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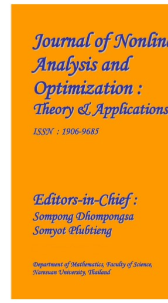

PARTIAL REPLACEMENT OF CEMENT IN CONCRETE WITH WOOD HUSK BIO-CHAR

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ABSTRACT

The porous carbon known as biochar (BC) is created when biomass is pyrolyzed at high temperatures in an anoxic environment. Because it can trap BC in inert materials and cut cement consumption at the same time, the use of pulverized BC as a cementitious materials mixture has lately garnered research impetus.**[1]** An overview of the application of BC particles as an additive or cement substitute in cementitious composites during the past few decades is given in this research. The physicochemical characteristics of BC are thoroughly reviewed and discussed, along with how BC affects the hydration kinetics, workability, mechanical properties, physical qualities, and durability of mortar or concrete**[2,3]**. Cementitious composites' permeability is reduced and their mechanical strength is increased when 1%–3% BC is substituted for cement in weight.

The fineness of the carbonaceous particles, the feedstock, the temperature during pyrolysis, and the manner of treating the BC all have a direct impact on the properties of the BC-cement composites.**[4]** It is anticipated that additional study will yield cementitious materials based on BC for the preparation of a particular BC for a particular use as cementitious mixture. India produces about 960 million metric tons of solid waste annually, including wood waste, which can cause environmental problems. The wood industry is growing rapidly, with about 600–700 units operating across the country. The industry needs to utilize, market, or dispose of its waste properly.

Regulatory bodies are paying more attention to the environmental effects of the cement and concrete sectors, and in order to produce more sustainably, new solutions must be developed**[5]**. One potential solution to lessen the associated negative effects, such carbon dioxide emissions

and raw material consumption, is to employ waste materials as fillers in cement-based admixtures or as a partial replacement of cement and/or aggregates**.[6]** This study investigates the potential application of biochar, a porous, carbon-rich solid by-product obtained through carefully controlled thermochemical conversion of leftover biomass, as a structural concrete filler.[5] The biochar utilized in this investigation comes from a commercial facility that uses the pyro-gasification of wood waste to create energy**[7-10]**. Following its initial chemical and morphological analysis, biochar is added to concrete in a variety of percentages, up to 10% of the cement's weight, as a **fille[11]**. Its introduction's effects on the internal matrix microstructure, the physical and mechanical properties of both fresh and hardened concrete, are assessed and contrasted with those of a reference concrete. A variety of curing times (up to 365 days) and conditions (wet and dry) are processed in order to assess the long-term behavior and internal curing action of biochar on concrete.
Key words: Wood husk, Biochar (pyrolysis process), Biochar concrete cubes, Compressive strength.

INTRODUCTION

It is projected that 60% of people on Earth will reside in cities by 2030. Despite making up only 3% of the planet's land area, cities consume 60%–80% of its energy and emit 70% of its carbon emissions**[12]**. All efforts toward more environmentally friendly cities and industries, as well as toward consumer behavior and product processes that can advance both economic growth and public health while safeguarding the environment, are highly encouraged by the 2030 Agenda for Sustainable Development. Since the cement and concrete industry represents the cornerstone of both contemporary and future cities, it is also the focal point of initiatives aimed at enhancing the resilience and sustainability of the urban environment by allowing population expansion to be sustained while using ecologically friendly building practices**[13-16].**The adoption of more environmentally friendly building materials is unquestionably the first step toward achieving this goal. In this context, research attention has been directed toward concrete, the world's most widely used building material with a production volume of almost 20 billion cubic meters**[17-20]**. It is important to note that since the 1990s, manufacturers of cement and concrete have paid more attention to the energy consumed, the natural resource consumption, and the pollutant emissions associated with their production. It should be highlighted that the cement business, which includes the CO2 released in the clinker industrial process from the calcination of limestone, the burning of fuels in the kiln, and the production of power, accounts for roughly 5–7% of worldwide anthropogenic CO2 emissions**[21].**Through the application of circular economy principles, numerous attempts have been made to mitigate these adverse effects by creating "eco-friendly" concretes that aim to recycle the organic and inorganic waste that is primarily generated by society and industry. This is an urgent problem that needs to be resolved**[22,23]**. Over the past few decades, various types of industrial waste or recycled materials have been added to cement-based products in order to partially replace cement (such as fly ash, silica fume, ground granulated blasted furnace slag, ceramic and glass waste or aggregates (mainly plastics, glass, fly ash, slag, construction and demolition waste)**[24]**. The outcomes in terms of material performance have varied [**6**].The term "biochar" refers to char that is made by biomass pyrolysis, a low-oxygen process that breaks down organic materials at temperatures between 350 and 1000 degrees Celsius. As a result, the final product is usually characterized by large specific surface areas, high pore volumes, and good absorptive capacity in addition to a low ratio of H/C and O/C, which is thought to be an indicator of the degree of chemical stability and carbonization grade. Biochar is utilized today for a variety of purposes, primarily in agriculture as a soil amendment to increase soil fertility, promote plant growth, and supply crop nutrition**[25,26]**. Its ability to fix a significant portion of carbon, as well as its porous structure and water retention property, make it an excellent choice**[27].**Biochar can be used to create lighter materials with better thermal insulation and sound absorptioncapabilities because it typically has low bulk density, low thermal conductivity, and high porosity. Furthermore, its porous microstructure encourages water retention during the mixing stage when added to cement-based composites. This identifies a significant reduction in workability, necessitating the addition of water to the mixture and lowering mechanical strengths as a result**[28]**. However, the inclusion of biochar has a negative effect on flowability; this can be overcome by using superplasticizer. However, the water that has been absorbed is later released, which encourages further reaction and curing and, as a result, somewhat improves mechanical characteristics. Gasification, which typically takes place between 900 °C and 1100 °C, slow pyrolysis (400 °C − 650 °C), or fast pyrolysis (650 °C − 850 °C) can all be used to make biochar. Syngas is the primary output of these processes; waste by products include liquids (tar) and char. Research on chars obtained from commercial plants is relatively rare, although the majority of studies in technical literature focus on the application of biochar derived from pyrolysis plants, which are frequently built for research purposes in a lab or pilot scale . Nonetheless, a sizable amount of waste needs to be disposed of, as the biochar generated by industrial pyro-gasification plants is typically used to produce thermal and electric energy**[29,30].** Therefore, studies are being conducted to see if this trash may be reused in an industrial setting.This study intends to investigate the impact of adding biochar produced from an industrial pyro-gasification power plant to a typical concrete mixture consisting of cement, sand, and coarse aggregate. To assess biochar's impact on concrete's workability, density, shrinkage, compressive and flexural strength, and post-cracking behavior, it is added as a filler in a reference concrete mix at varying percentages, up to 10% by weight of cement, following a chemical and morphological characterization. The created "eco-concretes" are assessed and compared to a reference concrete that does not contain biochar in terms of their fresh and hardened physical-mechanical properties as well as their internal matrix microstructure**[31]**. Different curing times (up to 365 days) and circumstances (wet and dry) are processed. Since the creation of the mechanical strength is a crucial factor in design practice over time and has not yet received much attention in research on cement-based materials containing biochar, this work also attempts to shed light on how the inclusion of biochar affects the long-term behavior of concrete.

MATERIAL USED:

CEMENT:

Cement, in general, adhesive substances of all kinds, but, in a narrower sense, the binding materials used in building and civil engineering construction**[32,33]**. Cements of this kind are finely ground powders that, when mixed with water, set to a hard mass. Setting and hardening result from hydration, which is a chemical combination of the cement compounds with water that yields sub microscopic crystals or a gel-like material with a high surface area. Because of their hydrating properties, constructional cements, which will even set and harden under water, are often called hydraulic cements**[34]**. The most important of these is Portland cement

WOOD HUSK:

The wood husk is the by product of furniture and construction site.Wood waste is any unwanted or discarded material that comes from the processing, manufacturing, or use of wood. This includes tree stumps, trees, tree limbs, bark, sawdust, chips, scraps, slabs, millings, and shavings**[35]**. Wood waste can be natural, such as sawdust and leftover wood from sawmills

Fine aggregate:

Usually, sand is used as fine aggregate. It varies in different sizes from 70 microns to 4.75mm,the most common mineral in the sand is quartz–also known as silicon dioxide and it possesses highly resistant to weather. This is formed when silicon and oxygen combine. Feldspar is the most found group of minerals on the earth's surface and forms about 65% of the terrestrial lrocks. When the wind and sea whip up on the shores, they transport these teeny-tiny granules to the beach and make up the sand with this combination. Sand is a non-renewable resource which never happens twice**[36]**. It is available through various sources desert sand, river sand, lakes and, sea sand, volcanic sand, olivine sand etc., with different colours like white, black, red orange colour, white-grey colour, light-brown colour etc.

Coarse aggregate:

Gravel is the most used coarse aggregate**[37,38,39]**. The size varies from 4.75 to 37.5mm. There are 2 types of aggregates are there rounded and angular, Rounded aggregates require less w/c ratio and byusing these aggregates it improves the workability of concrete but this type of aggregates arenotpreferred when strength is the primary requirement due to its less interlocking mechanism and weak bond strength.

DESIGN MIX CALCULATIONS

PROCEDURE :-

STEP 1 :- Stipulations for Concrete Mix Design

Grade designation : M 30

Type of cement : OPC 53 grade confirming to IS 8112

Maximum nominal size of aggregate : 20 mm

Minimum cement content : 320 kg/m3

Maximum water-cement ratio : 0.45

Workability : 50-75 mm (slump)

Exposure condition : Severe (for reinforced concrete)

Method of concrete placing : Pumping

Degree of supervision : Good

Type of aggregate : Crushed angular aggregate

Maximum Cement Content : 450 kg/m3.

STEP 2 :- Test Data for Materials (to be determined in the laboratory)

Specific gravity of cement : 3.12

Specific gravity of Coarse aggregate : 2.74

Specific Gravity of Fine aggregate : 2.56

STEP 3 :- Target Strength for Mix Proportioning

$f_{target} = f_{ck} + 1.65 \times S$

Explanation of Terms:

ftarget = target average compressive strength at 28 days,

f_{ck} = characteristic compressive strength at 28 days, and

S = standard deviation

The Standard deviation, s is taken as 5.0 N/mm2 (Table I of IS 10262:2009)
Therefore, target strength = 30 + 1.65 x 5.0 = 38.25 N/mm2

STEP 4 :- Selection of Water-Cement Ratio
From Table 5 of IS 456:2000,
Maximum permissible water-cement ratio is 0.45
STEP 5 :- Selection of Water Content
From Table 2 of IS 10262:2009, maximum water content =186 litres (for 25 to 50 mm slump range) for 20 mm aggregate.
Estimated water content =186+(6/100) x 186 =197 litres.
STEP 6 :- Calculation of Cement Content
Water-cement ratio =0.45
Cement content = 197/0.45 = 437 kg/m3
From Table 5 of IS 456, the minimum cement content for 'Severe' exposure condition is 320 kg/m3
In our case, it is 437 kg/m3 which is greater than 320 kg/m3, hence satisfied.
STEP 7 :- The Proportion of the Volume of Coarse Aggregate and Fine Aggregate Content
From Table 3 of IS 10262:2009, the Volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for a water-cement ratio of 0.50 = 0.60.
In the present case, the water-cement ratio is 0.45. Therefore, the volume of the coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is less by 0.10, the proportion of the volume of coarse aggregate is increased by 0.02 (at the rate of -/+ 0.01 for every ± 0.05 change in the water-cement ratio)**[38]**. Therefore, the corrected proportion of the volume of coarse aggregate for the water-cement ratio of 0.45 = 0.61.
Note – In case if the coarse aggregate is not an angular one, then the volume of coarse aggregate may be required to be increased by 10 percent based on experience.
For pumpable concrete, these values should be reduced by 10 percent.
Therefore, volume of coarse aggregate = 0.61 x 0.9 = 0.549.
Volume of fine aggregate content =1 – 0.549 =0.451
STEP 8 :- Mix Calculations
a) Volume of concrete = 1m^3
b) Volume of cement = (Mass of cement/specific gravity of Cement) X (1/1000)
= (437/3.15) X (1/1000)
= 0.1387 m^3
c) Volume of water = (Mass of water/specific gravity of water) X (1/1000)
= (197/1) X (1/1000)
= 0.197 m^3
d) Volume of all aggregate = (a – (b + c)
= 1 – (0.1387 + 0.197)
= 0.6643 m^3
e) Mass of coarse aggregate = Volume of all Aggregate X Volume of Coarse Aggregate X Specific Gravity of Coarse Aggregate X 1000
= 0.6643 x 0.549 x 2.74 x 1000
= 999.279 kg/m^3
f) Mass of fine aggregate = Volume of all Aggregate X Volume of Fine Aggregate X Specific Gravity of Fine Aggregate X 1000

= 0.6643 x 0.451 x 2.74 x 1000
= 820.902 kg/m^3

STEP 9 :- Concrete Mix Proportions

Cement = 437 kg/m^3
Water = 197 litres
Fine aggregates = 820.902 kg/m^3
Coarse aggregate = 999.279 kg/m^3
W/c = 0.45
For 1 Cube of size 150mm*150mm*150mm
Volume of the cube = 150*150*150 = 3375000 mm^3 = 0.003375 m^3
Cement = 1.474 kg
Fine aggregates = 2.77 kg
Coarse aggregate = 3.372 kg
W/c = 0.45

METHODOLOGY

Materials and grade of mix:

- Wood husk cement, fine aggregates, and coarse aggregates are needed for this combination.
- Determine the proper design mix and compute the material proportioning using ratios.
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- Determine the proper design mix and compute the material proportioning using ratios.

Preparing surface cubes:

- Getting the cubes' surface ready
- First, gather the materials needed in accordance with the design composition.
- Form the 150 x 150 x 150 mm biochar cubes into 1%, 3%, 5%, and 7% concentrations.
- After a full day of drying, take out the molds. To cure, submerge the cubes in water.
- To get the findings, test the cubes for seven and twenty-eight days.

Measuring of materials:

- Calculate the required quantity of materials for the cubes as per design mix ratio.
- Next measure the materials quantity and cast the cubes accordingly.

Concrete mixing

- Dry mix: - To begin, combine all the components and stir them together without adding water.
  Mixing the ingredients by hand ensures consistency.
- Wet mix: - After the dry mixing, add water according to the w/c ratio and stir the ingredients for five minutes.
  Efficient mixing produces high strength, whereas slow mixing also lessens slump.

Concrete placement :

- After 30 minutes of mixing, pour the concrete into the previously prepared molds, making sure the molds are tight to prevent water leaks before pouring the concrete.
- Concrete hardens and loses qualities such as strength, durability, weather resistance, and workability when it is placed later.

Compacting & finishing:

- The is concrete is compacted using tamping rod with 25 blows.
- After pacing concrete in mould the blows are provided using tamping rod.

- Compaction should be done to makes the mix dense, to avoid pores and good compaction improves the strength of concrete**,** it should be done with machine compaction. For smooth finishing of surface, finishing should be done by using trowels and removing access concrete to make even surface.

Demulding and curing:

- After 24hrs demould the moulds and remove the cubes.
- Then curing takes place, here curing should be done by placing the cubes in the water and make the burlaps wet during curing period of 7 days and 28 days.
- Proper curing should be maintained throughout the entire time because proper curing leads to increase in strength, reduces shrinkage cracks and improves good hydration process.

EXPERIMENTATIOn

Compression test:

Compression strength test is used to measure the force required to compress the material. Compression tests are conducted by loading the test specimen between two plates, and then applying a force to the specimen by moving the cross-heads together**[39]**. During the test, the specimen is compressed, and deformation versus the applied load is recorded. It is one of the most important properties of concrete and mortar.

Procedure:

Specimen (concrete cube), CTM (Compression testing machine)
1) Clean the cube with dry cloth to remove water content on the surface after curing
2) Remove excess concrete on the surface by trowel and make the cube even.
3) Lift the cube carefully and place it in the middle of the CTM.
4) Set the loaded spring to make in contact with the surface.
5) After contact is made set the loading degree to 0.
6) Then apply the load gradually onto the cube.
7) Note the readings when the first break (crack) formed and final breakage (ultimate load).

RESULT

Load applied on the specimen = 240KN. @7 day – curing,
compressive strength = 24 N/mm2 , @28 day – curing,
compressive strength = 39 N/mm2

Percentage Of Biochar	**Compressive strength of cubes 3days (N/mm^2)**	**Compressive strength of cubes 7days (N/mm^2)**	**Compressive strength of cubes 28days (N/mm^2)**
0	**13.6**	**19.2**	**30.42**
1%	**13.9**	**19.95**	**31.33**
3%	**14.6**	**21.34**	**31.69**
5%	**16.83**	**23.5**	**33.12**

7%	**15.59**	**21.67**	**31.97**
9%	**14.77**	**20.82**	**30.43**

Variation in Compressive Strength of Concrete

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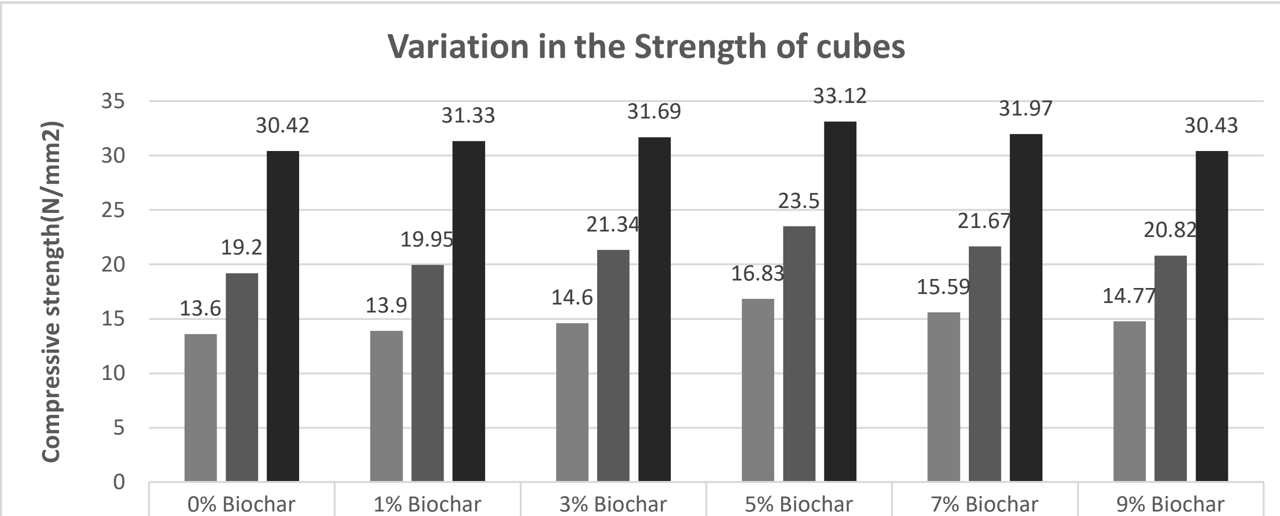

	0% Biochar	1% Biochar	3% Biochar	5% Biochar	7% Biochar	9% Biochar
3days	13.6	13.9	14.6	16.83	15.59	14.77
7days	19.2	19.95	21.34	23.5	21.67	20.82
28days	30.42	31.33	31.69	33.12	31.97	30.43

Fig.1 COMPRESSIVE STRENGTH OF NORMAL AND BIOCHAR CONCRETE CUBES

CONCLUSION :

1. Bio char is which is obtained from the wood husk goes through the carbon sequestration process which leads to greater strength.
2. As the pyrolosis process is used for the production of Biochar which does not effects the environment, this is an raising of the Eco-Friendly construction method with the use of this material in the construction.
3. From the results, it is finally concluded that addition of biochar in the cement concrete helps in increasing the compressive strength.
4. From this study it can be observed that there is an increased in the Compressive Strength of the concrete upto 5% of the increments of Biochar.
5. Increase of Biochar Percentage Greater than 5% when incremented with 7% and 9% there is Decrease in the Compressive Strength of the concrete.
6. As the excess addition of Biochar in the cement is leading to the failure in the structures so it is concluded that 5% of replacement of Biochar in the cement is the Optimum for the Biochar produced for the Wood husk .

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