EVALUATING THE WATER REPELLENT EFFECT OF RICE HUSK ASH IN HARDENED CONCRETE

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Abstract— Rice-husk-ash, a pozzolanic additive to concrete, has the potential of serving as a water repellent admixture in concrete, considering its very high amorphous silica content. In this work rice-husk was calcined at temperature range of 500^{o}C to 600^{o}C and the grey ash ground to fine powder passing BS sieve size of 0.075mm, and was used to prepare concretes containing different percentages of rice-husk-ash added to the mix by weight of the cement content. In the same vain a proprietary admixture, proprietary name: Water Seal, was used to prepare similar concrete cubes at same varying percentages of 0%, 2%, 4%, 7%, 10% and 12% as the rice-husk-ash, where zero percent served as the control. It was observed, in water absorption experiment; that at 6 to 7 days water immersion the cumulative weights of water absorbed by the various concrete cubes became constant for all cubes containing either rice-husk-ash or the proprietary water repellent admixture, with the quantity of water absorbed reducing with increase in the percentage admixture add for both admixtures. At 2% dosage of the admixtures, after 7 days of water immersion of the concretes, weights of water absorbed were 0.19kg and 0.25kg for concrete cubes containing rice-husk-ash and concrete cubes containing Water Seal, respectively; while the control absorbed 0.75kg of water. This is a reduction in water absorption of about 75%; with the concrete containing rice-husk-ash performing a little better. It was concluded that 2% rice-husk-ash addition to concrete by weight of cement content, which incidentally is the same quantity prescribed by the manufacturers of Water Seal for their product, would be appropriate for use of rice-husk-ash as alternative water repellent admixture in concrete. Rice-husk-ash was then recommended as a good water repellent admixture in concrete and can be used as alternative to most proprietary products at a dosage of 2% by weight of cement content.

Index Terms— Admixture, Concrete, Effectiveness, Porous, Rice-husk-ash, Water repellent, Water Seal

1 INTRODUCTION

Concrete is a commonly used construction material worldwide. One of its major setbacks is its porosity. Concrete naturally contain microscopic pores and capillaries, wide enough to permit molecules of harmful liquids and gases into the concrete, and which reduces the life span of the concrete product. It also reduces the performance of the structure in which the concrete is used and causes total nuisance to the users of the facility, e.g. concrete roofs, swimming pools, septic tanks, oversite concretes, all water bearing and water retaining structures[1]. One of the most effective ways of solving this porosity problem in concrete is by the use of a suitable admixture.

Proprietary admixtures that deal with water sealing of concrete are many and various, especially in Nigeria where this research was carried out. Because of the improved performance they impart on concrete exposed to dampness and water percolation, water sealing (water repellent) admixtures are gaining wider popularity in the construction industry on daily bases. One good example is in fish farming industry where it is used to plaster the inside face of fish ponds made of sand-crete blocks, which is a much cheaper alternative to a more costly reinforced concrete pond. This not only makes the pond totally water tight, but also reduces the cost of construction of the pond.

The causes of pores and capillaries in concrete are in two folds: (i) excess water that is left in the concrete after full hydration of the cement, which normally occupies spaces in concrete as pore water, when dried up leave empty pores in the hardened concrete (ii) in the hydration of cement, the volume of hardened concrete (cement gel) produced during the chemical reaction is always less than the total volume of water and cement that chemically combine to form it; this again leaves another type of pore in the concrete known as gel pore[2].

From casual experience, one would know that a fresh concrete cast and finished, neglecting losses of moisture through bleeding, normally retains its volume even in hardened state. It follows, therefore, that the capillary water and gel water aforementioned, leave the concrete with complex interconnected pores of various microscopic sizes, when they dry up. Based on this, concretes are innate porous materials. It is through these pores that deleterious substances which enter into the concrete gain contact with as much surface area of the concrete as possible and drastically reduce the durability of the concrete [3].

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Control of pores in the hardened concrete can be achieved by reducing the water-to-cement ratio and using richer mixes. Richer mixes are known to have less pores, because of more hydration products that result. Lower water-to-cement ratio naturally result into less empty capillary pores. Many literature on concrete uphold that at a water-to-cement ratio of 0.7, the pores and capillaries in concrete are so large and interconnected that the durability and strength of the concrete become questionable for structural application [1].

The best and most budget friendly way of handling porosity problems in concrete is by making use of a suitable admixture, such as a mineral or a pozzolanic admixture. Use of pozzolanic admixture has been in practice since the time of Roman Empire. The Romans used volcanic ash, a natural pozzolana, to produce quality binders with lime [4]. More recently, in 1930 fly ash was also discovered to be a good pozzolana. Just a few decades ago, ash from rice-husk was discovered to be a very reactive pozzolana [5][6], but its use as a concrete admixture is yet to gain the required popularity.

The effectiveness of pozzolana in eradicating pores in hardened concrete is based on the fact that pozzolanas begin to behave like cement as soon as they are in contact with lime and water. Incidentally, hydrated lime, water and cement gel are the main products of cement hydration. Pozzolanas pick up from there, reacting with the lime and water and depositing more cement gel, closing the pores and making the concrete denser, more watertight and more durable.

Today very reactive rice-husk-ash can be produced from very simple contrivances for calcination. A lot of research has been carried out on rice-husk over the years with a lot of satisfactory results. It not only increases the strength of concrete, it also reduces water absorption in concrete which holds a great promise for the durability of concrete [6]. Rice-husk-ash can be applied to concrete either in substitution for cement content or in addition to the cement content in preparation of concrete. In both methods excellent results are obtainable [7],[8],[9]

The aim of this study is to evaluate the effectiveness of rice-husk-ash as a water absorption inhibitor in concrete by comparing the quantity of water absorbed by concrete containing rice-husk-ash with that of a proprietary water repellent admixture that is commonly used, when concretes from both are tested by immersion. The result of this work can increase the demand for rice-husk-ash as concrete admixture, and improve the ease of handling and disposal of the agro-waste in rice producing parts of the world.

2 METHODOLOGY

i. Materials and Equipment

The materials used were coarse sand, crush granite aggregate, Portland cement, rice-husk-ash and a proprietary water repellent admixture, Water Seal. The sand was a well graded clean river-sand, rounded in shape, and maximum size of 2mm to 3mm. The coarse aggregate was a crushed granite aggregate of maximum size of 19mm and average size of 16mm, free from rock dust. Rice-husk was calcined in a locally contrived furnace at uncontrolled temperature of 500-700^{o}C. The resulting ash, grey in color, was ground to fine powder passing through BS sieve 0.075mm. The cement was a grade 42.5N Portland limestone cement, by Nigerian standard. The proprietary water repellent admixture, Water Seal, was purchased from a local dealer. The equipment used were 150 by 150 by 150-mm cube mold, weighing balance, mold oil, shovel, trowel, slump cone, glass plate, a meter rule, curing tank and a tamping rod.

ii. Experimental procedures

The quantities of sand, gravel, cement, rice-husk-ash, proprietary admixture and water were carefully calculated and weighed out using mix proportion of 1:2:4 and a water-to-binder ratio of 0.53. These materials were batched in such a quantity that was sufficient for three concrete cubes. Cement, rice-husk-ash and sand were first thoroughly mixed using shovel on a non-absorbed surface, before the coarse aggregate was added and mixed again, after which water was added and final mixing was done until a uniform paste was obtained. Slump test was conducted on each batch and three concrete cubes cast to B.S 819 standard. This process was applied independently to 0%, 2%, 4%, 7%, 10% and 12% rice-husk-ash additions and to the similar percentages of the proprietary admixture, Water Seal. A total of 33 cubes were cast: 3 cubes as control (containing no admixture), 15 cubes for varying percentages of rice-husk-ash and another 15 cubes for similar varying percentages of the proprietary water sealing admixture. The 33 cubes were cured in water for 28 days. At the expiration of 28 days they were brought out of the curing tank to dry for three days, after which their various weights were taken and the cubes re-immersed in water for 7 days, with their new weights measured after each day. The cumulative weight of water absorbed at each day of measurement was obtained by subtracting the weight of the concrete cubes before immersion from the new weight obtained on the day of measurement and the averages were recorded.The result of water absorption for the concrete cube specimens containing rice-husk-ash are presented in Table 1. The result of water absorption for the specimens containing the proprietary admixture is given Table 2. The slump test results are also presented (Table 3).

Table 1: Cumulative water absorbed, in kilogram, by the concrete containing rice-husk-ash as admixture

Percentage of Rice-husk- ash	Days of Immersion						
	1 day	2 days	3 days	4 days	5 days	6 days	7 days
0%	0.30	0.30	0.45	0.65	0.65	0.65	0.75
2%	0	0.05	0.05	0.15	0.19	0.19	0.19
4%	0	0.05	0.05	0.15	0.20	0.20	0.20
7%	0.05	0.05	0.05	0.15	0.20	0.20	0.20
8%	0	0	0	0.05	0.05	0.05	0.10
10%	0	0	0.05	0.05	0.05	0.05	0.10

Table 2: Cumulative water absorbed, in kilograms, by the concrete containing the proprietary water repellent admixture, Water Seal.

Percentage of water sealing admixture	Days of Immersion						
	1 day	2 days	3 days	4 days	5 days	6 days	7 days
0%	0.30	0.30	0.45	0.50	0.65	0.65	0.75
2%	0	0.05	0.15	0.15	0.10	0.25	0.25
4%	0	0	0	0.05	0.10	0.10	0.10
7%	0	0	0	0.05	0.05	0.05	0.05
10%	0	0	0	0.05	0.05	0.05	0.05

Table 3: Slump test results for the respective Water Seal and RHA contents in the concrete cubes

Admixture (%)	Slump values(mm)	
	RHA	Water seal
0	80	80
2	65	70
4	55	62
7	49	49
10	30	27
12	20	24

In Table 1 and 2, it can be observed that the quantity of water absorbed by either of the concretes, reduced with increase in the dosage of the admixtures up to 7% dose. The control, zero percent admixture, absorbed 0.75kg of water after 7 days of immersion. At a dosage of 2% rice-husk-ash, the water absorbed reduced to 0.19kg and similarly to 0.25kg for the proprietary admixture. This is approximately a reduction of 75% in water absorbed for both concretes, with rice-husk-ash performing better. For other dosages greater than 2%, the reduction in water absorbed at 7 days water immersion ranged from 86% to 94% with the proprietary admixture performing a little better than rice-husk-ash. Table 3 also shows that the workability of the concretes containing either of the admixtures are similar

If all experimental errors are considered negligible, it can be deduced from the results that both admixtures have equal strength in sealing water out of concrete. Bearing in mind that this result will be improve significantly as the age of the concrete increases to 3 months, one can also conclude that both admixtures are effective in sealing water out of concrete. The prescribed dosage for Water Seal by the manufacturer is 2%, therefore rice-husk-ash can equally be applied at 2% dosage for sealing water out of concrete. The appropriateness of this prescription lies in the fact that at the age of 3 month, significantly more water will be seal off for both admixtures, since high percentage sealing of 74% has already been achieved at the age of 28 days.

4 CONCLUSION AND RECOMMENDATIONS

We conclude by noting that rice-husk-ash is a very effect admixture for sealing water out of concrete. Its effectiveness is comparable to some proprietary admixtures already in use. It is then recommended that rice-husk-ash be added to fresh concretes during mixing at a dosage of 2% by weight of the cement content for concretes used in construction of swimming pools, damp proof courses, fish ponds, etc. to improve significantly the durability and performance of the concrete facilities.

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