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Effect of Unburnt Rice Husk on the Properties of Concrete

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Abstract

In the recent years, there have been considerable efforts all over the world to reuse by-products in order to sustainably conserve our environment. In this sense, rice husk is also an agricultural bi-product and its ash after being burnt has widely been used to replace Portland cement in the construction industry due to the fact that it is rich in pozzolanic content. However, no studies have been conducted to identify the definite temperatures to which rice husk can be heated to produce the perfect qualities required for enhancement of concrete. This prompted us to find out whether utilizing ground unburnt rice husk would as well be fit to be used in partial replacement of cement. This would save time and other resources used in heating rice husk to ash. This study evaluates how different contents of rice husk added to concrete may influence its workability, water absorption and compressive strength of concrete with 0, 1.5, 2.5, 5, 7.5 & 10% cement replacement at fixed water cement plus ground rice husk at 0.5. The results were compared to a controlled sample and the viability of adding ground rice husk to concrete was verified. For water absorption the results were negative as addition of ground un burnt rice husk resulted in increasing water absorption of concrete which is generally not good for its durability purposes. Values of workability varied with addition of ground un burnt rice husk but still within the allowable limits for concrete to be used on some construction works. Also, there was a break through on the compressive strength with 1.5% replacement of cement with ground un burnt rice husk achieving the target strength. Basing on this, we can therefore infer that cement can be reduced up to 15% with un burnt ground rice husk without compromising compressive strength requirements of concrete more especially in situations where water absorption is not very important.

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Keywords: Rice Husk;By-product; Re – use ;Pozzolanic; Workability; Water Absorption ; Compressive Strength

1.0. Introduction

Traditionally, concrete has always been defined as a mixture of aggregates (fine and coarse aggregates), cement and water that initiate the hydration process [1]. Its strength is commonly considered as its most valuable property, although other properties like durability, workability and permeability may be also important [2]. Cement and water form a paste that binds aggregates together to a concrete matrix while aggregates themselves are structural fillers.

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Generally, this traditional concrete is not sustainable because firstly, it consumes huge quantities of virgin materials which are non-renewable [3]. Secondly, the principal binder in traditional concrete is Portland cement which is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change [4]. This shows that there is a need to explore renewable and less environmental devastating options such as utilizing ground rice husk that is generally an agricultural by-product [5].

In the recent years, there have been successful attempts to utilize Rice Husk Ash (RHA) in partial replacement of Portland cement in concrete production [1]. This is because RHA is a highly reactive pozzolanic material as it contains a high amount of silicon dioxide [6]. According to [7], Portland cement can be replaced with RHA up to 12.5 % in the matrix without compromising on strength and durability requirements of concrete which generally reduces the cost of concrete production. However, burning rice husk to produce RHA is not easy as it requires a controlled combustion process in order not to emit greenhouse gasses into the atmosphere [8]. Also, no studies have been conducted to identify the definite temperatures to which rice husk can be heated to produce the perfect qualities required for enhancement of concrete.

Basing of this background, we were prompted to carry out this study with an aim of finding out whether utilizing ground unburnt rice husk would as well be fit to be used in partial replacement of cement as for RHA.

2.0. Materials and Methods

2.12. Materials

Concrete mixes to be examined were made in the laboratory using cement, aggregates (fine and coarse), and water and ground rice husk.

Cement: Ordinary Portland cement (Grade 32.5) with a specific gravity of 3.15 conforming to US EAS18-1:2001was used. **Water:** Drinking water was used at a fixed water cement plus ground rice husk ratio of 0.5. **Ground Rice Husk:** The rice husk was ground and its weight recorded. The percentage replacement of cement with ground rice husk in the concrete mix was 0, 1.5, 2.5, 5, 7.5 & 10. **Aggregates:** River sand was used as fine aggregates with specific gravity and dry density of 2.7 and 1630 kg/m^3, respectively all complying with the specifications. Also, their particle sizes were within the specified lower and upper limits as shown in table 1.

Table 1. Particle Size Distribution for Fine Aggregates

Sieve Size	Percentage Passing	Specified limits of percentage Passing	
		Lower Limit	Upper Limit
37.50	100.0		
20.00	100.0		
10.00	100.0		100
5.00	93.5	89	100
2.00	70.3	60	100
1.18	36.4	30	100
0. 60	18.6	15	100
0.30	9.0	5	70
0.15	3.8	0	15

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Coarse aggregates of flakiness index of 24 as shown in table 3, specific gravity and dry density of 24, 2.66 and 2640kg/m^3 all complying with the specifications were used. Also, their particle sizes were lying within the specified grading envelopes as shown in table 2.

Table 2: Particle Size Distribution for Coarse Aggregates

Sieve Size	Percentage Passing	Specified limits of percentage Passing	
		Lower Limit	Upper Limit
37.50	100.0	100	100
20.00	94.5	85	100
14.0	49.9	0	70
10.0	13.9	0	25
5.00	0.0	0	5

Table 3: Flakiness Index for Coarse Aggregates

BS Sieve Size (mm)	Weight Retained On Grading Sheet(g)			Percentage Retained	
50	0			0.0	
37.5	0			0.0	
28	0			0.0	
20	125.48			5.5	
14	1008.02			44.6	
10	814.41			36.0	
6.3	100.04			4.4	
5.0	214.55			9.5	
Total	2262.5				
Initial Dry Weight(g)	2262.5				
Pass BS Gauge(mm)	Pass Wt (g)	Retained BS Gauge(mm)	Retained Wt (g)	Wt (g) per Fraction	Individual Flakiness
63.0	0.0	50.0	0.0	0.0	0.0
50.0	0.0	37.5	0.0	0.0	0.0
37.5	0.0	28.0	0.0	0.0	0.0
28.0	0.0	20.0	0.0	0.0	0.0
20.0	33.2	14.0	92.3	4.1	0.0
14.0	119.4	10.0	888.6	39.3	13.4
10.0	212.0	6.3	602.4	26.6	35.2
6.3	34.9	5.0	65.1	2.9	53.7
Reported FI (%)	24				
Specified Limits (%)	35				

2.2. Mixture proportions

The target strength of concrete was C 20/25 for the control mix at 28days. According to a study conducted by [9] on the determination of appropriate mix ratios for concrete grades using Portland cement of grade 32.5, cube strength of 25MPa can be achieved using a mix ratio of 1:1.5:3 and so was adopted. Batching by weight was adopted in a mix ratio of 1:1.5:3 while replacing cement with ground rice husk at 0, 1.5, 2.5, 5, 7.5 & 10%. The 100% Portland cement mix was used as a control mix experiment. For both mixes, water-cement (inclusive ground rice husk) content ratio was kept constant at 0.5.

2.3. Methods

2.3.1 Workability

For every mix, two slump tests were carried out in accordance with BS1881: Part102:1983 using a cone of 200,100 and 300mm as base diameter, top diameter and height, respectively. The average values of the true slumps at the corresponding percentage replacement of cement with ground rice husk were recorded.

2.3.2 Compressive Strength

A total of thirty-six concrete cubes of 150 mm × 150 mm × 150 mm were prepared. They were compacted in two layers each with 35 strokes of a compacting rod in accordance with BS4550-3.4:1978. They would be allowed to set for 24 hours before removing their respective moulds and then placed in curing tank where they would be left for 7, 14 and 28days before compression. In each category of cement replacement, two cubes would be crushed at each of the specified dates and their resulting failure load noted. The compressive strength was calculated as shown in equation (1).

$$\text{Compressive Strength (MPa)} = \frac{\text{Failure Load}}{\text{Cross sectional Area}} \qquad (1)$$

The average values of compressive strength at specified dates and percentage replacements from the two cubes would be recorded.

2.3.3 Water Absorption

The percentage of water absorption can be defined as residual water remained in concrete. Water absorption percentage can be evaluated according to weights of specimens measured accurately after water curing for 72 hours and drying phase conducted in oven dry at 105 °C. Then specimens placed for another 1 hour in cold water and weighed [8]. Basing on these independent processes we were able to determine the water absorption of the cubes prepared using equation (2).

$$\text{Water Absorption (\%)} = \frac{100(\text{Wet weight} - \text{Dry weight})}{\text{Dry weight}} \qquad (2)$$

In this case, a total of twelve concrete cubes were used; two for each percentage replacement of cement with ground rice husk. The average values of water absorption from the two cubes at the specified percentage of cement replacement were obtained and be recorded.

3.0 Results and Discussion

3.1Workability

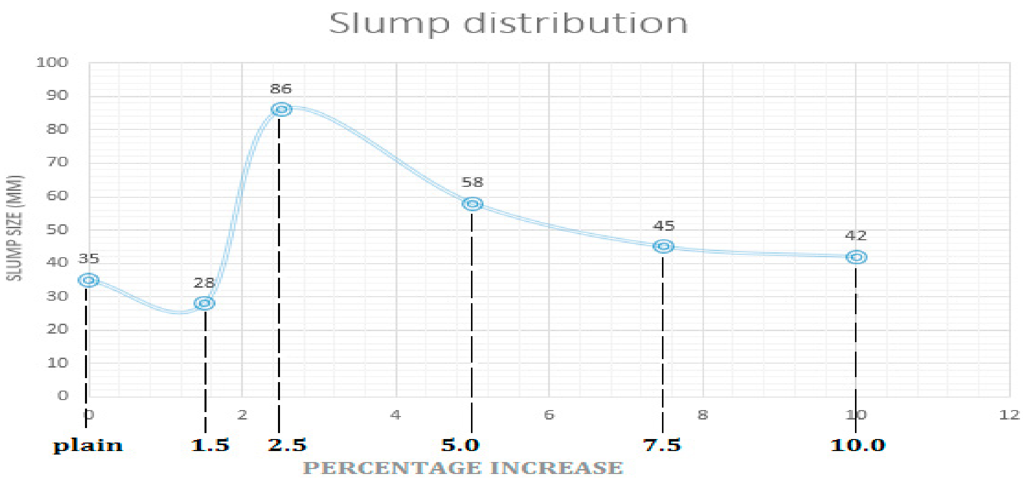

Figure 1: Sump for different Percentage Replacements

According to figure 1, it is observed that there were varying values of slumps for different percentage replacements of cement with ground rice husk. For the control mix, the slump was at 35mm that reduced to 28mm after replacing cement with 1.5% ground rice husk. This shows that the ground rice husk has an affinity for water so drained water from concrete, therefore, reducing the slump. Increasing the amount of ground husk to 2.5% led to an increase in slump up to 86mm. This shows that the ground rice husk was saturated and could not absorb more water leaving a lot of free water that resulted in a large slump. Further increase in ground rice husk resulted in a decrease in a slump. From the general trend, it can be observed that any percentage increment of ground rice husk while replacing cement equal or above 1.5% resulted into a decreased slump while percentage increment of ground rice husk, less than1.5% resulted into an increase in a slump. However, the overall average slump was still within the specifications for concrete to be used.

3.2 Compressive Strength

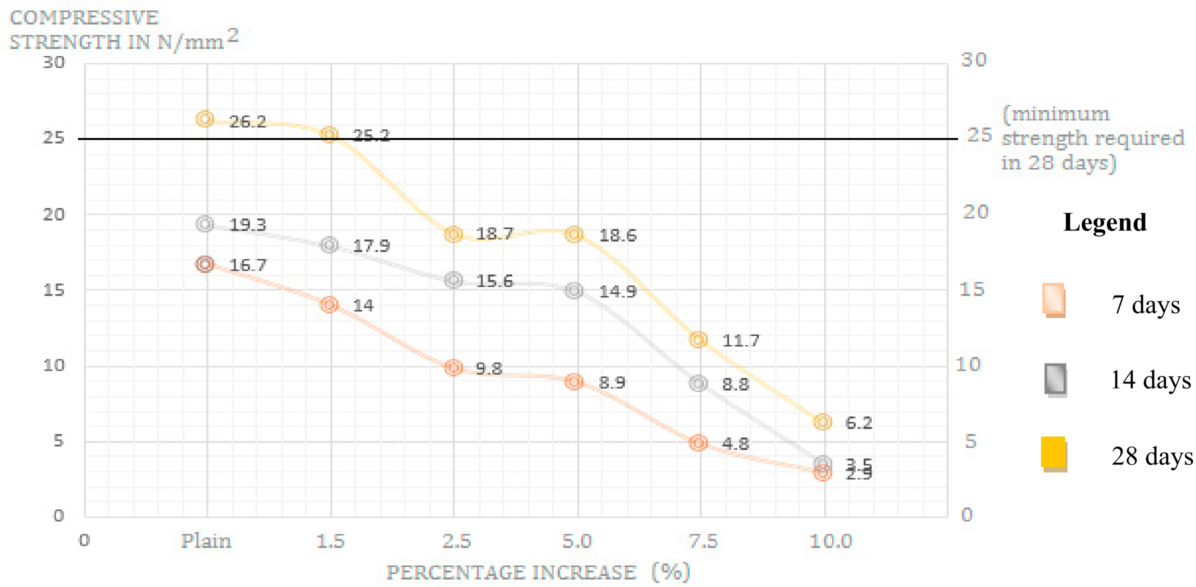

Figure 2: Compressive Strength for different Percentage Replacements

The target mean strength for the mix as designed was 25N/mm^2. This was only met by a control mix (0% replacement) and the 1.5% replacement of cement with rice husk in the concrete at 28days as shown in figure 2. The test results clearly show that the higher values of percentage replacement of cement with ground husk results in decreasing strength. This disagrees with other studies done especially on partial replacement of cement with RHA. Replacement of cement with RHA results into an increase in strength due to the fact that it is a pozzolanic material and reach in amorphous silica so contributes to the binding properties of concrete [1].

3.3 Water Absorption

According to figure 3, it is seen that any attempt to replace cement with ground rice husk resulted in increasing values of water absorption. This disagrees with other studies done especially on partial replacement of cement with RHA. Generally, cement replacement with RHA results in lower water absorption values due to the fact RHA is finer than cement [7]. Increasing values of water absorption can be explained by the fact ground rice husk particles are coarser compared to those of cement. This was exhibited by the control mix with lower absorption values compared to any replacement.

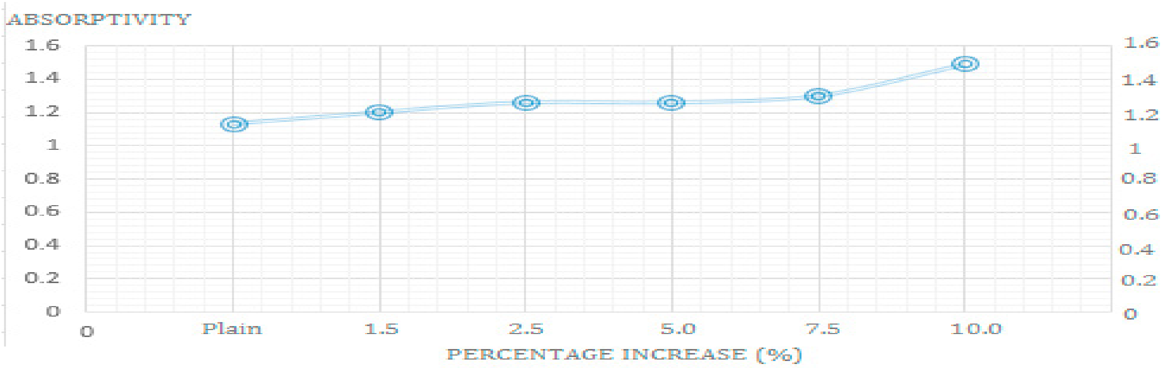

Figure 3: Water Absorption for different Percentage Replacements

4. Conclusion

- The values of slumps different percentage replacements of cement with ground unburnt rice husk varied but still within the specifications for concrete fit for use in construction.
- Replacement of cement with ground rice husk in concrete at 1.5 % achieved target strength, therefore, this results in reduced demand for cement in a mix.
- Replacement of cement with ground rice husk in concrete increased its water absorption which is not good for durability purposes.

5. Recommendation

Cement can be replaced with ground rice husk at 1.5% without compromising the strength requirements of concrete. Water-repelling materials are recommended for use in this type of concrete since results showed that it absorbs more water compared to normal concrete to ensure its durability.

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