Influence of Particle Size and Firing Temperature on Burnt Properties of Rice/Clay Mix

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ABSTRACT

Composite clay bricks containing various additions of rice husk grouped into four particle size ranges were molded under 5MN/m^2 compaction pressure, dried and fired at 500 C, 600 C, 700 C and 800 C, respectively. Compressive strength, water absorption and density measurements show that small additions (≤ 1%) of rice husks lead to improved compressive strength and a decrease in the amount of water absorbed. Rice husk additions above this limit reduced the compressive strength and density of the bricks and increased the amount of water absorption. Optimum properties of the bricks were observed for the particle size range (425 ‹ x ‹ 600) μm.

(Keywords: burnt bricks, rice husk, compressive strength, water adsorption)

INTRODUCTION

The building industry in Nigeria is greatly expanding and the demand for various types of cement for construction blocks is becoming alarming. The cost of cement is getting out of reach of most Nigerians. Cheaper and locally abundant construction materials offer a potential solution. Bricks are an important substitute for cement in Nigeria. The problem with the bricks produced, however, is for them to meet basic standards for proper performance.

Bricks are classified by both the average or minimum compressive strength and the percentage water absorption [1, 2]. According to this classification, minimum compressive strength of bricks should be 3.5 MN/m^2 and the water absorption should not exceed 20%. Some bricks manufactured in open kilns, however, fall short of this specification. Additional ingredients are required to produce good quality bricks. Various additives have been used by different researchers such as sawdust and spent lubrication oil [3, 4], fly ash [5-7], rice hull [8] and rice husk ash [9]. The inclusion of additives in brick-making has been reported to (a) produce bricks with thermal conductivities lower than those of normal bricks, (b) reduction in fuel consumption when firing bricks with additives , (c) production of bricks with higher strength, and (d) reduction in water absorption [3,5,7].

The main objective of this research was to investigate the scope of the use of rice husks in brick making. The effect of the rice husk/clay mix ratios for the different particle sizes of the rice husks and temperature of the formed bricks were also studied in the context of their effects on the compressive strength and water absorption.

EXPERIMENTAL WORK

The clay sample was collected from a site where local burnt bricks are manufactured in Makurdi, Benue State of Nigeria. The additive rice husks, a waste product of a rice mill in Makurdi were also collected from a stock pile around the building of the rice mill. The clay samples and the rice husks were analyzed using the x-ray absorption spectroscopy. Chemical composition of the clay and rice husks is shown in Table 1.

The clay sample was then ground and sieved with all the particles passing through 425μm sieve. They were thereafter kept relatively dry in the laboratory until molded into bricks. The scooped representative of the rice husks was powdery thus there was no need for further grinding. The rice husks were then sieved and categorized into four particle size ranges: (a) (600 ‹ x ‹ 850) μm, (b) (425‹ x ‹ 600) μm (c) (300‹ x ‹ 425) μm and a complex mix (d) (300 ‹ x ‹ 850) μm. The rice husk sample was further sun dried to reduce its moisture content.

Table 1: Chemical composition of clay and rice husks %

	Silica	Alumina	Ferric Oxide	Titanium Oxide	Potassium Oxide	Sodium Oxide	Calcium Oxide	Calcium Carbonate	L.O.I.
Clay	46.97	10.68	5.50	1.22	2.35	0.06	1.73	-	31.49
Rice Husks	24.15	0.47	0.32	-	-	-	-	0.75	74.31

Two sets of bricks of 86mm x 86mm x 85mm were cast in the laboratory, those with clay only and those with the additive rice husks (i.e., composite brick). The sample was mixed with sufficient quantity of water to obtain working consistency for molding. The ones with clay only were produced separately and the others with the additive (sieved rice husks) were grouped into the four particle size distributions. For each particle size group, five bricks were produced with the percentage of the additives ranging from 1-5% of the mass of the brick without additive.

Freshly molded bricks were left inside the laboratory building away from direct 12 days and then dried in a multipurpose furnace at 120 C for another 48 hours in order to ensure proper drying at the core. The bricks were then kept in the laboratory for firing at different furnace temperatures for 24 h. All together, six bricks were fired each cycle at the temperatures of 500 C, 600 C, 700 C and 800 C in a muffle furnace. Cooling was done in the furnace to avoid thermal stress which could result from a sudden change in the surrounding temperature. A total of about 600 bricks were cast for the experimentation. The bricks were then tested for compressive strength, water absorption and density.

RESULTS AND DISCUSSION

Tables 2, 3 and 4 show the result of the variation of the compressive strength values, amount of water absorbed and the density for each category of the bricks.

The effect of weight percent rice husks (as an additive) in clay bricks fired at 500 C, 600C, 700 C and 800 C is shown in Table 2. The result shows there was an increase in the compressive strength with the additive. It must also be pointed out that 700 C seems to be the critical temperature for the firing.

At the temperature of 800 C, we observed a decrease in all the values of the compressive strength. This may be due to the reactions of alumina, which when completed made the brick brittle, shrink and warp [10].

Water absorption of all the bricks with different proportion of rice husks decreases with increasing proportion of the rice husks. There was also a decrease with increasing temperature. However, the density of the burnt bricks increased with increasing temperature and peaked at 700 C. There was also a decrease in the density of the bricks proportional to the increase of the rice husks additive.

The two important properties of burnt bricks, namely compressive strength and water absorption can be improved substantially by adding rice husks. The compressive strength of the rice husk/clay mix has been found to increase with the rich husk content.

Observations suggested that firing at 700 C yields the optimum performance. Since the addition of rice husks to clay reduced the density of the brick, it was possible to produce lightweight bricks with the rice husk/clay mix.

Table 2: Variation of the Compressive Strength Values of Bricks with Particle Sizes (a) (600 ‹ x ‹ 850) µm; (b) (425‹ x ‹ 600) µm; (c) (300‹ x ‹ 425) µm ;and (d) (300 ‹ x ‹ 850) µm Fired at Different Temp.

Percentage of Rice Husk in Bricks %		Compressive Strength of Composite Brick at 500^0C MN/m^2	Compressive Strength of Composite Brick at 600^0C MN/m^2	Compressive Strength of Composite Brick at 700^0C MN/m^2	Compressive Strength of Composite Brick at 800^0C MN/m^2
(a)	0	6.0	7.2	7.5	6.8
	1	6.5	6.0	9.0	8.0
	2	10.5	7.0	13.0	10.0
	3	11.5	8.0	14.0	10.5
	4	13.0	11.0	14.0	12.5
	5	14.0	13.0	16.0	13.5
(b)	0	6.0	7.2	7.5	6.8
	1	6.5	8.0	8.0	7.0
	2	7.5	9.5	10.0	8.0
	3	14.0	11.0	14.5	14.0
	4	14.0	12.0	16.0	15.5
	5	15.0	13.0	17.5	16.5
(c)	0	6.0	7.2	7.5	6.8
	1	7.0	8.0	8.0	9.0
	2	8.0	9.0	12.0	10.0
	3	9.5	10.5	14.0	10.5
	4	11.0	12.0	16.0	13.0
	5	13.0	14.0	16.0	15.0
(d)	0	6.0	7.2	7.5	6.8
	1	7.0	8.0	9.0	8.5
	2	8.0	9.0	10.0	10.0
	3	9.5	11.0	15.0	10.5
	4	12.0	12.0	16.0	12.0
	5	13.0	14.0	17.0	14.5

Table 3: Variation of the Amount of Water Absorbed by Bricks with Particle Sizes (a) (600 ‹ x ‹ 850) µm; (b) (425‹ x ‹ 600) µm; (c) (300‹ x ‹ 425)µm; and (d) (300 ‹ x ‹ 850) µm Fired at Different Temperatures.

Percentage of Rice Husk in Bricks %		Amount of Water Absorption of Composite Brick at 5000C %	Amount of Water Absorption of Composite Brick at 6000C %	Amount of Water Absorption of Composite Brick at 7000C %	Amount of Water Absorption of Composite Brick at 8000C %
(a)	0	16.5	15.5	14.6	13.6
	1	16.3	14.6	14.5	13.3
	2	15.6	14.2	14.4	13.3
	3	15.4	13.8	13.7	13.2
	4	15.3	12.3	13.3	12.7
	5	15.1	11.8	12.1	12.1
(b)	0	16.5	15.5	14.6	13.6
	1	16.3	15.4	12.9	13.5
	2	15.7	15.3	16.3	13.0
	3	15.5	14.3	18.2	12.8
	4	14.5	14.3	19.1	12.8
	5	14.0	13.3	16.7	12.0
(c)	0	16.5	15.5	14.6	13.6
	1	16.2	14.5	14.5	13.6
	2	16.1	14.0	14.1	13.5
	3	15.7	13.7	13.7	13.3
	4	15.6	13.2	12.9	13.2
	5	14.3	11.9	12.7	12.7
(d)	0	16.5	15.5	14.6	13.6
	1	16.0	15.0	14.5	13.5
	2	15.8	14.0	13.8	13.3
	3	14.9	13.1	13.8	13.1
	4	12.7	12.0	13.7	12.5
	5	11.3	11.0	12.6	12.3

Table 4: Variation of the Density Values of Bricks with Particle Sizes (a) (600 ‹ x ‹ 850) µm; (b) (425‹ x ‹ 600) µm; (c) (300‹ x ‹ 425)µm; and (d) (300 ‹ x ‹ 850) µm Fired at Different Temperatures.

Percentage of Rice Husk in Bricks %	Density of Composite Brick Fired at 5000C (x 103 kg/m3	Density of Composite Brick Fired at 6000C (x 103 kg/m3	Density of Composite Brick Fired at 7000C (x 103 kg/m3	Density of Composite Brick Fired at 8000C (x 103 kg/m3
(a) 0	2.04	2.10	2.27	2.21
1	2.03	2.09	2.25	2.17
2	2.01	2.08	2.20	2.14
3	2.00	2.08	2.19	2.12
4	1.97	2.07	2.16	2.10
5	1.92	2.05	2.14	1.93
(b) 0	2.04	2.10	2.27	2.21
1	2.00	2.10	2.25	2.19
2	1.94	2.09	2.19	2.17
3	1.93	2.08	2.17	2.09
4	1.90	2.06	2.16	2.08
5	1.84	2.05	2.13	2.06
(c) 0	2.04	2.10	2.27	2.21
1	2.03	2.10	2.26	2.19
2	2.00	2.09	2.21	2.18
3	1.95	2.02	2.20	2.13
4	1.90	2.01	2.14	2.05
5	1.83	1.98	2.12	1.93
(d) 0	2.04	2.10	2.27	2.21
1	1.96	2.08	2.26	2.10
2	1.95	2.07	2.22	2.08
3	1.93	2.01	2.20	2.05
4	1.93	1.94	2.15	2.01
5	1.83	1.90	2.10	2.00

CONCLUSION

The two important properties of burnt bricks, namely compressive strength and water absorption can be improved substantially by adding rice husks. The compressive strength of the rice husk/clay mix has been found to increase with the rich husk content. Firing at 700 C yielded optimum performance. Since the addition of rice husks to clay reduced the density of the brick, it was possible to produce lightweight bricks with the rice husk/clay mix.

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