

An Evaluation of Properties of Cement Mortar with Rice Husk Ash as Replacement to Cement

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ABSTRACT

Replacement of 43 grade Ordinary Portland Cement with Rice Husk Ash at increments of 5 per cent in 1:5 cement mortar has been carried out. The materials were characterized and the percentage of water required in cement mortar to achieve a flow around 115 per cent has been ascertained using flow table test for each replacement level. The amount of water required to produce the desired consistency in fresh mortar increased with increase in RHA content. Further, the compressive strength of mortar at 7 days and 28 days of curing, as well as triplet shear bond strength of mortar at 28 days has been determined. The compressive strength results indicate that a replacement level of 20 percent is suitable.

I. INTRODUCTION

1.1 General

Mortar is one of the constituents of masonry, which is responsible for creating a uniform stress distribution across the masonry by correcting the irregularities of the masonry blocks. It is also responsible for accommodating deformations related to thermal expansion and shrinkage. Mortar as a plaster provides smooth, watertight surface over the masonry, and fills up undulations and joints in masonry.

For better performance of masonry, it is always desirable to have stronger building units and weaker mortars. However, in most parts of India, the strengths of bricks are lower than that of mortar. IS 2250-1981 stipulates that the characteristic compressive strength required for 1:5 cement mortar is 5 N/mm² to 7.5 N/mm². The use of RHA as a replacement to cement could not only help us offset the exploitation of natural resources but also results in a low density mortar.

1.2 Rice Husk Ash

Rice husks are the natural sheaths that form on rice grains during their growth. At the time of refining rice, the husks which come out from this process usually have no commercial interest. Most of the husk from the rice milling industry is either burnt or dumped as waste in open fields and a small amount is used as fuel for boilers, electricity generation, etc. Paddy on an average consists of 72% of rice, 5 - 8% of bran, and 20 - 22% of husk, on weight basis. This husk contains about 75 - 80 % organic volatile matter and the balance 20 - 25 % of the weight of this husk is converted into ash during the firing process, is known as rice husk ash (RHA). This RHA usually contains around 85% - 97% amorphous silica with small amount of alkalis and other trace elements [1].

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II. RELATED WORK

2.1 MATERIALS AND METHODOLOGY

Materials Used

1. Binder: Ordinary Portland Cement(Chettinad 43 grade)
2. Rice Husk Ash (RHA)
3. Fine aggregate: Natural river sand
4. Table moulded bricks
5. Water

Methodology

1. Conducting basic tests on materials.
2. Determination of consistency of mortar using flow table test by replacing cement with RHA at increments of 5 per cent by weight of cement.
3. Casting and testing mortar cube specimens for each replacement level.
4. Casting and testing brick triplets by sandwiching mortar between the bricks.

The mortar chosen for the present work is of the proportion 1:5 (C:FA). IS 2250-1981 designates this mix as MM5, whose characteristic compressive strength ranges from 5 N/mm² to 7.5 N/mm².

2.2 TESTS ON MATERIALS

2.2.1 Properties of Cement

Sl. No.	Particulars	Values obtained
1	Specific Gravity	3.09
2	Normal Consistency	29%
3	Initial setting time	37 mins.
4	Final setting time	178 mins.
5	Fines retained in IS 90 micron sieve	4%

Table 1 : Properties of Cement

2.2.2 Properties of RHA

Sl. No.	Particulars	Properties
1	Colour	Gray
2	Shape texture	Irregular
3	Mineralogy	Non crystalline
4	Particle size	>45 micron
5	Odour	Odourless
6	Specific gravity	2.3
7	Bulk Density	500-700 kg/m ³

Table 2 : Properties of RHA

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2.2.3 Properties of Fine Aggregate

Sl. No.	Particulars	Values obtained
1	Specific Gravity	2.65
2	Bulking	23.45%
3	Bulk Density (Uncompacted)	1495.62 kg/m ³
4	Bulk Density (Compacted)	1623.13 kg/m ³
5	Fineness Modulus	2.95

Table 3: Properties of Fine Aggregate

2.3 TESTS ON MORTAR

2.3.1 Test on Fresh Mortar

a) Flow table test

2.3.2 Tests on Hardened Mortar

a) Compressive Strength Test

b) Shear bond strength test using brick triplets

Flow Table Test on Cement Mortar

Consistency is an important characteristic feature of the cement mortar. The mortar should be fluid enough to be spread on the masonry units or to plaster it on vertical surfaces. The consistency was measured using the flow table apparatus as specified in I.S. 2250, 1981. The flow table conformed to I.S. 5512, 1983 specifications. Superplasticizer was used for all mixes except for the control mix. The mortar mixes were prepared by replacing sand by GBFS at increments of 10 percent by weight of sand.

The review of literatures [2], [3] indicated that a consistency/ flow percentage of 110- 115 is required for a workable mortar. Hence, a target consistency of around 115 percent was fixed and the water cement ratio was decided accordingly. The amount of water required to produce desired consistency for each replacement level of cement with RHA is furnished below:



Plate 1: Flow Table Test

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Replacement Percentage of Cement with RHA	Water-Cement Ratio
0	1.2
5	1.2
10	1.2
15	1.25
20	1.25
25	1.25

Table 4: Water Cement Ratio of Mortar Mixes

Compressive Strength of Mortar

Mortar Cubes of size 70.6mm were cast by adopting the water-cement ratio obtained in the flow table test. The compressive strengths were determined at ages of 7 and 28 days. The table shows the strength variation of the mortar mixes with various percentages of RHA.

Replacement Percentage	Compressive Strength (N/mm ²)	
	7 days	28 days
0	3.06	6.40
5	2.66	7.06
15	2.12	7.25
20	2.31	5.80
25	1.32	3.98

Table 5: Compressive Strength of Mortar Cube Specimens

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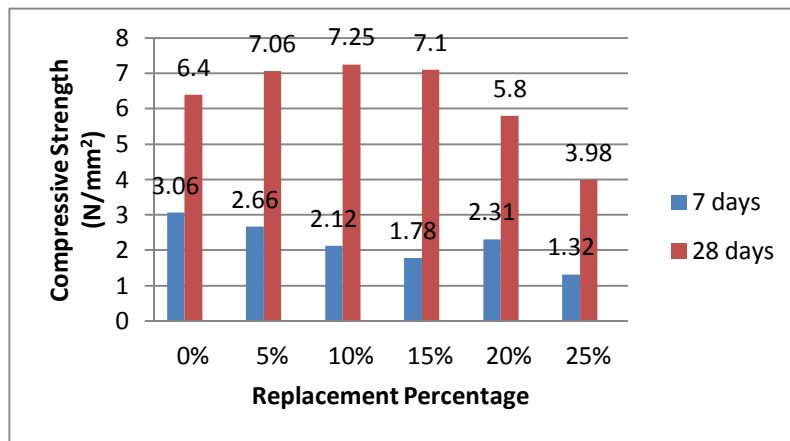


Figure 1: Compressive strength of cement mortar

Remarks: The 28 days strength of mortar increased initially upto 10 percent replacement and later reduced with the increase in RHA content. At 28 days, the strength of the mortar fell beyond the characteristic compressive strength at a replacement level of 25 percent. The maximum compressive strength was observed at 10 percent replacement level. At 25 percent replacement, the strength fell below the minimum stipulated strength of 5 N/mm² as per IS 2250, 1981.

Triplet Shear Bond Strength Test

In this study, a three brick assembly was used to obtain the shear bond strength of the brick mortar joints at 28 days of curing. The bottom two bricks of the triplet were rested on the bottom platform of the compression testing machine, while the middle brick was not restrained against any movement. The vertical load was applied to the middle brick so as to impart shear force to brick-mortar interface at the joint. All the tests were performed without pre-compression load. Hence the values of bond shear strength obtained are corresponding to zero pre compression.



Plate 2: Triplet Shear Bond Strength Test Set-up

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Replacement Percentage	Shear Bond Strength (N/mm ²)
0	0.819
5	0.450
15	0.301
20	0.144
25	0.103

Table 6: Variation of Shear Bond Strength of Mortar at 28 Days of Curing

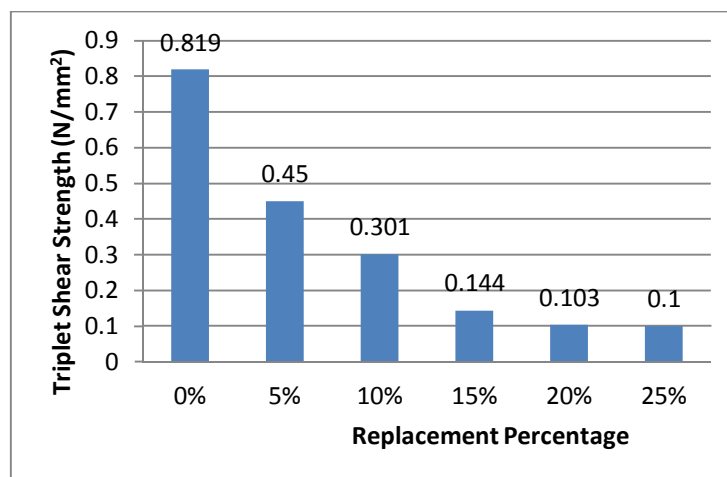


Figure 2: Variation of Shear Bond Strength of Mortar at 28 Days of Curing

Remarks: The shear strength of mortar reduced with increase in RHA content. This is indicative of the poor bond development between the brick and mortar interface.

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2.4 INFERENCE

With the limited scope of present work, following inferences have been drawn.

- The materials collected from their sources have been characterized.
- The water cement ratios required to achieve desired consistency for 1:5 mortar with various percentages of RHA have been arrived at using flow table test. It is observed that the water cement ratio required to achieve desired consistency increases with increase in RHA content in mortar. This is probably due to the surface area and absorption of RHA.
- As per IS 2250-1981, 1:5 cement mortar is categorized under MM5 grade mortar, whose 28 days compressive strength requirement is between 5 to 7.5 N/mm².
- The 28 days compressive strength of mortar varies from 6.4 to 3.98 N/mm² for various replacement levels of cement with RHA in cement mortar.
- The shear bond strength of mortar also decreased gradually from 0.819 N/mm² to 0.10 N/mm² with increase in RHA content. This indicates that there is poor bond development between the brick and mortar with RHA.
- From the viewpoint of compressive strength requirement as per IS 2250-1981, a replacement level 20% of RHA in mortar is suggested, whose compressive strength is 5.8 N/mm². However, mortar mixes with lower strength can be recommended for non-structural applications.

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