EXPERIMENTAL INVESTIGATION OF FIBRE REINFORCED CONCRETE USING HEMP FIBRE AND SILICA FUME

Boobalan S C[1], Karthik Raj S[2], Sandeep R[3]

[1]*Assistant Professor, Department of Civil Engineering, Sri Krishna College of Engineering and Technology, Tamil Nadu, India*

[2]*Undergraduate Student, Department of Civil Engineering, Sri Krishna College of Engineering and Technology, Tamil Nadu, India*

[3]*Undergraduate Student, Department of Civil Engineering, Sri Krishna College of Engineering and Technology, Tamil Nadu, India*

Abstract

Nowadays the construction and use of buildings are responsible for at least 50 percent of the CO_2 emissions from human activity. Therefore using materials with a much lower environmental impact is crucial to reduce environmental damage and resource consumption. Designing and building with hemp fibre is a real demonstration of a total commitment to 'saving the planet' and protecting the health and well-being of a building's occupants. In this study, special type of concrete such as fibre reinforced concrete is prepared and tested with silica fume and hemp fibre in various proportions. For each proportion of mix, standard sizes of cubes, cylinders and prisms were cast and tested for compressive strength, split tensile strength and flexural strength at the age of 7 days and 28 days. The addition of silica fume shows early strength gaining property to the concrete and addition of hemp fibre reduces carbon dioxide emission from the construction. From the various proportions of concrete mix tested, finally 10% of silica fume and 0.5% of hemp fibre given the maximum strength to the concrete.

Keywords: *Fibre reinforced concrete, Silica fume, Hemp fibre, etc.*

--***--

1. INTRODUCTION

Concrete is a mixture of cement, water and aggregates with or without admixtures. The cement and water will form a paste that hardens as a result of a chemical reaction between the cement and water. The paste acts as glue, binding the aggregates into a solid rock-like mass. The quality of the paste and the aggregates dictate the engineering properties of the construction material. It is well known that conventional concrete designed on the basis of compressive strength does not meet many functional requirements such as impermeability, resistance to frost, thermal cracking adequately. This research is carried out to meet the above concerned requirements with the help of hemp fibre reinforced concrete (HFRC) with silica fumes.

Silica fume is one of the artificial pozzolana, commonly used as mineral admixture in HPC. It improves durability primarily by reducing permeability to water and chlorides. It is added as replacement for 10% of cementitious material.

Hemp is a controversial bio product with promising performance as a sustainable building material. The fact that hemp is an organic, natural product makes it highly relevant in the present reality of global pollution and struggle for coping with planetary warming. The construction sector is among the leading industries when it comes to energy consumption, release of CO_2 and is responsible for great amounts of waste and pollution. While comparing the various fibres, hemp fibre has high tensile strength and strong tolerance for an alkali environment. These properties make hemp fibre a good reinforcement material.

The objective of this research is to increase flexural and tensile strength of concrete by using hemp fibre. For enhancing the compressive strength and durability by adding silica fume with the hemp fibre.

It is reported that to reduce shrinkage, creep and increase the tensile property, concrete specimens had been prepared and tested with silica fume of 10% replacement mixed with polypropylene fibre of 0.5% achieved higher strength when compared to various percentages [5]. Reinforced concrete beams were casted and tested with two point loading by adding the hemp fibres in various proportions, test results shown that 0.5% addition had increase of 25% load carrying capacity to the beams [6]. As per Dilip Kumar Singha Roy and Amitava Sil, properties of hardened concrete had been determined with various percentages of silica fume and it was noted that 10% replacement of cement with silica fume had given higher value [7].

2. EXPERIMENTAL PROGRAMME

2.1 Materials

2.1.1 Cement

The Portland Pozzolana Cement conforming to IS 1489-1991 was used in this study. The specific gravity, initial and final setting time of PPC were 3.15, 30 and 600 minutes respectively.

2.1.2 Fine Aggregate

Locally available river sand conforming to grading zone II of IS 383-1970. Sand passing through IS 4.75 mm sieve will be used with the specific gravity of 2.65.

2.1.3 Coarse Aggregate

Locally available crushed blue granite stones conforming to graded aggregate of nominal size 12.5mm as per IS 383-1970 with specific gravity of 2.72.

2.1.4 Silica Fume

Silica fume was obtained from Elkem India (P) Ltd., Navi Mumbai conforming to ASTM C1240 as mineral admixture.

2.1.5 Hemp Fibre

Hemp fibre available in the market was used for this experimentation. The length of the fibre was 40mm and the diameter of 1.2mm with the aspect ratio of 33.

2.1.6 Water

Casting and curing of specimens were done with the potable water that is available in the college premises.

2.2 Mix Proportions

In this study, control specimens were designed as per IS 10262-2009 to achieve M30 grade of concrete. Silica fume was used to reduce PPC at 10% and the hemp fibre of 0%, 0.5% & 1% were used. The mix proportion of different mixes is shown in Table 1.

Table – 1: Concrete Mix Proportions

Mix	**MCS**	**MSF**	**MSFH 1**	**MSFH 2**
Cement (kg/m^3)	413	372	372	372
FA (kg/m^3)	988	988	988	988
CA (kg/m^3)	883	883	883	883
SF (%)	0	10	10	10
GF (%)	0	0	0.5	1.0
Water (lit/m^3)	197	197	197	197

2.3 Casting and Testing of Specimens

For each concrete mix, three number of concrete cubes, cylinders and prism were cast and tested as per IS 516-1959. To obtain a homogenous mix, aggregates were mixed and binders were added to the mix. After remixing, water was added to the dry mix. Cube specimens were used to determine the compressive strength, cylinder specimens were used to determine the split tensile strength and prism specimens were used to determine the flexural strength. After casting, the mould specimens were left in the casting area for 24 hours then de-mould and allowed for wet curing. The specimens were cured for 28 days period to determine the compressive, split tensile and flexural strengths.

3. RESULTS AND DISCUSSION

3.1 Compressive Strength

The cube compressive strength results at 28 days for different replacement levels such as 0% & 10% of cement with silica fume and 0%, 0.5% and 1 % of hemp fibre are presented in Table 2. The development of Compressive Strength with ages for the above different mixes was plotted in the form of graph as shown in Figure 1. The cube compressive strength was observed as 41.58 N/mm^2 for 10% SF and 0% HF there is an increase of strength by 46.5% when compared to control specimen and for the same with 10% SF and 0.5% HF there is an increase of strength by 59.75% for the same with 10% SF and 1% HF there is an decrease of strength by 27.29%. The compressive strength development is due to the pozzolanic reaction of silica fume and the presence of hemp fibre. The rapid rate of strength development is due to the fact that for lower water-binder ratio, the cement particles are held at closer interval than for higher water-binder ratios. Also due to the action of silica fume on calcium hydroxide, more gel is formed. These two factors enhance the formation of a continuous system of gel, which provides better development of strength at early ages since, silica fume starts react with calcium hydroxide and produces C-S-H gel immediately.

Table – 2: Compressive Strength Results

Mix	**MCS** (N/mm^2)	**MSF** (N/mm^2)	**MSFH1** (N/mm^2)	**MSFH2** (N/mm^2)
7 days	21.04	32.1	34.78	17.5
14 days	25.79	37.8	41.2	20.26
28 days	28.369	41.58	45.32	22.286

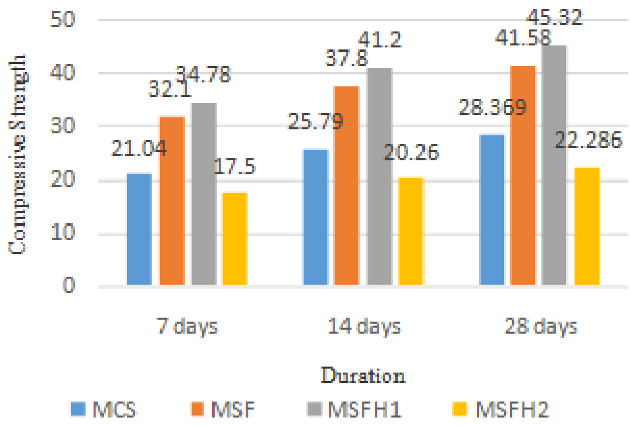

Fig – 1: Compressive Strength Results

3.2 Split Tensile Strength

The split tensile strength results of mixes at the age of 28 days for different replacement levels such as 0% & 10% of cement with Silica fume and 0%, 0.5% and 1% of Hemp fibre are presented in Table 3. The development of Split tensile strength with ages for the above different mixes was plotted in the form of graph as shown in Figure 2.The cylinder split tensile strength was observed as 6.3 N/mm^2 for 10% SF and 0.5% HF there is an increase of strength by

40% when compared to control specimen. For the same with 10% SF and 0% HF there is an increase of strength by 18.75% over control specimen. From the test results it was observed that the maximum split tensile strength is obtained for mix with 10% SF and 0.5% HF.

Table – 3: Split Tensile Strength Results

Mix	MCS (N/mm^2)	MSF (N/mm^2)	MSFH1 (N/mm^2)	MSFH2 (N/mm^2)
7 days	3.1	2.508	3.06	2.6
14 days	3.16	3.1	5.2	2.7
28 days	4.5	4.75	6.3	3.27

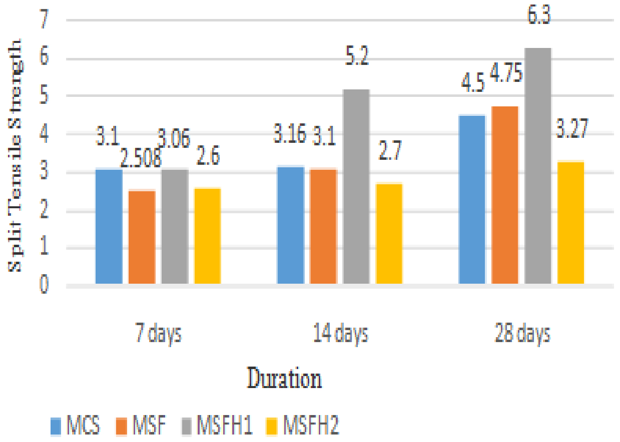

Fig – 2: Split Tensile Strength Results

3.3 Flexural Strength

The Flexural Strength results of mixes at the age 28 days for different replacement levels such as 0%, 10% and 20% of cement with Silica fume are presented in Table 4. The development of Flexural Strength with ages for the above different mixes was plotted in the form of graph as shown in Figure 3. The prism flexural strength was observed as 5.430 N/mm^2 for 10% SF and 0.5% GF there is an increase of strength by 13.2% when compared to control specimen and for the same with 10% SF and 0% GF there is an decrease of strength by 1.9%. From the test results it was observed that the maximum flexural strength is obtained for mix with 10% SF and 0.5% GF. In the replacement of SF the mix with 10%SF+0.5%GF was observed that the maximum Flexural strength at the water-binder ratio of 0.26.

Table – 4: Flexural Strength Results

Mix	MCS (N/mm^2)	MSF (N/mm^2)	MSFH1 (N/mm^2)	MSFH2 (N/mm^2)
7 days	3.2	4	3.8	2.4
14 days	5	5	4.7	3.6
28 days	5.3	5.2	6	4.2

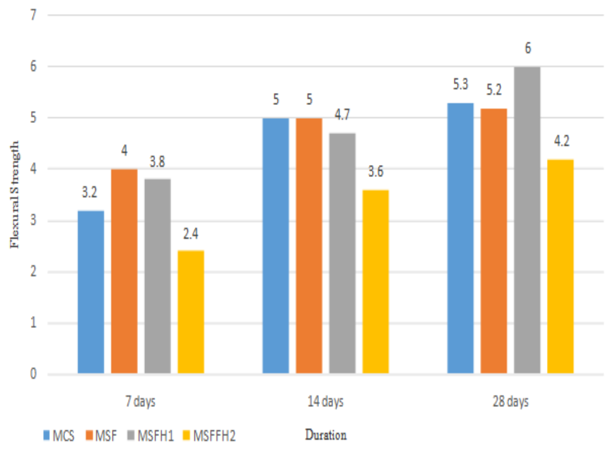

Fig – 3: Flexural Strength Results

4. CONCLUSION

The following conclusions are arrived from this study,

1. The effect of silica fume and hemp fibre in the concrete are studied. From the obtained results, 0.5% Hemp fibre can be taken as the optimum dosage, which can be used for attaining maximum possible strength at the age of 28 days for Hemp fibre reinforced concrete.
2. From the obtained results, 10% silica fume can be taken as the optimum dosage, which can be used for giving maximum possible strength at the age of 28 days for Hemp fibre reinforced concrete.
3. The percentage increase in compressive strength at 28 days of 10% silica fume with 0.5% hemp fibre over control specimen without silica fume and hemp fibre is 59.75%.
4. The percentage increase in split tensile strength at 28 days of 10% silica fume with 0.5% hemp fibre over control specimen without silica fume and hemp fibre is 40%.
5. The percentage increase in flexural strength at 28 days of 10% silica fume with 0.5% hemp fibre over control specimen without silica fume and glass fibre is 13.2%.
6. From the experimental results, the optimum percentage recommended as 0.5% hemp fibre volume with 10% silica fume for achieving maximum benefits in compressive, split tensile and flexural strength.

The utilization of silica fume in an effective manner in concrete instead of dumping it as an industrial waste material. Usage of naturally available hemp fibre will have positive effect in the atmosphere

REFERENCES

[1]. IS 516-1959 (Reaffirmed 1997), 'Methods of Tests for Strength of Concrete', Bureau of Indian Standards, New Delhi, India.

[2]. IS 383-1970, (Reaffirmed 1997), 'Specification for Coarse and Fine Aggregate from Natural Sources for Concrete', Bureau of Indian Standards, New Delhi, India.

[3]. IS 456-2000, (Fourth Revision) "Plain and Reinforced concrete -Code of practice" Bureau of Indian Standards, New Delhi, India.

[4]. IS 10262-2009, "Guidelines for concrete mix design" Bureau of Indian Standards, New Delhi, India.

[5]. Rahul Dogra., Ankit., " Effect of Silica fume on various properties of Fibre Reinforced Concrete" - International Journal of Civil Engineering and Technology, Vol.7, 2016, 542-548.

[6]. K.Ramadevi., S.Deepa Shri., "Flexural Behaviour of Hemp fibre Reinforced Concrete Beams" – APRN Journal of Engineering and Applied Sciences, Vol.10, 2015, 6147-6150.

[7]. Dilip Kumar Singha Roy., Amitava Sil., "Effect of Partial replacement of Cement by Silica fume on Hardened Concrete" – International Journal of Emerging Technology and Advanced Engineering, Vol.2, 2012, 472-475.