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Enhance the Compressive Strength of concrete using Agricultural waste and Industrial waste.

Vikash Agarwal[1], Shriyanka Dehariya[2], Vivek Sahare[3], Pranjali Akare[4], Ankita V. Mandal[5]

1 (Assistant Professor), CIVIL ENGG, Priyadarshini College of Engineering, Nagpur, Maharashtra, India
2 student, CIVIL ENGG, Priyadarshini College of Engineering, Nagpur, Maharashtra, India
3 student, CIVIL ENGG, Priyadarshini College of Engineering, Nagpur, Maharashtra, India
4 student, CIVIL ENGG, Priyadarshini College of Engineering, Nagpur, Maharashtra, India
5 student, CIVIL ENGG, Priyadarshini College of Engineering, Nagpur, Maharashtra, India

ABSTRACT:

The construction industry is currently grappling with numerous sustainability and environmental challenges. One significant issue is the management of agro-industrial waste, which, however, holds potential for enhancing the strength of concrete. This study investigates the utilization of agro-industrial waste as a supplementary cementitious material to produce stronger, more sustainable concrete. The research focuses on the use of rice husk ash (RHA) and fly ash (FA) from agro-industrial waste to improve the sustainability of concrete. It examines the mechanical properties of concrete produced with varying proportions of these materials. Specifically, the study analyzes how the compressive strength of concrete incorporating different percentages of RHA and FA (10%, 15%, 20%, 25%, and 30%) evolves over different curing periods (7 days, 14 days, and 28 days). Our findings indicate that the optimal partial replacement percentages for enhancing compressive strength are 20% for fly ash and 15% for rice husk ash. When both materials are combined, the ideal proportions are 20% fly ash and 10% rice husk ash. The study reveals that concrete incorporating agro-industrial waste not only gains strength over time but also addresses the issue of land disposal of such waste, thereby mitigating the environmental impact of the construction industry. This research is significant as it contributes to the development of sustainable concrete solutions and offers valuable insights for researchers exploring the use of agro-industrial waste in construction.

Introduction:

Concrete, a fundamental construction material, derives its strength and durability from the interlocking matrix formed by cement, aggregates, and water. However, conventional concrete production often comes at a significant environmental cost due to the high cement content. Recently, there has been a surge in interest in sustainable alternatives that reduce reliance on cement while maintaining or even enhancing concrete performance. This has led to the exploration of supplementary cementitious materials (SCMs) such as rice husk ash (RHA) and fly ash (FA). RHA and FA, by-products of agricultural and industrial processes, respectively, have garnered attention for their pozzolanic properties. When incorporated into concrete, these materials react with calcium hydroxide produced during cement hydration, forming additional cementitious compounds. This pozzolanic reaction not only improves the mechanical properties of concrete but also offers an environmentally friendly solution for managing waste materials. This study delves into the effects of utilizing RHA and FA on the compressive strength of concrete. Through a systematic examination of factors such as mix design parameters, curing regimes, and material characteristics, the research seeks to optimize the use of RHA and FA in concrete formulations. By elucidating the mechanisms underlying the enhancement of compressive strength, this study aims to provide valuable insights for the development of sustainable concrete mixtures. Furthermore, this research evaluates the long-term performance and durability of concrete containing these waste materials. By subjecting concrete specimens to rigorous testing protocols and environmental exposure, the study assesses the resilience and durability of sustainable concrete mixtures under real-world conditions. The findings of this research hold significant implications for the construction industry, offering practical strategies for reducing the environmental footprint of concrete production while enhancing structural performance. By promoting the adoption of RHA and FA as viable alternatives to conventional cementitious materials, this study contributes to the advancement of sustainable construction practices and the realization of a more resilient and resource-efficient built environment.

PROBLEM STATEMENT

Concrete, widely employed in construction, owes its popularity to durability and long-term viability in retaining structures like walls and channels. Cement, an essential ingredient in concrete production, is augmented by additional admixtures to confer various properties on the final mix. With increasing demand for concrete, there's a parallel rise in the need for cement. However, cement production releases by-products, including CO_2, nitrogen, and sulfur dioxide. Notably, CO_2 constitutes 76% of greenhouse gases, significantly contributing to global warming.

To mitigate CO_2 emissions, researchers explore alternatives to traditional cement. Concrete can now be produced using industrial by-products instead of cement, thereby reducing its environmental impact. Additionally, the accumulation of waste in landfills poses ecological challenges. By incorporating diverse waste materials into construction practices, the building sector can enhance waste management efficiency. The modern era underscores the importance of innovation and reusing industrial waste for environmental sustainability. Cement production, in terms of CO_2 emissions, negatively impacts the environment, accounting for nearly 5.0% of global pollution caused by CO_2 emissions. Achieving a clean, green, and zero-waste approach that promotes sustainable steel industry development involves recycling and repurposing all solid waste generated during the steel-making process.

APPLICATION OF PROPOSED PROJECT TO STUDY

Using waste in concrete serves several important purposes, leading to both environmental and economic benefits:

- Waste reduction
- Enhanced strength and durability
- Improved workability
- Lower permeability
- Reduced heat of hydration
- Reduced environmental impact
- Cost savings

Methodology:

One of the primary objectives of this study is to assess the properties of fresh and hardened concrete by incorporating various amounts of steel industry waste. The study follows a systematic approach through several phases:

Mix Design: A mix design is conducted for M20 grade concrete.

Casting and Curing of Cube Specimens: After preparing the mix, cube specimens of size 150mm x 150mm x 150mm are cast and cured.

Testing of Cubes: The cubes undergo compression tests for strength, permeability tests, and flexural tests to assess durability.

Results and Discussion: Following the different tests, the results and conclusions are analysed and discussed.

MATERIALS

Cement: is a fine powder made from materials such as limestone, clay, and other minerals. It is essential in construction, binding sand and gravel to create concrete. When mixed with water, cement undergoes hydration, forming a hard and durable material used in foundations, roads, bridges, and various structures.

The hydration process forms compounds like calcium silicate hydrate (C-S-H) and calcium hydroxide (CH), which contribute to concrete's strength and durability. Typical ordinary Portland cement composition includes:
Tricalcium Silicate (C_3S): 50% [$3CaO.SiO_2$]
Dicalcium Silicate (C_2S): 25% [$2CaO.SiO_2$]
Tricalcium Aluminate (C_3A): 10% [$3CaO.Al_2O_3$]
Tetracalcium Aluminoferrite (C_4AF): 10% [$4CaO.Al_2O_3.Fe_2O_3$]
Gypsum (Calcium sulfate): 5% [$CaSO_4.2H_2O$]

Fine Aggregate: Sand is a naturally occurring granular material composed mainly of finely divided rock and mineral particles, primarily silica (silicon and oxygen).
Fine aggregate, with particle sizes less than 4.75mm, fills voids between larger particles (like gravel) and binds the mixture. Essential for achieving desired concrete properties, such as strength, durability, and workability.

Must meet quality standards, including particle size distribution, cleanliness, and strength.

Coarse Aggregate: Consists of larger granular particles, typically greater than 4.75mm. Common materials include crushed stone, gravel, and recycled materials.

Fly Ash and Rice Husk Ash Rice Husk Ash (RHA) : By-product from burning rice husk, containing about 90% SiO_2. Exhibits high pozzolanic characteristics, enhancing concrete strength, impermeability, and workability. Fly Ash Enhances both fresh and hardened concrete performance. Benefits fresh concrete by reducing water requirement and improving workability. Benefits hardened concrete by increasing strength, reducing permeability, and improving durability.

Water: Must be clean, free from impurities and harmful substances. Potable water is generally suitable. Should have low chloride content and a pH between 6 and 8. Temperature should be moderate to avoid affecting concrete setting time and strength. Regular testing ensures quality standards are met.

Admixtures: Mid PCE Base high-performance admixture, ViscoFlux-2203+, is used to modify the properties of concrete, enhancing workability and performance.

Testing on Material :

***Fine Aggregate**:*

Sr. No	Test	Permissible Limit	Our Results	Reference IS Codes
1	Fineness modulus of fine aggregate	2.6 - 2.9	2.64	IS 38319770
2	Water absorption of fine aggregate	Should not be exceed 3%	1%	IS 383-Part 3 1963
3	Bulking of sand	15 - 30%	23%	IS 2386 Part 3 - 1963
4	Silt content of sand	Should not be exceed 8%	4.12	IS 2386 Part 2 - 1963
5	Specific gravity of fine aggregate	2.5 - 3	2.62	IS 2386 Part 3 - 1963

Course Aggregate :

Sr. No	Test	Permissible Limit	Our Results	Reference IS Codes
1	Fineness modulus of coarse aggregate	3.5 - 6.5	3.45	IS 383 – 1970
2	Water absorption of coarse aggregate	Should not be exceed 3%	2.02%	IS 2386 Part 3 – 1986

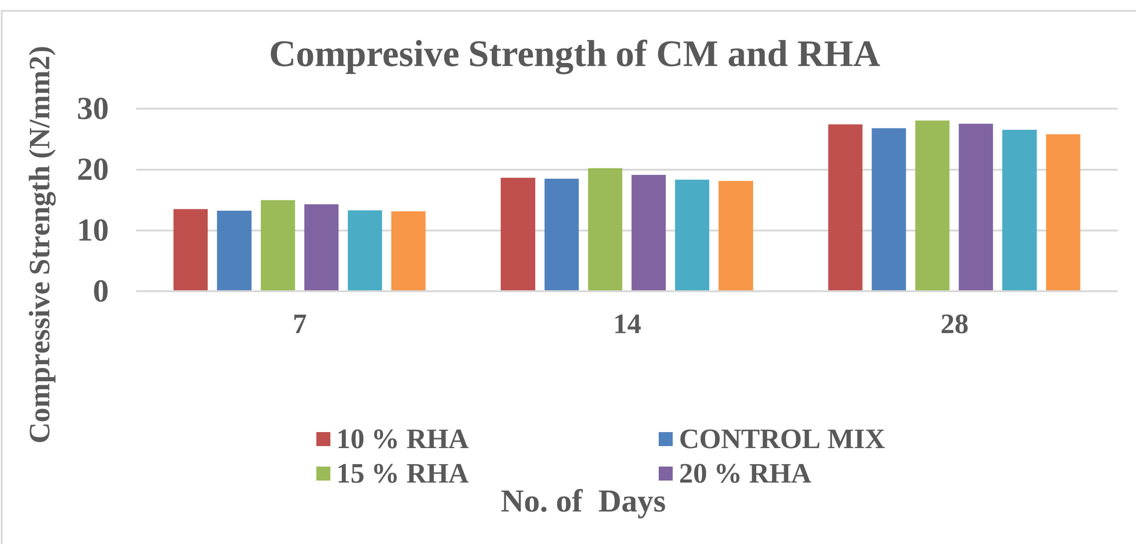
3	**Water absorption of coarse aggregate**	**2.5 - 3**	**2.82**	**IS 2386 Part 3 – 1986**

Results

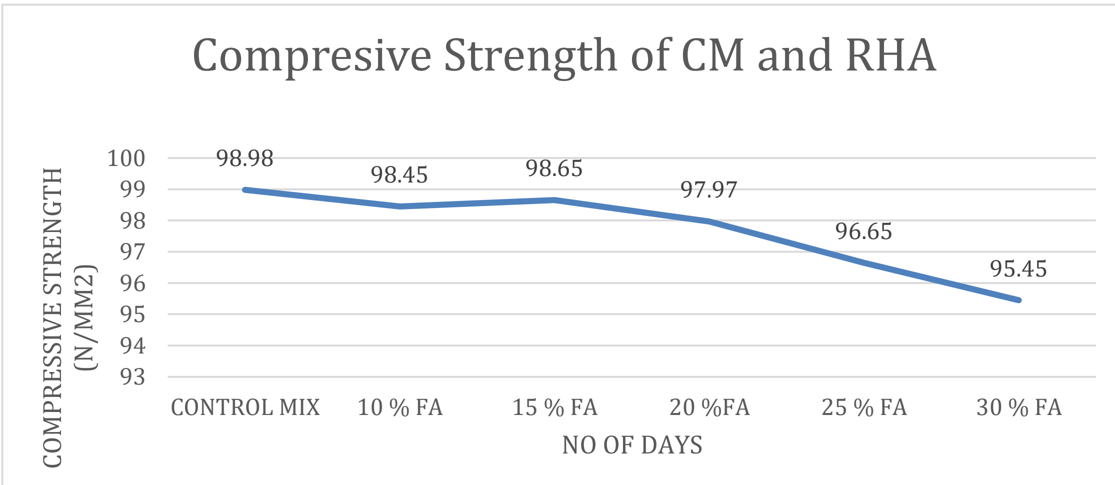
Comparative Strength Of Concrete M20 Grade

I % REPLACEMENT OF CM AND RHA

% replacement	7 Days N/mm2	14 Days N/mm2	28 Days N/mm2	Slump Height mm
CONTROL MIX	13.25	18.51	26.79	98.98
10 % RHA	13.52	18.65	27.43	97.56
15 % RHA	14.99	20.23	28.09	98.65
20 % RHA	14.30	19.13	27.56	97.97
25 % RHA	13.29	18.35	26.64	96.65
30 % RHA	13.12	18.15	25.84	95.45

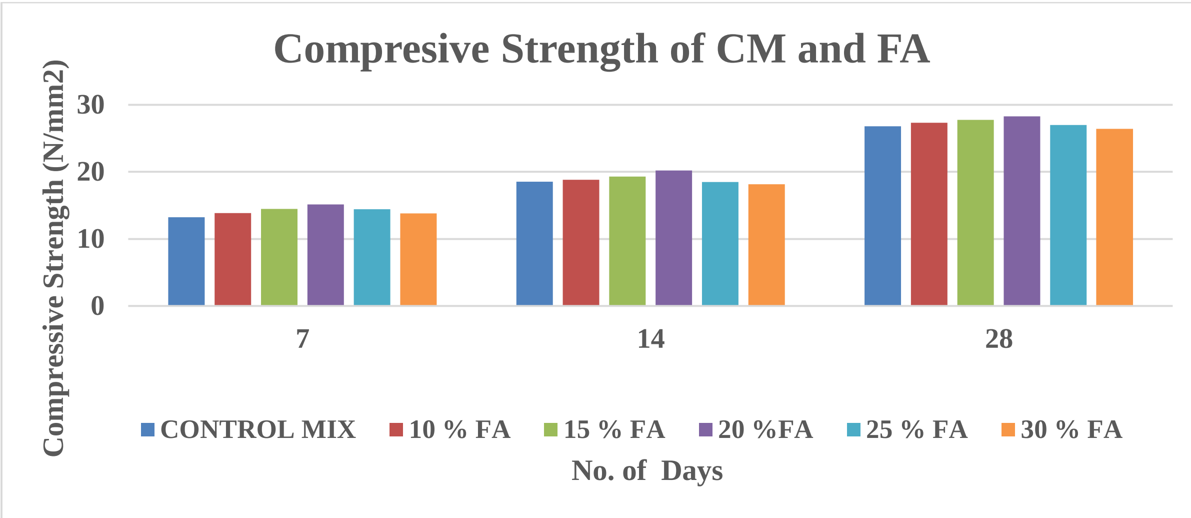


% REPLACEMENT	Slump Height
CONTROL MIX	98.98
10 % FA	98.45
15 % FA	98.65
20 %FA	97.97
25 % FA	96.65
30 % FA	95.45

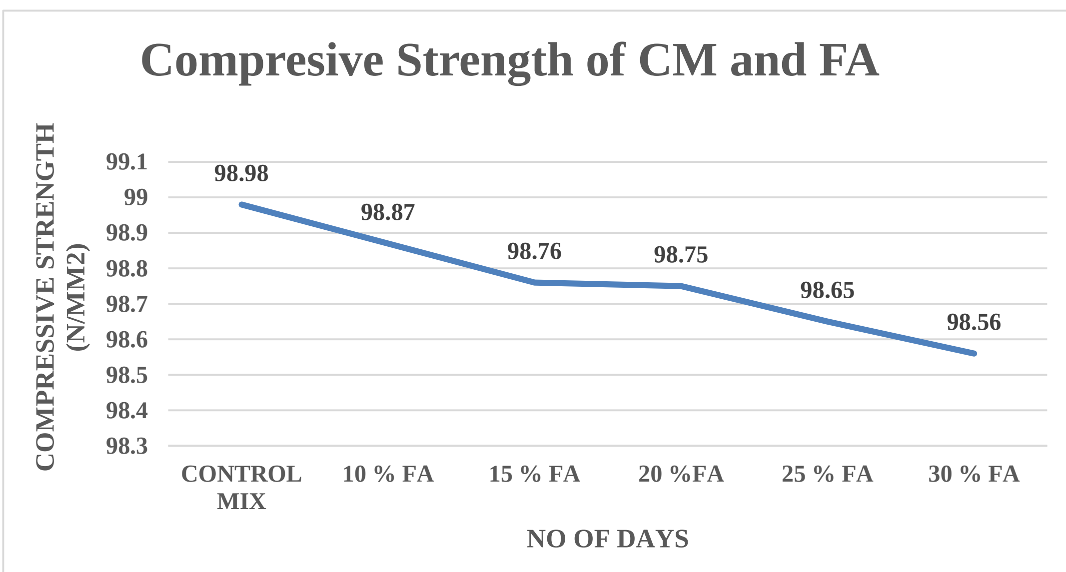


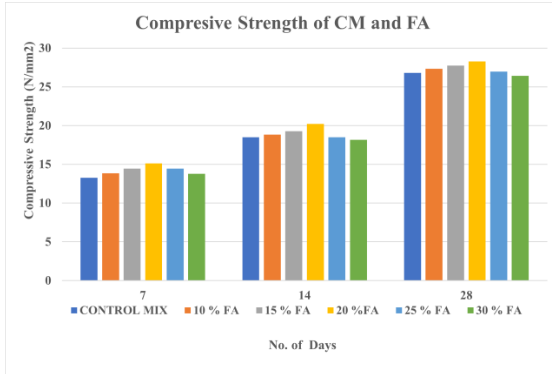
II % REPLACEMENT OF CM AND FA

% replacement	7 Days N/mm2	14 Days N/mm2	28 Days N/mm2	Slump Height mm
CONTROL MIX	13.25	18.51	26.79	98.98
10 % FA	13.83	18.84	27.33	96.45
15 % FA	14.45	19.28	27.75	97.89
20 % FA	15.12	20.22	28.29	98.75
25 % FA	14.44	18.5	26.97	97
30 % FA	13.78	18.17	26.42	96.45



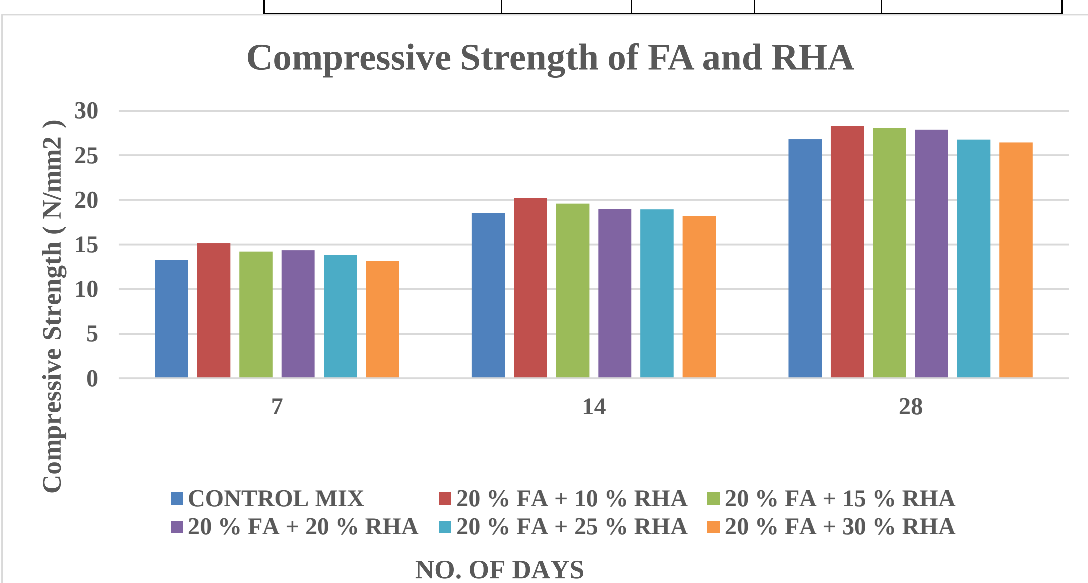
% REPLACEMENT	Slump Height
CONTROL MIX	98.98
10 % FA	98.87
15 % FA	98.76
20 %FA	98.75
25 % FA	98.65
30 % FA	98.56

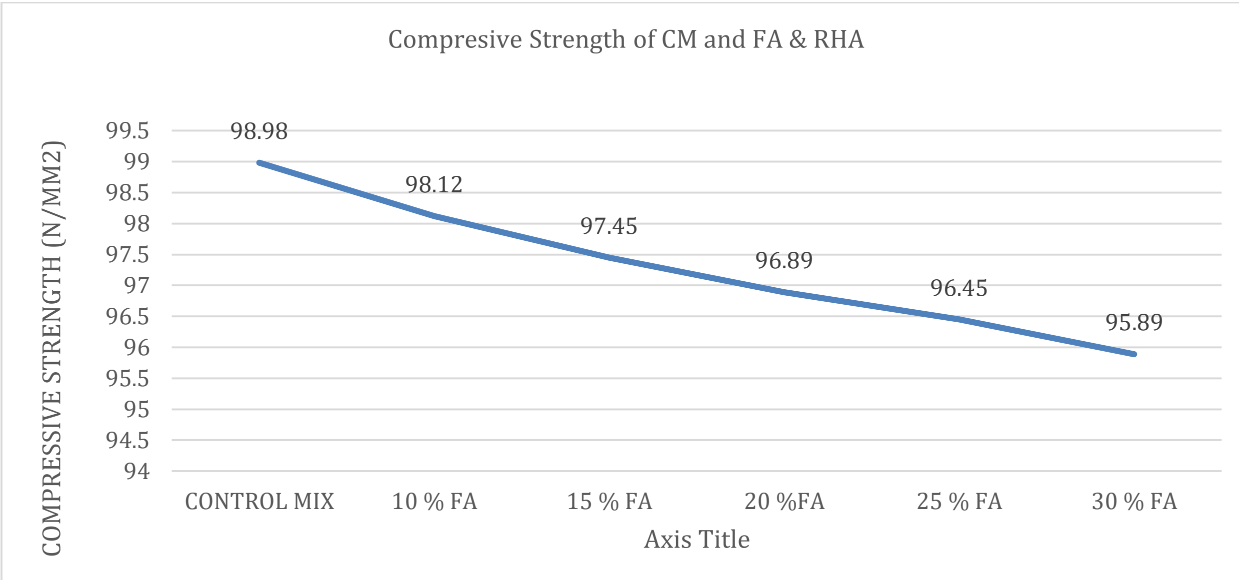




III % REPLACEMENT OF CM AND RHA AND FA

% replacement	7 Days N/mm2	14 Days N/mm2	28 Days N/mm2	Slump Height mm
CONTROL MIX	13.25	18.51	26.79	98.98
20 % FA + 10 % RHA	15.13	20.18	28.32	98.12
20 % FA + 15 % RHA	14.2	19.58	28.05	97.45
20 % FA + 20 % RHA	14.35	18.97	27.86	96.89
20 % FA + 25 % RHA	13.83	18.95	26.75	96.45
20 % FA + 30 % RHA	13.16	18.21	26.44	95.89





Conclusion

- Besides enhancing compressive strength, we also observed improvements in workability and a reduction in the heat of hydration.
- Using RHA and FA, both known for their pozzolanic properties, contributes to the formation of additional calcium silicate hydrates, enhancing overall strength and durability.
- Higher replacement percentages result in higher compressive strength.
- The optimum replacement percentage for RHA is 15%.
- The optimum replacement percentage for FA is 20%.

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