1%
4.	Unit weight	1876.15 kg/m³
5.	Crushing value	43.4%

D. Water

Water is a critical component of cement, as it increments over certain dimension influences the water-concrete proportion and accordingly diminishes the quality. The pH estimation of water utilized is 6.5.

E. Silica fume

Silica fume can be described as grey tinted powder having both pozzolanic and cementitious properties. Because of the pozzolanic property the silica present in the SF reacts with the calcium hydroxide which sorts during the water balance process of concrete and gives the last product as C-S-H gel.

Fig. 4 Silica fume

Table. 4 Properties of Silica Fume

S.No	Property	Result
1.	Fineness	99%
2.	Specific gravity	3.33
3.	Consistency	53%
4.	Initial setting time	10 minutes
5.	Final setting time	65 minutes

F. Steel fiber

The length and diameter of the crimped steel fiber used is 30mm and 0.5mm respectively. The aspect ratio of fiber is defined as the length to thickness (L/D) ratio. Here the aspect ratio of crimped steel fiber is 60. The material was bought from Jeetmull Jaichandlall, Madras Pvt Ltd.

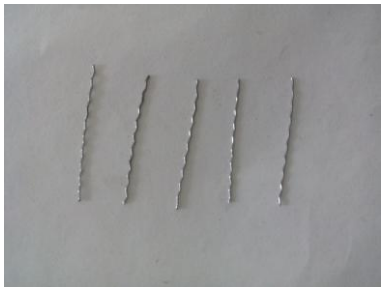

Fig. 5 Steel fiber

G. Polypropylene fiber

The aspect ratio of polypropylene fiber used is 139.33 with the length and thickness of 6.2mm and 0.0445mm respectively. The specific gravity of polypropylene fiber is 1.33. The material was bought from MJ suppliers, Madurai.

Fig. 6 Polypropylene fiber

IV. MIX PROPORTION

The mix design has been done based on IS 10262-2009: Indian Standard Concrete Mix Proportioning Guidelines.

Table. 5 Mix Proportion

S.No	Material	Quantity (kg/m³)
1.	Cement	437.78
2.	Fine aggregate	659.34
3.	Coarse aggregate	1098
4.	Water	197
5.	w/c ratio	0.45

Thus the mix ratio of concrete is 1:1.52:2.52

Table. 6 Mix Propotrioning For Adopted Mix

Mix	Cement	SF	FA	CA	Steel fiber	PP fiber
	(kg/m³)					
M1	437.78	0	659.3	1098	0	0
M2	415.89	21.9	659.3	1098	16.8	7.2
M3	394	43.8	659.3	1098	16.8	7.2
M4	372.11	65.7	659.3	1098	16.8	7.2
M5	350.23	87.6	659.3	1098	16.8	7.2

V. EXPERIMENTAL PROGRAM

A. Compressive strength test

Compressive strength test out is completed at particular ages about cubes. The specimen of standard dice of (150 mm back button 150 logistik x one hundred and fifty mm) utilized to determine the compressive strength of concrete. Dice specimen of size 100mm x 100mm x 100mm can also be used. The fabric was assessed and the supplies were blended manually. The concrete was filled in distinct layers inside the mould and layer was compacted with the aid of tamping fishing rod. The example of beauty was taken out of mould following 24 hours, treated in tidy water to get 7 and 28 days and nights. After 1 week and twenty eight days of solving, the individuals are applied for, wiped dry out and then analyzed for compressive strength according to Indian Common in compression testing equipment. The dice is placed so that the load works perpendicular for the compacted aspect. Load can be applied before the failure in the specimen. The supreme load is certainly noted

Compressive strength of the specimen is calculated using the formula,

$$f_{ck} = \frac{P}{A}$$

Where, f_{ck} = Compressive strength (N/mm²)
P = Ultimate load (N)
A = Loaded area (150mm x 150mm)

Fig. 7 Compression testing machine

B. Flexural strength test

The example of standard crystal of 100 x 100 x 500mm was utilized to decide the flexural quality of cement. Three examples were tried for 7 and 28 days. The material was gauged and the materials were blended physically. The solid was filled in various layers in the shape and each layer was compacted with the assistance of packing pole. The example was expelled from form following 24 hours, relieved in clean water for 7 and 28 days .After 7 days and 28 days of restoring, the examples are taken out, cleaned dry and afterward tried for flexural quality according to Indian Standard in general testing machine. Flexural quality is discovered utilizing focus point stacking framework. The example is situated in the gear so that the weight is put on the best surface as cast inside the shape. The hub of example is typically cautiously agreed with the hub of the starting gadget. Burden is connected until the disappointment of the example. A definitive burden and breaking load is noted. The flexural quality of the example is communicated as modulus of burst, fb and is determined utilizing the equation

$$,f_b = \frac{3}{2}\frac{PL}{bd^2}\ (N/mm^2)$$

Where, P = Ultimate load (N)
L = Centre to centre distance between the supports (400mm)
b = Breadth of the specimen (100 mm)
d = Depth of the specimen (100 mm)

Fig. 8 Flexural test for prism

C. Durability test

Acid attack test

For the acid attack test, cube of size 150mmx150mmx150mm was cast and cured for 28 days. After 28 days curing cube was taken out and allowed for drying for 24 hours. The cube was then weighed. For acid attack 5% dilute hydrochloric acid is used. The cube is immersed in acid solution for a period of 90 days. The concentration is being maintained throughout this period. After 90 days the specimen is taken out from acid solution, the surface of specimen is cleaned and weighed. The changes in appearance due to acid attack are observed.

Fig. 9 Acid attack on cube

D. Sulphate attack test

Sulphate attack is a frequent occurrence in natural or perhaps industrial circumstances. Of all the sulphates, magnesium sulphate causes optimum damage to the concrete. The word sulphate assault denotes a rise in the volume of cement insert in tangible due to the chemical substance action between products of hydration of cement and solution made up of sulphate contaminants. In the solidified concrete, calcium mineral aluminate moisturizer reacts with all the sulphate sodium from outdoors. The product of reaction is usually calcium sulphoaluminate.

For the sulphate attack test, cube of size 150mmx150mmx150mm was cast and cured for 90 days. After 90 days curing cube was taken out and allowed for drying for 24 hours. The cube was then weighed. For sulphate attack, ferrous sulphate solution of 0.6N is used. The cube is partially immersed in ferrous sulphate solution for a period of 90 days. The concentration is being maintained throughout this period. After 90 days the specimen is taken from ferrous sulphate solution. After the completion of 90 days, cube is taken from the ferrous sulphate solution and the changes are observed.

Fig. 10 Sulphate attack on cube

VI. RESULTS AND DISCUSSIONS

Table. 7 Test Results

Mix	% of silica fume	Average compressive strength(N/mm²)		Average flexural strength (N/mm²)	
		7 days	28 days	7 days	28 days
M1	0	24.29	34.66	3.4	5.6
M2	5	21.33	32.67	3.8	6.2
M3	10	27.48	35.78	3.3	5.6
M4	15	22.79	31.71	2.6	4.4
M5	20	18.96	29.40	2	3.8

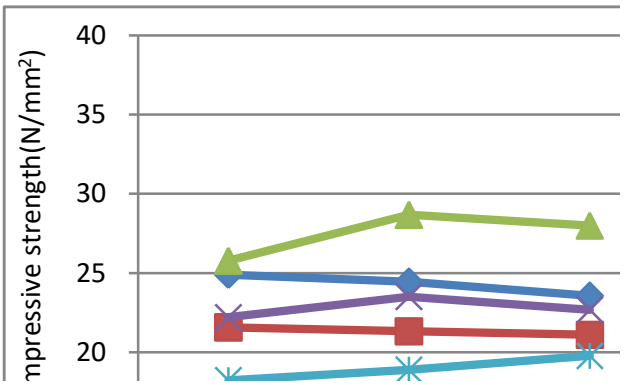

Fig. 11 Comparison chart for 7days cube test results

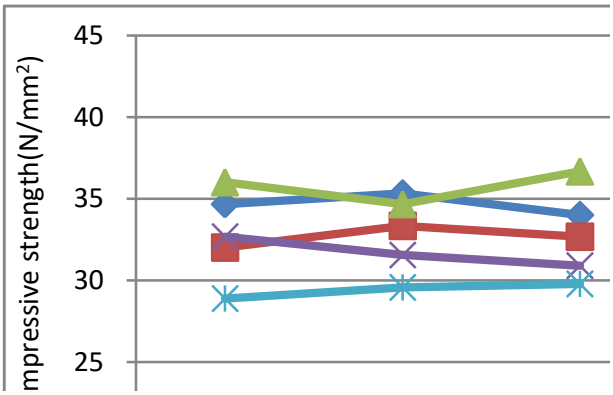

Fig. 12 Comparison chart for 28days cube test results

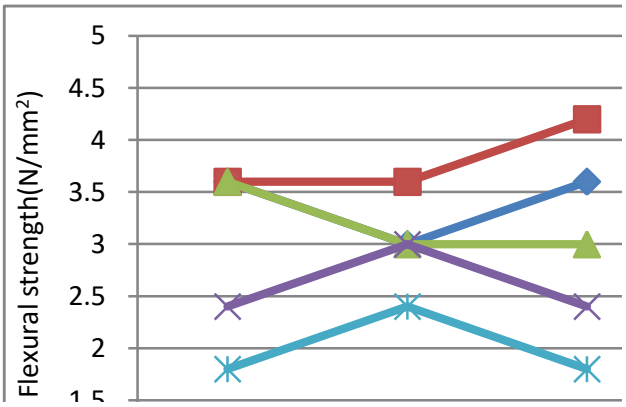

Fig. 13 Comparison chart for 7days prism test results

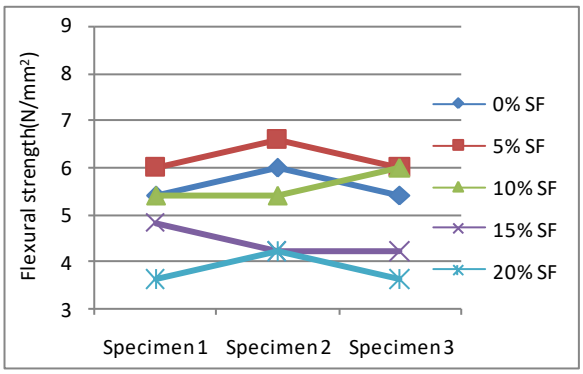

Fig. 14 Comparison chart for 28days prism test results

VII. CONCLUSION

The following conclusions were made

1) The compressive strength initially decreases slightly and then increases.

2) It is observed that the compressive strength of cubes increases upto 10% replacing of cement with silica fume.

3) The comparison chart shows that the compressive strength initially decreases slightly, and then reaches the optimum value for 10% replacement of cement with SF and then decreases for 15% and 20% replacement.

4) Cement replacement upto 10% with SF along with constant percentage of fibers leads to increase in flexural strength for M30 grade of concrete.

5) From 15% there is a decrease in flexural strength for 7 and 28days of curing.

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