International Journal of Advanced Technology in Engineering and Science
Vol. No.5, Issue No. 04, April 2017
www.ijates.com
ijates
ISSN 2348 - 7550

INCLUSION OF COIR FIBER IN HIGH STRENGTH CONCRETE BLENDED WITH SILICA FUME

T. Bhuvana Vijaya[1], Assistant Prof. Smt. B. Ajitha[2]

[1]M.Tech Student, Structural Engineering, JNT University, Anantapur (India)

[2] Assistant Professor, Department of Civil Engineering, JNT University, Anantapur (India)

ABSTRACT

The use of supplementary cementitious materials is fundamental in developing low cost construction materials. By addition of pozzolanic materials, the various properties of concrete viz, workability, durability, strength, resistance to cracks and permeability can be improved and emissions of CO_2 can be decreased. Silica fume is known to improve the both mechanical characteristics and durability of concrete; also it acts as perfect filler due to its fineness. Inclusion of fibers in concrete is to delay and control the tensile cracking of composite material Here an attempt is made to reuse coir fiber materials as fiber composites in concrete which not only solve the ductility problem but also the problem of waste disposal to some extent. Thermally, coir fiber decreases the room temperature than the atmosphere temperature.

In this project an attempt has been made to study the suitability of silica fume as a mineral admixture and its effects on the properties of high strength concrete with the inclusion of coconut fiber. Concrete mixes are planned to made 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 cubes and cylinders 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.

Keywords: Cementitious material, coir, high strength concrete, silica fume, waste disposal.

I. INTRODUCTION

During past few years, need of high strength concrete has been increased than the normal strength concrete (NSC), because of growth in population and industrial area. To fulfill the requirements of increased population and the needs of developing industrial areas, construction of multi-storied buildings and high rise buildings is the only way for civil and structural engineers. Now a days usage of high strength concrete increased to have more durable and high stiffness buildings. So many researchers are inventing various new types of concrete composites in the laboratories by utilizing the waste industrial byproducts, domestic wastes and agricultural wastes etc; for the partial replacement of conventional construction materials, to make the concrete composite such as eco friendly, cost effective, durable and high strength. In high strength concrete mixes water- cement ratio is very low and cement content is high. This increase in cement content leads to the high emissions of CO_2 and less strength than the target strength. To overcome this, some waste industrial byproducts which are known as pozzolans are used in the concrete composites for the partial replacement of cement content. Fly-ash, silica fume, metakaolin, blast furnace slag and ground granulated blast furnace slag etc; are such various pozzolanic industrial byproducts. Among these pozzolans silica fume is the highly reactive due to high content of amorphous silica and large surface area. It acts as perfect filler due to its fineness. Silica fume is a byproduct resulting from the reduction of high-quartz with coal or coke and wood chips in an electric arc furnace during the production of silicon material or silicon alloys. Silica fume is used in two different ways; as a cement replacement in order to reduce the cement content and as an additive to improve the concrete properties. Chemically, silica fume reacts with calcium hydroxide (CH) from cement hydration at faster rates to form extra C-S-H gel compared with other pozzolans. From micro-structural modification perspective, silica fume reduces the porosity of interfacial transition zone (ITZ) and accumulation of water under aggregate particles by its physical effect.

Generally, concrete is weak in tensile and flexure. Due to that reason reinforcement will be provided. Generally steel reinforcement is adopted to overcome high potentially tensile stresses and shear stresses at weaker zones in the concrete member. Even though the addition of steel reinforcement significantly increases the strength of concrete, the development of micro cracks must be controlled to produce concrete with homogenous tensile properties. The introduction of fibers is brought in as a solution to develop concrete with enhanced flexural and tensile strength, which is a new form of binder that could combine Portland cement in bonding with cement matrices. Fibers are most generally discontinuous, randomly distributed throughout the cement matrices. Several kinds of fibers such as steel, poly propylene, nylon, coir, jute, sisal, glass and carbon etc; are available in variety of shapes, size and thickness. To make cost effective eco friendly, earth quake resistant (Majid Ali et al.,2012) concrete composite, incorporation of natural fibers is recommended. Among the natural fibers coir fibers are easily available everywhere. These fibers have light weight, high strength to weight ratio, corrosion resistance, non- abrasiveness, thermal insulation and less wear and tear (Majid Ali et al.,2012).These properties make FRC composite a good alternative for innovative construction. Their application in construction includes both upgrading existing structures and building new ones, which can apply to various types of structure, for example offshore platforms, buildings and bridges (Thou, 2005). In spite of these advantages, there are two important reasons for lack of interest in developing these coir fiber concrete composites widely not only in India but also in other developing countries.

1. Balling effects- reduce the workability of mix
2. Embrittlement- decay of natural fiber in alkaline medium

To overcome this, matrix modification using pozzolanic material has been used to improve the durability of fiber and fiber composites.

The scope of study is to conduct experimental studies on enhancement of properties of concrete in which silica fume is used as pozzolanic material (mineral admixture) and coconut fibers are incorporated. The following tests were done on the concrete composite blocks:

1. Workability
2. Compressive strength
3. Split tensile strength

II. LITERATURE REVIEW

HSC usually contains one or two mineral additives which are used as partial replacement for cement. Therefore, the term water/cement (w/c) ratio used in reference to normal strength concrete (NSC) is replaced by w/b ratio, where the binder is the total weight of the cementitious materials (cement + additives). The minimum w/b ratio for full hydration of cement pastes is approximately 0.36 [1]. For NSC this limit is usually exceeded for workability requirements. However, in the case of HSC, complete hydration is not essential for full strength to be attained and therefore it can be made with w/b ratios less than 0.36. HSC's have been made with w/b ratios as low as 0.2. However, high dosages of super plasticizers are required to maintain workability [2]. **Patnaikuni and Patnaik [1]** suggests that a w/b ratio of 0.23 is an optimum value for maximum compressive strength of very high-strength concrete mixes.The incorporation of mineral admixtures such as silica fume, fly ash, slag or rice-husk ash is common in production of HSC concrete. These cementations by-products facilitate the manufacture of high strength concrete.The major purpose of introducing silica fume to the concrete mix is to achieve high strength and durability. The presence of silica fume also enhances the effectiveness of super plasticizer, which consequently reduces w/b ratio required to achieve a certain level of workability **Mak, S.L., [2].** Normally, 3 to 10% of silica fume is used for high performance concrete. **Behnood & Ziaria [4]** found that the silica fume has more pronounced effects on compressive strength than a decrease in w/b ratio. The optimal value for silica fume and w/b were estimated to be 6% and 0.35 respectively. In an experimental study, **Ting et al. [5]** concluded that about 10% replacement of cement by silica fume is the optimum dosage.

Baruah and Talukdar [6](2007) investigated the mechanical properties of plain concrete (PC) and fiber reinforced concrete (FRC) with different fiber volume fractions ranging from 0.5% to 2%. Steel, synthetic, jute and coconut fibers were used. Here, the discussion is limited to the coconut fiber reinforced concrete (CFRC) only. The cement: sand: aggregate ratio for plain concrete was 1:1.67:3.64 and the water cement ratio was 0.535. Coconut fibers having lengths of 4 cm and an average diameter of 0.4mm with volume fractions of 0.5%, 1%, 1.5% and 2% were added to prepare CFRC. It can be seen that CFRC with 2% fibers showed the best overall performance amongst all volume fractions. The compressive strength, splitting tensile strength, modulus of rupture and shear strength of CFRC with 2% fibers by volume fraction were increased by 13.7%, 22.9%, 28.0% and 32.7% respectively, compared to those of PC. Their research indicated that all these properties were also improved for CFRC with 0.5%, 1% and 1.5% volume fraction in comparison to that of PC. Even for CFRC with a small fiber volume fraction of 0.5%, the corresponding properties were increased up to 1.3%, 4.9%, 4.0% and 4.7%, respectively.

Islam et al. [7](2012) conducted an experimental investigation on the properties of coir and steel fibers reinforced normal-strength and high-strength concrete. Mix design was performed as per ACI method. Here, the discussion is limited to CFRC only. The fiber volume fractions of 0%, 0.5%, and 1.0% were considered for a constant fiber length of 30 mm. In both normal strength concrete (NSC) and high strength concrete (HSC), the workability significantly reduced as the fiber dose increased. This research showed that 0.5% and 1.0% coir fibers improved flexural strength of NSC by 60%, and 0.5% coir fiber gives improved flexural and tensile strengths of HSC by 6% only. Also, the addition of coir fibers in both types of concrete increased the ductility and toughness of concrete, whereas reduction of compressive strength was observed in the case of HSC.

III. METHODOLOGY

In this study mixes are planned to made with2%fiber and silica fume with varying proportion of 5, 10, 15, 20.Control mix was taken with 0%fiber and 0%silicafume.

3.1 Collection of raw materials

International Journal of Advanced Technology in Engineering and Science
Vol. No.5, Issue No. 04, April 2017
www.ijates.com
ijates ISSN 2348 - 7550

The materials used in this study are:

Ordinary Portland Cement (OPC) : 53grade ACC Cement

Silica Fume : Collected from the industries

Coconut fiber : Raw fiber collected from the coir industries in the East Godavari district.

Fig.1 Coir Fiber

These fibers are chapped into 40mm length and soaked in the water for 10 hours before casting to reduce the water absorption.

Water : Collected from the local fresh water sources

Fine aggregate : River sand passing through 4.75mm sieve size

Coarse aggregate : Aggregates passing through the 16mm sieve size taken 60% &10mm sieve size aggregates taken 40%

Admixture : FOSROC SP 430

3.2 Basic test results of materials

For all the materials used in the project following basic tests were conducted according to the IS specifications. All test results are shown in

Table 3.1 Basic tests results of materials

S.No.	Material	Particulars	Obtained value
1	Cement	Specific gravity	3.15
		Normal consistency	26.50%
		Fineness of cement	285
		Fineness	3%
		Initial setting time(min)	39
		Final setting time(min)	185
		soundness (mm)	1
2	Fine aggregate	Specific gravity	2.45
		Finness modulus	3.015
		Bulk density(kN/m^3)	16.7
		Bulking of sand	27.53%
		Grading of sand	Zone-II
3	Coarse aggregate	Specific gravity	
		i)16mm-60%	
		ii)10mm-40%	2.658
		Fineness modulus	2.08
		Flakiness index	18.96%
		Elongation index	24.64%
		Impact value	20.36%
		Crushing value	20%
4	Coir Fiber	Specific gravity	1.12
		Water absorption	98%
		Thickness of fiber	0.05mm
		Chopped length of fiber	50mm

Table 3.2 Physical properties of SilicaFume

Physical properties	Results
Physical State	Micronized powder
Odour	Odourless
Appearance	White Colour Powder
Colour	White
Pack Density	0.76 gm/cc
pH of 5% Solution	6.9
Specific Gravity	2.63
Moisture	0.06%
Oil Absorption	55ml/100gm

Table 3.3 Chemical Properties of Silica Fume

Chemical properties	Results
Silica (SiO_2)	99.89%
Alumina (Al_2O_3)	0.04%
Ferric Oxide (Fe_2O_3)	0.04%
Titanium Oxide (TiO_2)	0.00%
Calcium Oxide (CaO)	0.00%
Magnesium Oxide (MgO)	0.00%
Pottasium Oxide (K_2O)	0.00%
Loss on ignition	0.02%
Heavy metals	
Lead (Pb)	0.00%
Arsenic (As)	0.00%

Table3.1

International Journal of Advanced Technology in Engineering and Science
Vol. No.5, Issue No. 04, April 2017
www.ijates.com
ijates
ISSN 2348 - 7550

VI. EXPERIMENTAL WORK

4.1 Mixes

Four mixes are planned by replacing cement content with silica fume in percentages of 5,10, 15 and 20 by weight of cementitious material and 2%coir fiber was incorporated in all the mixes. As usual, plain concrete in which 0%silicafume and 0%coir fiber was taken as control mix. For each mix 9 Cubes of 150x150x150mm size and 9 Cylinders of 150mm dia and 300mm length size were casted.

4.2 Mix Proportions (As per IS 10262-2009)

4.2.1 Mix Proportions for M_{60} grade of concrete

Material	Water	Cement	Fine aggregate	Coarse aggregate
in kg/m^3	149	465	623	1181
Ratio	0.32	1	1.34	2.54

4.2.2 Mix proportions for coir fiber reinforced concrete blended with silica fume (M_{60} grade)

Taking control mix proportions as reference, mix proportions for other mixes were calculated.

Here, the mix proportions for the mix in which 10%silicafume and 2%fiber was incorporated are given below.

Material	Water	Cementitious	Fine aggregate	Coarse aggregate
in kg/m^3	149	511	598	1134
Ratio	0.29	1	1.17	2.22

4.3 Casting the specimens

Taking the control mix design (i.e. 0%silica fume&0% fiber) 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 fiber was incorporated for the w/b ratio 0.32. Total 45 Cubes(150x150x150mm) and 45 Cylinders (150mm dia and 300mm length) 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

4.4 Process of mixing

Weights of all the materials were measured. Initially, coarse aggregate of 16mm was poured on clean water tight flat-form and made it flat. One fourth of coir fibers were placed on the coarse aggregates. On that coarse aggregate of 10mm was placed flat and another one fourth of coir was placed on it. Like that fine aggregate, cement and silica fume are placed and in between them coir fiber was kept equally. All these dry aggregates are mixed thoroughly. Measured super plasticizer was mixed in water thoroughly. This mixture was added to dry aggregates in step manner and mixed those thoroughly.

Fig. 2 Dry materials

Fig. 3 coir fiber reinforced concrete

4.5 Workability

To determine workability of fresh concrete the following tests were conducted.

1. Slump cone test
2. Vee-Bee consistometer test
3. Compaction factor test

4.6 Casting

The specimens were kept clean and oiled. Ensured that, there should be no gaps in the moulds to avoid the leakage of slurry. Concrete was poured in the moulds in three layers and tamping was done thoroughly at every layer. Finally, leveling to the top surfaces of specimens was done. These moulds were kept for drying for 24 hours, after that those were de-molded and concrete specimens are kept in fresh water for curing.

Fig. 4 casting of cubes

Fig. 5 cylinders

Tests:

To know the hardening properties of concrete the following tests are conducted on the specimens for 3, 7 and 28 days from time of mixing the water to the dry materials

1. Compressive strength test (Cubes)
2. Split tensile strength test (Cylinders)

V. RESULTS AND DISCUSSIONS

5.1 Workability

Workability of coir fiber reinforced concrete is decreased than the control mix, due to the presence of coir fiber. The results of workability are shown in the following Table 5.1

ijates
ISSN 2348 - 7550

Table 5.1 Results of Workability of mixes

S.No.	Mix No.	Slump Value (mm)	Vee-Bee time (sec)	Compaction factor
1	Mix 1	40	13	0.84
2	Mix 2	0	18	0.712
3	Mix 3	0	16	0.72
4	Mix 4	0	15	0.74
5	Mix 5	0	14	0.755

5.2 Compressive Strength

The compressive strength of concrete is determined by testing the cubes under compressive testing machine. The results of compressive strength are shown in the Table 5.2. Maximum compressive strength occurred at Mix 2(10%silica fume&2%fiber) and it is nearer to the target strength.

Table 5.2 Results of Compressive Strength

S.No.	Mix No.	Compressive Strength (N/mm^2)		
		3 Days	7 Days	28 Days
1	Mix 1	34.45	46.25	64.93
2	Mix 2	36.25	47.85	66.14
3	Mix 3	37.30	49.72	68.50
4	Mix 4	31.60	44.50	60.19
5	Mix 5	28.09	38.74	54.68

Fig. 6 Compressive testing of a specimen

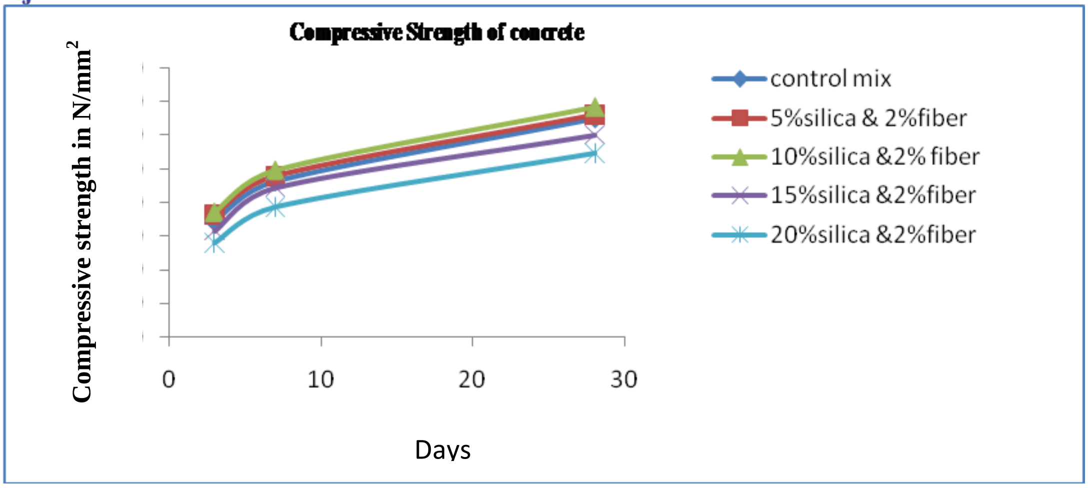


Fig. 7 Curing Period v/s Compressive strength

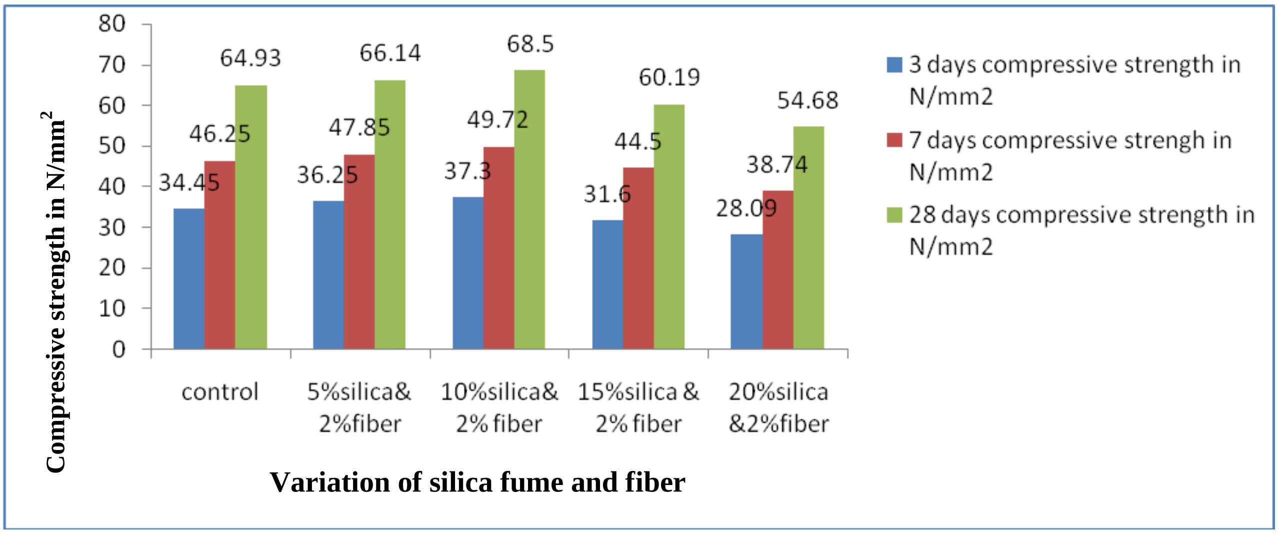
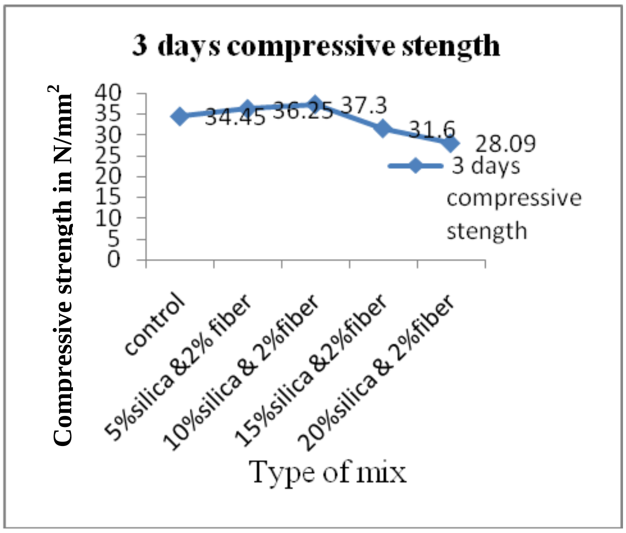
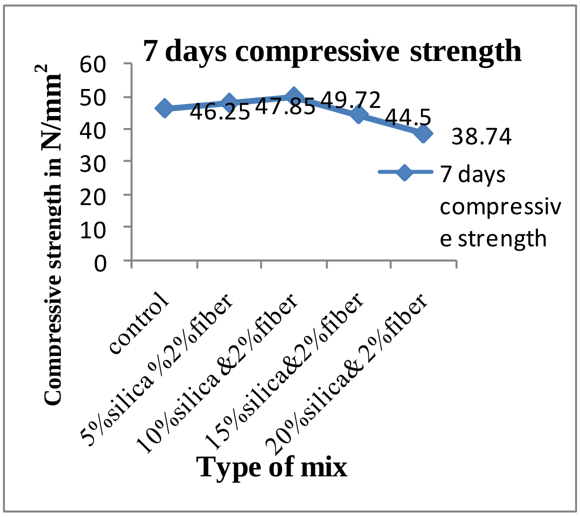


Fig. 8 Variation of silica fume and fiber v/s compressive strength





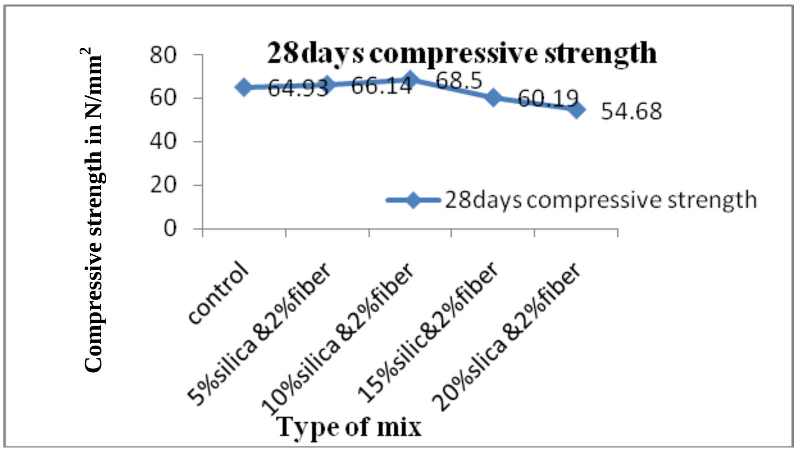


Fig. 9 Variation of silica fume and fiber v/s Compressive strength at 3, 7 and 28 days

5.3 Split tensile strength

Split tensile strength test was conducted for the cylinders of 150mm dia and 300mm length. The obtained values are tabulated in Table 5.3.Compared to conventional concrete crack width is for this fiber reinforced concrete. Splitting of specimens into two pieces can be controlled completely with this coir fiber.

Table 5.3 Results of Split tensile strength

S.No.	Mix No.	Split Tensile Strength in N/mm^2		
		3 Days	7 Days	28 Days
1	Mix 1	3.09	3.54	4.39
2	Mix 2	3.14	3.57	4.46
3	Mix 3	3.26	3.92	4.52
4	Mix 4	3.15	3.63	4.41
5	Mix 5	3.04	3.47	4.23

Fig. 10 Minute crack after testing cylinder

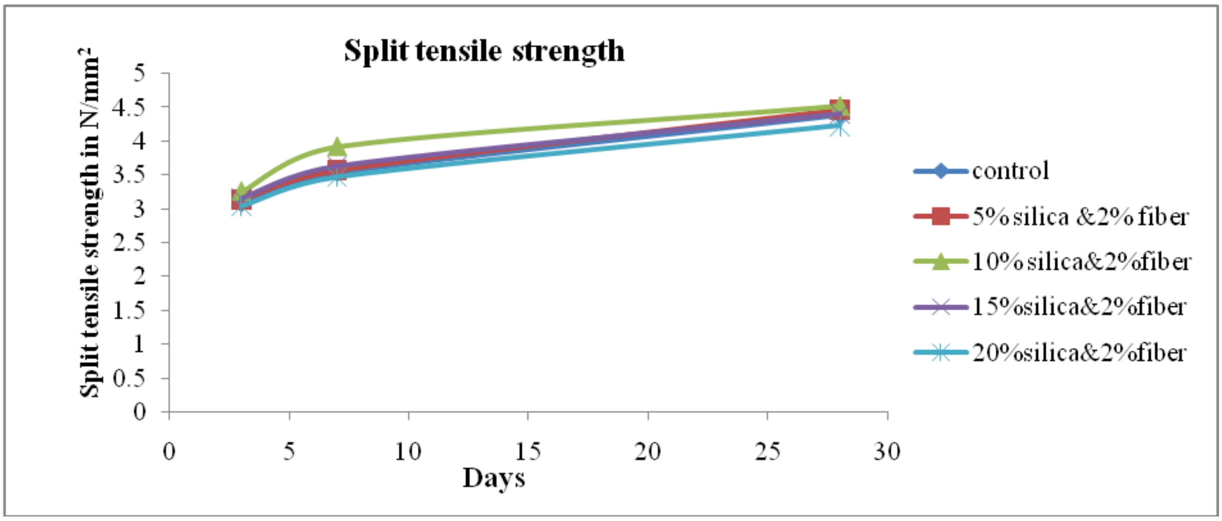


Fig. 11 Curing period v/s Split tensile strength

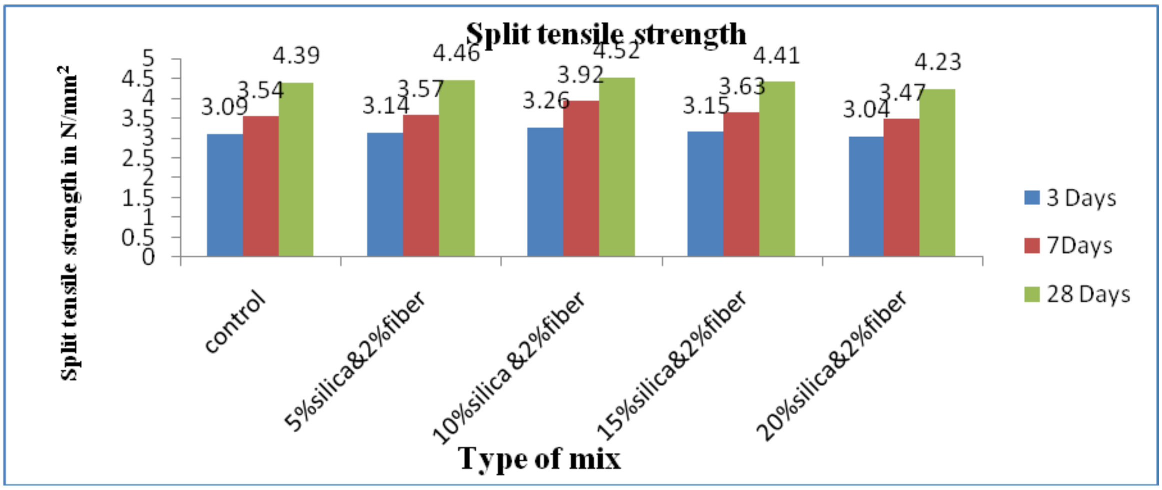
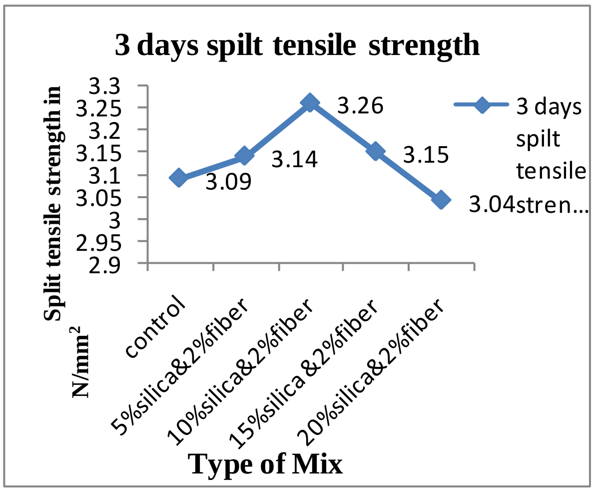
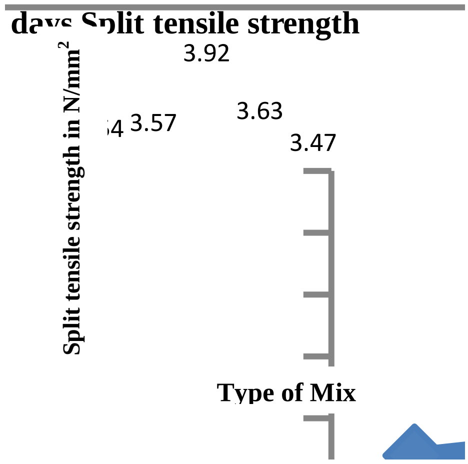


Fig. 12 Variation of silica fume and fiber v/s Split tensile strength





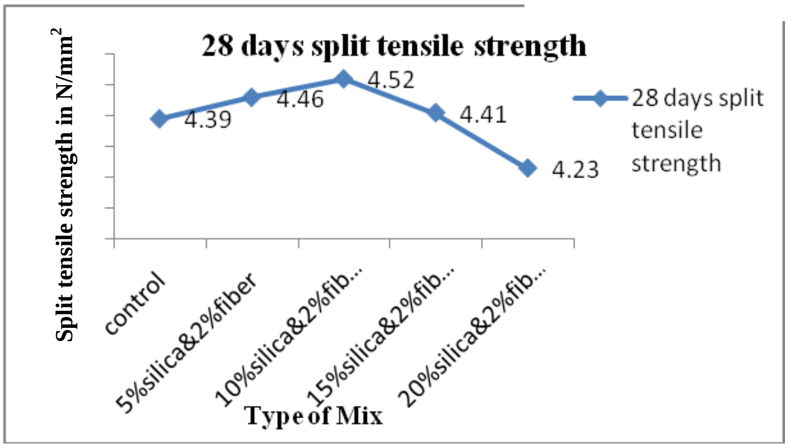


Fig. 13 Variation of silica fume and fiber v/s Split tensile strength at 3, 7 and 28 days

VI. CONCLUSIONS

Based on the experimental investigations carried out in this study, salient conclusions are given summarized below--

Workability: Compared to conventional concrete, workability of fiber reinforced concrete blended with silica fume is very low. Even, silica fume and super plasticizer used in the mix slump had not fall due to the coir fiber and low water content. Compaction factor and vee-bee time also concluded that the workability of coir fiber reinforced concrete is very low.

Compressive strength: At mix 1 & mix 2 compressive strength slightly increased than control mix. 28 days compressive strength is maximum at mix 2 (10%silica fume&2%fiber) and the increment is 5.5%.Cracks occurred while testing were very low. Ductility of concrete has improved with the coir.

Split tensile strength: Maximum split tensile strength occurred at mix 2 (10%silicafume &2%fiber) is 4.52 N/mm^2 and the increment compared with control mix is 3%. Compared to conventional concrete, width of cracks occurred while testing under CTM are very low. Splitting of specimens into two pieces can be avoided completely with the inclusion of coir fiber.

Finally, It can be concluded that the presence of coir fiber increases ductility of concrete.

VII. SCOPE FOR FUTURE STUDIES

It is necessary to study the effect of length of fiber on high strength concrete widely.

There is need of study on improving workability of high grade fiber reinforced concrete without affecting the strength parameters.

REFERENCES

[1] Patnaikuni I. and Patnaik, A.K., "Design and Testing of High-Performance Concrete" Int. conference of Rehabilitation, Renovation, Repair of Structures, Visakhapatnam, India, 1992.

[2] Mak, S.L., "Defining Performance and Basic Considerations for Materials and Mix Design", Proceedings of a workshop on Technology, Design and Applications of HSC/HPC at the University of Melbourne,Australia, Ed. P. Mendis, Feb. 1994.

[3] Neville, A. M. "Properties of concrete", New York, Wiley, 1996.

[4] Behnood, A., and Ziaria, H, "Effects of silica fume addition and water to cement ratio on the properties of high-strength concrete after exposure to high temperatures" Cement and Concrete Composites 30(2), 2007,pp. 106-112.

[5] Ting, E.S.K., Patnaikuni, I., Pendyala, R.S. and Johanson, H.A., "Effectiveness of Silica fumes available in Australia to Enhance the strength of Very High Strength Concrete", International conference on The Concrete Future, Kuala Lumpur 1992.

[6] Baruah, P. and Talukdar, S. 2007. A comparative study of compressive, flexural, tensile

[7] and shear strength of concrete with fibres of different origins. *Indian Concrete Journal,* 81(7): 17-24.

[8] Islam, S. M., Hussain, R. R. and Morshed, M. A. Z. 2012. Fiber-reinforced concrete incorporating locally available natural fibers in normal- and high-strength concrete and a performance analysis with steel fiber-reinforced composite concrete. *Journal of Composite Materials,* 46(1):111-122.

[9] IS 10262:2009, "Guidelines for Concrete Mix Design". Bureau of Indian Standards, New Delhi, India.