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Strength Properties of Blended Cement Mortar with Metakaolin and Rice Husk Ash

Pitti Venkata Suneel[1], Pola Naga Lakshmi[2]

[1]*Assistant Professor, Department of Civil engineering & Srinivasa Ramanujan Institute of Technology(A)*
[2]*Assistant Professor, Department of Civil engineering & Srinivasa Ramanujan Institute of Technology(A)*

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Abstract - This study investigates the feasibility of using rice husk ash (RHA) and metakaolin as substitutes for Ordinary Portland Cement (OPC) in mortar production to reduce greenhouse gas emissions associated with construction. The study employs MM3 grade mortar, with RHA replacing cement at varying percentages (0%, 5%, 10%, and 15%), while metakaolin consistently substitutes 10% of the cement. Compressive strength tests are conducted on specimens cured for 7, 14, and 28 days to assess performance. The study utilizes OPC 53-grade cement with a water-cement ratio of 0.4. In total, four mortar mixes are prepared, and each mix comprises nine specimens, totaling 45 specimens. Initially, conventional mortar is evaluated for its physical and mechanical properties. The study aims to contribute to ongoing efforts in the construction industry to explore sustainable alternatives to conventional materials, such as RHA and metakaolin, while ensuring the requisite strength properties of mortar are maintained.

***Key Words*: Rice husk ash, metakaolin, cement, sand, mortar and compressive strength**

1.INTRODUCTION

The utilization of rice husk ash and metakaolin as partial substitutes for cement in blended cement mortar presents significant strength advantages and environmental benefits. Rice husk ash, derived from husk burning, is highly pozzolanic due to its rich silica and alumina content. Cement, second only to water in global consumption, faces increasing demand, particularly in developing nations like India. However, rapid cement production contributes to environmental challenges, including carbon dioxide emissions. Substituting rice husk ash for cement offers a sustainable solution, addressing waste management and reducing environmental impact. Additionally, metakaolin, a calcined clay, has gained interest for its potential applications in enhancing concrete properties and reducing cement usage, particularly with the impending closure of coal-fired power industries in the United Kingdom. This exploration covers the mechanical, physical, and durability properties of cementitious systems, alongside considerations of other pozzolanic materials and alkali additives, contributing to the advancement of sustainable construction practices.

2. METHODOLOGY

This research used the following materials are-

Cement: In this research work was used OPC 53 Grade cement which is manufactured by Nagarjuna Cement.

Table -1: Physical properties of cement

S .No.	Properties	Results
1.	Specific gravity	3.15
2.	Initial setting time	31 minutes
3.	Final setting time	610minutes
4.	Normal Consistency	32%
5.	Fineness	3%

Rice husk ash: It is collected from locally available rice mill industry. The collected RHA is sieved from 90µ sieve.

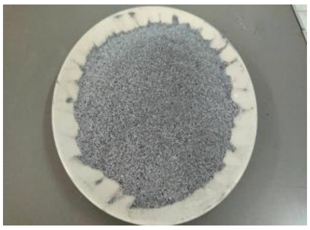

Fig -1: Rice husk ash

Metakaolin: In this research work metakaolin has been collected from kaolin techniques private limited. Its particle size is smaller than cement particles.

Fig -2: Metakaolin

Fine aggregate: Locally available Chitravathi river sand has been used. Specific gravity is 2.65

Water: In this research work tap or municipal water is utilized for alloying and curing of specimens.

Casting of Specimens: Following the mixing process, the mortar was carefully poured into standard metallic molds measuring 70.6mm x 70.6mm x 70.6mm. Each layer of mortar was compacted 25 times using a tamping rod to ensure proper consolidation. Prior to pouring the mortar, the inner surfaces of the molds were coated with machine oil to facilitate easy removal afterward.

Fig -3: Mortar moulds

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Curing Specimens: After 24 hours of casting, the specimens were carefully removed from the molds. Subsequently, they were immersed in a clean water tank for curing. All specimens were cured for the desired duration to ensure proper development of strength and other properties.

Fig -4: Curing of mortar specimens

3. RESULTS AND DISCUSSIONS

In this research work to investigates the cement mortar compressive strength properties of cement with partial replacement of metakaolin and rice husk ash in MM3 Grade for different mix proportions. Compressive strength results were placed in Table – 1. For better understanding graphical representation of the test results are place in Fig -5.

Table -1: Compressive strength results for MM3 Grade mix

Mix No.	Mix Proportions	Compressive Strength (f_{ck}) MPa		
		7 Days	14 Days	28 Days
M0	C100%+MK0%+RHA0%	7.90	8.02	8.25
M1	C90%+MK10%+RHA0%	8.75	11.03	12.18
M2	C85%+MK10%+RHA5%	8.9	12.82	15.38
M3	C80%+MK10%+RHA10%	8.65	9.83	11.23
M4	C75%+MK10%+RHA15%	6.10	7.25	7.69

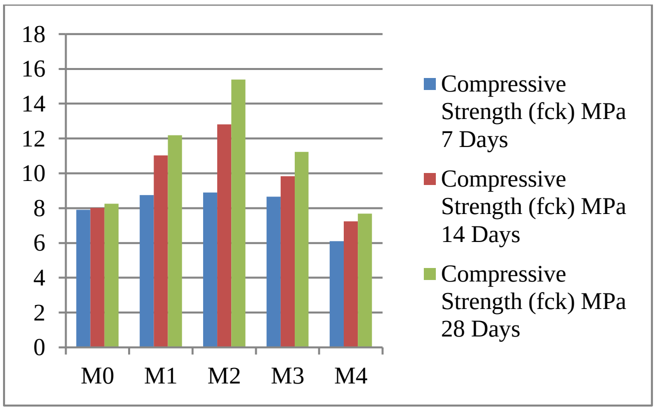

Fig -5: Compressive strength results for MM3 Grade

From the above graph the compressive strength test results concluded that the comparison of M0 mix, increases by partial replacement of cement with metakaolin and rice husk ash M1, M2, M3 and slightly decreases the strength for mix M4. When metakaolin 10% and rice husk ash 5% attains maximum compressive strength respectively.

4. CONCLUSION

In summary, this investigation underscores the benefits of incorporating rice husk ash (RHA) into mortar formulations. RHA offers cost-effective and environmentally friendly advantages. When combined with metakaolin (MK) as cement substitutes, RHA significantly enhances mortar strength compared to conventional mixes. Particularly noteworthy is the optimal blend of 5% RHA and 10% MK, consistently yielding superior compressive strength. This blend not only reduces construction costs but also ensures the safe disposal of RHA. Moreover, the substantial decrease in production costs highlights the feasibility of using 5% RHA and 10% MK replacements in mortar formulations. This study confirms the efficacy of RHA and MK in construction, providing a sustainable solution that mitigates environmental risks associated with waste disposal.

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BIOGRAPHIES

Mr.P.Venkata Suneel
Assistant Professor
Department of Civil Engineering
Srinivasa Ramanujan Institute of Technology (Autonomous)