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Beneficial Effect of Rice Husk Ash on Wall Cement Plastering

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Abstract: Rice is the staple food in Sri Lanka, with over 270 million tons produced annually. It is the most common agricultural waste, with difficult handling, storage, and transportation being the main issues. As a result, using these natural agro waste material aids in lowering construction costs, preventing emissions, and increasing quality and consistency. As a result, a strong idea in the building industry is to use rice hush ash (RHA) as a partial substitute for cement plastering. A total of 24 coating plates were molded and tested in order to accomplish this goal Various proportions of cement, river soil sand, partly substituted with differing percentages of rice husk ash were used to test stiffness, compressive strength, flexural strength, water absorption, and thermal conductivity. Test findings show that 12.5 percent of RHA (sample 4) may be advantageously added up to improve the strength when contrasting the Sri Lankan standard and British Standard Specifications of wall cement plastering mixture. In 12.5 percent (sample 4) RHA, the maximum compressive and flexural pressure are 278 $kg.cm^{-2}$ and 0.50 $kgcm^{-2}$, respectively. The average mass, water absorption, and thermal conductivity of sample 4 were 1685.19 kgm^{-3}, 5.67, and 0.64 WmK^{-1}, respectively. The findings clearly show that cement-RHA-sand wall plastering is preferable to the building site.

Keywords: Rice Husk Ash; Wall Cement Plastering; Compressive Strength; Flexural Strength; Water Absorption; Eco-friendly

1. Introduction

Most residents in developing countries live in substandard housing due to low incomes; others are made of mud, cadjan, metal, glass, or cardboard, resulting in dangerous and cruel living conditions. It is a smart way to build lower cost building materials, but adequate housing will become more impoverished. It is a traditional practice in Sri Lanka and some other nations. However, it varies by location due to different methodologies used and the properties of the primary materials. The cost of cement has gradually increased the cost of constructing a house in Sri Lanka.[1]

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Rice husk is an agricultural by-product that is both organic and abundant. In developed countries alone, nearly 100 million tons of rice husk are eligible for use per year. RHA, on the other hand, is treated as waste and disposed of at a landfill. As a result, increased RHA use has tremendous waste management capacity.

RHA can be used profitably in the silica extraction process,[2,3] as a pozzolanic substance,[4,5] and in other applications. The silica survives in two forms: amorphous and crystalline, depending on the temperature and length of the fire.

Rice husk ash (RHA) is an agro waste substance that can be used to increase the consistency of wall plastering which has strong pozzolanicity and can be ignited at a certain temperature. Since RHA is abridged calcium hydroxide, which developed capacity for efflorescence and effects of alkali-silica reactivity, and decline due to particle packing, RHA is accountable for resilience, power, and resistance to chemical attack, augment the workability, and minimize the thermal conductivity, permeability.[6]

This study intends to enhance the production process by using admixtures in addition to cement. These admixtures are used to improve the bond between the particles and, as a result, the effectiveness of wall cement plastering. These admixtures are either pozzolanic or cementitious in nature. Any of the examples are rice husks, sawdust, tar, ground nut shell etc.

2. Experimental Section

2.1. Materials

2.1.1. Sand

Sand is a granular aggregate that occurs naturally and is smoother than gravel. It is the main material used in the construction of any building, providing strength and other properties that render the structure sturdy and rigid. River sand was used in this work to

Table 1. Chemical compositions of cement[1]

Oxide compositions	Values in %
SiO_2	20.70
Al_2O_3	5.75
Fe_2O_3	2.50
CaO	64.00
MgO	1.00
MnO	0.20
Na_2O	0.60
K_2O	0.15
ZnO	-
P_2O_5	0.05
SO_3	2.75
LOI	2.30

Fig. 1. Photo image of wall cement coating plates.

separate clay, gravel, dust, and organic matter. Prior to use, it was purified. Sand size was determined using 425 m sieves in accordance with Sri Lankan Standards SLS 882:1989.[7] The categorical gravity of the sand was 2.60.

2.1.2. Cement

This work makes use of Pozzolona Portland cement, which is widely used in building and also serves as a primary binding medium according to Sri Lankan standards SLS 107: Part 1: 2008.[7] Table 1[1] lists the chemical composition of the cement.

2.1.3. Water

Fresh water was used to synthesize the materials in order to form a cement gel with strong particle interconnection. According to Sri Lankan standards 522: Part 1:1989,[7] which allowed for the use of any organic material.

To blend the ingredients, fresh water was used that was free of organic matter of some kind, as specified by Sri Lankan Standards. It initiates a chemical reaction in the cement and with other ingredients, resulting in the formation of cement gel.

2.1.4. Rice Husk Ash (RHA)

The rice husk was obtained as a waste from rice in the Batticaloa district of Sri Lanka. This substance was burned and turned into ashes in a furnace for two hours at temperatures ranging from 500 to 900°C.[8] Following the combustion, grey-whitish ash of large particle size is produced, which was defined as the same size about 425 mm. Previous research has shown that amorphous RHA has higher

Table 2. The ratios of coating plate with raw material

Sample	Cement ($C \pm 0.1$)g	Sand ($S \pm 0.1$)g	Rice husk ash ($R \pm 0.1$)g
1	300	900	00
2	250	900	50
3	200	900	100
4	150	900	150
5	100	900	200
6	50	900	250

Pozzalanic activity than crystalline RHA,[9] which contributes to the enhancement of the stability, thermal, and mechanical properties of its composite. Different types of paddy can have different properties.

2.2. Methodology

Initially, the raw materials needed to render the coating plate (cement, sand, rice husk) were gathered. They were cleaning up after themselves and removing foreign bodies. The rice husks were burned, and the ash was filtered. In this analysis, the performance of wall coating is investigated by producing a coating plate from raw materials. They were cast in dimensions of 300 mm 150 mm 300 mm and the best mix of various ratios (Table 2). The amount of rice husk ash was varied in increments of 50 g up to a limit of 250 g. Water was added as required, and the materials were turned over to ensure adhesion. Hand mixing was used. After mixing the materials, the mixture was condensed into the mould layer by layer and pounded thoroughly. After a few minutes, the mould was gently removed without scratching the coating plate, as shown in Fig. 1. After separating the blocks from the mold, they were laid out and allowed to dry for 7 days in direct sunlight. The new formulation was tested for particle size, water absorption, and compressive power.

2.3. Analysis of Wall Cement Plastering Plates

Density, particle size analysis, compressive strength, flexural strength, and water absorption were the physical and mechanical properties of the wall coating samples that were tested in accordance with Sri Lankan standards.

2.3.1. Particle Size Analysis

Sand and rice husk ash particle size measurements were performed. The majority of the fine RHA and sand particles went through 425 mm sieves according to British Standard Test sieves.

2.3.2. Water Absorption (WA) Analysis

Each sample had three coating plates analyzed. Water absorption mass was measured in a well-ventilated room with direct sunlight at temperatures ranging from 35°C to 40°C. The dry coating plates were soaked in clean water at room temperature for 72 hours without any prior partial immersion. Water should have unrestricted access to all surfaces of the coating plates as far as possible. The coating plate was weighed in a balance after the surface water was brushed away with a wet rag. Each coating plate was weighted within three minutes of being removed from the bath. The percentage of water absorption was determined using equation (1), and the average values were computed.

$$WA = \frac{\text{Wet weight of the brick} - \text{Dry weight of the Brick}}{\text{Dry weight of the Brick}} \times 100\% \qquad (1)$$

2.3.3. Compressive Strength (CS) Analysis

The compressive intensity study was performed in accordance with Sri Lankan Standards 855: Part 1: 1989,[7] which is comparable to ASTM C67-05.[10] The coating plate surface was smoothened to form strong surface contacts between the wall coating plate and the pressing disks. The compressive strength of wall cement coating plates was determined using a Universal Testing Machine and a pressure scale with a sensitivity of 2 kgcm^{-2}. At lack of force, the width and length of the plate is measured. The overall compressive intensity was calculated using the equation.

CS = Applied force at the peak / Area of the plate (2)

2.3.4. Thermal Conductivity (TC) Analysis

Thermal conductivity is used to calculate the cooling effect of a house. The Lee's Disc process was used in the laboratory to analyze thermal conductivity, and the same procedure was followed for the wall cement coating plates. Thermal conductivity is the potential to pass heat through a substance, and it was calculated using the following equation.

$$k = \frac{t_1}{(T_0 - T_1)}\left[\frac{V^2}{SR} - \frac{k_1}{t_2}(T_0 - T_2)\right] \qquad (3)$$

Where k and k_1 are thermal conductivity of the brick and the insulating disc respectively, *V* is the voltage, *R* is the resistance of the coil, *S* is the surface area of the brick, *ρ* is the density of the brick, *E* is the thermal effusivity, t_1 and t_2 are the thickness of the plate and insulating disc and T_0, T_1 and T_2 are the heated face temperature of wall coating plate, non-heated face temperature of wall coating plate and non-heated face temperature of insulating disc respectively.

2.3.5. Flexural Strength (FS) Analysis

To assess the flexural strength of the wall cement plastering layer, three-point bending tests were performed using a Universal Testing Machine available in the Department of Physics at Eastern University in Sri Lanka in accordance with Sri Lankan standards 855: Section 1: 1989.[7] The coating plate surfaces were smoothened in order to achieve appealing parallel surfaces that would form uniform contacts. The applied force at failure, as well as the other physical parameters of the wall cement coating layer, were registered in order to calculate the flexural strength using equations (4). The average flexural strength was calculated and compared to Sri Lankan norms.

$$MR = FL / wh^2 = 3Fa / 2wh^2 \qquad (4)$$

Where MR is flexural strength, (kPa), L is length, (mm), w and h are width and height of the block, (mm) respectively, a is distance between line of fracture and the nearest support, (mm), and F is applied force failed (kN).

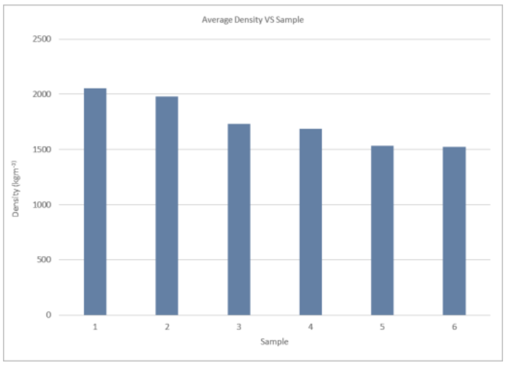

Fig. 2. Average density of wall cement plastering plate as a function of RHA.

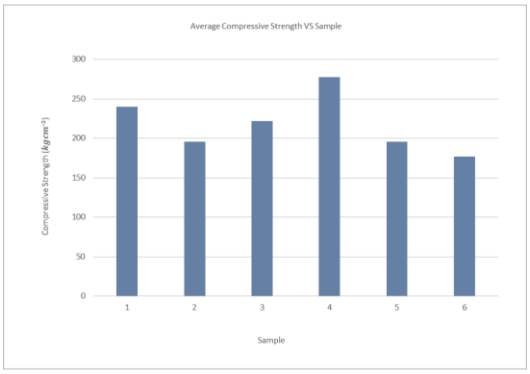

Fig. 3. Average compressive strength of wall cement plastering plate as a function of RHA

3. Results and Discussions

3.1. Density Analysis

The density varies with the percentage of RHA, as seen in the graph (Fig 2). Sample 1, which is the normal commodity and commonly used in Sri Lanka, has a maximum average density of 2051.86 kgm^{-3}. In addition, as the percentage of RHA is increased, the average density of cement plastering plate decreases slightly. This declining behaviour is caused by the addition of cement to RHA, which results in large particles with greater abysses and a lower density. The lowest value was found in Sample 6, which was 1523.97 kgm^{-3}. However, by compared the RHA doped wall plastering plate to the normal wall plastering plate, there is a significant difference.

3.2. Compressive Strength Analysis

Fig. 3 depicts the compressive strength study. The compressive power ranges from 278 kgcm^{-2} to 177 kgcm^{-2} on average. The weight of the regular product sample 1 is 240 kgcm^{-2}. While the compressive intensity rises dramatically as the percentage of RHA increases, and Sample 4 (12.5 percent RHA) achieves the highest benefit, it then begins to decline as the percentage of RHA increases. The raise behavior is the result of stabilization of the cement content due to higher percentage of SiO_2 RHA. Therefore, 12.5 percent RHA (Sample 4) is the maximum suitable percentage to form a good bonding to increase the strength of the wall plastering construction. Because of the flabby form of RHA particles (RHA > 12.5%), the open pores increase, lowering compressive power.

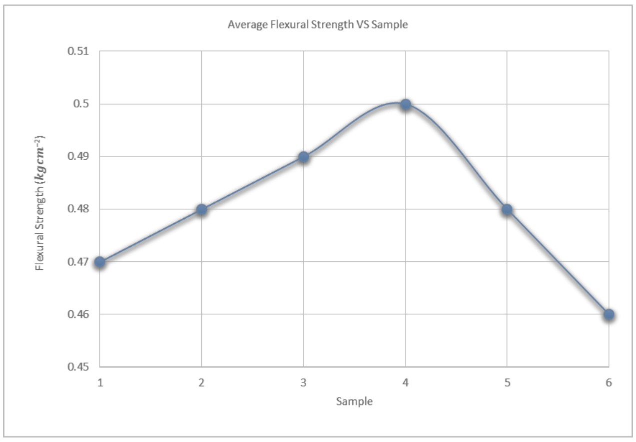

Fig. 4. Average flexural strength of wall cement plastering plate as a function of RHA.

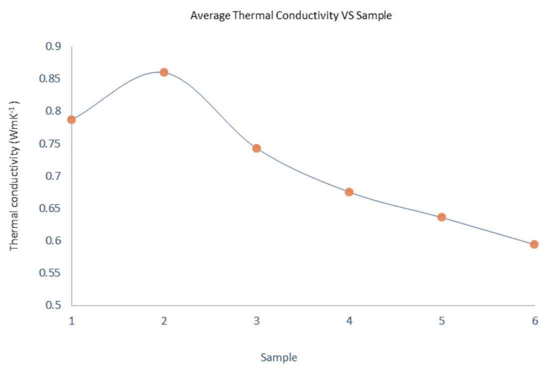

Fig. 5. Average thermal conductivity of wall cement plastering plate a function of RHA

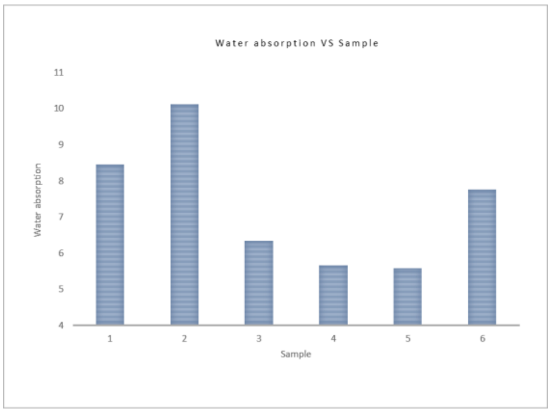

Fig. 6. Average water absorption of wall cement plastering plate as a function of RHA

3.3. Flexural Strength Analysis

Fig. 4 shows the average flexural strength of a wall plastering plate as a result of different RHA doping percentages. With rising the RHA percentage, the flexural intensity increases smoothly up to 0.47 kgcm^{-2} from 0.50 kgcm^{-2} and then declines to 0.46 kgcm^{-2}. The behavior of flexural strength is very similar to the behavior of compressive strength, as can be observed. Sample 4 (12.5 percent RHA) has the highest value, indicating that the compressive intensity is strong.

3.4. Thermal Conductivity Analysis

Fig. 5 depicts the difference in thermal conductivity of a wall cement plastering layer. The thermal conductivity reduces as the percentage of RHA is increased; in particular, the thermal conductivities of a cement-RHA mixture range from 0.86 to 0.57 WmK^{-1}. The porosity of the mixture increases as the RHA level rises. As a result, these pores help to lower the sample's thermal conductivity. The thermal conductivity of the normal mixture (Sample 1, 0% RHA) is 0.80 WmK^{-1}, which is significantly higher than that of the RHA admixture. This finding demonstrates that the RHA is clearly beneficial to the enhancement of thermal conductivity in building materials.

3.5. Water Absorption Analysis

Water absorption is one of the most important metrics for evaluating the construction site's efficiency. The water absorption of wall cement plastering plate as a result of RHA percent is shown in Fig. 6. As seen from the Fig. 6, the water absorption declines dramatically as RHA percent increases before sample 5, while sample 6 has a higher absorption value of 7.77. It ranges between 5.67 and 10.33. It shows that sample 2 has the highest absorption ability when compare to the other samples. This demonstrates that the RHA plays a significant role in the cement-RHA-sand mixture (Fig. 6). The findings specifically satisfy recommended meaning as per the Sri Lankan Standard 855: Part 1: 1989[7] and British Standard BS 5628: Part 1:2005[11] which lie within the standard values. The decreasing behavior is determined by the presence of porosity and the influence of the RHA particles' stiffness.

4. Conclusions

The key goal of this study was to see whether adding rice husk ash to wall cement plastering could increase the strength and lower the cost. When different percentages of RHA were doped into various physical properties, it was concluded that partial replacement of RHA improved the physical properties when compared to the Sri Lankan standard commodity. The findings of this study showed that RHA substitution produces the best results. In comparison to the traditional wall plastering plate, the current instinctive plastering plate with 12.5 percent RHA (sample 4) has the maximum compressive and flexural strength values. Sample 4 had the highest average density of 1685.19 kgm^{-3}, but sample 1 had the highest value of 1, 2051.86 kgm^{-3}. Thermal conductivity was 0.64 WmK^{-1}, and water absorption was 5.67, all of which were smaller than the values of normal wall cement plastering layer. This modern wall cement plastering plate can be made on site, resulting in low costs, semi-labor expertise, and a thriving local economy. Not only has this been accomplished by introducing the use of locally available natural agro waste products for ecological purposes. As a result, 12.5 percent of RHA (sample 4) can be recommended for construction site use.

Conflicts of Interest

The authors declare no conflict of interest.

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