INVESTIGATION ON THE PERFORMANCE AND DURABILITY OF HEMP CONCRETE

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Abstract- *The fibers are most effective material to concrete strength. Hemp (Cannabis sativa) is an agricultural crop that can be used as a building material. Hemp concrete has many advantages as a building material but it is not load-bearing and must be used in combination with a load-bearing wooden frame. In this project Cylinders, Prisms, and Cubes of standard dimensions have been made to introduce hemp Fiber with varying mix ratio such as 0.25%, 0.50%, 0.75%. Various tests are conducted to find the property of the hemp concrete materials. The main test such as Compressive Strength for Concrete and Split Tensile Strength for Concrete and Flexural Strength for Concrete have been conducted. On comparing the results of Hemp fiber Concrete with that of conventional concrete, 0.50% additionally adding of Hemp Fiber showed maximum compressive Strength value at 28 days 12.8%, and the Split Tensile Strength value at 28 days 58.28%. Mechanical properties like Flexure Strength and Durability properties have been conducted. Study of microstructure of concrete is also determined.*

***Key Words*: Hemp Fiber, Addition of Hemp Fiber, Compressive Strength, Split Tensile Strength, Flexural Strength**...

1. INTRODUCTION

The most of the natural fibers are have been also investigated such the fibers are Wood, Sisal, Jute, Bamboo, Coconut, Asbestos and Rock Wool, are examples that have been used and investigated. The natural fibers are used to increasing the flexural strength and also providing a ductile post-cracking behaviour, especially for the industrial hemp samples. Similar to the compression tests, specimens prepared with 0.75 or 1% hemp fibers and 20% reduction in coarse aggregate provided relatively good results.

2. MATERIALS USED

2.1 CEMENT

The cement used for this study is Ordinary Portland Cement (OPC) Of 43 grade as per IS 12269-1987.

Fig -1: Cement

2.2 SAND

The processed sand is marketed in three grades (Grade I, Grade II, and Grade III). Fine aggregate is normally considered material that will pass through sieve having 4.75 mm (No.4) mesh. River sand, (Grading zone-II conforming to IS: 383-1987) was used as fine aggregates in the experimental investigation.

2.3 HEMP FIBER

Hemp (botanical name: Cannabis sativa) is a waste material from the agricultural production. General chopped hemp size used is 1.0-2.5, Because of its highly porous structure and strong capillarity effects inside the tubes, hemp is able to absorb large amounts of water (up to 10 times its own weight) . Hemp aggregate absorbs big quantities of water (325% of its own weight at 24 h), as a result it can hold mixing water that is required for hydration and carbonation.

2.4 WATER

The qualities of water samples are uniform and potable condition. The pH value ranging from 6-8 and the water content is free from the organic matter and the solid content should be within the permissible limit conforming to IS 3025-1964.

2.5 FINE AGGREGATE

The coarse aggregate is taken from the crushed Basalt rock, conforming as per IS: 383 was to be used. Coarse

aggregate were used in this project 20 mm and retained in 4.75 mm sieve.

3. MATERIALS PROPERTIES

Table – 1: Properties Of Cement

S. No.	Description	Result Obtained
1.	Normal consistency	30%
2.	Initial setting time (min)	43
3.	Final setting time (min)	442
4.	Specific gravity of cement	3.15

Table – 2: Properties Of Fine Aggregate

S. No.	Description	Result Obtained
1.	Fineness modulus	2.52
2.	Specific gravity	2.56
3.	Grading zone	II

Table – 3: Properties Of Hemp Fiber

S. No.	Description	Result Obtained
1.	Water Absorption	90%
2.	Specific gravity	1.5

4. RESULTS AND DISCUSSION

4.1 COMPRESSION TEST

The Compressive strength depends on water-cement ratio, cement strength, quality of material, and quality control during production of concrete. Test specimen of cube size is 150mm×150mm×150mm were casted and cured for 28 days in tap water. After the specimens are dried in open air, subjected to Cube Compression Testing Machine. The results were reported, the Cube Compressive Strength (f_{cu}) was computed from the fundamental principle as

Calculation

Compressive strength is calculated using the following formula

$$f_{cu} = \text{load at failure / Cross sectional area} = P/A_s \ (N/mm^2)$$

Where,
P = Load at failure (N)
A_s = Area of the specimen (mm^2)

Table – 4: Compressive Strength of Concrete with Hemp Fiber

S.No.	Addition of Hemp fiber %	Compressive strength (f_{ck}) N/mm^2		
		7th day	14th day	28th day
1	0%	18.25	20.12	24.04
2	0.25%	20.13	21.45	25.12
3	0.50%	22.03	23.65	27.12
4	0.75%	21.05	22.14	26.09

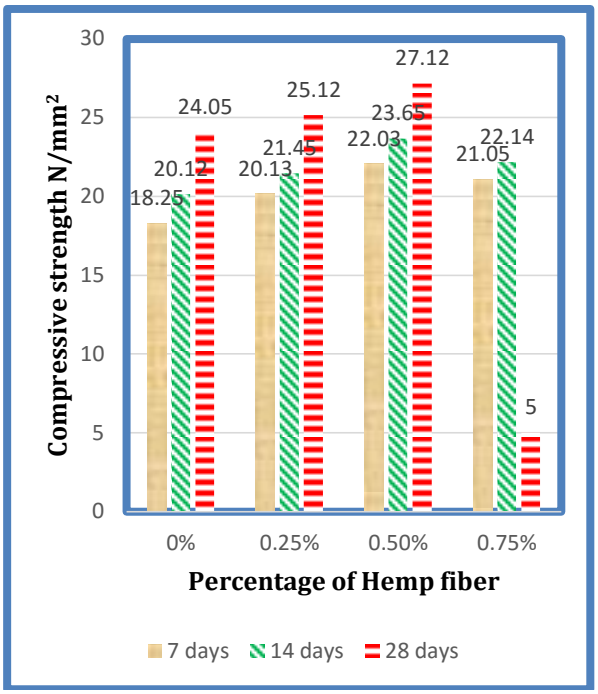

Fig -2: Compressive Strength Results

In 28 day curing Compressive Strength value for the control mix was 25.12 N/mm², for adding 0.50% Hemp fiber the Compressive Strength value is 27.12 N/mm², the strength was gradually increased and reduced to 26.09 N/mm² for 0.75% addition of Hemp fiber. **Strength increment is 0.50% more than the nominal mix when Hemp fiber is added upto 0.75%and this percentage the strength decreases.**

4.2 SPLIT TENSILE STRENGTH TEST

Determination of split tensile strength of concrete specimens, and the cylinder specimens of diameter to length ratio1:2 was selected, with diameter as 150 mm and the length as 300 mm. After the specimens are dried in open air, subjected to split tensile test under universal testing machine. The rate of loading was adjusted as 0.11 to 0.023 MPa/sec as per ASTM C496-90.while testing the specimens, plywood pieces one at the top and the other at the bottom. The split tensile strength (f_{sp}) was obtained using the formula,

$Fsp = 2P/\pi DL$ (N/mm^2)

Where,

P = load at failure (N).

D = Diameter of specimen (mm).

L = Length of specimen (mm).

Table – 5: Split Tensile Strength of Concrete with Hemp Fiber

S.No.	Addition Of hemp fiber %	Split tensile strength of concrete (f_{ck}) N/mm^2		
		7th day	14th day	28th day
1	0%	1.70	1.94	2.13
2	0.25%	2.03	2.12	2.56
3	0.50%	2.82	3.18	3.37
4	0.75%	2.12	2.92	3.01

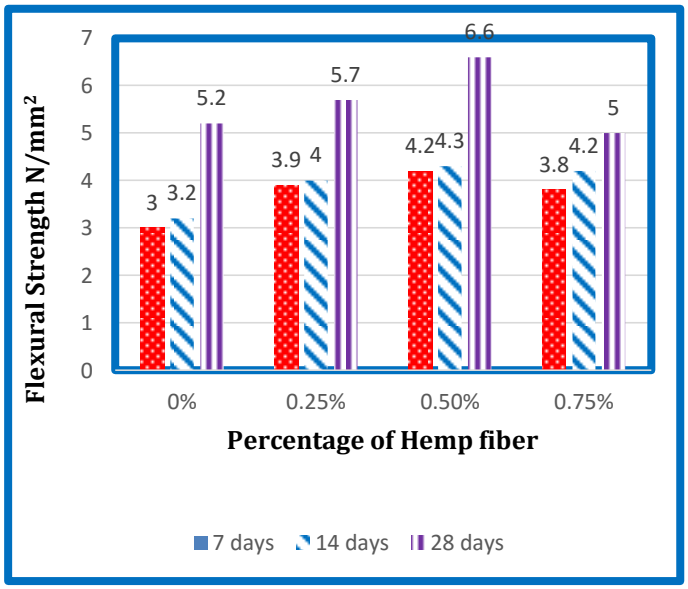

Fig -3: Split Tensile Strength Results

In 28 day curing Split Tensile Strength value for the control mix was 2.56 N/mm^2, for adding 0.50% Hemp fiber the Compressive Strength value is 3.37 N/mm^2, the strength was gradually increased and reduced to 3.01N/mm^2 for 0.75% addition of Hemp fiber. Strength increment is 0.50% more than the nominal mix when Hemp fiber is added upto 0.75%and this percentage the strength decreases.

4.3 FLEXURAL STRENGTH TEST

The beam specimen of size 100mm x 100mm x 500 mm were casted to determine the Flexural strength of concrete with various percentages of Hemp Fiber. Specimens were dried in open air after 28 days at curing and it is subjected to flexural strength test. Apply the load at a rate that constantly increases the maximum stress until rupture occurs. The fracture indicated in the tension surface within the middle third at span length. Finally the Flexural strength is calculated by using simple bending equation the bending stress

$\sigma = Pl/bd^2$ (N/mm^2)

Table – 6: Flexural Strength of Concrete with Hemp Fiber

S.No.	Addition Of hemp fiber %	Flexural strength of concrete (f_{ck}) N/mm^2		
		7th day	14th day	28th day
1	0%	3.0	4.0	5.2
2	0.25%	3.2	4.1	5.7
3	0.50%	4.2	**4.3**	**6.6**
4	0.75%	3.8	4.2	5.6

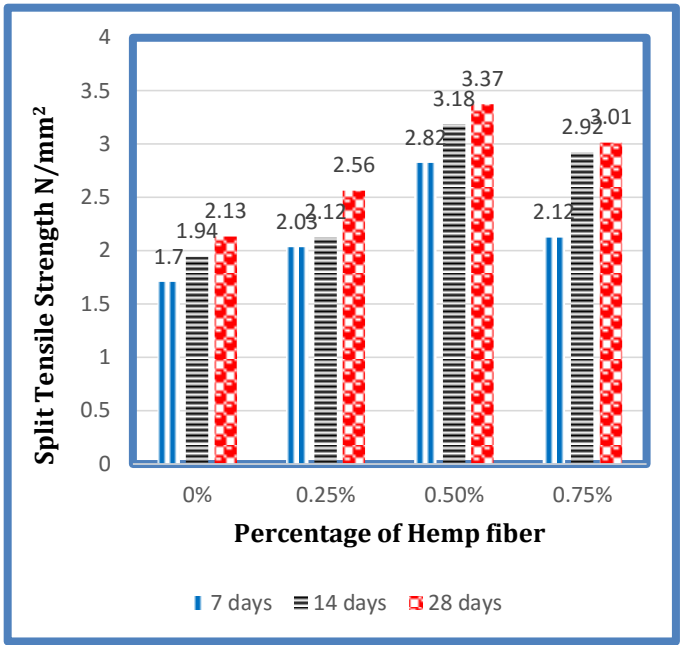

Fig -4: Flexural Strength Result

- In 14th day curing, the flexural strength value for the control concrete was 3.2 MPa and Hemp Fiber -0.25% was 4.0 and beyond this percentage of adding of hemp Fiber, strength was gradually increased 4.3 MPa for 0.50% addition of Hemp Fiber and the Flexural strength was gradually decreased 4.2 MPa for 0.75 % addition of Hemp Fiber.

- In 28th day curing the flexural strength value for the control concrete was 5.2 MPa and Hemp Fiber-0.25% was 5.7 MPa and beyond this percentage of adding of Hemp Fiber, strength was gradually increased and reaching 6.6 MPa for 0.50% addition of Hemp fiber and the Flexural strength was gradually decreased 5.6 MPa for 0.75 % addition of Hemp Fiber.

5. CONCLUSION

- On performing the various test is Mechanical properties, Durability properties are studied and the following conclusions are arrived.
- On comparing the results of Hemp concrete with that of conventional concrete, 0.50% additionally adding of Hemp fiber showed maximum Compressive strength value.
- On 0.50% addition of Hemp concrete, the Compressive Strength is 20.7%, 17.5% and 12.8% higher than that of the conventional concrete at 7 days, 14 days and 28 days curing respectively.
- On comparing the results of Hemp concrete with that of conventional concrete, 0.25%,0.50% and 0.75% additionally adding for Hemp fiber showed maximum Compressive strength value at 28 days 4.49%, 12.8% and 8.52%.
- The Split Tensile Strength of Concrete percentage is 65.8%, 63.97% and 58.2%, additionally added for Hemp fiber 0.50%. Hence the Split Tensile Strength value is higher than that of the conventional concrete at 7 days, 14 days and 28 days curing respectively.
- On comparing the results of Hemp concrete with that of conventional concrete, 0.25%, 0.50% and 0.75% additionally adding for Hemp fiber showed maximum Split Tensile Strength value at 28 days 20.18%, 50.21% and 41.31%.
- Hence it is concluded that the optimum amount of Hemp fiber is 0.50% which shows improved Mechanical, Durable properties of Hemp concrete.
- The Flexural Strength of Concrete percentage is 40%, 7.5% and, 26% additionally added for Hemp fiber 0.50%. Hence the Flexural Strength value is higher than that of the conventional concrete at 7 days, 14 days and 28 days curing respectively.

Hence it is concluded that the Optimum amount of Hemp fiber is 0.50 % which shows improved Mechanical, Durable and Microscopic properties for Hemp Fiber Concrete.

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