iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** VI **Month of publication:** June 2026

DOI: https://doi.org/10.22214/ijraset.2026.83772

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue VI June 2026- Available at www.ijraset.com

Use of Rice Husk Ash in Concrete Blocks

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Abstract: ***With an ever increasing concern over environmental issues associated with the production of Ordinary Portland Cement (OPC) and also the need for managing wastes, researchers are looking into supplementary cementitious materials (SCMs).Rice Husk Ash (RHA), a agricultural byproduct obtained from burning of millinghusks under controlled temperatures is known for it's high amorphous silica content and therefore it is a high reactive pozzolanic .This study was to determine the possibility and the effects of using RHA as a partial substitute of cement in manufacturing standard concrete blocks. The study examines effect of RHA on workability, compressive strength, unit weight and durability and came to the conclusion that optimum replacement level could be used to produce structural concrete blocks which will be economical and ecologically safe.***

I. INTRODUCTION

In the construction industry there is a constant search for alternative materials which are sustainable, affordable, and can replace the conventional ones, especially cement and concrete. Various pozzolanic supplementary cementitious materials have been explored. Amongst these rice husk ash is one such material. RHA has been gaining attention owing to its high silica content and pozzolanic reactivity and the vast availability of rice husk in rice producing countries. The rice husk is a waste by-product of milling of rice. The disposal of this material can cause pollution through open burning and landfills. Controlled combustion of rice husk results in rice husk ash. RHA seems to have potential of being used as a replacement of cement in concrete block construction. This paper discusses on using RHA in concrete block construction and highlights on its characteristics, behavior, advantage and limitations.

Concrete blocks are being widely used in the modern construction practice both for load-bearing and non-load bearing structures as it has high durability, cost effective, and easy to produce. However the production of cement a vital binding component of concrete block is having highest percentage of total man made CO 2 emission and is highest energy consuming industry as 7-8% of global man made CO 2 emission is generated from the production of cement. Hence agriculture waste materials can be an effective answer for developing durable and sustainable construction blocks and these waste materials can be effectively replaced with cement. Rice husk is being identified as suitable agriculture waste for use in concrete blocks.

The chemical composition of rice husk ash mainly constitutes amorphous silica. Generally, it contains 80-95 % silica depending upon the temperature and period of burning of the rice husk. With high silica content RHA is found to have pozzolanic reaction. In presence of calcium hydroxide and water RHA forms extra calcium silicate hydrates which contributes for concrete strength. The efficiency of RHA in replacing cement may depend on the parameters of burning temperature, duration and grinding fineness of RHA. The microstructure properties of concrete are being enhanced due to the addition of properly burnt and ground RHA thus increasing the compressive strength, reducing permeability and improving durability of concrete.

The use of rice husk ash in concrete block has been researched on various percentages of replacement of cement from 5-30 % by weight. The use of smaller percentage of RHA may even increase the concrete block strength compared to plain concrete blocks due to the filler and pozzolanic effect whereas higher percentage can even reduce the strength if not carefully optimized. Moreover, resistance against sulfate and chloride attack in concrete block may be improved with the inclusion of RHA, thus makes it suitable for durable construction especially in marine environment.

As per sustainability, rice husk ash is playing vital role by reducing waste generated from agriculture and by resource conservation. In many countries, the availability of rice husk is high which makes RHA readily and affordably available. By utilizing RHA for concrete block it would ultimately lead to decrease in usage of Portland cement in construction which eventually contribute for environmental protection. Further the application of agriculture waste reduces landfill and open burning which can cause considerable impact in environment due to the emitted pollution. This initiative leads to use the waste material efficiently.

However, the RHA used in construction has various limitations and is not widely implemented for practical applications, these problems are related with inconsistent quality and variable performance, proper burning technique should be taken care to reduce crystalline silica content, as with crystalline silica, the pozzolanic activity of RHA will not enhance the strength, RHA is being normally replaced with cement in ground form; this is very fine when compared with cement and it does cause increased cost of production of RHA concrete blocks.

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In the final estimation, the use of RHA as a cementitious supplementary material in concrete blocks could be one such approach, which could contribute toward sustainable construction by being an affordable, efficient and available alternative to cement. This review paper tries to bring together current knowledge related to rice husk ash concrete blocks and their prospects in future.

II. LITERATURE REVIEW

1) B. Mehta , P.K., Symposium Paper Publication (5 January 1995)

Describe how cement mortar is durable in presence of rice husk Ash (RHA).The strength and durability of mortar with different replacement level(10%, 20% and 30%) ofOrdinaryPortland cement (OPC)by RHA is analyzed in this work. The RHA was manufactured by an uncontrolled combustion. The test specimen was cast with 2.73 FMriver sand. It was stored in controlled curing environment for testing time. The results indicates that the Addition of RHA reveals promising result for 20% replacement level OPC at 90 days. In the durability test, all specimens pass at 20 cycles except 25% replacement level of 30%.When the RHA is produced by an uncontrolled combustion of the burning temperature varies from about 3,000-4,500 C, ignition of some rice husk cannot be fully completed; there exists a certain portion of unburned carbon in the ash produced. The activity of amorphous silica depends directly upon the surface area of the ash. Few of the researchers found that temperature and time are responsible for burning of rice husks to be active. In uncontrolled combustion process like burning of Rice Husks in heaps; the burning duration is influenced by the surroundings such as atmospheric temperature, humidity and wind velocity. So there were limited studies conducted using rice husks ash produced by uncontrolled combustion**.**

2) P V Rambabu,et.al. "Experimental Study on Rice Husk Ash for Optimum Level of Replacement of Cement in Concrete" International Journal of Engineering Research & Technology 2015

The pervious study on rice husk ash showed optimum percentage of replacement of Rice husk ash in cement is 10% by weight of cement. Aim of the present paper is to get max value in the optimum range (up to 10% replacement) which provide improved strength and durability. RHA possesses good pozzolanic nature and good pozzolanic activity due to its highest silica content.Rice husk ash is mainly consisting of amorphous silica (90% SiO2), 5% Carbon and 2% K2O. The Rice husk ash is replaced partially at different percentage (0%, 5%, 6%, 7%, 8%, 9%, 10%) by weight of cement. This concrete is designed with mix and cured for a period of different days (28, 60, 90 days). This paper show that replacement of OPC with RHA is 6%, where optimum compressive strength is increased, due to high pozzolanic activity of RHA. Attack of Sulfuric acid (H2SO4) on the properties of replaced RHA concrete and on compressive strength of concrete mixture is used as scope. The obtained result show that rate of increase of compressive strength with curing age is decrease with increase in concentration of H2SO4 at 28, 60, 90 days but at 6% replaced RHA concrete shown good resistance against sulfuric acid.

3) Ramakrishnan S, Velrajkumar G, Ranjith S R.S. Publication (January 2014)

This paper explains the concrete behavior for pavement replacing the different percentage of ashes hush up by weight of cement for quality control concrete mixture M40. The purpose of this paper is to study the effect of the rice husk ash (RHA) on the different concrete parameters and its property to make a concrete which is economical for the rigid pavements. An attempt was made to use the bending strength of concrete to reach the design of rigid floor which has more than the bending resistance as required by IRC: 58-2002. A detailed test were carried out to evaluate the performance of different concrete parameters by partial replacement of cement with RHA in the concrete and its behavior to make concrete economical for rigid pavements.

4) Mehta and Pirth (2000)

studied the use of ORS to reduce the temperature in high strength concrete mass and obtained results showing that the RHA is very effective in reducing the temperature of the concrete mass compared to OPC concrete. Malhotra and Mehta (2004) reported later that RHA pattern with finer particle size OPC improves concrete properties, including higher amounts substitution results in lower water absorption values and the addition of RHA causes an increase in the compressive strength. The results of the compressive strength of concrete cubes show that compressive strengths reduced RHA increased the percentage. However, the compressive strength increased the number of days for each percentage increased hardening RHA replacement.

5) "Strength and Durability Performance of RHA Concrete" – Ganesan et al. (2008)

In a separate study on the effect of RHA on mechanical and durability of concrete, Ganesan et al. (2008) experimented on varying percentages from 5 to 30 % of cement replaced with RHA and tested for compressive strength, permeability and resistance of chloride.

According to the findings, cement replaced by RHA ranging from 10-20% showed better compressive strength over plain concrete due to the pozzolanic reactivity of the particles and micro-filling property that filled small pores to improve the matrix. Lower permeability to water and greater resistance to the penetration of chloride was also indicated due to decrease of pore interconnectivity and so the durability of concrete was increased in a more hostile environment. Hence, the authors stated RHA is a feasible supplementary cementitious material for a strength and durability improved concrete block without increasing the cost and environmental impacts.

6) *"Influence of Rice Husk Ash on Fresh and Hardened Concrete Properties" – Habeeb and Mahmud (2010) Habeeb and Mahmud (2010)*

Evaluated the effect of Rice Husk Ash on the properties of fresh and hardened concrete, the workability and compressive strength of concrete and also the density and water absorption of concrete. In this study the work done showed that the properly burnt Rice Husk Ash increases the properties of concrete at optimal proportion but excess proportion showed reverse effect on the strength of concrete while the workability is affected negatively. Researchers said that, strength and workability of concrete are optimized at 10% RHA replacement of cement. In this study it was concluded that concrete compressive strength increases with increasing pozzolana activity from RHA and the absorption of water decrease as there was improvement in pore refinement. Excessive proportion affects the strength negatively whereas workability also affected negatively. Researchers suggested that controlled burning and fine grinding of rice husks are essential to attain the benefits from the RHA. It concluded that RHA can be utilized as a green replacement material for high quality concrete blocks.

7) *"Application of Rice Husk Ash in High-Performance Concrete" – Bui et al. (2005)*

In addition, Bui et al (2005) also studies the feasibility of using rice husk ash for manufacturing high performance concrete blocks. It analyses strength development and durability properties of RHA blended concrete. Microstructural changes due to using RHA were investigated and described. The researchers claim that RHA blended concrete reached a higher compressive strength compared to conventional concrete by means of generation of more C-S-H gel. The finer particle size of RHA led to a denser packing and void reduction of concrete. The study also found that RHA improved chloride and chemical resistance of the blended concrete as it possessed a higher durability. The RHA usage helps reducing the cement demand, thus contributing to less carbon emission. Bui et al (2005) concluded that RHA was successful for manufacturing high performance concrete blocks.

8) *"Sustainable Concrete Technology Using Rice Husk Ash" – Kartini (2011)*

A research by Kartini (2011) conducted on application ofRice Husk Ash(RHA) in sustainable concrete technology looked at environmental, economic and technical advantages of using RHA as a cement substitute. The author observed that the use of RHA made the concrete denser and durable due to decrease in water absorption and modification of the pore structure. The resistance of the concrete to chemical attack and weathering effects was also enhanced by addition of RHA. Besides enhancement of concrete properties, economic aspect due to utilization of a low cost agricultural waste was also addressed. The lesser amount of cement usage has also contributed in reduced amount of greenhouse gases and consequently the carbon foot print is reduced. The author finally concluded that RHA is a suitable sustainable material for concrete block manufacturing and suggested it for wider application in construction for eco friendly building concept**.**

III. MATERIALS AND METHODOLOGY

A. *Materials:*

1) *Cement*

OPC grade 53 as per IS 12269:1989 was used for the mix. Cement was used as the main binder in the mix, its specific gravity is 3.15.

2) *Fine Aggregate*

Crushed granite stones (Manufactured sand, M-sand) were used as fine aggregate. The fine aggregate has specific gravity of 2.70. Water absorption percentage of fine aggregate is 1.0%. Fine aggregate has a grading zone of Zone I as per IS 383.

3) *Coarse Aggregate*

Crushed angular coarse aggregate, with a nominal size of 20 mm was used as coarse aggregate. The specific gravity and percentage of water absorption for the coarse aggregate used was 2.80 and 0.4%.

4) Water

The portable fresh water that was free from foreign material and harmful matter was used. Water with ph around 7 was used for the whole process of casting and curing.

5) Rice Husk Ash (RHA)

Rice husk ash obtained from burning rice husk in a controlled atmosphere. Rice husk ash was partially replaced by cement. The Rice Husk Ash showed high percentage of silica content & pozzolonic nature. The proportions at which the cement was replaced by rice husk ash are:

0% (control mix)
5%
10%
15%

6) Chemical Admixture

superplasticizer, according to IS 9103, was assumed for this mix and was to be added to preserve the workability of the concrete.

B. Methodology

1) Mix Design

Mix design for M30 grade concrete was developed as per IS 10262:2009. The mean compressive strength was calculated using required standards. The water cement ratio considered was 0.50. Target slump value of 100mm was adopted for mix design. The mix design was carried out by trial.

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2) Materials Collection and Weighing

Materials Cement, fine aggregate, coarse aggregate, Rice Husk Ash were weighted according to the mix proportion design. The RHA to be treated and sieved was prepared.

3) Replacement of Cement with Rice Husk Ash

The Rice husk ash was used to replace Cement by the required percentages ranging from 0% RHA to 15% RHA in steps of 5%.

4) Mixing of Ingredients

Cement, rice husk ash, fine aggregate and coarse aggregate are dry mixed together thoroughly so as to obtain a homogeneous mix. Water is then added, while continuously mixing, until the mix is homogeneous and workability is achieved.

5) Casting of Blocks

The fresh concrete mix is cast into required blocks and properly compacted to achieve minimum air voids. A smooth surface is obtained by finishing each block.

6) Demoulding and Curing

After initial setting of the cement the blocks are removed from the mould. The blocks are placed for water curing. They are to be cured at the ages 3, 7, 14 and 28 days.

IV. MIX DESIGN IDENTIFICATION

Mix ID	Curing Age	RHA Replacement	Description
A1	3 days	0%	Concrete block with RHA as partial cement replacement
A2	3 days	5%	Concrete block with RHA as partial cement replacement
A3	3 days	10%	Concrete block with RHA as partial cement replacement

A4	3 days	15%	Concrete block with RHA as partial cement replacement
B1	7 days	0%	Concrete block with RHA as partial cement replacement
B2	7 days	5%	Concrete block with RHA as partial cement replacement
B3	7 days	10%	Concrete block with RHA as partial cement replacement
B4	7 days	15%	Concrete block with RHA as partial cement replacement
C1	14 days	0%	Concrete block with RHA as partial cement replacement
C2	14 days	5%	Concrete block with RHA as partial cement replacement
C3	14 days	10%	Concrete block with RHA as partial cement replacement
C4	14 days	15%	Concrete block with RHA as partial cement replacement
D1	28 days	0%	Concrete block with RHA as partial cement replacement
D2	28 days	5%	Concrete block with RHA as partial cement replacement
D3	28 days	10%	Concrete block with RHA as partial cement replacement
D4	28 days	15%	Concrete block with RHA as partial cement replacement

V. RESULT

Experimental Compressive Strength Data

RHA Replacement	3 days (MPa)	7 days (MPa)	14 days (MPa)	28 days (MPa)
0%	6.69	10.03	13.38	17.81
5%	6.40	9.46	12.52	16.14
10%	6.13	8.90	11.70	14.44
15%	5.87	8.37	11.14	13.93

Experimental Compressive Strength data for RHA concrete blocks.

The compressive strength of all concrete blocks increased with curing age due to continuous cement hydration. Incorporation of RHA slightly reduced strength compared to the control mix; however, 5–10% RHA showed satisfactory performance because of its pozzolanic activity and filler effect.

Beyond 10% replacement, strength decreased significantly due to reduction in cementitious content and increased water demand.

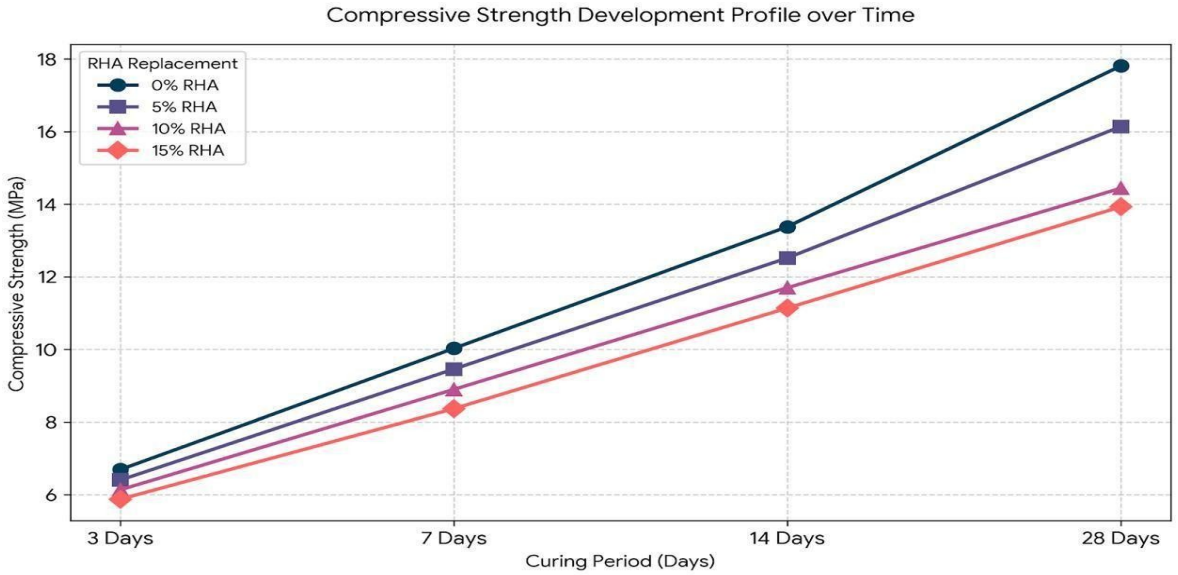

Figure. Compressive strength versus curing age for different RHA replacement levels

Compressive strength of all the concrete blocks increased with curing age due to continued hydration of cement. Control mix (0% RHA) showed greater strength while strength decreased with increase of RHA content. Concrete blocks with 5-10% replacement of RHA produced good compressive strength values because of pozzalanic effect and filler effect of RHA. Replacement of 15% of RHA brought significant decrease in compressive strength due to less cement content and higher water demand.

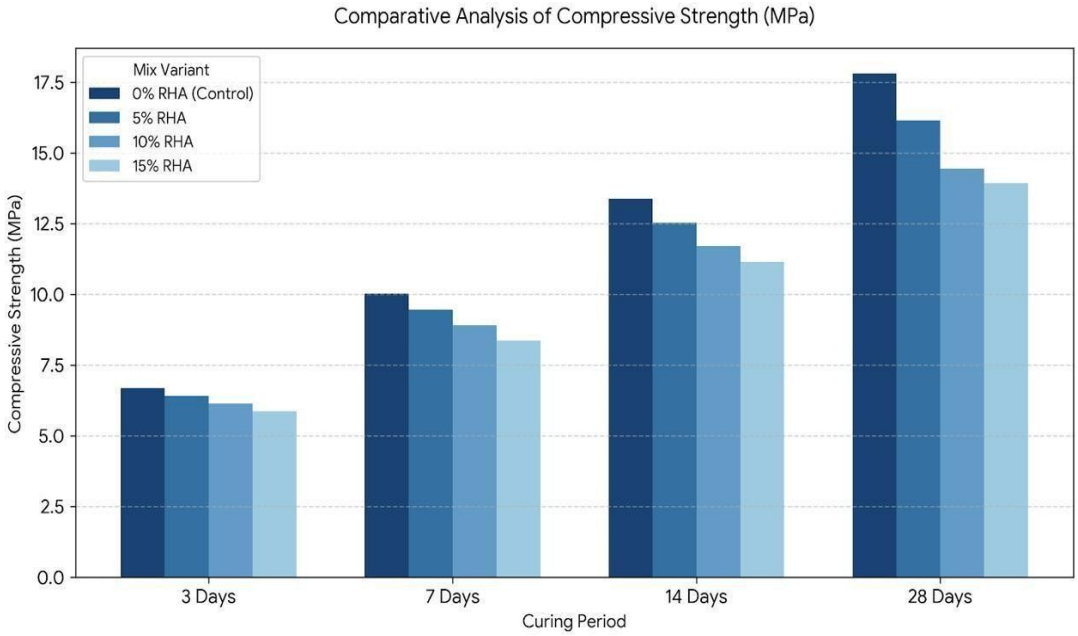

Figure . Comparison of 28-day Compressive strength of concrete blocks

All mixes show progressive strength gain from 3 to 28 days due to continuous cement hydration. At early stages (3–7 days), higher Rice Husk Ash (RHA) content decreases strength via the dilution effect, reducing initial binder volume . During later stages (14–28 days), amorphous silica in RHA reacts pozzolanically with liberated Calcium Hydroxide, generating secondary Calcium Silicate Hydrate (C-S-H) gel to densify the micro-matrix.The 5% to 10% range is ideal, maintaining 81%–91% of control strength (14.44–16.14 MPa). Beyond 10%, excess unreacted silica increases water demand and porosity, reducing structural performance.

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Cost comparison:

COST COMPARISON OF CONVENTIONAL CONCRETE BLOCKS WITH RICE HUSK ASH INTEGRATED CONCRETE BLOCKS

Particulars	Unit	Conventional Block (0% RHA)	5% RHA Block	10% RHA Block	15% RHA Block
Cement Content per Block	kg	1.20	1.14	1.08	1.02
RHA Content per Block	kg	0.00	0.06	0.12	0.18
Cement Cost	₹	9.60	9.12	8.64	8.16
RHA Cost	₹	0.00	0.12	0.24	0.36
Fine Aggregate Cost	₹	2.50	2.50	2.50	2.50
Coarse Aggregate Cost	₹	3.00	3.00	3.00	3.00
Water & Miscellaneous Cost	₹	0.50	0.50	0.50	0.50
Total Material Cost per Block	₹	**15.60**	**15.24**	**14.88**	**14.52**
Approximate Cost Saving per Block	₹	—	0.36	0.72	1.08
Percentage Cost Saving	%	—	2.31%	4.62%	6.92%

In comparison to the cost of production for 100 concrete blocks, there are considerable reductions in cost due to the use of Rice Husk Ash (RHA). The conventional blocks would have costs of 1560, while the 5%, 10% and 15% RHA blocks would cost 1524, 1488 and 1452 respectively. This leads to savings up to 108 for every 100 blocks at 15% replacement and it can be argued to be the better economical and ecological performance.

VI. FUTURE WORK AND CHALLENGES

Although RHA offers good advantages in concrete blocks regarding mechanical properties and environment but recent findings indicated its drawbacks and application in the industrial process.
Further Studies:

1) Advancement in Production and Control:

The rheology of the RHA mix concrete needs to be optimized in 3DCP applications so that they should be shape retainable and extrudable as well, yielding good surface finish by utilizing fine particles (Harnessing rice husk ash, 2026). The pozzolanic activity of RHA can be further optimized by combining MWCNTs or fibers to enhance tensile and flexural strength and counter the brittleness (Performance evaluation, 2026). Fully replacing the cement with RHA and silica in concrete block production is an ideal approach that should be explored in detail as there is a growing demand for it (Harnessing rice husk ash, 2026).

2) Long-term durability and Performance:

The durability performance of RHA concrete is studied to be very good in case of sulphates and chlorides. However it should be studied in highly chemical environments in addition to longer term freeze thaw cycling (>20 years) (Abdulla, 2025; Optimizing rice husk ash, 2026). Due to the slow pozzolanic rate of RHA at >28 days hydration time, further research needs to be done to know the long term strength gain using advanced imaging techniques like SEM/XRD (Mitigating Environmental Impact, 2025).

3) Sustainability and LCA:

Environmentally sustainable RHA production methods need to be found and investigated, which is an alternative to open field burning, this includes controlled pyrolysis on industrial level, yielding a carbon neutral RHA (Harnessing rice husk ash, 2026). International quality standard and grading for RHA should be established to guarantee uniformity for different types of rice and combustion process (Optimizing rice husk ash, 2026).

4) Technical and Practical Issues:

The higher water demand required due to the high surface area and porosity of RHA particles necessitates the use of more super plasticizers (Abdulla, 2025; Harnessing rice husk ash, 2026). A drop in the compressive strength is seen at 10-20% RHA addition due to the dilution effect and decrease in hydration, the loss of strength due to high substitution is quite high (Performance evaluation, 2026; Muhammed Koya, 2015). The properties of RHA strongly depends on the temperature at which the rice husk is burned. The optimum temperature is in the range of 500-700 degrees C. Crystalline structures appear at temperatures>700 degrees C with lower pozzolanic reactivity than the amorphous structures (Harnessing rice husk ash, 2026). Leaching of silica from RHA into the soil increases soil pH. Air pollution is seen to be increasing due to air burning of rice husk (Mitigating Environmental Impact, 2025).

VII. CONCLUSION

1) The increase in compressive strength with curing age in all the mixes represents continuous hydration and cementitious matrix development from 3 days to 28 days.

2) The compressive strength of the control mix (0% RHA) was found to be 17.81MPa at 28 days which was taken as the reference for measuring RHA mixed concrete.

3) As the replacement level increases the compressive strength of the RHA mixed concrete was found to decrease, this happens due to the decrease in cement quantity and very slow pozzolanic reaction of RHA at earlier ages.

4) Strength of the all RHA mixed concrete was found to be developing with age (although slow) indicating that pozzolanic reactivity of RHA contributes to long-term strength gain.

5) Strength of 5% RHA mixed concrete was found to be 16.14 MPa at 28 days representing a loss of mechanical properties of only about 90.6% compared to control mix.

6) Strength of 10% RHA mixed concrete was found to be 14.44 MPa at 28 days which falls under a reasonable limit for structural and masonry blocks as well and cement substitution is significant.

7) At 15% replacement level, concrete block had the lowest strength of 13.93 MPa at 28 days indicating high percentage of RHA has detrimental effect on load carrying capacity.

8) 5-10% RHA substitution range is considered as an optimum range considering strength performance, durability, sustainability and material economy.

9) A combination of strength retention and cost reduction due to substitution in this range makes it a technically sound and sustainable option.

10) Economic evaluation of 5-10% RHA replacement provides reduced cement substitution, reduced cost of cement production and usage of agricultural waste products..

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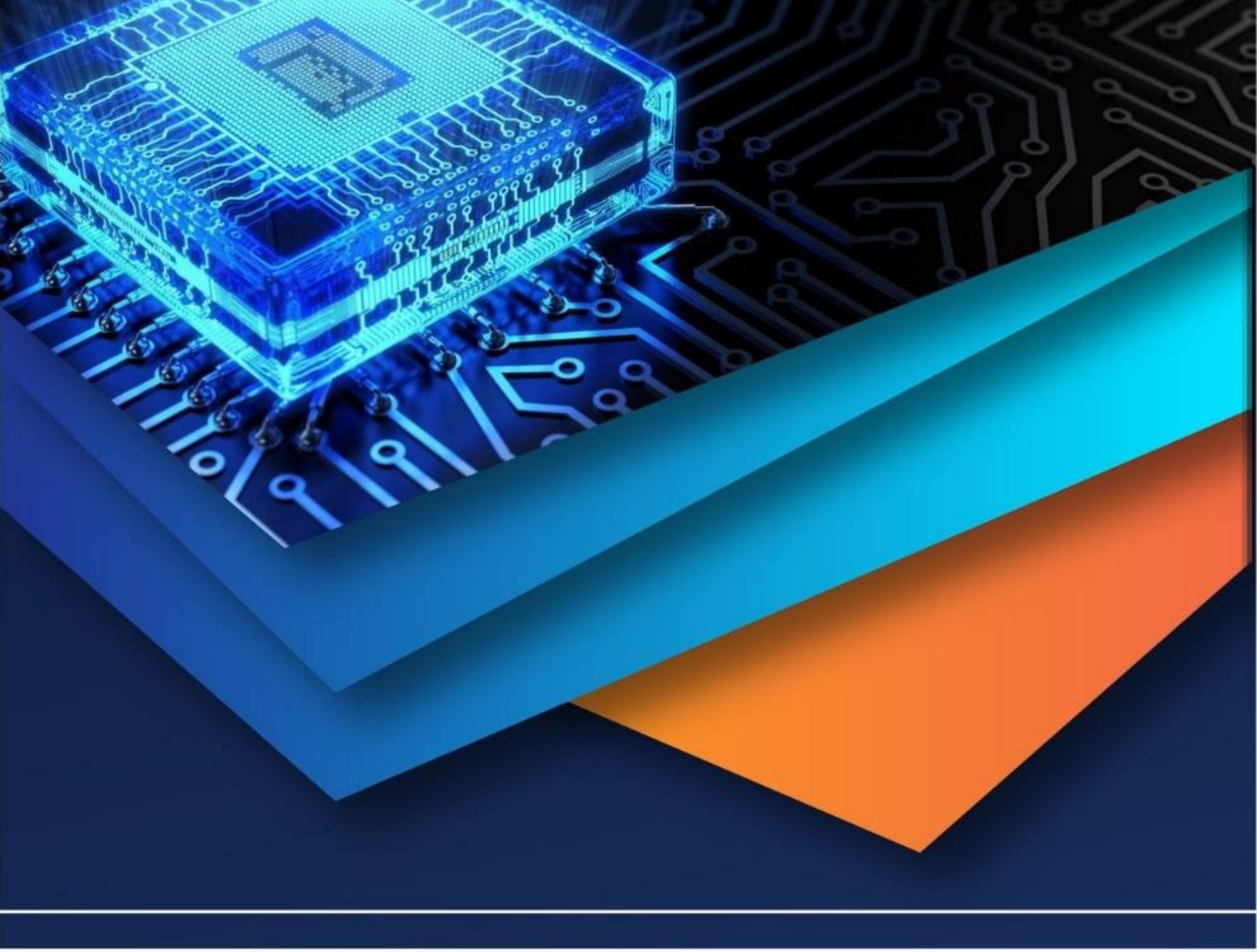

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