RESEARCH ARTICLE OPEN ACCESS

Green Concrete Development: Utilizing Coconut Fiber and Rice Husk Ash for Enhanced Strength and Durability

Binit Gopal [1], Hemant Kumar Sain [2]

[1]M.Tech Student, Department of Civil Engineering, Arya College of Engineering & Research Centre, Jaipur, Rajasthan, India
[2] Assistant Professor, Department of Civil Engineering, Arya College of Engineering, Jaipur, Rajasthan, India.

ABSTRACT

The green concrete market is driven by reduced carbon footprints, increased construction in developing nations, and lower water consumption. Additionally, green concrete provides excellent thermal insulation and high fire resistance, improving the durability of structures. Natural fibers, sourced from plants, geological processes, and animals, include materials like coconut, sisal, jute, bamboo, banana, palm, hemp, linen, cotton, and sugar cane. These fibers are cost-effective and widely used in construction materials to reduce expenses and facilitate handling. Traditional concrete, despite its strength and moldability, suffers from brittleness and low tensile strength. To reduce its environmental impact, alternative materials like industrial waste are being incorporated. Coconut fiber and rice husk ash (RHA), for instance, are considered for use in concrete. In this study, two concrete grades, M-30 and M-40, are tested with coconut fibers added at 0%, 1.5%, and 3.0% by weight of cement and RHA replacing cement at 0%, 5%, 10%, 15%, 20%, and 25%. The goal is to create green concrete with enhanced strength compared to conventional concrete.

Keywords — Green Concrete, OPC, Eco-Friendly, Coconut Fiber, Rice Husk Ash.

I. INTRODUCTION

Green concrete is a groundbreaking development in the construction industry, marking a significant move towards sustainability and environmental stewardship. Traditional concrete production, particularly using ordinary Portland cement (OPC), is a major source of CO_2 emissions, accounting for about 8% of global human-induced emissions, and heavily depletes natural resources, raising concerns about its long-term environmental impact.

As global infrastructure demands grow, the need for sustainable construction materials becomes increasingly urgent. Green concrete, made from eco-friendly waste materials and innovative alternatives to conventional binders and aggregates, offers a promising solution. Incorporating materials such as alkali-activated binders, supplementary cementitious materials, and recycled components, green concrete not only reduces CO_2 emissions but also enhances the performance and durability of concrete structures.

The adoption of green concrete is driven by several compelling factors. It significantly lowers the carbon footprint of construction projects, aligning with global efforts to mitigate climate change. Additionally, green concrete reduces water usage by up to 20%, which is crucial in regions facing water scarcity. Its production process generates less waste, further minimizing environmental harm.

Beyond its environmental benefits, green concrete offers practical advantages for construction. It provides excellent thermal insulation and high fire resistance, enhancing the safety and energy efficiency of buildings. Furthermore, structures built with green concrete often exhibit improved compressive and tensile strength, better sulfate resistance, and enhanced workability compared to traditional concrete.

As the construction industry continues to evolve, the integration of green concrete highlights the potential for innovative materials to drive sustainability without compromising performance. This introduction to green concrete underscores its importance in addressing contemporary construction challenges and paving the way for a more sustainable future.

II. MATERIALS USED

The following materials are mainly used in this work.

- Sand
- Aggregate
- Water
- Rice Husk Ash
- Coconut Fiber.

Characteristic		Requirement
Fineness value of cement		225 m^2 /kg (Min.)
Soundness value of cement		10 mm (Max.)
Initial setting time value of cement		30 min. (Min.)
Final setting time value of cement		600 min. (Max.)
Compressive strength of cement	7 days	33 N/mm^2 (Min.)
	28 days	43 N/mm^2 (Min.)

Fig 1. Physical Properties of OPC

Ingredient	Percentage
Lime (Cao)	62.00%
Silica (SiO2)	22.00%
Alumina (Al2O3)	5.00%
Calcium sulphate (CaSo4)	4.00%
Iron oxide (Fe2O3)	3.00%
Magnesia (MgO)	2.00%
Sulphur (S)	1.00%
Alkalies	1.005

Fig 2. Chemical Properties of OPC

Property Test	Natural Sand	
	Dry	SSD
Sp. Gravity	2.62	2.67
Density	1466 kg/m^3	1544 kg/m^3
Bulk Density	1582 kg/m^3	1630 kg/m^3
Sp. Gravity (Apparent)	2.70	
Water Absorption	1.38 %	

Fig 3. Properties of Sand

Rice Husk Rice Husk Ash

Fig 4. Rice Husk & Rice husk ash

Property of RHA	Value
Mean particle size	64.1µm
Specific gravity	2.08
Fineness passing 45µm	97%

Fig 5. Physical Properties of RHA

Fig 6. Extracted Coconut Fibres

III. RESULTS AND DISCUSSION

The obtained different results are shown in the figures below in which mainly discussed about the compressive strength analysis on M30 and M40 grade cement with 7 and 28 days.

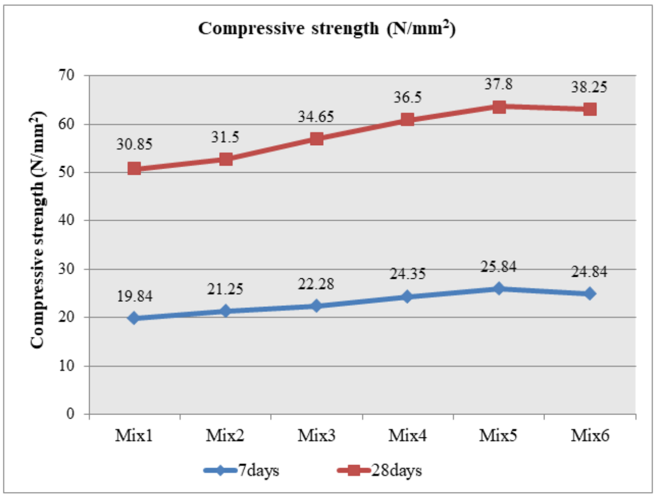

Fig 7. Comparison of Compressive Strength at 7 days and 28 days for Concrete Grade M30 with 0% Fiber

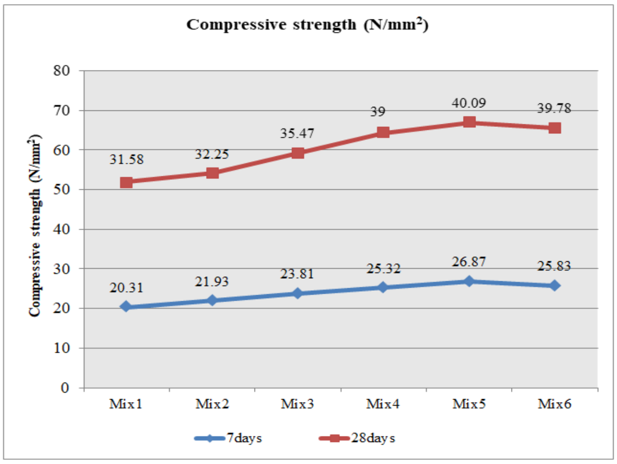

Fig 8. Comparison of Compressive Strength at 7 days and 28 days for Concrete Grade M30 with 1.5% Fiber

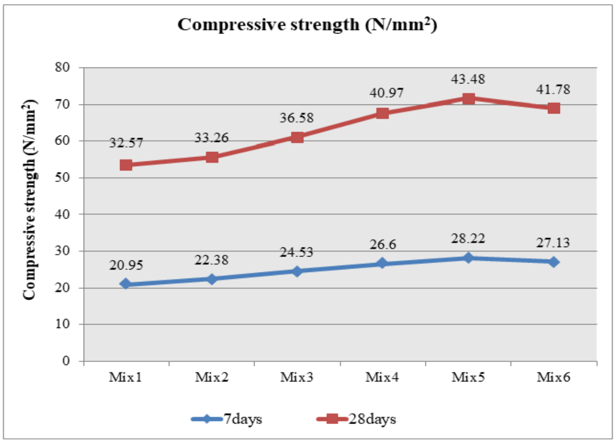

Fig 9. Comparison of Compressive Strength at 7 days and 28 days for Concrete Grade M30 with 3% Fiber

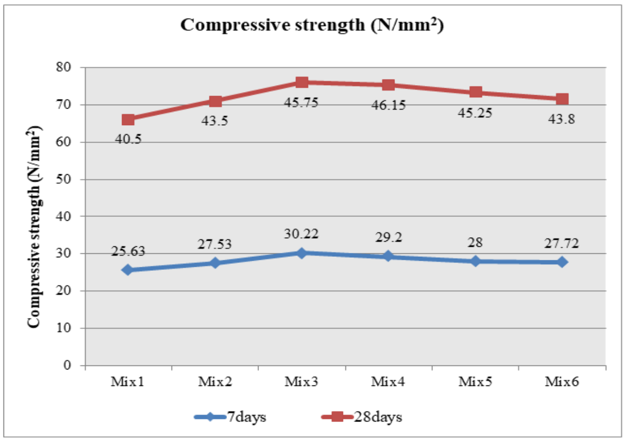

Fig 10. Comparison of Compressive Strength at 7 days and 28 days for Concrete Grade M40 with 0% Fiber

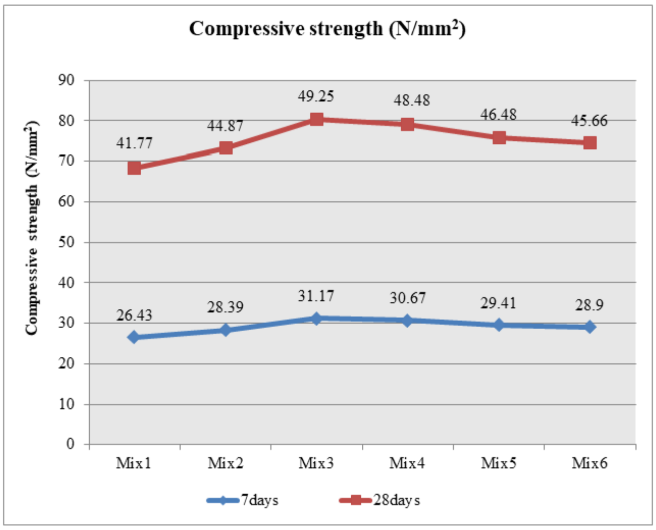

Fig 11. Comparison of Compressive Strength at 7 days and 28 days for Concrete Grade M40 with 1.5% Fiber

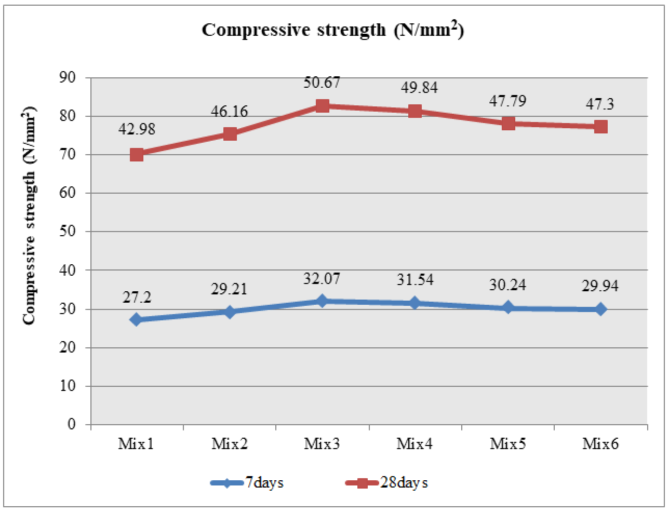

Fig 12. Comparison of Compressive Strength at 7 days and 28 days for Concrete Grade M40 with 3% Fiber

IV. CONCLUSIONS

The maximum slump value for conventional M-30 grade concrete was 79mm, while for M-40 grade concrete it was 68mm, indicating that the slump value for M-30 was higher than that for M-40. The slump value decreased when cement was replaced with rice husk ash (RHA). For M-30 grade concrete, the percentage change in slump value was 24.05%, and for M-40 grade concrete, it was 25%. This reduction continued up to a 25% replacement of cement with RHA.

When coconut fiber was also added to the concrete samples, further reductions in slump value were observed. For M-30 grade concrete with 1.5% coconut fiber, the slump value reduced to 57mm, and for M-40 grade, it reduced to 48mm. With a 3% addition of coconut fiber, the slump value for M-30 was 58mm and for M-40 was 47mm.

For M-30 grade concrete, the compressive strength at 7 days was 19.84 N/mm², which increased with the replacement of cement with RHA. At 28 days, the compressive strength was 30.85 N/mm², with significant improvement up to 20% RHA content, after which changes in compressive strength were minimal. The percentage increase in compressive strength at 7 days was 30.24%, and at 28 days it was 22.52%. When 1.5% coconut fibers and RHA were used together, the compressive strength increased by 35.43% at 7 days and 29.95% at 28 days. With 3% coconut fibers, the increase was 42.23% at 7 days and 40.94% at 28 days.

For M-40 grade concrete, the compressive strength at 7 days was 25.63 N/mm², enhanced by the replacement of cement with RHA. At 28 days, the compressive strength was 40.50 N/mm², with improvements noted up to 15% RHA content, after which further changes were minimal. The percentage increase in compressive strength at 7 days was 13.92%, and at 28 days it was 13.95%. When 1.5% coconut fibers and RHA were used together, the compressive strength increased by 21.63% at 7 days and 21.60% at 28 days. With 3% coconut fibers, the increase was 25.12% at 7 days and 25.11% at 28 days.

REFERENCES

[1] S. P. Munoz-Pereza, E. Sánchez-Díazb, D. Barboza-Culquib, J. M. Garcia-Chumacero, "Use of recycled concrete and rice husk ash for concrete: A review", Journal of Applied Research and Technology, Vol. 22, pp. 138-155, 2024.

[2] M. Nehdi, J. Duquette, A. El Damatty, "Performance of rice husk ash produced using a new technology as a mineral admixture in concrete", Cement and Concrete Research, Vol. 33, pp. 1203 – 1210, 2023.

[3] Kartik Chawla, Vinayak Jain, Udit Prabhakar, Abhay Gahlot, Yash Kashyap, Mr. Ashish Juneja, "A Study on Production of Green Concrete using Coconut Fibre and Rice Husk Ash", International Journal of Multidisciplinary Innovation and Research Methodology, Vol. 2, Issue. 2, pp. 26-34, 2023.

[4] Dhanalakshmi Ayyanar, J. Jeyaseela, S. Karthika, A. Leema Margret, "An Experimental Study on Concrete with Partial Replacement of Cement By Rice Husk Ash and Bagasse Ash", E3S Web of Conferences 387, 2023.

[5] Dr. I.C.Sharma Mr Kshitij Gupta, "Structure Health Monitoring Using Vibration-Based Technique", International Journal for research in applied Science& Engineering Technology, Vol. 7, 2019.

[6] Ms Geetanajali Ganguly, Dr. I.C.Sharma, "Sustainable Solid Waste Management, Smart Cities and Swatch Bharat Initiative", Institute of Technology & Engineering Jaipur, 2017.

[7] Dr.PBL Chaursia, Er.Raj P Sekhwat, Dr. I.C.Sharma, "Utalization of Marble Slurry in Concrete Replacing Fine Aggrigate", American journal of engineering research, Vol. 4, Issue. 1, 2015.

[8] Ishwar Chand Sharma & Dr. N.C. Saxena, "Engineering Utilization Of Marble Slurry", International journal of civil engineering and technology(IJCIET), Vol. 3, Issue. 2, pp. 1-6, 2012.

[9] . Manoj Kumar Sharma, Hemant Kumar Sain, "Develop Approximate Analytical Models for Separated Seismic Analysis of Connected Buildings by SAP 2000", International Journal of Engineering Trends and Applications (IJETA), Vol. 11, Issue. 1, pp. 22-26, 2024.

[10] Hemant Kumar Sain, Krishana wadhwani, Rohit Vashishth, Vikash Siddh, “Experimental Study of Floating Concrete With Light Weight Aggregate”, Third International Conference on Advances in Physical Sciences and Materials 2022, AIP Conference Proceedings, 2023.

[11] Sneha Mathew, Hemant Kumar Sain, "An Innovative Study on Utilisation of Pareva Dust and Quartz Sand in Concrete", Key Engineering Materials, Vol. 961, pp. 135-140, 2023.

[12] Manoj Kumar Sharma, Hemant Kumar Sain, "A Review on Seismic Analysis of Connected and High Rise Buildings", International Journal of Engineering Trends and Applications (IJETA), Vol. 11, Issue. 1, pp. 18-21, 2024.

[13] Dr I .C.Sharma, Gori Shankar Soni, "Assessment of Limestone Dust and Chips as Eco-friendly Alternatives in Concrete Production", International Journal of Engineering Trends and Applications (IJETA), 2024.