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An Experimental Study on Cement Mortar with Partial Replacement of Rice Husk Ash in Cement

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ABSTRACT –

This project summarizes the experimental studies on strength characteristics of cement mortar in which rice husk ash (RHA) is used as partial replacement of Ordinary Portland cement. Cement mortar paste were proportioned with varying dosages of RHA as partial replacement of OPC in the range of 0%, 5%, 10%, 15% and 20% by weight of cement. The compressive strength test was carried out as per relevant Indian Standard Code of practice.

Fig.1.Graphical abstract

1. Introduction

1.1 Need for the study

Studying the replacement of RHA in M20grade cement mortar Rice husk is an agricultural waste which is produced in millions of tones RHA is obtained by the combustion of rice husk and has been found to be super pozzolanic. Such studies contribute to civil engineering knowledge, supporting sustainable construction practices. Before adoption rigorous testing ensures compliances with standards fastening innovation and addressing challenges like climate change and resource scarcity. Overall experimental research on RHA replacement offers valuable insight into feasibity. Performance benefiting both academia and construction industry applications.

1.2 History of study

The history of research on experimental studies involving the replacement of locally available materials in M20 grade cement mortar dates back several decades. Initially, investigations primarily focused on traditional concrete constituents and properties. As alternative materials like RHA (rice husk ash) as replacement. Experiments will assess fresh and hardened cement, fine aggregate properties, mechanical and durability performance and experimental implication. Cost analysis recommendation for practical implementation will be provided. Along with documentation of procedure and finding. Despite potential variations in scope, addressing these aspects ensures a comprehensive investigation into the use of RHA in cement fine aggregate production.

1.3 Scope of the work

The project aims to study the feasibility of using locally available rice husk ash as a partial replacement material in M20 grade cement mortar. This involves reviewing existing literature, characterizing cement properties, and developing cement mortar mix designs with varying percentages of rice husk ash replacement. Experiments will assess fresh and hardened cement mortar properties, mechanical and durability performance, and environmental implications. Cost analysis and recommendations for practical implementation will be provided, along with documentation of procedures and findings. Despite potential variations in scope, addressing these aspects ensures a comprehensive investigation into the use of red soil in concrete production.

1.4 Objectives of the study

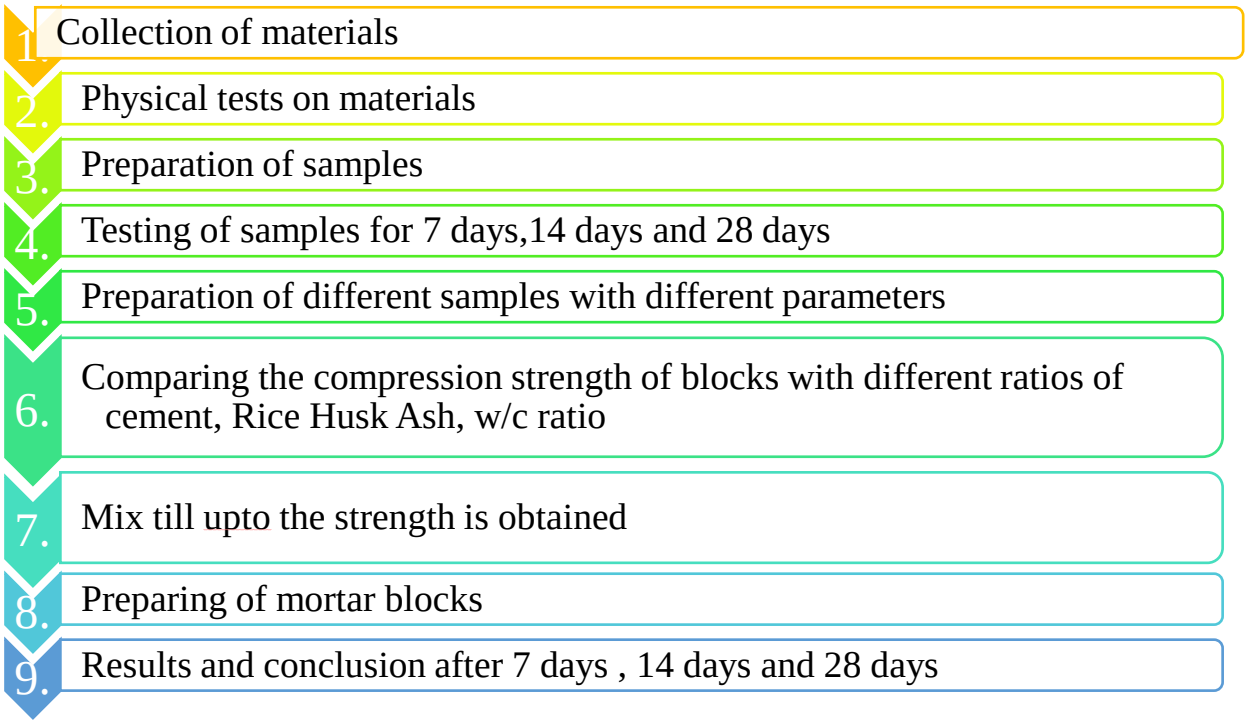
- To determine the feasibility and potential benefits of using rice husk ash as a replacement for cement in mortar.
- Identify the optimal mix proportions of rice husk ash cost-effectiveness, and sustainability in M20 grade cement mortar.
- To investigate permeability properties of cement mortar containing different percentage of rice husk ash with cement.
- To assess the impact of replacing cement mortar on the strength.
- To investigate compressive strength properties of cement mortar containing different percentage of rice husk ash with cement

1.5 Previous researchers study

Cement mortar with 10% RHA replacement shows improved compressive compared to standard cement mortar. Optimal replacement of cement with RHA is found to be 10%, maintaining compressive strengths above 30 MPa.rice husk ash in cement mortar exhibits improved mechanical properties, with compressive and tensile strength exceeding nominal strength. Rice husk ash mortar is cost- effective and environmentally friendly. Importance of exploring alternative materials like RHA, due to depletion of natural resources and environmental concerns. Studies provide insights into feasibility and effectiveness of alternative materials in mortar production, with practical recommendations for mix optimization. Waste materials like fly ash and crushed stone dust, and recycled aggregates, showcasing improvements in strength properties. Utilization of alternative materials addresses environmental concerns, offers economic benefits, and emphasizes sustainability in construction practices.

2. Methods and Materials

2.1 Methodology



Preparing the cement mortar with mix ratio of 1:3(cement: fine aggregate). Take fine aggregate with size of less than 4.75mm IS sieve(i.e.,1.16mm). Mixing of Rice Husk Ash in different proportions of 0%, 5%, 10%, 15% and 20% with cement. Mix the cement, Rice Husk Ash and fine aggregate in 1:3 ratio. After mixing thoroughly, add water in the required consistency.

2.2 Materials Used

2.2.1 Cement

A cement is a binder, a chemical substance that sets, hardens, and adheres to other materials to bind them together (OPC 43 GRADE).

2.2.2 Fine aggregate

Fine aggregates for M20 grade , per IS 383, must adhere to grading zone II specifications, ensuring optimal particle size distribution. They should be free from harmful substances, organic impurities, and clay lumps to maintain desired concrete properties. Zone-II<4.75mm

2.2.3 RICE HUSK ASH(RHA):

HA generally refer to an agricultural by-product burning husk under controlled temperature at 500

2.2.4 WATER:

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement.

2.3 Cement mortar mix design

2.3.2 Mix design

For M20 cement mortar mix design, typically use a 1:3 ratio of cement and fine aggregate by volume. Adhere to relevant national or international standards like IS 10262 or ACI 211.1.

Table1: Quantity of materials

% of replacement	**0%**	**5%**	**10%**	**15%**	**20%**
Cement(kg's)	1.139	1.089	1.02	0.968	0.911
Fine Aggregate (kg's)	3.798	3.798	3.798	3.798	3.798
Rice Husk Ash(kg's)	0	0.021	0.0435	0.0649	0.087
Water(ltrs)	0.492	0.4901	0.486	0.475	0.480

2.3.3 Batching and mixing of materials

2.3.3.1 Batching: Precisely measuring and proportioning the materials required for cement, water, and sometimes admixtures based on a specific mix design.

2.3.3.2 Mixing: Thoroughly combining the batched materials in a mixer to achieve a homogeneous mixture with uniform distribution of components, ensuring the desired properties of the mortar.

2.3.3.3 Uniformity: Batching ensures consistency in material proportions, while mixing ensures uniform distribution, crucial for achieving the desired strength, workability, and durability of the mortar.

2.3.3.4 Quality Control: Proper batching and mixing techniques are fundamental to maintaining c quality, meeting project specifications, and ensuring structural integrity.

Fig1: Batching

Fig2: Mixing

Fig3 : casting

Fig4: Compressive strength test

3. Results and Discussion

3.2 Material Properties

For M20 cement mortar mix design, Portland Pozzolana Cement (PPC) should comply with IS 1489 standards. Fine aggregate (F.A) should adhere to IS 383 grading specifications for particle size and shape. RHA should be free from organic matter and comply with relevant local specifications for use as a supplementary material in mortar mixes.

Table2: Properties of materials

Material Characteristics	Fine Aggregate	Cement	Rice husk ash
Fineness(mm)	2.75	6.60	3.83
Specific Gravity	2.56	3.04	2.24
Density(kg/m³)	1600	1420	550
Water absorption (%)	2.00	-	-

3.3 Compressive strength:

The analysis of compressive strength reveals that mortar cubes incorporating a 10% substitution of cement with RHA outperform those with 0%,5%,10% and 20% replacements. This underscores a diminishing trend in mortar strength as the proportion of cement replaced by RHA increases. Consequently, exceeding the 10% substitution threshold may exacerbate the compromise in compressive strength. It highlights the criticality of meticulously managing material substitutions to ensure optimal performance in construction applications. Careful consideration of substitution rates is paramount to maintain desired mortar strength levels and uphold structural integrity. Professional judgment and thorough testing are essential for determining the most effective substitution ratio for specific project requirements.

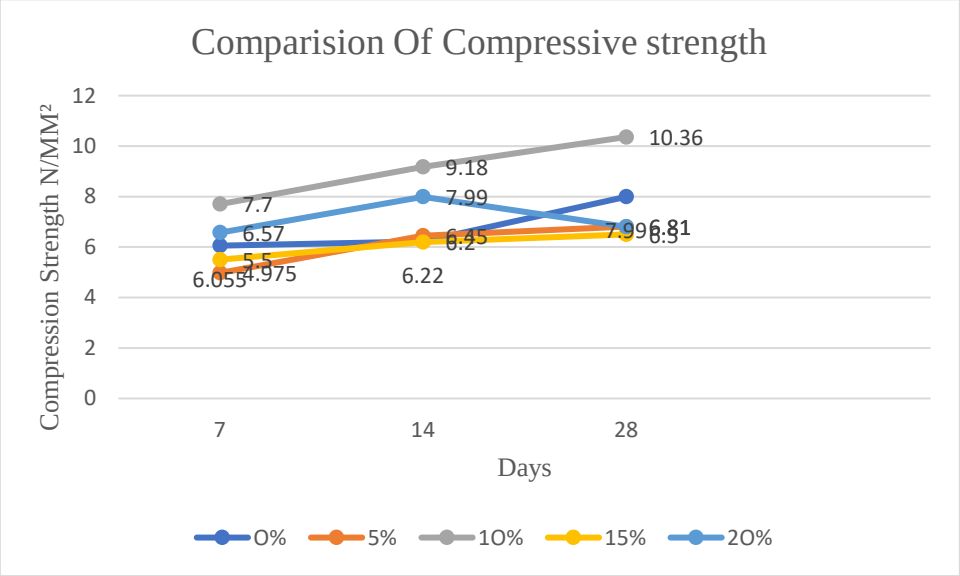


Fig8: Comparison of compressive strength

3.4 Crack propagation in Compression Strength

For mortar M20 mix design, crack propagation is managed according to ASTM C1581 standards. This involves monitoring crack development under controlled conditions to assess durability. Adhere to standardized testing procedures and criteria outlined in ASTM C1581 to evaluate crack propagation characteristics. Results inform adjustments to mix designs or construction practices to mitigate potential durability issues.

Table4: crack width in compressive strength tests

% of replacement	0%	5%	10%	15%	20%
Maximum crack width	2.5	2	2.7	1.65	1.95

3.5 Optimum percentage and Cost-effectiveness

The utilization of rice husk ash in cement mortar has shown promising outcomes, particularly with a 10% replacement rate, surpassing the performance of other RHA substitution levels. This replacement proportion has demonstrated notable improvements in both strength and crack width reduction throughout various curing periods, including 7, 14, and 28 days. Notably, the incorporation of 10% RHA has led to enhanced mortar strength while

effectively minimizing crack propagation. Overall, the observations consistently highlight the efficiency of a 10% RHA replacement, showcasing its potential to positively impact mortar properties and structural integrity across different curing durations.

Assessing the cost-effectiveness of substituting cement with RHA in cement mortar entails a comprehensive evaluation of factors such as availability, cost differentials, transportation expenses, and any necessary processing. Conducting a thorough cost-benefit analysis considering these factors is imperative to gauge the economic viability of rice husk ash replacement. While RHA may offer cost advantages in certain regions, its suitability for concrete and long-term durability implications must be carefully assessed. Additionally, comparing upfront cost savings with potential maintenance or performance-related expenses over the mortar's lifespan aids in determining overall cost-effectiveness. Consulting with industry experts and conducting field trials provides valuable insights into the feasibility and economic viability of incorporating rice husk ash as a replacement material in cement mortar production.

4. Conclusions

The results of the study show that the RHA produced from Argo waste can be used as partial replacement of ordinary Portland cement in cement mortar pastes. From the test results it can be concluded that if approximately 10% of cement is replaced by equal amount of RHA, there is not any significant depreciation in the compressive strength. Thus, the RHA can be used as partial replacement of cement in the regions where the material is locally available

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