EXPERIMENTAL INVESTIGATION ON THE PHYSICAL PROPERTIES OF HEMP CONCRETE ON ADDITION OF LOW CARBON MATERIAL

J Keren Kana[1], Mr. M. Srihari[2], Dr .S. Suresh Babu[3]

[1]PG Scholar, Department of Civil Engineering, Adhiyamaan College of Engineering, TN, India.
[2]Assistant Professor, Department of Civil Engineering, Adhiyamaan College of Engineering, TN, India.
[3]Head of the Department, Department of Civil Engineering, Adhiyamaan College of Engineering, TN, India.

Abstract - *With concern growing in regards to global warming, climate change and the depletion of the Earth's resources, a new focus on environmental sustainability has arisen throughout the world. Sustainability is "the maintenance of ecosystem components and functions for future generations" .Sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Thus a sustainable building material can be defined as a material that is harvested, produced or manipulated to a usable building form in such a way as to have no negative impact on future generations during the material's life cycle and disposal. The building and construction industry accounts for up to 40% of the world's energy usage and approximately 40% of its raw material usage. More sustainable building materials therefore have the potential to have a large impact on global environmental problems.*

In this paper, the experimental investigation is done in hemp concrete of m_{40} grade on addition of fly ash which is a low carbon material and it is tested for compressive and split tensile strength. This study investigates the potential use of hemp fiber and optimum percentage addition of fly ash in hemp concrete. Fly ash is an effective substitute for Portland cement and economical.

Key Words: Sustainability, Sustainable Building, Low carbon materials, Hemp concrete, Fly ash.

1. INTRODUCTION

Concrete have been tested and approved as the mainstay materials for the building and construction industry. However, each of these materials must be extracted or harvested at one or several sites, transported to a different location for processing, and transported again to the construction site for installation.

The amount of energy required for these operations and the disposal of material is called embodied energy. For each of these steps, energy is used and waste is produced, albeit at varying levels depending on which material is harvested. Timber is generally recognized as the material with the least embodied energy of the three. More sustainable building materials, such as straw bale and earth, have substantially less embodied energy than processed materials. With concern growing in regards to global warming, climate change and the depletion of the Earth's resources, a new focus on environmental sustainability has arisen throughout the world.

Sustainability is "the maintenance of ecosystem components and functions for future generations" and sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Thus a sustainable building material can be defined as a material that is harvested, produced, or manipulated to a usable building form in such a way as to have no negative impact on future generations during the material's life cycle and disposal.

1.2 Low Carbon Material

Low carbon building materials are those which emit lesser carbon into the atmosphere in comparison with other building materials. These materials could be recycled easily and would be able to reuse.

There is no emissions threshold under which a building material would qualify as a low carbon building material. But to be genuinely "Climate Change neutral", a low carbon building material would have to achieve at least 80% green house gas reduction compared to traditional buildings.

According to the Stern Review on the Economics of Climate Change, our emissions would have to be reduced by 80% compared to current levels in order not to exceed the Earth's natural capacity to remove green house gas from the atmosphere. By comparison, a regular building releases about 5,000 kg CO2e/m2 during its entire lifetime (though it varies a lot, depending on the project type and where it is located). Thus, this emission could be greatly reduced with the use of low carbon building materials in construction.

2. MATERIALS USED

2.1 Hemp Fiber

Hemp is a fast growing annual crop (1.5 - 4m height) which is mainly grown for its high tensile strength natural fiber which grows in the stem around the woody core of the plant.

This woody core of the plant is chopped up into small sizes (5-25mm) and mixed with lime, water and a small quantity of cement to form a bio-composite mix called hempcrete.

Fig -1: Stem of Hemp showing fibers

Separation of hurd and bast fiber is known as de-cortication. Traditionally, hemp stalks would be water-retted first before the fibers were beaten off the inner hurd by hand, a process known as scutching.

As mechanical technology evolved, separating the fiber from the core was accomplished by crushing rollers and brush rollers, or by hammer-milling, wherein a mechanical hammer mechanism beats the hemp against a screen until hurd, smaller bast fibers, and dust fall through the screen.

After the Marijuana Tax Act was implemented in 1938, the technology for separating the fibers from the core remained "frozen in time". Recently, the new high-speed kinematic de-cortication has come about, capable of separating hemp into three streams; bast fiber, hurd, and green microfiber.

Table -1: Properties of hemp Fiber

S.No	Properties	Values
1.	Water Absorption	0.68
2	Specific Gravity	1.48

2.2 Fly Ash

Fly ash is also called as flue ash or pulverized flue ash (PFA). It is a by-product of the coal combustion process, particularly in the electricity generating power stations. It is formed when fine particulates of burned coal fuse in suspension and are driven out with flue gases.

As they are driven out of the combustion chamber, the fused material cools and forms glassy particles called as fly ash. Modern coal-fired power plants generally make use the particle filtration equipment to catch the fly ash before it reaches the chimneys. There are two classes of fly ash namely Class C and Class F.

Fig -2: Classes of Fly Ash

The chemical components of fly ash will depend on the type of coal being burnt and its origin. Typically, if the coal derives from coal-bearing rock strata, the fly Ash will include silicon dioxide (SiO_2), Aluminum oxide (Al_2O_3) and calcium oxide (CaO).

Table -2: Properties of Fly Ash

S.No	Properties	Values
1.	Water Absorption	0.68
2	Specific Gravity	1.48

2.3 Cement

Ordinary Portland cement of 53 grade conforming to IS 12269. The physical properties of the cement used in this work were tested prior to use as per laid down IS specifications.

Table -3: Properties of Cement

S.No	Properties	Values
1.	Fineness of Cement	5%
2	Percentage of Water	28%
3.	Initial Setting Time	55 mins
4.	Final Setting Time	10 hrs
5.	Specific Gravity	3.25

2.4 Fine Aggregate

The Fine Aggregate was screened to remove deleterious materials and tested as per procedure given in IS 2386-1963.

Table -4: Properties of Fine Aggregate

S.No	Properties	Values
1.	Fineness Modulus	3.79
2	Specific Gravity	2.76
3.	Water Content	1.2%

2.5 Coarse Aggregate

Coarse Aggregate is an important constituent in concrete, reduce shrinkage and effect economy. One of the most important factors that influence the workability of concrete is gradation of aggregates.

Table -5: Properties of Coarse Aggregate

S.No	Properties	Values
1.	Fineness Modulus	3.11
2.	Specific Gravity	2.51
3.	Moisture Absorption	0.8%

2.6 Water

The water used for the concrete mix was ensured to be free from harmful chemicals, organic material, oil, chloride, silt and suspended materials conforming IS 456-2000.

3. CASTING

The proper mix design is done to achieve the target mean strength and using of materials with required proportion as per the Indian Standard code provisions. The compressive strength of hemp concrete was determined by cubes. The split tensile strength was determined by cylinder.

3.1 Mixing of Concrete

Thorough mixing of material is necessary for the production of uniform course. The mixing should ensure that the mass becomes homogenous, uniform in color and consistency. As the mixing cannot be thorough, it is desirable to add 10% more materials. The mixing was done by concrete mixer. First, water was poured inside the drum. Rotate the drum and then add coarse aggregate, cement in the desired quantity and Hemp in 10%, 15% and 20% to obtain the hemp concrete. And, the fly Ash hemp concrete was obtained by the addition of Fly Ash in 5%, 10% and 15% to the potential hemp concrete mixture. The drum was rotated without seize in order to obtain a homogenous mixture.

3.2 Casting of Specimen

Cube moulds of size 150mm × 150mm ×150mm and cylinder moulds of size 150 mm diameter and height 300 mm were used for casting the specimen. The fresh mixed concrete was poured into the moulds and the top surface was flattened with a trowel. The casted specimen were allowed to set for 24 hours and then removed from the mould.

Fig -3: Casted cubes

Fig -4: Mixing of concrete

4. RESULTS AND DISCUSSIONS

4.1 Compressive Strength

For cube compression testing of hemp concrete and fly ash hemp concrete, 150 mm cubes were employed. The compression test on the hemp concrete cubes was done by replacing cement by 10%, 15% and 20% of hemp. Also, the compressive test was done on the cast specimen of replacement with 5%, 10% and 15% addition of Fly Ash to the hemp concrete.

Fig -5: Compression test on Cubes

Compression Strength = Applied Load/ Area

Table -6: Compressive Strength test results of hemp concrete

Mix Name	Hemp Fiber	Compressive Strength in 7 days	Compressive Strength in 28 days
CC	0	22.4	24.5
HC-1	10%	19.49	25.5
HC-2	15%	22.53	30.36
HC-3	20%	21.59	27.41

Table -7: Compressive strength test results of Fly Ash hemp concrete

Mix Name	Hemp Fiber	Compressive Strength in 7 days	Compressive Strength in 28 days
CC	0	22.56	23.94
FHC-1	5%	24.16	31.18
FHC-2	10%	25.64	35.61
FHC-3	15%	25.25	34.68

4.2 Split Tensile strength

For split tensile test on hemp concrete and fly ash hemp concrete of cast cylindrical specimen were employed. The split tensile test on the hemp concrete cubes was done by replacing cement by 10%, 15% and 20% of hemp. Also, the split tensile test was done on the cast specimen of replacement with 5%, 10% and 15% addition of Fly Ash to the hemp concrete.

Table -8: Split tensile test results of hemp concrete

Mix Name	Hemp Fiber	Split Tensile Strength in 7 days	Split Tensile Strength in 28 days
CC	0	2.14	2.86
HC-1	10%	1.82	2.92
HC-2	15%	3.82	2.42
HC-3	20%	3.36	2.16

Table -9: Split tensile test results of Fly Ash hemp concrete

Mix Name	Hemp Fiber	Split Tensile Strength in 7 days	Split Tensile Strength in 28 days
CC	0	2.08	2.92
FHC-1	5%	2.21	3.26
FHC-2	10%	2.51	4.13
FHC-3	15%	3.31	3.41

4.3 Software Analysis

The results were tabulated and the software analysis was done by designing a concrete beam with the obtained values using ansys software and the outputs were taken.

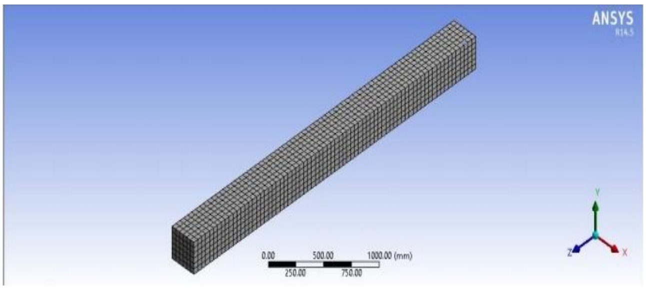

Fig -6: Modeling and Meshing of concrete beam

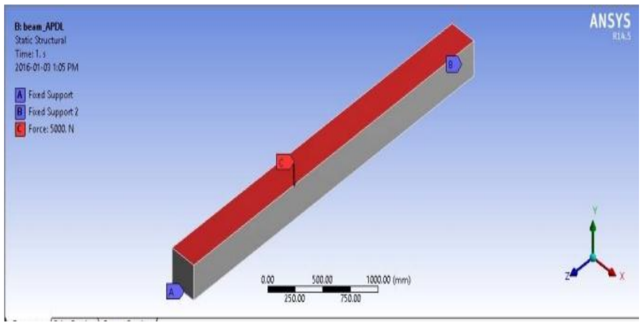

Fig -7: Application of point load at the end of the beam

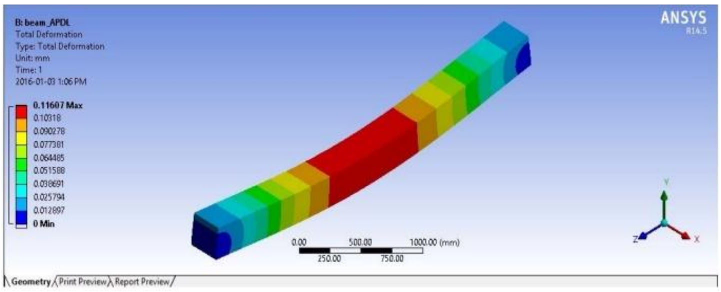

Fig -8: Total deflection of the beam

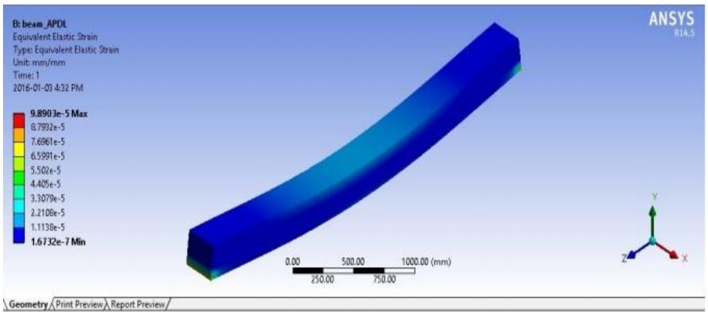

Fig -9: Equivalent Elastic strain

5. CONCLUSIONS

- It was found that the compression and split tensile strength increases for 15 % replacement of cement with hemp.
- The optimum percentage of fly ash is found to be 10% from compression and split tensile strength test.
- Compressive strength of fly ash-hemp concrete with 10% fly ash gives higher compressive strength as compared to conventional concrete.
- The software analysis using ansys have proved that a Sustainable beam could be designed with fly ash-hemp concrete.
- The usage of cement is reduced by the replacement of fly ash. Fly Ash-Hemp concrete paves a way to develop a sustainable concrete.

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