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Effect of processed rice husk ash on the production of Conventional bricks

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Abstract— The effects of processed rice husk ash (RHA) on the various properties of conventional bricks were studied. The measured properties were Particle size distribution, bulk density, compressive strength, 24-hour immersion water absorption and shrinkage. The effect of processed rice husk ash percentage and normal RHA on the bulk density and compressive strength of bricks was also studied. Both bulk density and compressive strength of bricks decreased with an increase in the percentage of RHA content. In the present work, different percentages of RHA and processed RHA were used with red clay. Among them, 8% processed RHA containing brick showed better quality compared to others. From XRD, It reveals that processed RHA act as binding agent more effectively than that of without processing RHA.

Index Terms—Prcessed RHA, XRD, Bulk density, Pozzolan, Water absorption

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1 Introduction

BRICKS are a widely used construction and building material around the world. The dried-clay bricks were used for the first time in 8000 BC and the fired clay bricks were used as early as 4500 BC. The worldwide annual production of bricks is currently about 1391 billion units and the demand for bricks is expected to be continuously rising. Formal bricks are produced from mud with high temperature kiln firing and thus contain high embodied energy and deliver large carbon footprint. It is likewise mentioned that there is a shortage of clay in many regions of the globe. To protect the clay resource and the environment, some countries such as China have started to limit the use of bricks made from clay. In many countries of the world, on that point is already a dearth of natural source material for the production of the conventional bricks. For environmental protection and sustainable development, many researchers have studied the use of waste materials to produce bricks. A wide variety of waste materials have been studied to produce bricks with different methods. The commercial production of bricks from waste materials is still very limited. The possible reasons relate to the methods for producing bricks from waste materials, the potential contamination from the waste materials used, the absence of relevant standards, and the slow acceptance of waste materials-based bricks by industry and public. For wide production and application of bricks from waste materials, further research and development is needed, not simply on the technical, economic and environmental aspects, but also on standardization, government policy and public education related to waste recycling and sustainable evolution.

In this study we use ash and its derivatives with red clay for the production of light weight bricks. Red clays is one of the most abundant natural mineral materials on earth. For brick manufacturing, clay must possess some specific properties and characteristics. Rahman [1] made fired bricks using clay–sand mixes with different percentages of rice husk ash. The results indicated that (i) the inclusion of rice husk ash increased the compressive strength of bricks; (ii) the optimum firing duration was 4 h at 1000 °C, and (iii) the bricks made of clay–sand–rice husk ash mixes could be used in load bearing walls. Waste glass powder such as boro silicate glass, coloured glass and sodalime glass was used in the production of bricks as fluxing agent on the sintering temperature of bricks to enhance the physic-mechanical properties of bricks [2-3]. Sutcu and Akkurt [4] indicated that the paper processing waste could be utilized together with brick raw materials to produce porous and lightweight bricks with reduced thermal conductivity and acceptable compressive strength. Such clays must have plasticity, which permits them to be shaped or molded when mixed with water; they must have sufficient wet and air-dried strength to maintain their shape after forming. Also, when subjected to appropriate temperatures, the clay particles must fuse together. Topcu & Isikdag [5] studied the manufacturing heat insulation as heat conductivity resistant bricks with clay and perlite. Chen et al.[6] focused on the feasibility of the making eco-friendly bricks by utilizing the hematite tailings. Lingling et al. [7] studied the effect of fly ash that was used as raw material with high replacing proportion of clay by volume on properties and firing parameters of bricks.

Rice husk is a major agricultural waste with a unique residue with high ash silica content. The ash contains above 90% silica with a highly porous, lightweight, specific surface area. Cigarette butts could be regarded as a potential addition to raw materials used in the manufacturing of light fired bricks [8]. Rice husk ash has been applied as

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amendment in many materials. This is due to its high porous insulating property. Moreover, rice husk has an abundant supply worldwide. Chen et al. [9] studied the feasibility of utilizing hematite tailings and class F fly ash together with clay to produce bricks. Kute and Deodhar [10] indicated that the inclusion of fly ash in general increased the compressive strength and decreased the water absorption of bricks. Chou et al. [11] conducted systematic study on utilization of class F fly ash to replace part of the clay and shale in production of bricks using the conventional kiln firing procedure. Kayali [12] studied the performance of Flash Bricks, bricks produced from fly ash. The Flash Bricks were about 28% lighter than clay bricks and had a compressive strength greater than 40 MPa.

The aim of the work is to reduce energy consumption by using various types of waste materials. Because of urban development and population growth, energy consumption is increasing day-by-day. So with respect to the limited sources of energy in many countries and risks that threat the environment, many studies related to the construction industry is carried out which encompass significant part of energy consumption. A research shows that energy demand will increase about 50% until 2050 and the share of the developing countries will be about 80% of the amount. Thus, in order to prevent excessive energy consumption and to reduce the environmental risks, bricks as the oldest building materials are more considered [13]. The use of waste management, for this purpose waste products as recycled materials (additives) have been the production used in of bricks [14].

2 Materials and Method

Chemicals used to perform experiments were analytical grade of purity. All the chemicals were used without further treatment. Sodium hydroxide pellate (NaOH), Sodium carbonate (Na2CO3), Hydrochloric acid (HCl), Nitric acid (HNO3), Methyl red indicator, ammonia (NH4OH) solution, Ammonium nitrate (NH4NO3), Ammonium oxalate ((NH4)2C2O4), Diammonium hydrogen phosphate ((NH4)2HPO4), Ammonium thiocyanate (NH4SCN) were used in this work.

The process of manufacturing of bricks from clay involves preparation of clay with various types of waste materials, molding and then drying and burning of bricks. In this work various types of waste materials and their derivatives with red clay were used for the production of high-quality bricks. Rice husk ash (RHA) and processed RHA prepared were mixed with red clay by different composition. The bricks are building materials which are generally available as rectangular blocks but for research convenient bricks were prepared with 2”x2”x2” size by molding the clay mixture. After molding process, the bricks contain some amount of moisture in it. So, drying should be done otherwise they may crack while burning. The drying of raw bricks was kept in an electronic oven at 110ºc for 24 hours. The dry bricks were ignited in a muffle furnace at 1000ºc for 5 hours. After reaching that temperature kept the bricks for 30 minutes.

Red clay is an important material on the development of bricks and is very essential to know the composition of red clay through chemical analysis process. In this work locally available red clay were used. Red clay is decomposed by fusion in a platinum crucible in presence of Hydrochloric acid with sodium carbonate unnecessarily. Chemical composition of red clay and RHA were investigated by ASTM C-114 method and the results are listed in table-1.

TABLE 1
CHEMICAL COMPOSITION OF RAW MATERIALS

Parameters	Red clay	Rice Husk Ash (RHA)
SiO_2	63.11	88.47
Al_2O_3	14.66	2.70
CaO	4.96	1.48
MgO	1.98	1.18
Fe_2O_3	4.68	2.51
Mixed oxide	19.35	5.22
Loss on ignition (LOI)	9.64	2.82

Before treated with NaOH, RHA was washed several times. Suspended impurities can be removed by this process. After that, the resulting wet RHA was dried in an oven at about 100°c for several days. Dry RHA was grinding in a ball machine about 4hrs. After that this RHA could be treated with NaOH. The solution containing Carbon residues were separated by filtration through Whatman No. 41 ash less filter paper. The filtrate solution is concentrated by slowly evaporating in a water bath.

3 Result and Discussion

The process of manufacturing of bricks from clay involves preparation of clay with processed rice husk ash, molding and then drying and burning of bricks. In this work bricks are prepared with clay and different composition of processed RHA, RHA without any processing and purchased sodium silicate. Usually bricks are building materials which are generally available as rectangular blocks but for research convenient bricks were prepared with 2”x2”x2” size by molding the clay mixture. The dry bricks were ignited in a muffle furnace at 1000ºc for 5 hours. After reaching that temperature kept the bricks for 30 minutes. Chemical composition of these as made bricks and raw materials were investigated by ASTM C-114 method and the results are listed in table 1.
Size gradation affects many properties of an aggregate. It affects bulk density, physical stability and permeability. With careful selection of gradation, it is possible to achieve high bulk density, high physical stability and low permeability. This is important because in pavement design a workable, stable mix with resistance to water is important. The gradation can be affected to achieve the desired properties for the particular engineering application. Another point is that fineness

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modulus expresses the degree of fineness of relevant particles. If the fineness modulus is in the range of 2.2-2.6 then this particles can be classified as fine particle. Size gradation refers to the proportions by dry mass of particles distributed over specified particle-size ranges. Particle size distribution curve for red clay and RHA were given Fig 1a) and b).

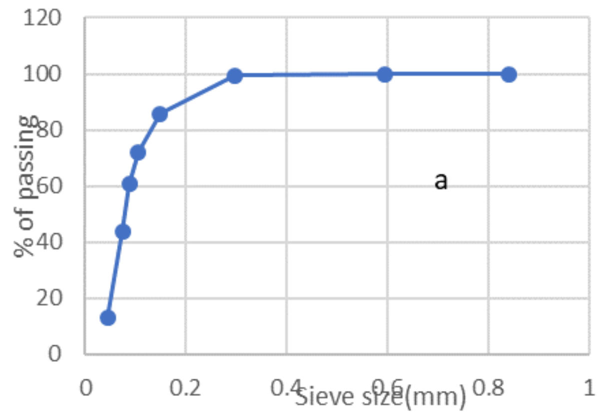

Fig. 1.a). Particle size distribution of red clay

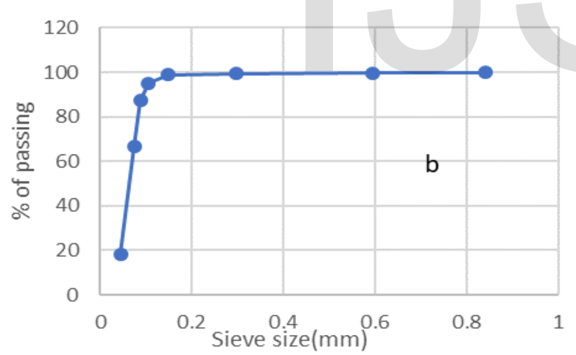

Fig. 1.b). Particle size distribution of rice husk ash

From percent passing (%) and sieve size (mm) analysis it could be draw particle size distribution curve or gradation curve of fine red clay as shown in figure-1a. Fineness modulus of fine aggregate is 2.13 that means the average aggregate size is in between 0.2 mm to 0.3 mm. The size distribution of ash is presented in figure-1b. Fineness modulus of rice husk ash was found as 1.3307 that means very fine particle size of rice husk ash. The increasing amount of rice husk ash in product of bricks decline the compressive strength because the combusted rice husk ash replaces with the space in the product which affect the density and compressive strength. Usually conventional bricks of Bangladesh have compressive strength between 2600 and 3000 psi.

Here in this study without any processing bricks made with only local red clay (the chemical composition of local red clay were given in table1) have compressive strength about 2700psi. But when added 8% RHA with this same red clay compressive strength

become about 2100 psi whereas using 8% processed RHA increasing compressive strength by 3475 psi which are more than conventional. Because processed RHA behaves like binding agent not only source of silica however 8% RHA behaves like only the source of silica so that it can't increase the strength of brick.

TABLE 2
COMPRESSIVE STRENGTH OF DIFFERENT COMPOSITIONS

Compositions	Compressive strength (psi)
Red clay (100%)	2700
Red clay (88%) + Processed RHA (12%) +35ml H_2O	1400
Red clay (90%) +Processed RHA (10%) +35ml H_2O	2850
Red clay (92%) + Processed RHA (8%) +35ml H_2O	3475
Red clay (94%) + Processed RHA (6%) +35ml H_2O	2980
Red clay (92%) + RHA (8%) +35ml H_2O	2100
Red clay (92%) + Silicate brick (8%) +35ml H_2O	3225

Effect of processed RHA addition on the bulk density of the bricks displays on the table-3. Bulk density of the brick and 8% RHA containing bricks were similar but addition of 8% processed RHA on bricks increasing bulk density. The higher the bulk density the lower is the void content to be filled by water. The porosity of a brick is defined as the ratio of the void volume to the bulk volume of a material. Bulk density and apparent porosity influence the quality of brick. Lower bulk density indicates void or empty space inside the brick which degrade the quality of the brick by absorbing water.

Water absorption is another important parameter for the durability of brick. When water infiltrates the brick, it decreases the durability of brick. So that the internal structure of the brick must be dense enough to avoid the intrusion of water. The applicability of bricks is strongly affected by water absorption where high water absorption is not desirable. In this study water absorption for 8% processed RHA containing brick has lower water absorption value than that of bricks without any processing and 8% RHA containing bricks which is an indication of improved durability of the brick containing 8% RHA.

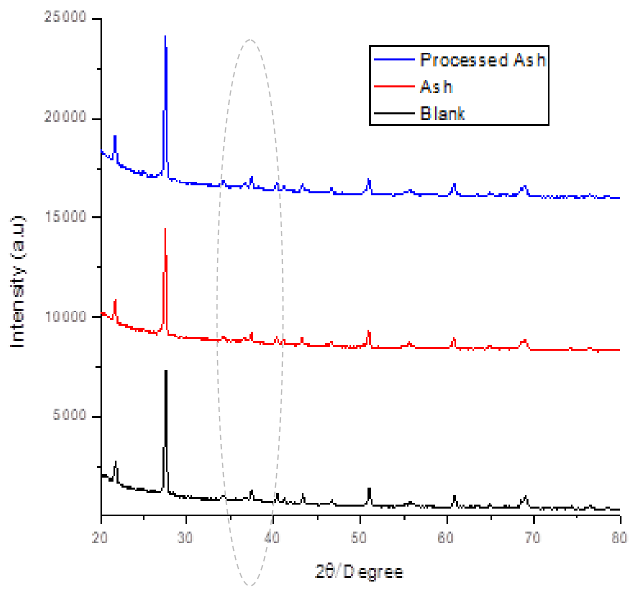

Fig. 2. XRD patterns of the brick samples containing blank brink (without adding any ash or processed ash), brick with 8% ash (RHA), brick with 8% Processed ash (processed RHA).

The XRD pattern (figure-2) show the glassy and crystalline phase bricks prepared only with red clay (without any ash or processed ash) in the figure it termed as blank and shows with black graph and also shows red color one bricks prepared with red clay and ash (RHA) and blue color one bricks prepared with red clay and processed RHA. The mineralogical composition of the fired brick samples was determined by powder XRD. Due to the re-crystallization of amorphous silica to crystalline with firing temperature some sharp and intense quartz peak has been observed for all of three bricks. It can be observed from figure that a new peak appears for the brick sample with ash and processed ash at around 37 2θ/degree marked with dotted line. Research work was still going on for the further analysis of XRD.

4 Conclusion

Manufacturing of bricks by the use of processed RHA with red clay offer more durable bricks for construction. In the present work, different percentage of RHA, processed RHA were used with red clay. Among them 8% processed RHA containing brick showed better quality compared to others. This type of bricks shows higher compressive strength and moderate shrinkage. The enhancement of brick properties with RHA is because RHA is an effective pozzolan that can contribute to develop strength of bricks. However, with the increase of RHA percentage higher than 8%, the compressive strength of bricks starts decreasing. Moreover, processed RHA shows higher compressive strength than that of without processing RHA. Although both of them have same XRD patterns but their compressive strength shows difference. It could be happened because processed RHA act as binding agent more effectively than that of without processing RHA. Moreover, carbon content of without processing RHA higher than that of processed RHA. So that binding insight brick containing processed RHA has tighter than that of others. Although this is an assumption and research work is on going to finding this questions answer and also trying to produce improving quality of bricks which have more compressive strength with other higher physical qualities.

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