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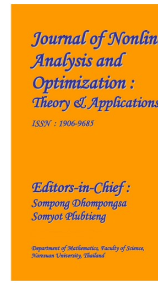

PERFORMANCE OF RICE HUSK BIO-CHAR AND ITS CHARACTERIZATION

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ABSTRACT:
Rice husks, the protective outer layers of rice grains, are a valuable renewable resource that can be utilized as fuel, insulation, fertilizer, or building material[1]. To mitigate potential environmental issues, it is crucial to manage rice residue sustainably. Fortunately, the thermo-chemical conversion of rice husks through techniques like pyrolysis, gasification, and combustion can create useful by-products such as bio-char. Bio-char, with its unique properties and stable chemical characteristics, can significantly reduce the burden on the environment and help address some of the problems in the cement industry, such as reducing CO2 emissions[2]. By analyzing the physical and chemical properties of the rice husk char and incorporating it into the concrete mix as a substitute for cement in varying weight percentages, we can produce concrete with the appropriate properties and improve the compression strength[3] .In addition to the benefits mentioned earlier, using such materials in construction has advantages such as better handling, less fluid separation, lower water requirement, and increased durability of the reinforcing bars against corrosion[4]. Biochar has a wide range of applications such as generating heat and electricity, cleaning flue gases, metallurgy, animal farming, agriculture, construction materials, and medicine. The use of biochar in cement production can reduce the need for cement over time by partially replacing it.[5] This approach promotes sustainable development and encourages the use of eco-friendly materials.

1. INTRODUCTION
Concrete is a highly sought-after building material globally, thanks to its unique benefits when compared to other construction materials. It is readily available due to its affordability and strength, and over 10 billion tons of concrete are produced each year. There has been concern that the production of cement, a key ingredient in concrete, releases pollutants into the environment [6]. To address this issue, researchers have explored the use of alternative materials to mix with cement to make concrete production more sustainable and cost-effective.[7] Bio-char is a sustainable material that has many benefits. It can be prepared quickly and easily and is environmentally friendly. It is also reusable and cost-effective. Bio-char has been used in various applications such as waste water treatment, chemical recovery, agriculture, carbon sequestration and anaerobic digestion [8]. One such material is rice husk bio-char, a carbon-rich substance obtained from the combustion of organic

waste(rice husk) in an oxygen-limited environment. Recent studies have shown that rice husk bio-char can be used as a supplementary contentious material in the production of sustainable concrete.[9] When used in this way, rice husk bio-char can enhance the chemical stability and storage potential of concrete, reduce conductivity, and serve as an internal curing agent, filter material, and carbon absorbent.

1. MATERIALS USED

- Cement: Cement is a substance used for construction that efficiently binds other materials together. Typically, it is used in combination with fine and coarse aggregate.[10] OPC and PPC cements are commonly used in the construction of structures. After being mixed with water, cement hardens and is known for its durability, versatility, and low maintenance requirements.[11] It is composed of various materials, including limestone, clay, silica, alumina, lime, iron oxide, and magnesia.[12] Building with cement offers many advantages, such as financial benefits, strength,[13] versatility, durability, fire resistance, and sustainability.
- Fine aggregates: Fine aggregates are sand which is made by erosion or broken pebbles and weathering of rocks which is transported from land or seas or rivers or any other marine environment. [14]Sand ranging in size from 0.06mm to 2mm.
- Coarse aggregates: Granular materials such as gravel and crushed stone are used as coarse aggregates for preparing concrete.[15] These aggregates are obtained either by blasting quarries or crushing them by hand or with crushers. They are typically [16] larger than 4.75mm and range in size between 9.5mm and 37.5mm in diameter.
- Water: The primary ingredient for creating a binding paste[17] through cement and aggregate is water. The process of hydration causes the hardening of concrete when water is added.[18] The amount of water used in concrete affects its properties such as work-ability, durability, permeability, strength, and resistance to weathering and cracking.[19] Water cement ratio is calculated by dividing the weight of water by the weight of cement used in a concrete mix, and the recommended ratio usually ranges from 0.4 to 0.6.
- Rice husk bio-char: Rice husk bio-char is a substance created through the process of [20]pyrolyzing rice husk at high temperatures without oxygen. This results in the formation of bio-char,[21] a stable form of carbon that can be utilized in multiple ways such as soil amendment for agriculture or as a carbon sink.[22] The primary objective behind the production of rice husk bio-char is to offer an eco-friendly solution [23] for managing rice husk waste while also generating a beneficial product. Additionally, rice husk bio-char can improve the chemical stability and storage capacity of concrete, decrease conductivity,[24] and function as an internal curing agent, filter material, and carbon absorbent.

2. MIX CALCULATION

A. Design mix for M30 for $1m^3$

1. Calculation of target mean strength

$$\begin{aligned} fck &= fck+1.65x \\ &=40+1.65*5 \\ &=48.25\ N/mm^2 \end{aligned}$$

2. Water-cement ratio
   Consider water-cement ratio=0.40 to 0.45 (From IS 10262, Table-5)
3. Size of aggregates
   Consider Fine aggregates = 4.75mm
   Coarse aggregates = 20mm
4. By reference of IS 10262-2009 CODE BOOK IS 456-2000[25]

Volume of cube =0.15*0.15*0.15 =0.003375m^3
Water cement ratio =0.45
Slump value = 100mm
Refer IS 456 and IS 10262-2009
Max Water Content For 20mm Aggregate = 186liters (for 20-50mm slump)
Max Water Content For 100mm slump = 186 + 6/100 x 186 = 197 liters
Cement Content = 197/0.45= 437 Kg
Cement content in m^3 = 437/3.15 x 1/1000 = 0.138 m^3
Water content in m3 = 197/1000 = 0.197 m^3
Total Aggregates = 1- (0.138 + 0.197) = 0.665 m^3
Material weight = material volume x percentage of total volume x material specific gravity x 1000
Fine aggregates = 0.665 x 0.3 x 2.72 x 1000= 542.64 kg
Coarse Aggregate = 0.665 x 0.4 x 2.8 x 1000= 744.8 kg
Dry Concrete = 1m
Wet Concrete = 1 x 1.52= 1.52 m^3
Cement content = 0.138 x 1.52 = 0.209 m^3
Mass of cement = 660.744 kg
Water = 0.197 x 1000 x 1.52 = 299.44 liters
Coarse aggregates = 744.8 x 1.52= 1132.096 kg
Fine aggregates = 542.69 x 1.52 = 824.88 kg

Quantities For 1 Cube:
Volume Of Cube = 0.003375m^3
Cement content = 0.003375 x 660.744= 2.23 kg = 2.4 kg
Water content = 0.003375 x 299.44= 1.01 liters
Coarse Aggregates= 0.003375 x 1132.096 = 3.8 kg
Fine Aggregates = 0.003375 x 824.88 = 2.8 kg

3. METHODOLOGY

A. Materials and grade of mix
- The required materials for this mix are rice husk, cement, fine aggregates and coarse aggregates[26].
- Now proceed with selecting the suitable mix design and determining the proportions of materials based on the required ratios.
- The mix proportions that were mentioned in the previous calculations should now be considered.[27]

B. Preparing the surface of cubes
- Initially take the required amount of materials as per the mixed design.
- Cast the cubes of size 150mm*150mm*150mm in 1%,3%,5%,7%,9%.
- After leaving them[28] to dry for a day, take out the moulds and submerge the cubes in water for the purpose of curing.
- Test the cubes for 3days, 7days & 28days to obtain the results.

C. Measuring of materials
- Calculate the required quantity of materials for the cubes as per the mixed design ratio[29].
- Now measure the material quantities and measure the cubes accordingly.

D. Mixing of Concrete

- Initially mixing should be done by placing and mixing all ingredients without any water.
- After mixing the materials uniformly, add water according to the prescribed water-to-cement ratio,[30] and ensure that all the components are mixed within 5 minutes of adding the water.
- To achieve optimal strength and minimize the slump, it is important to conduct the mixing process quickly.

E. Placing of concrete
- Firstly, pour the mixture of concrete into the molds that were prepared earlier. This should be done within 30 minutes of mixing. Make sure to secure the molds tightly to prevent any water leaks.[31]
- If the placement of concrete is delayed, it hardens over time which can lead to a reduction in its overall strength and durability.

F. Compacting and Finishing
- To enhance the strength of concrete, it is necessary to eliminate pores by compacting. This can be done either manually or by using a machine.
- To achieve a level and polished surface [32], it is recommended to utilize trowels to apply finishing touches to the concrete while also removing any excess material.

G. Demoulding and Curing
- After 24hrs has passed, take out the molds and extract the cubes from them.
- After the concrete has been set, it is important to cure it for a specific period of time.[33] This involves placing the concrete cubes in water for 3 days, 7 days, and 28 days to ensure proper hardening and strength development.
- It is important to maintain the curing time precisely as it helps to enhance the strength of the material and [34] also minimizes the chances of shrinkage and cracks.

H. Testing the cubes
- Remove the cubes from water and dry the cubes before the test.
- Now place the cubes carefully in the middle of Compression Testing Machine (CTM).
- Now SWITCH ON the machine and then apply load gradually on the cube and observe the cube when it started to crack[35].
- Note down the readings from CTM where the cracks are observed on the cubes.

4. RESULT

M30 CONCERTE CUBES WITH RICE HUSK BIO-CHAR									
S.NO	MIX RATIO	% RICE HUSK BIO-CHAR USED	GRAMS	COMPRESSION STRENGTH(N/mm^2)			% INCREASE IN STRENGTH(N/mm^2)		
				3 DAYS	7 DAYS	28 DAYS	3 DAYS	7 DAYS	28 DAYS
1	1:0.75:1.5	0	0	15.52	19.75	30.72	-	-	-
2	1:0.75:1.5	1	25	16	21.5	32.83	3.09	8.86	6.86
3	1:0.75:1.5	3	75	18.75	23	35	20.81	16.45	13.93

4	1:0.75:1.5	5	125	19.5	25.75	40.29	25.64	30.37	31.15
5	1:0.75:1.5	7	175	13	16	28	-16.23	-18.9	-8.85
6	1:0.75:1.5	9	225	11.25	14.25	22	-27.51	-27.8	-28.3

TABLE 1: - COMPESSIVE STRENGTH OF NORMAL & RICE HUSK- CHAR CUBES & PERCENTAGE INCREASED

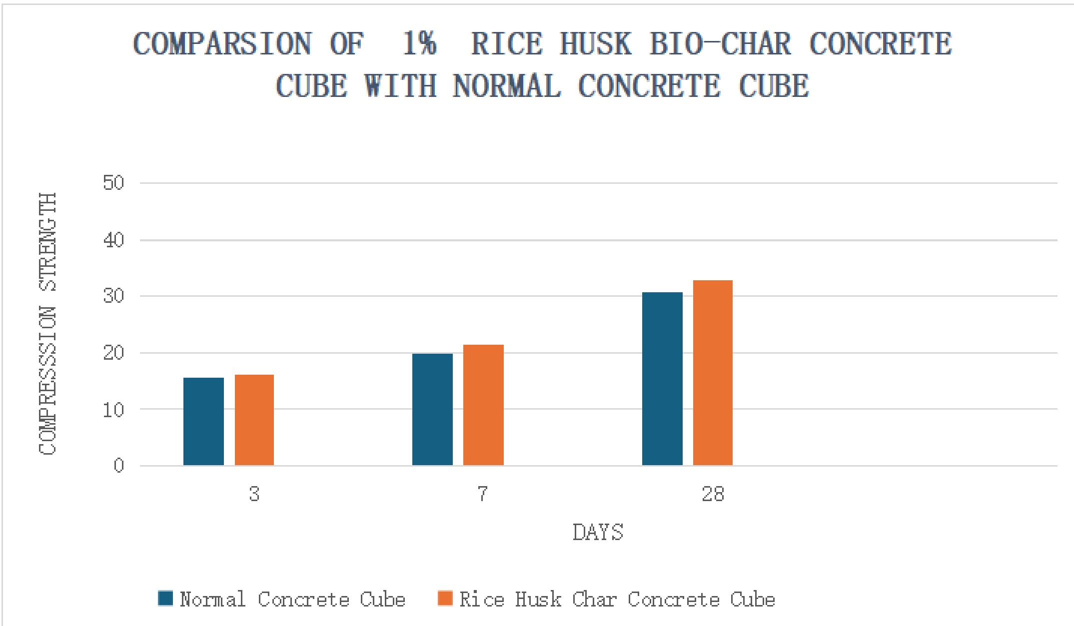

Fig1: - COMPARSION OF 1% RICE HUSK BIO- CHAR CONCRETE CUBE WITH NORMAL CONCRETE CUBE

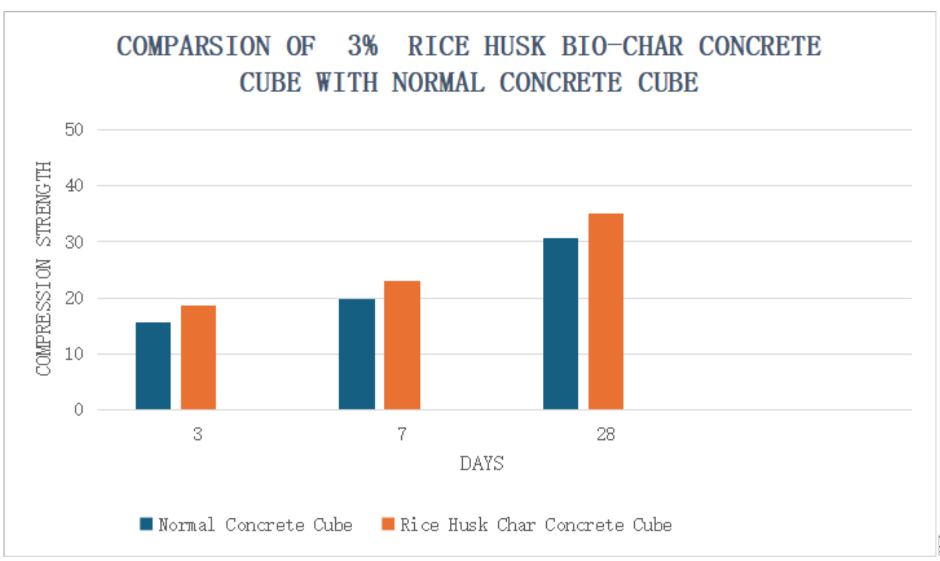

Fig2: - COMPARSION OF 3% RICE HUSK BIO-CHAR CONCRETE CUBE WITH NORMAL CONCRETE CUBE

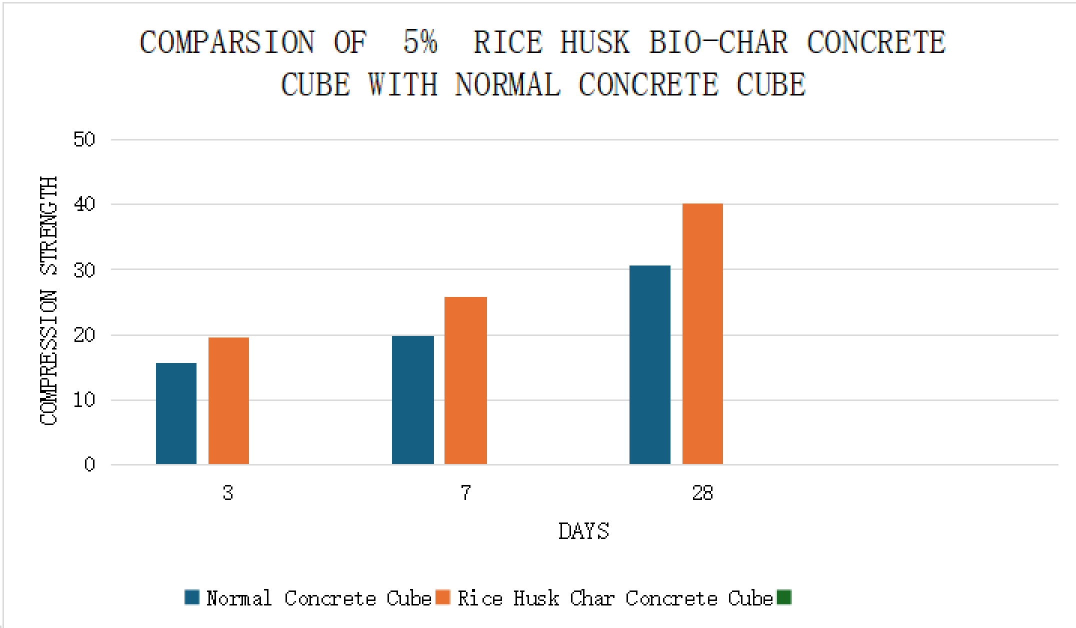

Fig3: - COMPARSION OF 5% RICE HUSK-CHAR CONCRETE CUBE WITH NORMAL CONCRETE CUBE

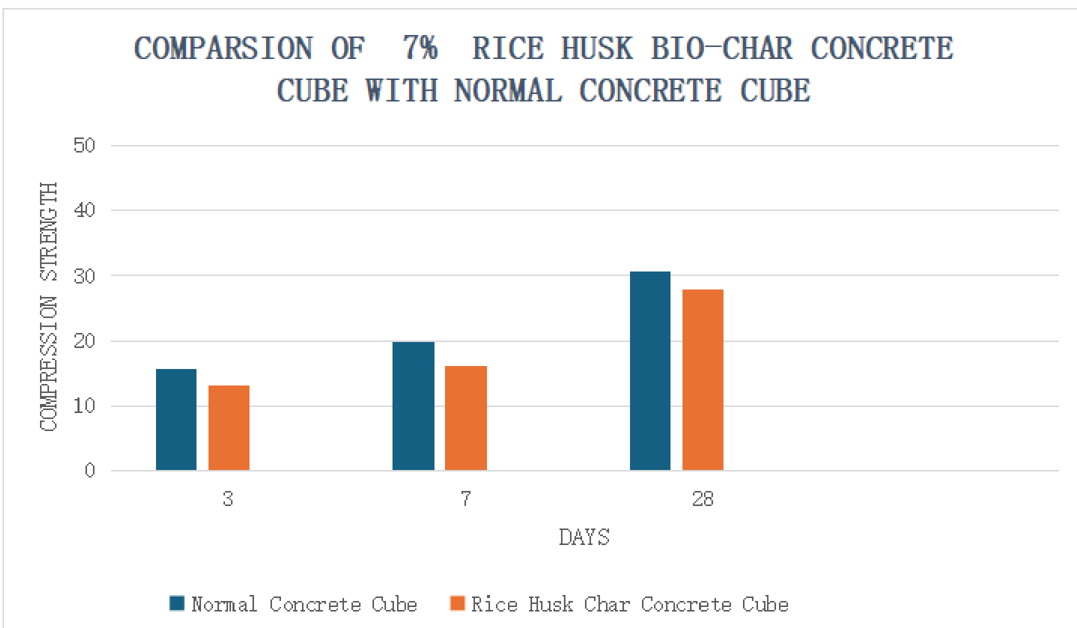

Fig4: - COMPARSION OF 7% RICE HUSK BIO-CHAR CONCRETE CUBE WITH NORMAL CONCRETE CUBE

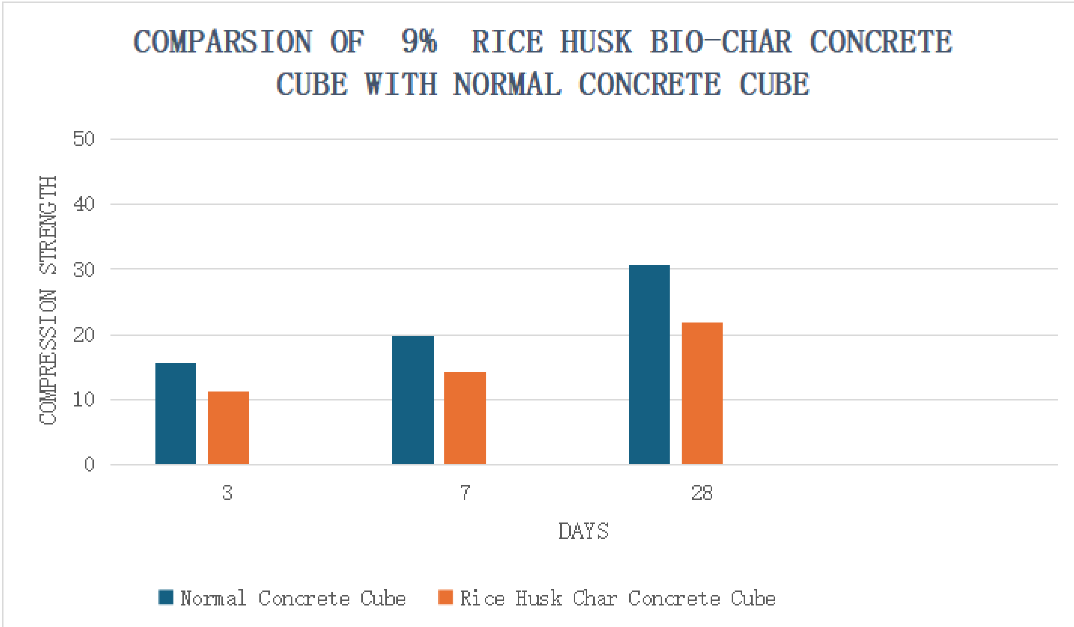

Fig5: - COMPARSION OF 9% RICE HUSK BIO-CHAR CONCRETE CUBE WITH NORMAL CONCRETE CUBE

5. CONCLUSION

Bio-char derived from rice husk is produced through the process of pyrolysis and has shown to be strong.[36] The efficient use of rice husk char in cement concrete cubes is found to be at its maximum when added in 1%, 3%, or 5% of its weight. If more than 5% of rice husk char is added, the cement concrete cubes lose their original characteristic strength. The table above displays[37] the characteristic compressive strength of cement concrete cubes (measuring 150mm x 150mm x 150mm) with different percentages of rice husk char[38] replacement based on its weight. When 1%, 3%, or 5% of rice husk char is added (25gm, 75gm, 125gm), the original compressive strength of the cement concrete cubes can be regained.[39] However, if more than 5% of rice husk char is added, the cement concrete cubes will lose their [40] original strength.

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