

EXAMINING THE DIFFERENT AGES OF COMPRESSIVE STRENGTH OF CONCRETE MADE WITH TERNARY BLENDED CEMENT

Vikas Kumar Sah¹, Dr. Vivek Soni²

¹M. Tech. Scholar, Madhyanchal Professional University, Faculty of engineering & Technology, School of civil engineering Bhopal, M.P., India.

²Assistant Professor, Madhyanchal Professional University, Faculty of engineering & Technology, School of civil engineering Bhopal, M.P., India.

ABSTRACT

Study on ternary blended concrete is quite compelling, particularly with the emphasis on sustainability and the enhancement of concrete properties through the use of mineral admixtures. Here's a summary of your findings. Research indicates that the use of fly ash and rice husk ash as partial replacements for cement in concrete can significantly enhance the mechanical properties of the concrete while also contributing to sustainability in construction. By optimizing the blend, it is possible to achieve stronger and more durable concrete without compromising workability, thus making it a viable alternative to traditional concrete mixes. This study could serve as a foundation for further research on optimizing mix proportions for various applications and conditions, potentially leading to broader adoption in the construction industry.

Key Word- Mechanical Properties, Ternary blended concrete, fly ash, Rice husk ash

1. INTRODUCTION

The study varied the replacement levels of fly ash and rice husk ash in concrete mixtures, up to a maximum of 40% by weight of cement. This included mixtures with different ratios of fly ash and rice husk ash to evaluate the optimal blend. Used in combination with the two supplementary materials.

Fly Ash

Fly ash is a byproduct produced from the combustion of pulverized coal in electric power plants. It is a fine, powdery material that is captured by emission control systems before it can escape into the atmosphere. Fly ash is primarily composed of silica, alumina, iron oxide, and calcium, and its chemical composition can vary depending on the type of coal burned and the combustion process used.

Types of Fly Ash

There are two main types of fly ash used in construction:

Class F Fly Ash:

- ❖ Derived from the burning of harder, older anthracite and bituminous coal.
- ❖ Has a lower calcium content (less than 20%).
- ❖ Contains pozzolanic properties, meaning it reacts with calcium hydroxide in the presence of water to form compounds possessing cementations properties.
- ❖ Requires a source of calcium, such as Portland cement, to activate its pozzolanic properties.

Class C Fly Ash:

- ❖ Produced from the burning of younger lignite or sub-bituminous coal.
- ❖ Has a higher calcium content (greater than 20%).
- ❖ Possesses both pozzolanic and cementations properties, allowing it to harden and gain strength when mixed with water.
- ❖ Can be used as a partial replacement for cement without needing an additional calcium source.

Applications of Fly Ash

Fly ash is widely used in the construction industry, especially in concrete production, due to its beneficial properties:

Concrete Production: Fly ash is commonly used as a partial replacement for Portland cement in concrete. It improves workability, reduces water demand, enhances durability, and increases the long-term strength of the concrete.

Soil Stabilization: Fly ash is used to improve the properties of soils, particularly for road bases and embankments. It helps to increase the soil's load-bearing capacity and reduce its compressibility.

Waste Management: Fly ash can be used in landfills to reduce the permeability of soil, thereby preventing the leaching of hazardous substances.

Geopolymer Concrete: Fly ash can be used to produce geopolymer concrete, an eco-friendly alternative to traditional Portland cement concrete. This type of concrete uses fly ash as the main binder, reducing the need for cement and consequently lowering CO₂ emissions.

Benefits of Using Fly Ash

Environmental Sustainability: Utilizing fly ash in construction helps reduce waste and the demand for raw materials. It also decreases greenhouse gas emissions associated with cement production.

Improved Concrete Properties: Fly ash enhances the workability and pump ability of concrete, reduces permeability, increases resistance to alkali-silica reactivity, and provides greater resistance to sulfate attack.

Cost Efficiency: Fly ash is often less expensive than Portland cement, providing a cost-effective option for concrete production.

Challenges and Considerations

Variable Quality: The quality of fly ash can vary significantly based on its source, making quality control essential.

Setting Time: Fly ash concrete may have a longer setting time compared to regular Portland cement concrete, which can affect construction schedules.

Availability: The availability of fly ash depends on the presence of coal-fired power plants, which may be limited in some regions.

Rice husk ash (RHA)

Rice husk ash (RHA) is a byproduct obtained from the burning of rice husks, which are the outer coverings of rice grains. It is highly valued in construction and environmental applications due to its unique properties. Here are some key points about rice husk ash:

Composition and Properties:

Silica Content: RHA is primarily composed of silica (SiO₂), which can range from 85% to 95% depending on the burning process. This high silica content makes RHA a valuable pozzolanic material, meaning it can react with calcium hydroxide in the presence of water to form compounds that possess cementitious properties.

Physical Characteristics: RHA is typically a fine powder with a high specific surface area, which enhances its reactivity. The color of the ash can range from white to black, depending on the burning temperature and duration.

Production Process:

Controlled Burning: For optimal use in concrete and construction, rice husks are often burned in a controlled environment, such as in a kiln, to produce RHA with high amorphous silica content. High temperatures (between 500°C and 700°C) are preferred to avoid crystalline silica formation, which is less reactive and could pose health risks.

Applications in Construction:

Cement Replacement: RHA is commonly used as a partial replacement for cement in concrete. Substituting cement with RHA not only reduces the overall cost of concrete but also enhances certain properties, such as durability, impermeability, and resistance to chemical attack.

Pozzolanic Material: When added to concrete, RHA reacts with the calcium hydroxide released during cement hydration to form additional calcium silicate hydrate (C-S-H), which improves the strength and durability of the concrete.

Insulation Material: Due to its low thermal conductivity, RHA can also be used as an insulation material in various construction applications.

Environmental Benefits:

Waste Utilization: The use of RHA in concrete helps in recycling agricultural waste, reducing landfill disposal, and minimizing environmental pollution.

Reduced Carbon Footprint: By replacing a portion of cement with RHA, the carbon footprint of concrete production can be reduced. Cement manufacturing is a significant source of CO₂ emissions, so using RHA helps lower the environmental impact.

Anil Kumar et al (2023) focuses on sustainable construction by incorporating a multi-blended cement system in concrete using Ordinary Portland Cement (OPC) along with glass powder and sugarcane bagasse ash as partial replacements for cement. Here's a summary of your study. Reduce cement usage by replacing it with waste materials like glass powder and sugarcane bagasse ash to promote sustainable practices. Determine the optimum mix ratio for a concrete grade of M20 with a water-binder ratio of 0.48. An inert material and potential recycling material that can reduce landfill waste. Used as a partial replacement for cement. Evaluate and compare the compressive strength of

concrete cubes at various replacement levels with conventional concrete to identify the optimum mix ratio. Could significantly contribute to sustainable construction practices by optimizing the use of recycled and waste materials in concrete, thereby reducing the reliance on conventional cement and improving environmental sustainability. Encourage the use of waste materials in construction, reducing environmental impact and promoting sustainable development.

Mohamed Amin et al (2019) the study concludes that incorporating RHA and FA in concrete mixtures not only contributes to sustainability by recycling waste materials but also improves the concrete's performance. RHA, in particular, offers significant benefits over FA in enhancing both the strength and durability of concrete, making it a preferable choice for producing sustainable concrete mixtures. Water permeability decreased as the cementations content increased. This was attributed to the reduction in air content, which generally enhances the concrete's impermeability. Mixtures with higher cementations content (like those in Group 3 with 550 kg/m³) had lower water permeability. Conversely, water permeability loss ratios increased as the cementations content decreased, indicating a correlation between lower cement content and higher permeability. RHA is more beneficial than FA in enhancing both mechanical and physical properties of concrete, particularly in mixtures with a cementations content of 450 kg/m³. The optimal replacement ratios for achieving the best mechanical properties were 10% and 30% RHA, depending on the desired outcome. The study investigates the impact of different replacement ratios of rice husk ash (RHA) and fly ash (FA) on the fresh and hardened properties of concrete. The aim is to assess the efficiency of using these recycled materials to produce sustainable (green) concrete.

2. METHODS

Procedure for Concrete Mix Design of M25 Concrete

Step-1 Determination of Target Strength

Harmsworth constant for 5% risk factor is 1.65. In this case standard deviation is taken from IS: 456 against M 25 is 4.0.

$$f_{target} = f_{ck} + 1.65 \times S = 25 + 1.65 \times 4.0 = 31.60 \text{ N/mm}^2$$

Where,

S = standard deviation in N/mm² = 4 (as per table -1 of IS 10262- 2009) For a tolerance factor of 1.65 and a standard deviation value of 4.0 the target mean strength of concrete comes out to be equal to 31.60 N/mm².

Step-2 Selection of water cement ratio

From table 5 of IS 456 on page no. 20, Maximum water-cement ratio=0.50 Based on experience, adopt water-cement ratio as 0.43, for the target mean strength and required workability 0.43<0.50, hence O.K.

Step-3 Selection of water content

From Table 2 of IS 10262- 2009, Maximum water content = 186 Kg (for Nominal maximum size of aggregate — 20 mm) Estimated water content = 186 – 20 = 166 liter /m³

Step-4 Calculation of cement content

Water-cement ratio = 0.46

$$\text{Cement content} = \frac{166}{0.46} = 360.86 \text{ approx. } 361 \text{ Kg/m}^3$$

The volume of coarse aggregate per unit volume of total aggregate is 0.634 Volume of fine aggregate is taken as 0.366

Step-5 Mix Calculations

The mix calculations per unit volume of concrete shall be as follows Volume of concrete = 1 m³

$$\text{Volume of cement} = \frac{\text{Mass of cement} \times 1}{\text{Specific gravity of cement} \times 1000}$$

$$\frac{361 \times 1}{2.82 \times 1000} = 0.128 \text{ m}^3$$

$$\text{Volume of water} = \frac{\text{Mass of water} \times 1}{\text{Specific gravity of water} \times 1000}$$

$$\frac{166 \times 1}{1 \times 1000} = 0.166 \text{ m}^3$$

Super Plasticizer @ 1.0% By Mass of cementations material) = 0.0029

Volume of all in aggregate = [a - (b + c + d)]

$$= 1 - [0.128 + 0.166 + 0.0029]$$

$$= 0.7031 \text{ m}^3$$

Mass of coarse aggregate = 1207 Kg

Mass of fine aggregate = 679 Kg

Table 1 Quantity Of Materials For 1m³ Of M25 Concrete

Cement	Sand	Aggregate	Water	Admixture
361	679	1207	166	1.61

In this study we replace cement with different percentages of industrial waste and agricultural waste to perform this study. Replacement of cement in such a way 0%, 5% (2.5% FA+ 2.5% RAH), 10% (5% FA+ 5% RAH), 15% (7.5% FA+7.5% RAH), 20% (10%FA+ 10% RAH) and 25% (12.5FA+ 12.5RHA). By substituting cement with these waste materials, we aim to analyze the impact on concrete's mechanical properties, durability, and sustainability. This approach can help in reducing the carbon footprint of concrete production and enhancing the reuse of waste materials.

So New composition we have to find out shown in table

Table 2 cementenious materials used in this study

S.N	Mix	Cement %	Fly Ash %	Rice Husk Ash %
1	CM	100	0	0
2	5%	95	2.5	2.5
3	10%	90	5	5
4	15%	85	7.5	7.5
5	20%	80	10	10
6	25%	75	12.5	12.5

Table 3 cementenious materials quantity

S.N	Mix	Cement %	Fly Ash %	Rice Husk Ash %
1	CM	361	0	0
2	5%	342.95	9.025	9.025
3	10%	324.90	18.05	18.05
4	15%	306.85	27.075	27.075
5	20%	288.80	36.10	36.10
6	25%	270.75	45.125	45.125

3. RESULT AND DISCUSSION

Compressive strength

To determine the compressive strength of concrete after 56 days and 90 days, you'll typically need to conduct compressive strength tests on concrete specimens that have been cured for the respective periods. Compressive strength tests are usually conducted according to standards like ASTM C39 or EN 12390-3.

If you have specific data or a mix design that you want to analyze, you can provide that information, and I can help calculate or interpret the results. Otherwise, here is a general overview of what to expect.

Typical Strength Gain Pattern:

- ❖ **7 days:** Concrete typically reaches about 60-75% of its 28-day strength.
- ❖ **28 days:** Concrete is usually tested for its standard compressive strength, and it's often expected to achieve its designed strength by this time.
- ❖ **56 days:** Strength gain continues, and concrete may reach approximately 105-115% of its 28-day strength, depending on mix design and curing conditions.
- ❖ **90 days and beyond:** Concrete can continue to gain strength beyond 28 days, especially in mixes with supplementary cementations materials (SCMs) like fly ash or slag. By 90 days, concrete may reach 110-125% of its 28-day strength.

Table 4 Compressive strength (Mpa) of different percentages of fly ash and rice husk ash

Mix	7Days	28 Days	56 Days	90 Days
CM	17.26	26.56	27.31	29.40
5%	18.48	28.87	30.42	31.85

10%	20.16	30.54	32.65	33.15
15%	20.36	31.32	33.47	35.35
20%	21.93	33.23	35.65	38.95
25%	19.58	30.12	31.52	33.65

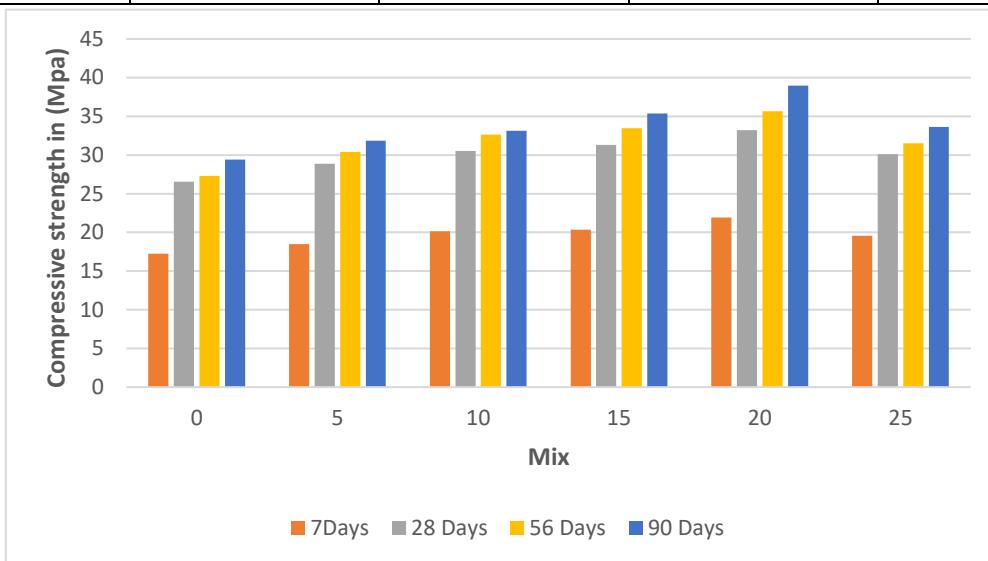


Figure 1 Different age of compressive strength

The observation you provided suggests that when a blend of Rice Husk Ash (RHA) and Fly Ash (FA) is used to replace up to 25% of Ordinary Portland Cement (OPC) in concrete, there is a noticeable effect on the strength development at different stages.

Early Strength Development (7 & 28 Days): The concrete with RHA and FA shows a slower early strength development compared to the control mix with only OPC. This can be attributed to the slower initial pozzolanic reaction of RHA and FA. Pozzolans typically have a delayed reaction as they rely on the calcium hydroxide produced during the hydration of OPC to react and form additional cementations compounds.

Later Age Strength: At 56 days and 90 days, the strength of the concrete containing the blend of RHA and FA exceeds that of the normal OPC concrete. This increase in later age strength is likely due to the continued pozzolanic reaction. Over time, the RHA and FA consume calcium hydroxide, a by-product of cement hydration, and form additional calcium silicate hydrate (C-S-H), which contributes to the strength and durability of the concrete.

4. CONCLUSIONS

This behavior is common when using supplementary cementations materials (SCMs) like RHA and FA, as they often provide long-term benefits in terms of strength gain and durability, despite slower early strength development. The slow early pozzolanic activity allows for the development of a denser microstructure over time, improving the mechanical properties and reducing the permeability of the concrete.

5. REFERENCES

- [1] Anil Kumar, Priyanka Dubey "Research on the Strength and Durability Characteristics of Concrete with Ternary Blend" © 2023, IRJEdT Volume: 05 Issue: 08 | Aug-2023.
- [2] Uma Maguesvari Muthaiyan "Investigating the properties of ternary-blended self-compacting concrete with fibre" Corresponding Author: Uma Maguesvari Muthaiyan Received on 03/12/2023 Accepted on 05/02/2024 DOI: <https://doi.org/10.1590/1517-7076-RMAT-2023-0346>
- [3] S. Ramesh Reddy1, P.Srinath2, Dr V. Bhaskar Desai "Some studies on strength properties of tetra blended concrete with partial replacement of cement by various pozzolanic materials and micro Al₂O₃" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 04 Issue: 03 | Mar -2017 www.irjet.net
- [4] Jean Bosco Nemeyabahizi , Aanchna Sharma "partial replacement of cement with combination of rice husk ash and ground granulated blast furnace slag in scc- an experimental analysis" International Journal of Civil Engineering and Technology (IJCET) Volume 8, Issue 5, May 2017, pp.773–782, Article ID: IJCET_08_05_087 Available online at <http://iaeme.com/Home/issue/IJCET?Volume=8&Issue=5> ISSN Print: 0976-6308 and ISSN Online: 0976-6316

- [5] Y. Pradeep Kumar Reddy, Y. Pramod Kumar Reddy, V. Vasugi "Experimental Studies on Ternary Blended Concrete" International Journal of Inventive Engineering and Sciences (IJIES) ISSN: 2319-9598, Volume-4 Issue-6, June 2017 Retrieval Number: F0757054617/2017©BEIESP
- [6] L. O. Ettu1, O. M. Ibearugbulem2, K. O. Njoku3, L. Anyaogu4, and S. I. Agbo5 "Strength of Ternary Blended Cement Sandcrete Containing Afikpo Rice Husk Ash and Saw Dust Ash" American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN : 2320-0936 Volume-2, Issue-4, pp-133-137 www.ajer.us
- [7] Satish H. Sathawanea*, Vikrant S. Vairagadeb and Kavita S Kene "Combine Effect of Rice Husk Ash and Fly Ash on Concrete by 30% Cement Replacement" Chemical, Civil and Mechanical Engineering Track of 3rd Nirma University International Conference 1877-7058 © 2013 The Authors. Published by Elsevier Ltd. Selection and peer-review under responsibility of Institute of Technology, Nirma University, Ahmedabad. doi: 10.1016/j.proeng.2013.01.009
- [8] A comparative study of the properties and durability of binary and ternary cementitious systems By C. Shiathas. T. Z. Muntasser and S.O. Nwaubani. Ahmed, S.F., Maalej, M., Paramasivam, P. and Mihashi, H. (2006), "Assesment of Corrosion-Induced Damage and its Effect on the Structural Behavior of RC Beams Containing Supplementary Cementitious Materials", Progress in Structural Engineering and Materials, (2), pp. 69–77. Anwar, M. (2008), "Concrete properties of ternary cementitious systems containing Fly Ash and Micro Silica" HBRC Journal Vol. 2 No.
- [9] Austin, S.A., Lyons, R. and Ing, M.J. (2004), "Electrochemical Behavior of Steel Reinforced Concrete during Accelerated Corrosion Testing", Corrosion, 60(2), pp. 203–21