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Experimental Investigation on Strength and Durability of Papercrete Bricks: A Sustainable Construction Material

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Abstract: ***The construction industry is currently facing a dual challenge: the depletion of natural resources due to the excessive excavation of topsoil for conventional clay bricks and the environmental pollution caused by the accumulation of waste paper in landfills. This research paper presents an experimental investigation into the development of "Papercrete Bricks," a lightweight composite material comprising re-pulped waste paper, Ordinary Portland Cement (OPC), sand, and lime. The study aimed to design a masonry unit that effectively recycles paper waste while maintaining structural integrity. The specimens were cast using a mix proportion of 1:1:0.5 (Paper: Sand: Cement) and cured for 28 days. Laboratory tests were conducted in accordance with IS 3495 standards. The results indicate that Papercrete bricks achieved a compressive strength of 3.13 MPa and a water absorption rate of 28.5%. Furthermore, the bricks exhibited a 25% reduction in dead weight compared to standard fly ash bricks. The study concludes that while Papercrete is not suitable for load-bearing walls due to high porosity, it is an excellent, cost-effective, and sustainable material for non-load-bearing partition walls and framed structure infills.***

Keywords: ***Papercrete, Sustainable Material, Waste Management, Compressive Strength, Lightweight Concrete, Green Building.***

I. INTRODUCTION

The rapid pace of urbanization in developing countries has led to an unprecedented demand for construction materials. Conventional Red Clay Bricks have been the backbone of construction; however, their production is environmentally damaging. It is estimated that the brick industry consumes millions of tons of fertile topsoil annually, leading to severe land degradation. Additionally, the firing process in kilns releases significant quantities of Carbon Dioxide (CO2) into the atmosphere.

Simultaneously, the disposal of Municipal Solid Waste (MSW), specifically paper waste, poses a significant challenge. Despite recycling efforts, a large volume of low-grade paper ends up in landfills, generating methane gas.

"Papercrete" offers a solution to both these problems. It is a fibrous cementitious composite that utilizes waste paper as an aggregate. By replacing the earthen material with paper pulp, Papercrete reduces the dead load of the structure and provides a productive end-use for waste paper. This research focuses on evaluating the engineering properties of Papercrete bricks to determine their suitability as a substitute for conventional masonry in non-load-bearing applications.

II. LITERATURE REVIEW

The concept of using organic fibers in concrete has been explored by various researchers. Fuller and Fafitis (2006)investigated the structural properties of Papercrete and reported that it possesses excellent ductility and elasticity, making it suitable for seismic-resistant structures, although it lacks the high compressive strength of concrete.

Chandurkar and Naik (2007) conducted a comparative cost analysis and found that Papercrete bricks are 30%–40% cheaper than conventional bricks. However, they highlighted the material's high water absorption as a critical drawback. Suganya (2012) suggested that a mix ratio of 1:1:0.5 yields the optimum balance between weight and strength. This research builds upon these findings by focusing on the comparative performance of Papercrete against commercially available Flyash bricks.

III. METHODOLOGY

A. Materials Used

1) Waste Paper: Collected from administrative waste (old records) and newspapers. The paper functions as a micro-reinforcement fiber.

2) Cement: Ordinary Portland Cement (OPC) 43 Grade, conforming to IS 8112.
3) Sand: River sand passed through a 4.75mm IS sieve to ensure a fine finish.
4) Lime: Used as an admixture to improve workability and bond strength.
5) Water: Potable water for pulping and mixing.

B. Manufacturing Process

The fabrication process involved the following steps:

1) Pulping: The waste paper was shredded and soaked in water for 4 days to degrade the cellulose bonds. It was then mechanically blended to form a consistent pulp.
2) Mixing: A volumetric mix ratio of 1 : 1 : 0.5 (Paper Pulp : Sand : Cement) was adopted. Lime (5% by weight of cement) was added.
3) Casting: The mix was poured into standard wooden molds of size 190mm × 90mm × 90mm and hand-compacted.
4) Curing: The bricks were demolded after 24 hours, sun-dried for 2 days, and then water-cured for 28 days to ensure complete hydration.

IV. EXPERIMENTAL ANALYSIS

The cured specimens were subjected to laboratory testing as per **Bureau of Indian Standards (IS 3495: 1992)**.

1) Compressive Strength Test: Five samples were tested using a Compression Testing Machine (CTM). The load was applied axially at a uniform rate of 14 N/mm²/min until failure. The compressive strength is calculated as: Strength=Cross Sectional AreaFailure Load
2) Water Absorption Test: The specimens were oven-dried, weighed (W1), and then immersed in water for 24 hours. The wet weight (W2) was recorded to calculate the percentage of absorption: Absorption(%)=W1W2−W1×100
3) Drop Test (Impact Resistance): A field test was performed by dropping the brick from a height of 1 meter to evaluate its toughness and resistance to shattering.

V. RESULTS AND DISCUSSION

A. Compressive Strength

The average compressive strength obtained was **3.13 MPa** (Average Load: 53.4 KN). While this is lower than the standard 3.5 MPa required for load-bearing Class A bricks, it falls within the acceptable range for partition walls. Unlike concrete, the failure mode was ductile; the bricks did not shatter but compressed, held together by the fiber network.

B. Water Absorption

The average water absorption was observed to be **28.5%**. This is significantly higher than the recommended limit of 20% for burnt clay bricks. The high porosity is attributed to the hydrophilic nature of cellulose. This indicates that Papercrete requires external plastering for waterproofing.

C. Weight Analysis

The average weight of the Papercrete brick was **2.25 kg**, whereas a standard Flyash brick of the same dimension weighs approximately **3.00 kg**. This represents a **25% reduction in dead weight**, which is highly beneficial for high-rise framed structures.

D. Comparative Analysis

Table 1: Comparison of Papercrete vs. Flyash Bricks

Parameter	Papercrete Brick	Flyash Brick
Density (Weight)	~2.25 kg (Light)	~3.00 kg (Heavy)
Compressive Strength	3.13 MPa	3.5 - 4.0 MPa

Water Absorption	28.5%	15 - 20%
Impact Resistance	High (Ductile)	Low (Brittle)
Eco-Friendliness	Excellent (Recycled)	Good

VI. CONCLUSION

Based on the experimental results, the following conclusions are drawn:

1) Papercrete bricks utilize waste material effectively, reducing landfill load and preserving natural topsoil.

2) With a compressive strength of 3.13 MPa, these bricks are suitable for non-load-bearing applications such as internal partition walls and compound walls.

3) The 25% weight reduction makes Papercrete an ideal material for reducing the dead load on structural frames, potentially lowering steel reinforcement costs.

4) The high water absorption (28.5%) is a limitation. Therefore, Papercrete walls should not be exposed to direct rainfall without waterproof plastering.

Future research should focus on the addition of waterproofing admixtures like silicon-based sealants to improve durability and water resistance.

VII. ACKNOWLEDGEMENT

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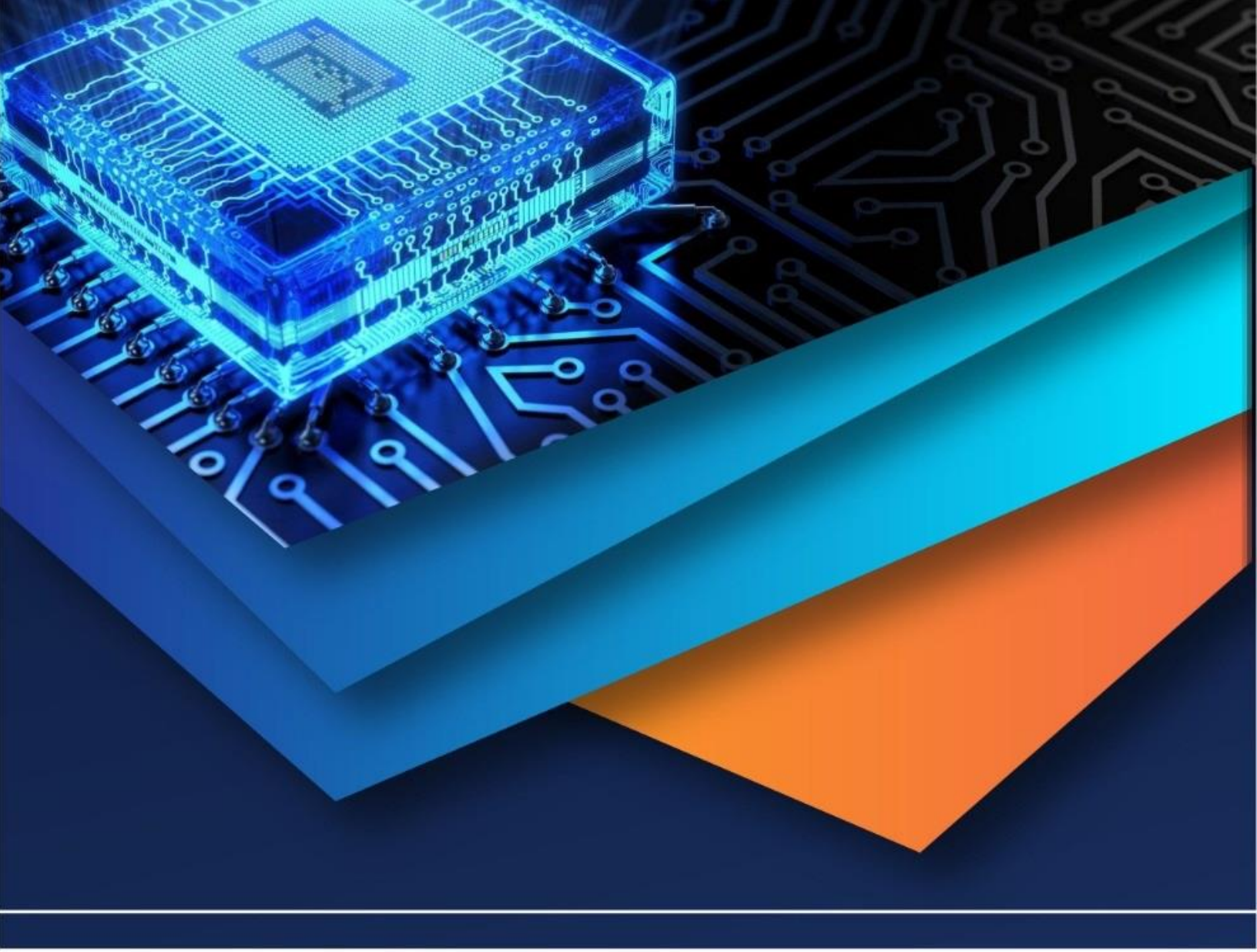
BIOGRAPHIES (Optional not mandatory)

	Chaitali Meshram Ms. Chaitali Meshram is a final-year undergraduate student pursuing a Bachelor of Technology in Civil Engineering at J D College of Engineering & Management, Nagpur. Her research interests include sustainable construction materials and green building technologies. She played a pivotal role in the literature review and data analysis for this project, focusing on the environmental impact assessment of waste paper recycling in masonry.
	Tuhin Mandal Mr. Tuhin Mandal is currently pursuing his B.Tech in Civil Engineering from J D College of Engineering & Management, Nagpur. He is an active member of the Civil Engineering Student Association. For this research, he was responsible for the site execution, including the procurement of raw materials, mix design optimization, and overseeing the manufacturing process of the Papercrete bricks.
	Shlok Rambhad Mr. Shlok Rambhad is a final-year Civil Engineering student at J D College of Engineering & Management, Nagpur. His academic focus lies in structural engineering and concrete technology. In this project, he handled the laboratory experimentation phase, conducting rigorous compressive strength and water absorption tests according to IS codes to validate the engineering properties of the samples.
	Ved Bisen Mr. Ved Bisen is pursuing a Bachelor of Technology in Civil Engineering at J D College of Engineering & Management, Nagpur. He has a keen interest in construction management and cost estimation. His contribution to this paper includes the detailed cost analysis, comparing the economic feasibility of Papercrete against conventional materials, and analyzing the weight reduction benefits for high-rise structures.
	Prof. Archana Mahajan Prof. Archana Mahajan is an Assistant Professor in the Department of Civil Engineering at J D College of Engineering & Management, Nagpur. She holds a Master’s degree in Civil Engineering and has extensive experience in teaching and research. Her areas of expertise include Concrete Technology, Sustainable Building Materials, and Structural Analysis. She guided this project, providing technical mentorship on mix design and standardized testing protocols.



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