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Effect of Rice Husk Ash Amounts and Sizes on the Properties of Normal Clay Bricks

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Abstract

A study was undertaken to investigate the effect of rice husk ash on the various properties of lightweight normal clay brick. The normal clay bricks for load bearing purposes are usually manufactured using only normal clay as raw material. But addition of rice husk ash into the clay can engender better qualities. Normal clay bricks of size 77mm × 38mm × 26mm different ash particle sizes (106-212 micron, 212-425 micron, 425-600 micron) and amounts (5%, 10%, 15%, and 20% of the brick volume) were prepared using stiff-mud process and uniaxial pressing. After drying and firing, various properties were measured like drying and firing shrinkage, apparent density and cold crushing strength. Both shrinkage and apparent density of the bricks decreased with increase in the percentage of ash content. Cold crushing strength slightly decreased with increasing the percentage of ash. The effect of ash particle size showed random behavior in the changes of the properties.

Keywords: Normal clay, brick, rice husk ash, shrinkage

1. Introduction

Brick is a small unit of construction material. Being a popular material for a long time brick retains heat, withstands corrosion and resists fire. The brick is the main material in construction due to strength, durability, loading, compactness and light weight. Bricks in Bangladesh are generally made from only clay and water. Many researchers studied the effect of rice husk ash to building materials based on waste utilization and growing cost of building materials [1]. For possessing pozzolanic activity several researches have been carried out to utilize rice husk ash in cement and concrete development [2-6]. But very few study of RHA utilization in brick manufacturing is found. In recent decades, the growing consumption and the consequent increase of industrial production has led to a fast decrease of available natural resources or raw materials in Bangladesh. On the other hand, a high volume of production waste or sub-products is generated but most of them are not directly recyclable. Traditionally, disposal as soil conditioner or land filling are the commonly used processes for their consumption, but alternative ways to reuse several types of waste materials have been attempted in recent years. The possibility of recycling of different waste materials in the brick industry is thus of increasing importance. Rice mills generate a byproduct known as husk. During milling of paddy, about 78% of weight is received as rice, broken rice and bran. Rest 22% of the weight of paddy is received as husk [7]. This husk contains about 75% organic volatile matter and the other 25% of the weight of this husk is converted into ash during the firing process, which is known as rice husk ash (RHA) [7]. This RHA in turn contains around 90% - 95% amorphous silica [2].

Bangladesh is a major rice producing country, and the husk generated during milling is mostly used as fertilizer or a fuel in the boilers for processing paddy, producing energy through direct combustion or by gasification [8, 9]. But this RHA is a great environmental threat causing damage to the land and the surrounding area in which it is dumped. Lots of ways are being thought of for disposing them by making commercial use of this RHA.

The main objective of this study is to utilize the ash in making bricks. Cold crushing strength is one of the major properties of bricks which indicates the resistance to compressive load [10, 11]. Shrinkage is also an important property as it corresponds to brick dimensions and cracking possibilities. So we investigated the effects of rice husk ash addition on the properties of fired construction bricks, without degrading their properties like cold crushing strength and density, with reducing shrinkage.

2. Experimental procedure

The Experimental procedure consisted of raw materials processing, sample preparation and measurement of the properties. The properties measured are drying and firing shrinkage, apparent density and cold crushing strength.

2.1. Raw material processing and preparation of the samples

Processing of raw materials included collecting the raw materials to be used for preparing the specimens and primary processing of these materials to make them suitable for making the samples. The raw materials used in the experiment were: normal clay, rice husk ash and water. The clay used here was normal clay, collected from a brick field where the clay is used for production of construction bricks. The lumps of the clay were crushed to make fine particles and then naturally dried for several days to remove the inherent moisture so that it cannot vary the moisture amount used for making the specimen. The clay particles were screened to avoid any unwanted foreign particles like stones, large aggregates or other substances and to get homogeneous fine clay. Rice husk ash was collected from local market which was sieved to get three different sizes: 106-212 micron, 212-425 micron and 425-600 micron. Preparation of specimens involved mixing, molding, drying and firing. Clay, water and uniformly sized ash were first proportioned according to volume percentage. 5%, 10%, 15% and 20% ash of the total brick volume were taken and mixed with 95%, 90%, 85% and 80% clay respectively adding 20% moisture through stiff-mud process. Hand molded bricks were prepared by using uniaxial pressing. The average brick dimension was 77mm × 38mm × 26mm. Green bricks were then subjected to air and sun drying for 5-6 days and to oven drying for 6 hours at 120℃. Firing was then done in the muffle furnace at 1000℃ for 6 hours and fired bricks were obtained after furnace cooling.
The manufacturing process of brick specimens is given in short in the figure 1.

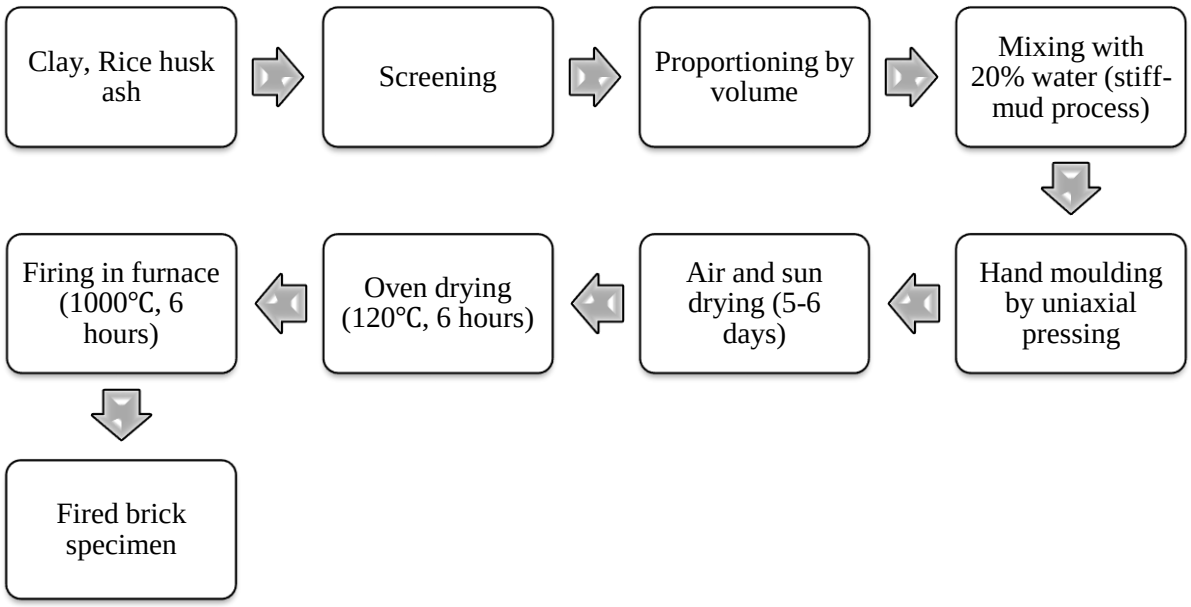

Figure. 1. Flow diagram showing the experimental procedure of brick specimen manufacturing

2.2. Measurement of properties

The drying and firing shrinkage, apparent densities and cold crushing strength among the properties of the specimens were measured and compared graphically for the three different amounts and sizes of ash. The measured procedures are described below.

2.2.1. Measurement of drying and firing shrinkage

The volumes of the bricks before drying, after drying and after firing were calculated by measuring the height, length and width of the bricks using slide calipers. Then the percentage of drying and firing shrinkage were measured form the difference between the initial volume and volume after drying and firing.

2.2.2. Measurement of apparent density

Apparent density defines the material present in a given volume**.** It includes the closed pore volume but excludes the open pore volume. Apparent density was measured from the weight per volume of the bricks after firing.

2.2.3. Measurement of cold crushing strength

The load needed to crush the specimens was measured by using universal testing machine. Cold crushing strength in MPa was calculated from those load values divided by the cross sectional area of the bricks.

3. Results and Discussion

3.1. Drying shrinkage

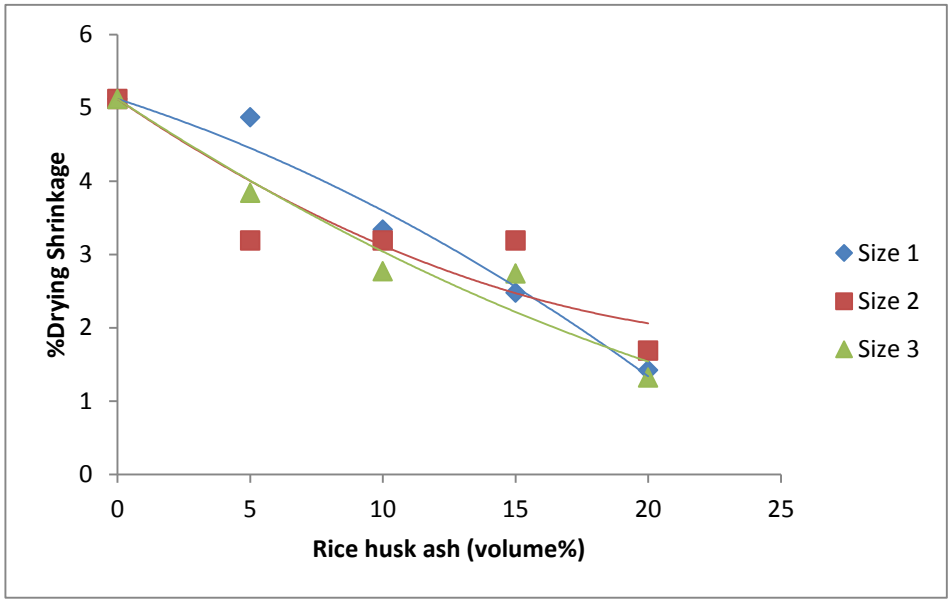

Figure. 2. Effect of rice husk ash on drying shrinkage of construction brick

From figure 2, the effect of rice husk ash addition on drying shrinkage of construction bricks is observed. For 100% clay brick the drying shrinkage is 5.12%. With the addition of rice husk ash, drying shrinkage minimizes accordingly. For all three sizes of ash particle this trend is followed. But there is no general effect of particle sizes of rice husk ash on the drying shrinkage.

The possible reason behind this is that, clay being the plastic part of the bricks absorbs water while mixing. During drying this water evaporates and shrinkage of bricks occurs. More the amount of clay more will be the shrinkage. Ash absorbs less water than clay and as it has a stable mass it does not shrink during drying. Increasing the ash content causes decrease of clay or the plastic part of the bricks. Thus less water absorption occurs during mixing causing less evaporation or less shrinkage.

3.2. Firing Shrinkage

From figure 3 we see that, for 100% clay, the firing shrinkage is the highest (4.8%) which decreases with increasing percentage of rice husk ash from 0% to 15% but does not much vary from 15% to 20%. We can generally say that firing shrinkage decreases with increasing amount of ash. But there is no much effect of the size of ash as the curves show random variation of shrinkage according to the size.

When the clay is fired, decomposition of clay occurs and combustible, volatile matter or moisture present is driven out and at high temperature of firing, fusion of various components of clay occurs. All these cause shrinkage of clay during firing. But rice husk ash used with clay is a non-plastic mass and has a stable volume. Ash also does not get fused during firing because it RHA has high melting point, 1440^0c [12, 13]. As rice husk ash does not shrink during firing, so increasing ash percentage, firing shrinkage decreases. In 20% volume of ash, we see an increase in the firing shrinkage. The reason may be such that ash got fused when the amount of it was larger.

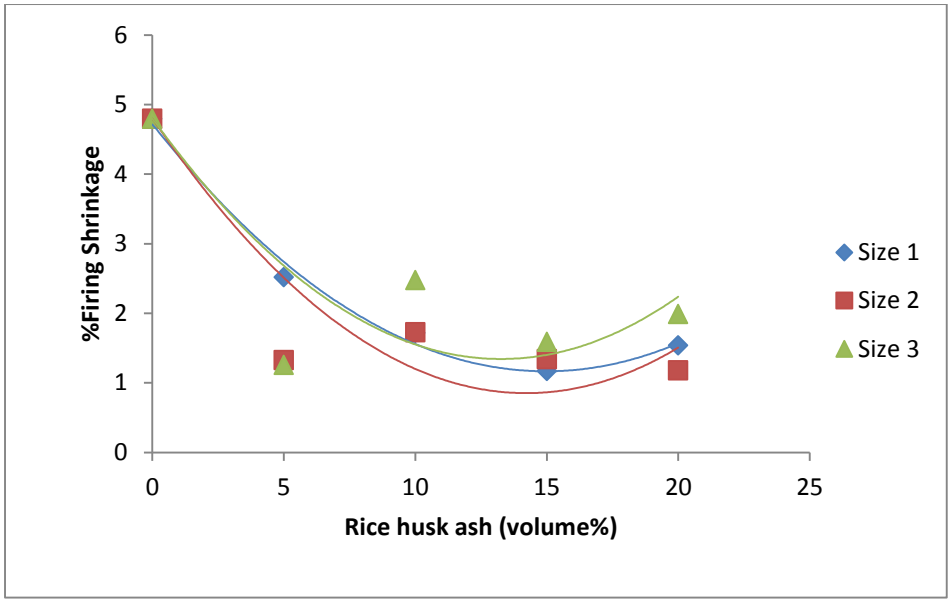

Figure. 3. Effect of rice husk ash on drying shrinkage of construction brick

3.3. Apparent Density

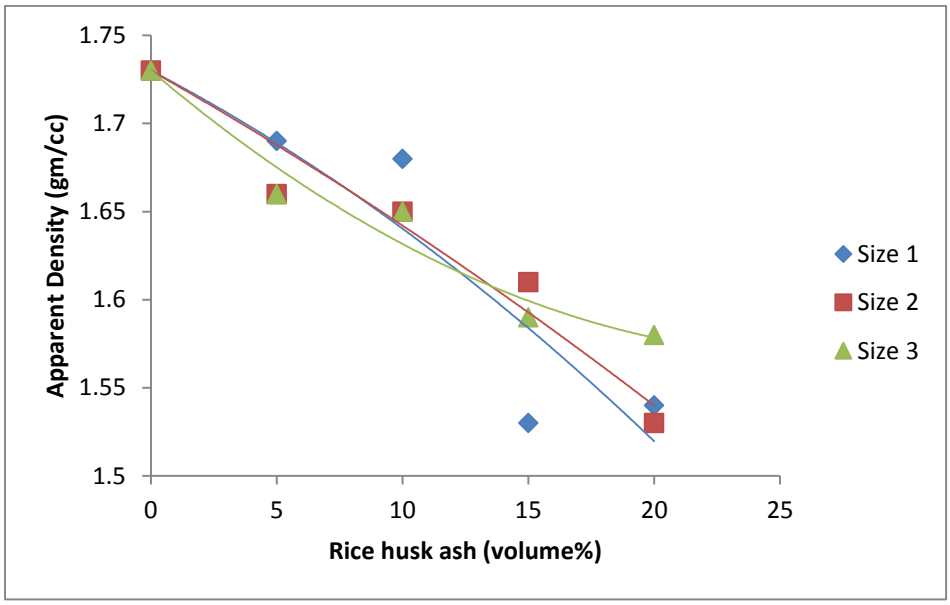

Figure. 4. Effect of rice husk ash on apparent density of construction brick

The effect of rice husk ash amount and sizes on apparent density is shown in figure 4 where the specimen with 100% clay shows maximum apparent density (1.73 gm. /cc). With increase in percentage of ash, the total porosity gradually increases and the apparent density gradually decreases. The effect of the particle size on apparent density is random thus avoidable.

Rice husk ash is a non-plastic part of the brick and thereby does not shrink on firing. Instead the particles tend to resist shrinkage. Only clay particles being plastic in nature shrink on firing which gives the overall shrinkage. A reduction in shrinkage means more presence of voids within the specimen which gives porosity in increasing proportion. An increase in porosity means decrease in mass due to more void space in the specimen and less shrinkage means less change in apparent volume which in turn gives a reduced apparent density. Moreover ash is lighter in weight than clay. Thus with increasing percentage of ash, the percentage of total porosity increases and apparent density decreases.

3.4. Cold Crushing Strength

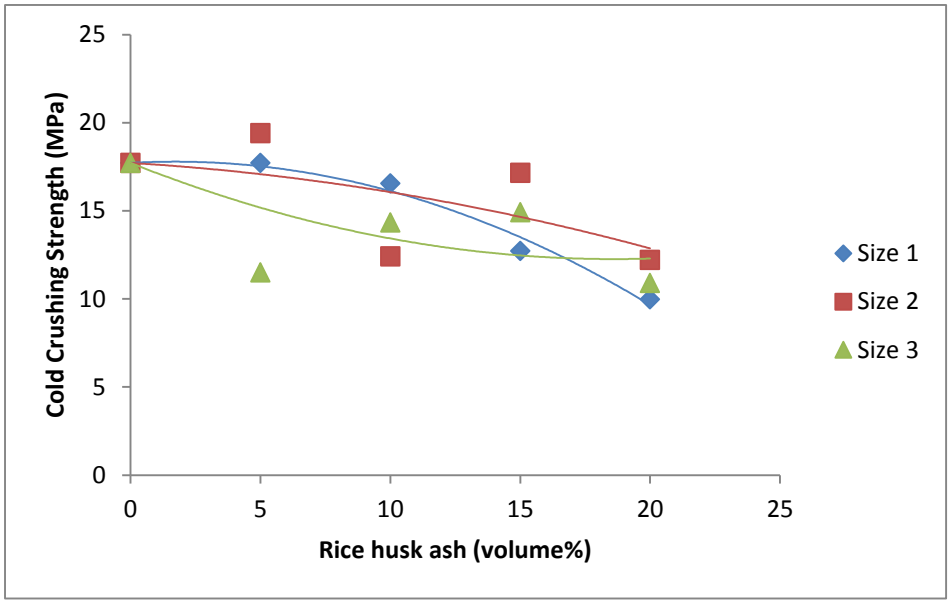

Figure. 5. Effect of rice husk ash on cold crushing strength of construction brick

The effects of rice husk ash amounts and sizes on cold crushing strength are shown in figure 5. Irrespective of the size of ash, the cold crushing strength of the specimens is the maximum for 100% clay or 0% ash. With increase in brick dust content, the cold crushing strength shows a little decreasing order. On firing, the non-plastic ash does not show any type of fusion or bonding. The clay particles have enough plasticity, are fused and give a fused mass of Al_2SiO_3, which provide strong bonding after firing. So the more the amount of the clay, stronger the bonding and the higher the load is required to crush it giving higher clod crushing strength. This is why; the specimen with 100% clay gives the maximum value of strength. The increase in ash amount means decrease in the clay amount proportionately which gives in turn fewer amounts of plasticity and thereby comparatively weaker bonding. So they will be crushed at lower load values giving lower cold crushing strength. But the slope of the decrease of cold crushing strength is not very steep i.e. the change is not so significant. So we can use ash in normal clay bricks without much affecting the strength of the bricks. The change in cold crushing strength with ash size is random thus we can say there is no specific effect of the size of ash.

4. Conclusion

To summarize the work from the results some effects of rice husk ash on the properties of clay brick can be concluded. The Drying shrinkage and firing shrinkage of normal clay bricks decreases with increasing amount of rice husk ash. There is no particular size effect of ash on normal clay bricks. The apparent density of the fired specimens also decreases with increase in the percentage of ash. The cold crushing strength of the fired specimens decreases with increasing in the ash percentage regardless of size. Therefore adding rice husk ash can be beneficial as they reduce shrinkage and produce lightweight bricks with moderate strength.

5. Acknowledgements

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6. References

[1] Agbede, I. O, and Joel, M, "Effect of Rice Husk Ash (RHA) on the Properties of Ibaji Burnt Clay Bricks", *American Journal of Scientific and Industrial Research, Vol. 2(4), pp. 674-677, 2011.*

[2] Md. Safiuddin, Mohd Zamin Jumaat, M. A. Salam, M. S. Islam and R. Hashim, "Utilization of Solid Wastes in Construction Materials", *International Journal of the Physical Sciences Vol. 5(13), pp. 1952-1963, 18 October, 2010.*

[3] Tanvir Hossain, Shuronjit Kumar Sarker, B.C. Basak, "Utilization Potential of Rice Husk Ash as a Construction Material in Rural Areas", *Journal of Civil Engineering (IEB), Vol. 39 (2) pp. 175-188, 2011.*

[4] K.-Y. Chiang, P.-H. Chou, C.-R. Hua, K.-L. Chien, C. Cheeseman, "Lightweight Bricks Manufactured from Water Treatment Sludge and Rice Husks", *J Hazard Mater; 171, pp. 76–82, 2009.*

[5] G. W. Carter, A. M. Cannor and D. S. Mansell, "Properties of Bricks Incorporating Unground Rice Husks", *J Building and Environment, Vol. 17, pp. 285-291, 1982.*
[6] Hwang Chao-Lung, Bui Le Anh-Tuan, Chen Chun-Tsun, "Effect of Rice Husk Ash on The Strength and Durability Characteristics of Concrete", *J Construction and Building Materials, Vol. 25, pp. 3768–3772, 2011.*
[7] Istuti Singh, Ashish Murari, Ajit Kumar, "Improvement in Geotechnical Properties of Natural Soil Using Rice Husk Ash and Lime", *SSRG International Journal of Civil Engineering (SSRG-IJCE) - EFES April, 2015.*
[8] K. N. Farooquea, M. Zamana, E. Halimb, S. Islama, M. Hossaina, Y. A. Mollahb and A. J. Mahmoodb, "Characterization and Utilization of Rice Husk Ash (RHA) from Rice Mill of Bangladesh", *Bangladesh Journal Of Scientific And Industrial Research, Vol. 44(2), pp. 157-162, 2009.*
[9] Danupon Tonnayopas, Perapong Tekasakul and Sarawut Jaritgnam, "Effects of Rice Husk Ash on Characteristics of Lightweight Clay Brick", *Technology and Innovation for Sustainable Development Conference (TISD2008).*
[10] Sedat Karaman, Sabit Ersahin, Hikmet Gunal, "Firing Temperature and Firing Time Influence on Mechanical and Physical Properties of Clay Bricks", *Journal of Scientific & Industrial Research, Vol. 65, pp. 153-159, February 2006.*
[11] Presertsan S and Theppaya T, "A Study towards Saving in Brick Making, Part 1: Key parameters for Energy Saving", *RERIC Int. Energy J, Vol. 17, pp. 145-56, 1995.*
[12] Sugita, "On the Economic Production of Large Quantities of Highly Reactive Rice Husk ash", *International symposium on innovative world of Concrete (ICI-IWC-93), Vol. 2, pp. 3-71, 1993.*
[13] A.D. Onojah, N.A. Agbendeh, C. Mbakaan, "Rice husk ash refractory: The temperature dependent crystalline phase aspects", *International Journal of Research and Reviews in Applied Sciences, Vol. 15(2), pp. 246-248, May 2013.*