Experimental Investigation on Flexural Behavior of High Strength Coir Fiber Reinforced Concrete beams with the partial replacement of Silica Fume

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Abstract - *Concrete is strong in compression but it is weak in tension. The tensile strength of concrete, generally improved by steel reinforcement due to its ductility properties. But, steel reinforcement is so expensive and micro cracks can't avoid. To avoid these micro cracks fiber reinforcement is used. Coir fiber is a natural fiber and easily available everywhere. Usage of coir fiber is easy, flexible, cheap and eco-friendly. Here an attempt has been made to study the flexural behavior of high strength coir fiber reinforced concrete partially replaced with varying percentages of silica fume. Concrete mixes are planned to make using ordinary Portland cement alone as control and also replacing cement by 5%, 10%, 15% and 20% of silica fume. In all the concrete mixes 2% coir fiber is added. For all the mixes beams of 600x150x150mm size were casted. Due to the presence of coir fiber workability is decreased. At the mix in which 10% silica fume and 2% fiber added, came better results than the control mix.*

Key Words: Coir Fibre, Ductility, Eco-friendly, Flexural behaviour, Pozzolana

1. INTRODUCTION

Concrete is brittle in tension and flexure. To overcome this reinforcement is provided in the concrete. In conventional methods steel bars are provided as reinforcement to resist the high potential tensile stresses and shear stresses at weaker zones, but steel bars can't resist the micro cracks. To avoid the micro cracks, fiber reinforcement is provided as secondary. This fiber reinforcement enhances the flexural and tensile strength of concrete. Generally, fibers are of two kinds, they are conventional and natural. Natural fibers are cheap, flexible and ecofriendly than conventional fibers. Natural fibers are the agricultural waste products. Coir, jute and sisal etc; are the various kinds of fibers available. In India, the production of coir fiber is more. Among all the natural fibers coir fiber is more suitable for concrete matrices, because they have light weight, high strength to weight ratio, corrosion resistance, less wear and tear and non-abrasiveness. Coconut fiber is an abundant, versatile, renewable, ecofriendly, cheap, lignocelluloses fiber and more resistant to thermal conductivity. Blending of cement with the Pozzolana improves the quality of concrete by decreasing the emissions of CO_2. Among all the Pozzolana, silica fume is more reactive due to the presence of amorphous silica in high content. Silica fume is a byproduct in the production of silicon alloys

2. MATERIALS

Cement

Portland Pozzolana Cement available in local market is used in this investigation. The cement used has been tested for various properties as per IS: 4031-1988 and found to be confirming to various specifications of IS: 1489-2013. The properties of cement were tested in accordance with IS 12269-2013 and results are given in Table 1.

Table -1: Properties of Cement

Sl.no	Properties	value
1	Specific gravity	3.15
2	Normal consistency	26.5%
3	Fineness of cement	285
4	Fineness	3%
5	Initial setting time(min)	39
6	Final setting time(min)	185
7	soundness (mm)	1.0

Coarse Aggregate

The Coarse aggregate was a normal weight aggregate with a maximum size of 16mm and was obtained from the local supplier and it was tested in accordance with IS 2386-2013. The results are given in Table 2.

Table -2: Properties of Coarse Aggregate

Sl.no	Properties	value
1	Specific gravity i)16mm-60% ii)10mm-40%	2.658
2	Fineness modulus	2.08
3	Flakiness index	18.96%
4	Elongation index	24.64%
5	Impact value	20.36%
6	Crushing value	20%

Fine aggregate: Good Quality River sand, free from silt and other impurities and which is locally available was used for the project. Basic properties of fine aggregate were tested in accordance with IS2386-2013 and results are given in Table 3.

Table -3: Properties of Fine Aggregate

Sl.no	Properties	value
1	Specific gravity	2.45
2	Fineness modulus	3.015
3	Bulk Density	16.70
4	Bulking of sand	27.53%
5	Grading of sand	Zone - II

Silica fume: Blending of cement with the Pozzolana improves the quality of concrete by decreasing the emissions of CO_2. Among all the Pozzolana, silica fume is more reactive due to the presence of amorphous silica in high content. Silica fume is a byproduct in the production of silicon alloys. The physical and chemical properties of silica fume are given in Table 4 & Table 5respectively.

Table -4: Physical Properties of Silica Fume

Sl.no	Physical Properties	Results
1	Physical State	Micronized powder
2	Odour	Odourless
3	Appearance	White color
4	Density	.76gm/cc
5	Moisture	0.058%
6	Ph of 5% solution	6.90

Table -5: Chemical Properties of Silica Fume

Sl.no	Chemical Properties	Results
1	Silica (SiO_2)	99.886%
2	Alumina (Al_2O_3)	0.043%
3	Ferric Oxide (Fe_2O_3)	0.040%
4	Titanium Oxide (TiO_2)	0.001%
5	Calcium Oxide (CaO)	0.001%
6	Magnesium Oxide (MgO)	0.000%
7	Pottasium Oxide (K_2O)	0.001%
8	Sodium Oxide (Na_2O)	0.003%
9	Loss on ignition	0.015%

Water: Potable water is generally considered satisfactory. In the present study, Potable water was used for both curing and mixing. The Ph value of water is 6.8.

Chemical Admixture: Addition of coir fibers in high strength concrete leads to poor workability condition. To overcome such constraint, Super plasticizer (Complast SP 430) of 1.2% by weight of cementitious material was used to get better workability condition.

Coir fiber: Coir fiber is extracted from outer shell of the coconut. The common name, scientific name and plant family of coconut fibre is coir, cocos, nucifera and Arecaceae (palm), respectively. There are two types of coconut fibres, brown fibres extracted from matured coconuts and white fibres extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance. White fibres are Smoother and finer but also weaker. Uniform length of fibers was obtained by using cutting machine. Length of fibers was measured by vernier scale and the diameter by micrometer. Specific gravity and density of coir fibers were determined using pycnometer.

Table -6: Properties of Coir Fibre

Sl.no	Properties	Values
1	Diameter of coir (D)	0.48 mm
2	Length of coir (L)	50 mm
3	Aspect ratio (L/D)	104
4	Specific gravity	1.12
5	Water absorption	98%

3. METHODOLOGY

Preparation of Test Specimens

Mix design is the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. In the trial mixes cubes were casted and tested to know the optimum w/c ratio for high strength concrete (M60). The mix with following proportions got the nearer target strength.

Table -7: Mix Ratio

Material	Cement	Fine aggregate	Coarse aggregate	water
In kg/m³	149	465	623	1185
Ratio	1	1.3	2.5	0.32

Taking the control mix design (i.e. 0%silica fume & 0% fibre) as reference weights of materials are calculated as shown above. In all the concrete mixes silica fume was varied in the percentages of 5, 10, 15, 20 by the weight of cementitious material content and 2% coir fibre was incorporated for the w/c ratio 0.32. Total 45 Beams

(600x150x150mm) for all the 5mixes including control mix.
Mix 1: 0% silica fume and 0% fiber
Mix 2: 5% silica fume and 2% fiber
Mix 3: 10%silica fume and 2% fiber
Mix 4: 15%silica fume and 2% fiber
Mix 5: 20%silica fume and 2% fiber

The moulds were kept clean and oiled and ensured that there is no leakage in the mould. Concrete was poured in the moulds and used needle vibrator for better compaction so that we can ensure that there is no honey comb voids in concrete beams. After placing concrete, made 24 hours drying, then de-moulded it carefully and kept those beams in fresh water pond curing.

4. Test and observations

Flexural Strength

Flexural strength of concrete was determined by testing the beam specimens (600x150x150mm) under flexural testing machine and results are tabulated as below

Sl.no	Mix	Flexural strength in N/mm²		
		3 Days	7 days	28 days
1	Mix 1	2.8	4.2	6.10
2	Mix 2	3.1	4.5	6.24
3	Mix 3	3.54	4.98	6.57
4	Mix 4	3.04	4.34	5.91
5	Mix 5	2.61	3.92	5.70

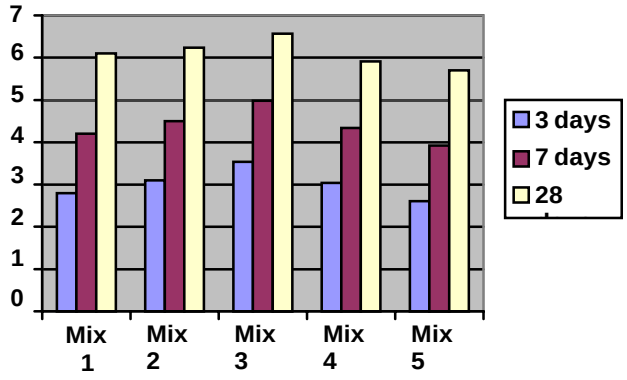

Chart -1: Overall Flexural Strength of Beams

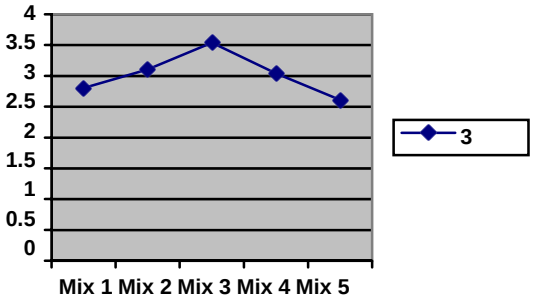

Chart -2: 3rd Day Flexural Strength of Beams

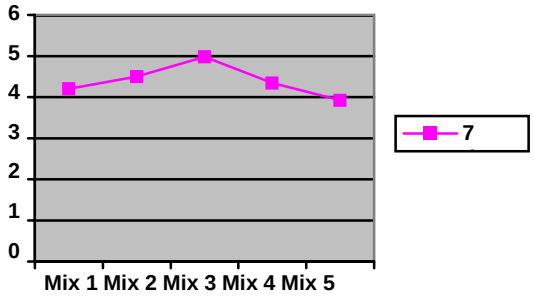

Chart -3: 7th Day Flexural Strength of Beams

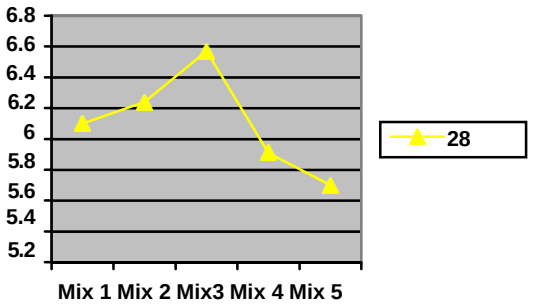

Chart -4: 28th Day Flexural Strength of Beams

5. CONCLUSIONS

- It is clearly evident that the mix 3 shows the better performance in flexural strength than the other mixes including control specimens and in all three types namely 3rd, 7th and 28 days. Further adding silica fume leads to loss of flexural strength of high strength concrete beams.

- 28 days flexural strength occurred at mix 3 is 6.57 N/mm², which is maximum average flexural strength achieved in the beam and it is 7.70% more than control mix.

- 28 days flexural strength occurred at mix 5 is 5.70 N/mm^2, which is minimum average flexural strength achieved in the beam and it is 13.24% less than mix 3 and got 6.55 % lesser value than the conventional concrete Mix 1.

- Same scenario happens in the 3rd and 7th day tests also, that is mix 4 and mix 5 achieved lesser strength than the mix 3, and hence we concluded that the further adding of silica fume more than 10 %, incorporated with coir fibres leads to loss of strength.

6. REFERENCES

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