



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.524

Volume 14, Issue 1, January 2025

Comparative Analysis of Material Additives in Pervious Concrete: Evaluating Compressive Strength and Permeability for Sustainable Construction

Prakash U. Barde¹, Nishigandha S. Deshkari², Shubham B. Kale³, Achal G. Gawande⁴,
Akanksha G. Torkadi⁵, Bharti D. Chavhan⁶, Pritesh A. Kohad⁷, Avinash R. Yadav⁸,
Dr. R. S. Tatwawadi⁹, Prof. S. A. Chavan¹⁰

U.G. Students, Department of Civil Engineering, J.D.I.E.T, Yavatmal, Maharashtra, India^{1,2,3,4,5,6,7,8}

Principal, J.D.I.E.T, Yavatmal, Maharashtra, India⁹

Professor, Department of Civil Engineering, J.D.I.E.T, Yavatmal, Maharashtra, India¹⁰

ABSTRACT: Permeable pervious concrete has gained significant attention as an environmentally friendly paving material, offering efficient storm water management and reducing urban heat island effects. Pervious concrete is a composite material comprising of coarse aggregate, concrete, and water. It is use in areas subjected to low traffic volumes and loads. This synopsis paper outlines our prospective research, which involves a comparative assessment of the effects of different materials on the compressive strength and permeability of pervious concrete. While the practical experimentation is yet to be performed, our primary focus is on the anticipated outcomes and the goal of identifying which material offers the greatest strength and properties needed for our project. We discuss the expected benefits of adding two distinct materials individually to pervious concrete: Different sizes of aggregate, Plastic waste. We aim to evaluate and compare the influence of each material on the mechanical and hydraulic properties of the concrete. Additionally, this research will involve the generation of correlation graphs to establish relationships between compressive strength and permeability for each material. By comparing these correlations, we seek to determine which material and what mix proportion provides the most desirable combination of compressive strength and permeability.

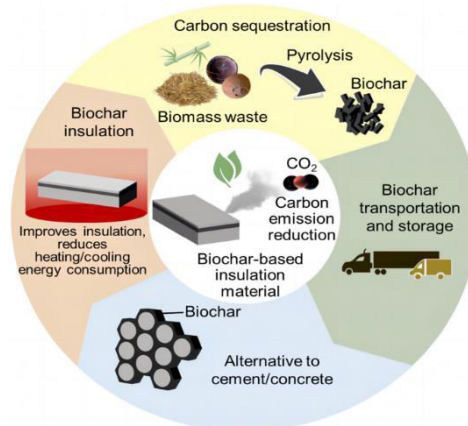


Fig 1

KEYWORDS: 1. Concrete 2. Portland cement 3. CO₂ emissions 4. Biochar 5. Organic waste 6. Sustainability 7. Silica 8. Calcium 9. Potassium 10. Pozzolanic reactions 11. Carbon sequestration 12. M20 grade concrete 13. Strength 14. Durability 15. Eco-friendly construction

I. INTRODUCTION

Concrete, a cornerstone of modern construction, relies heavily on Portland cement, which contributes 8–10% of global CO₂ emissions due to its energy-intensive production. To reduce cement dependency and enhance sustainability, biochar—a carbon-rich material from pyrolyzed organic waste—emerges as a viable alternative. Derived from residues like eggshells, wood waste, bamboo leaves, sugarcane bagasse, and rice husks, biochar is rich in minerals like silica, calcium, and potassium, which boost pozzolanic reactions, improving concrete's strength, durability, and performance. It also sequesters carbon, lowering cement's carbon footprint. This study examines biochar's integration into M20 grade concrete, offering a sustainable and durable construction solution.

"The Carbon Cost of Construction: Can Biochar Cement a Greener Future?"

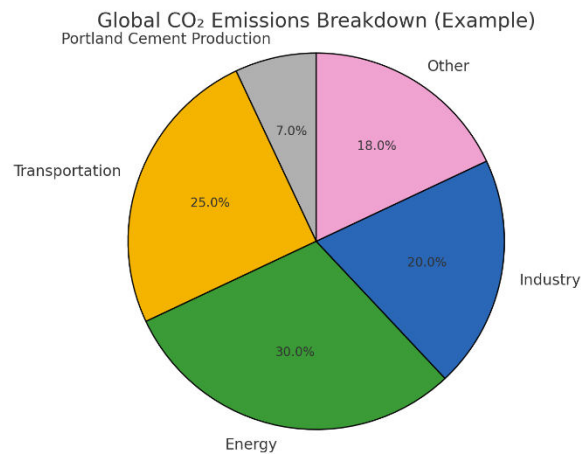


Fig 2

II. METHODOLOGY

Review of Relevant Literature → Material Selection and Identification → Mix Proportion Design → Optimal Fit Selection → Correlation Establishment → Result Analysis → Specimen Testing

Biochar Production

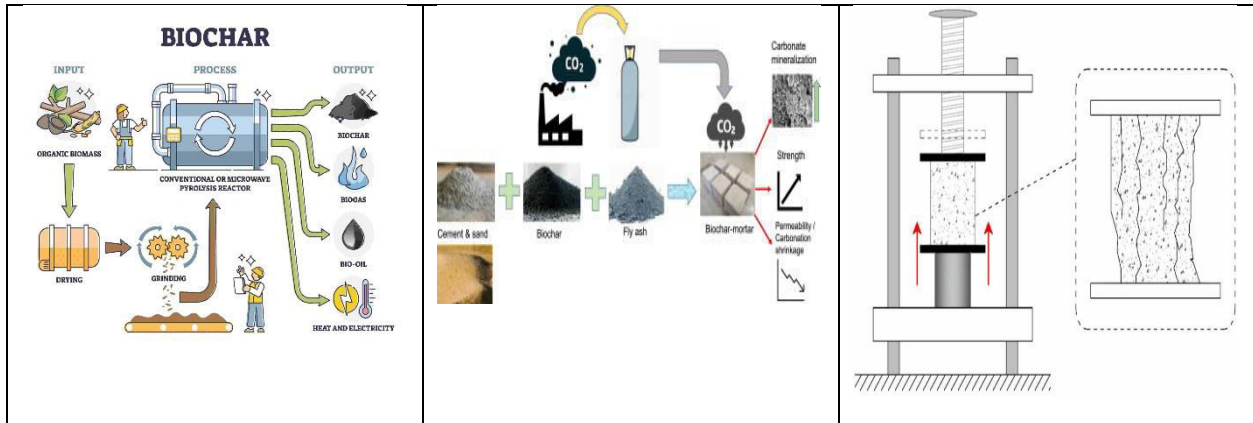
- Organic waste (e.g., eggshells, rice husks, wood waste, bamboo leaves, and sugarcane bagasse) undergoes pyrolysis at 400°C–700°C.
- The biochar is ground into fine powder for concrete incorporation.

Concrete Mix Design

- Portland cement is partially replaced with 5%, 10%, 15%, and 20% biochar by weight.
- M20 grade concrete (100% Portland cement, 0.5 water-cement ratio) is used as a control.

Testing and Analysis

- Compressive Strength: Tested at 7, 14, and 28 days for strength comparison.
- Durability Tests:
 - Water Absorption: Measures permeability and moisture resistance.
 - Freeze-Thaw Resistance: Evaluates temperature fluctuation performance.
 - Acid Resistance: Assesses resistance to acidic conditions.
- Carbon Sequestration: Quantifies carbon stored and CO₂ reduction.
- Biochar Characterization: XRF analysis identifies silica, calcium, and potassium content.



Biochar Production

Concrete Mix Design

Testing Process – Compressive Strength and Durability

III. CASE STUDY ANALYSIS

(A) Biochar-Enhanced Concrete

1. Eggshell Biochar: High in calcium carbonate, enhances hydration and setting time.
2. Wood Waste Biochar: Rich in silica and potassium, improves strength, thermal properties, and shrinkage resistance.
3. Bamboo Biochar: High silica, calcium, and potassium content boosts pozzolanic reactions for better strength and durability.
4. Sugarcane Biochar: Derived from bagasse, enhances mechanical properties and aids waste management.
5. Rice Husk Biochar: High silica promotes calcium silicate hydrate (C-S-H) formation, improving strength and durability.

(B) M20 Grade Concrete

- Widely used in residential and infrastructure projects.
- Performs well under standard conditions but has significant environmental impacts due to high cement usage.
- Challenges include moderate water permeability and reliance on Portland cement, necessitating sustainable alternatives.



Eggshell

Wood Waste

Bamboo

Sugarcane

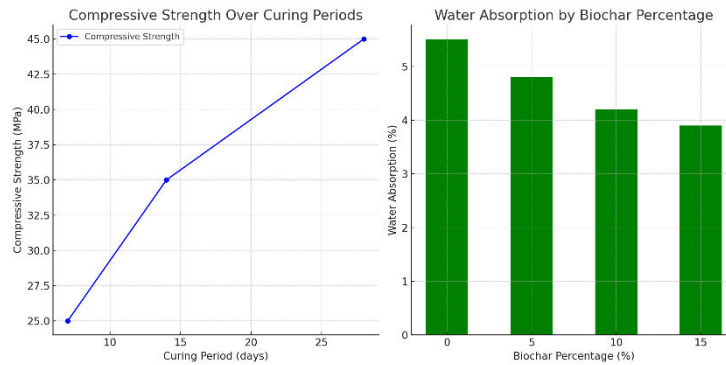
Rice Husk

IV. OBSERVATIONS

1. Mechanical Properties:
 - a. Biochar improves compressive strength at later curing stages (14–28 days), particularly with replacement levels up to 15%.
2. Durability:
 - a. Biochar reduces water absorption, improves freeze-thaw resistance, and enhances acid resistance, resulting in more durable concrete.

3. Carbon Sequestration:

- a. Biochar effectively locks carbon in a stable form, significantly reducing the carbon footprint of concrete production.



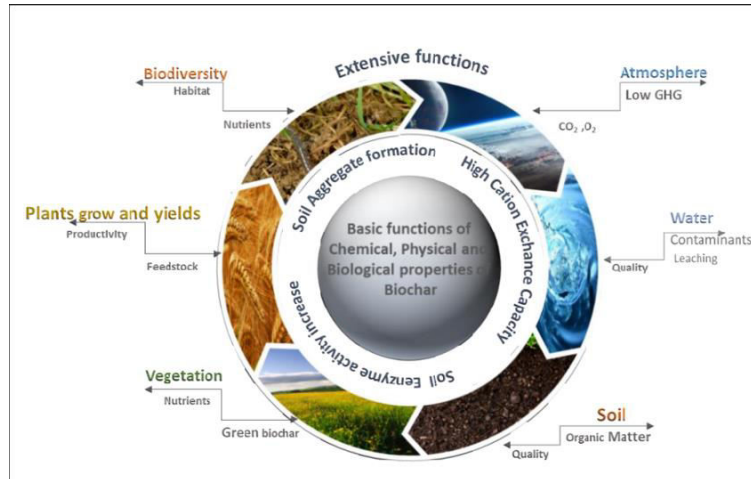
V. TESTS CONDUCTED

1. Slump Test: Measures workability and ease of placement.
2. Compressive Strength Test: Evaluates load-bearing capacity over curing periods.
3. Durability Tests: Include water absorption, freeze-thaw resistance, and acid resistance.
4. Carbon Sequestration: Quantifies carbon stored within the concrete matrix.



VI. DESIRED OUTCOMES

1. Reduced Cement Consumption:
 - a. Biochar reduces reliance on Portland cement, decreasing environmental impacts.
2. Enhanced Concrete Properties:
 - a. Improves strength, durability, and workability, making biochar-enhanced concrete suitable for diverse construction applications.
3. Carbon Sequestration:
4. Locks carbon in a stable form, mitigating climate change and promoting environmental sustainability



VII. CONCLUSION

Biochar-enhanced concrete is a sustainable alternative to traditional concrete. Replacing part of cement with biochar produced from organic waste, like the inside of eggshells, wood waste, bamboo, sugarcane, rice husk, will help reduce CO₂ emissions in the construction industry while enhancing the strength and durability of the concrete. Adding biochar to M20 grade concrete, used widely in construction, has the potential to add both performance and sustainability to it. This approach will deliver practical and effective solutions to more green, tougher, and resilient construction materials.

Mix Type	Strength (MPa)	Durability (Rating)	CO ₂ Reduction (%)	Key Highlights
Mix A (Standard)	40	High	0	Traditional mix, reliable for general use.
Mix B (Fly Ash)	38	Medium	25	Moderate strength, significant CO ₂ savings.
Mix C (Slag Cement)	42	High	30	Enhanced strength and durability with reduced CO ₂ .
Mix D (Recycled Aggregate)	36	Medium	20	Eco-friendly option with lower strength.
Mix E (Geopolymer)	45	Very High	50	Excellent performance, highest CO ₂ reduction.
Mix F (Fiber Reinforced)	50	Very High	10	Exceptional strength and durability, minimal CO ₂ savings.

Key Notes:

Strength (MPa): Compressive strength measured in megapascals.

Durability (Rating): Assessed on a relative scale (Medium, High, Very High).

CO₂ Reduction (%): Relative reduction in carbon emissions compared to the standard mix.

REFERENCES

- Habert, G., Roussel, N., & Jullien, A. (2010). Environmental Impact of Portland Cement Production. *Journal of Environmental Management*, 91(12), 2875–2887. |
- Lehmann, J., & Joseph, S. (2015). *Biochar for Environmental Management: Science, Technology and Implementation*. Routledge. |
- Siddique, R., & Chahal, V. (2018). *Rice Husk Ash in Cement-Based Materials*. Springer. |
- Kiatkittipong, W., & Tu, C. (2019). Biochar for Concrete: A Review. *Materials*, 12(15), 2365. |
- Tan, Z., & Zheng, X. (2017). Utilization of Biochar in Concrete for Sustainable Development. *Journal of Cleaner Production*, 154, 92–101. |

6. IS 456:2000. Plain and Reinforced Concrete - Code of Practice. |
7. IS 10262:2019. Guidelines for Concrete Mix Proportioning. |
8. Mehta, P.K., & Monteiro, P.J.M. Concrete: Microstructure, Properties, and Materials. |
9. Neville, A.M. Properties of Concrete. |
10. ACI Committee 211. Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details