International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 11, November 2015)

Pilot Plant Study on Energy Saving Brick from Rice Husk Ash

Sarker Kamruzzaman[1], Nahid Sharmin[2], Md. Moniruzzaman[3], Md. Sagirul Islam[4]
[1]Pilot Plant and Process Development Centre,
[2,3,4]Institute of Glass & Ceramic Research and Testing (IGCRT)
Bangladesh Council of Scientific and Industrial Research (BCSIR)
Dr. Kudrat-I-Khuda Road, Dhanmondi, Dhaka-1205, Bangladesh

***Abstract*-** **The technical and economical feasibility study of the process to produce energy saving and environment friendly brick from rice husk ash (RHA) has been discussed in this paper. The brick is not needed to burn like conventional brick which pollutes the air by emitting huge quantity of toxic elements. Heat and mechanical energy also saved as it was not compressed. After standardization of process parameters, the required units have been designed, fabricated and installed successfully. The main components of this brick are rice husk ash, lime, sand and binder. Five batch experiments have been carried out with different composition to get the desired compressive strength in the brick. Compressive strengths are 1.18 N/mm^2, 1.6 N/mm^2, 1.9 N/mm^2, 2 N/mm^2 and 2.1 N/mm^2 respectively. Peak loads are 3126 N, 6280 N, 9722 N, 10850 N and 12883 N respectively. Strains at brick are 1.18 %, 2 %, 2.4 %, 3 %, 3.6 % respectively. The price of each brick from the raw material is \$0.03. Increasing the amount of binder and lime, compressive strength and peak load of the brick can be improved which will increase the price too. Further study on brick can be extended to study the behavior for long term exposure with environment.**

***Keywords*-** **Compressive strength, calcium silicate hydrate (CSH) gel, strain, UTM, rice husk ash (RHA).**

I. INTRODUCTION

Rice, wheat, and maize are the three leading food crops in the world; together they directly supply more than 50% of all calories consumed by the entire human population. Rice is a staple food for nearly half of the world's seven billion people. However, more than 90% of this rice is consumed in Asia, where it is a staple for a majority of the population, including the region's 560 million hungry people [1].

Rice husk is one of the most widely available agricultural wastes in many rice producing countries around the world. Globally, approximately 600 million tons of rice paddy is produced each year. On average 20% of the rice paddy is husk, giving an annual total production of 120 million tones [2]. In majority of rice producing countries much of the husk produced from processing of rice is either burnt or dumped as waste [3]. Burning of RH in ambient atmosphere leaves a residue, called rice husk ash.

For every 1000 kgs of paddy milled, about 220 kgs (22 %) of husk is produced, and when this husk is burnt in the boilers about 55 kgs (25 %) of RHA is generated [3].

In many countries around the world initiatives were taken to develop low cost building brick using rice husk ash. Numerous patents, publications, reviews and reports on rice husk beneficial utilizations have appeared during last two decades. Suitability of RH to be used for different applications depends upon the physical and chemical properties of the husk such as ash content, silica content etc. RH finds its use as source raw material for synthesis and development of new phases and compounds such as, as a Fuel in Power Plant, Formation of Activated Carbon, as a source of Silica and Silicon Compounds, Porous SiO_2/C composite from RH, Insulating fire brick using RH etc[4,5,6].

As huge amount of rice husk ash produced in Bangladesh in every year, which contains pozzolanic amorphous silica component, will considerably reduce the cost of construction and can be utilized to develop low cost energy saving brick.

The main components of this brick are Rice husk Ash, Sand (Quartz), Lime ($CaCO_3$), Binder (port land cement) and Water. Five batches of experiment were performed with different composition of Rice husk Ash (50-53%), Sand (7-20%), Lime (26-34%), Binder Cement (0-6.5%) and Water. These components were mixed in mortar mixing machine and settled down in the aluminum block for obtaining desired shape and kept for 24 hrs for curing.

II. OBJECTIVE OF THE STUDY

The process to produce energy efficient low cost brick from rice husk was developed in the Institute of Glass and Ceramic Research and Testing (IGCRT) of BCSIR. Based on the developed process, technical and economical feasibility study was carried out through the following objectives

- To design and fabricate pilot plant for energy saving brick.
- To produce environment friendly brick.

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 11, November 2015)

- To develop and fabricate small size brick house model using the bricks.

III. Methodology

After standardization of the process parameters the required equipment or units has been designed and fabricated to carry out the pilot plant study. The brick can be obtained either by pressing (applying compression force) or non-pressing (without applying compression force) process. But this study was only limited to the non-pressing. Rice husk ash was collected from the rice mill close to Dhaka city. Sand, lime, cement were collected from local market. For the purpose of this study, dimensions of bricks were taken as 240 x 115 x 70 mm.

IV. Process Description

Rice husk Ash brick mainly consists of rice husk ash, sand (Quartz), lime ($CaCO_3$), binder (port land cement) and water. At first rice husk ash and sand had been sieved to remove unwanted coarse particle. Then the large lump sized lime was grinded to make smoother. Measured amount of rice husk ash, sand, lime and binder had been transferred to the mixer. Appropriate amount of water was fed to the mixer for prefect mixing. After loading all materials to the mixer machine, mixer machine operated for about 10 minutes until the prefect mixing was achieved.

After completing the mixing, all materials were unloaded. Brick block was filled with mixing materials. Then it was kept in room temperature for 24 hrs. After removing the blocks desired brick was obtained. Five batches of experiments were carried out with different composition of rice husk ash, sand (Quartz), lime ($CaCO_3$), binder (port land cement).

V. Chemistry Involve In The Process

When RHA is added to Portland cement, it reacts faster than fly ash in hydration process, which helps to improve the early age strength of brick, and also forms calcium silicate hydrate (CSH) gel around the cement particles which is highly dense and less porous. The formation of CSH gel in brick alters the micro structure of the brick with discontinuous pores. The pore refinement or densification reduces the permeability of brick and improves the resistance against chloride diffusion into brick. The following reactions take place during the mixing:

Portland cement + H_2O =CSH + $Ca(OH)_2$ (I)

Portland cement + H_2O+RHA =CSH + Unreacted silica (II)

There are two types of calcium silicate hydrate (CSH) gel which formed during reaction between RHA and

Portland cement: $Ca(OH)_2 + SiO_2 = CaO.\ SiO_2.\ (H_2O) + CaO.\ SiO_2.\ 2(H_2O)$ (III)

VI. Result Analysis And Discussions

Compressive strengths, peak loads and strains were measured using UTM (Model: Testometric 300KN). From the graphs (Figure III-VIII), it is clear that compressive strength, peak load and strain of brick depend on the composition of brick. Binder (port land cement) plays very important role for compressive strength and peak load. From the result of first batch of experiment that compressive strength and peak load of brick is very low without binder. Because in presence of binder (Portland cement), Rice husk ash reacts with binder and forms calcium silicate hydrate (CSH) gel around the cement particles which is highly dense and less porous, increase the strength of brick. From graph, it can be described that compressive strength and peak load increases with increase in the percentage of binder in the brick. Lime ($CaCO_3$) also plays important role for improving the strength of the brick. Compressive strength and peak load increases with increasing lime percentage. As rice husk ash is the main component of the brick, its percentage was kept around 50%. So increase in the sand amount resulting decrease in the binder and lime amount. Also from graph, Compressive strength and peak load decreases with increasing sand percentage. Strain at brick is another important parameter of brick. From graph, it is also observed that strain at brick increases with increasing in binder and lime amount and decreases with increasing in sand amount.

VII. Conclusion

Compressive strength observed from the pilot plant study for this brick is not sufficient to build high storey buildings. So the use of this brick should be limited to build one storey low cost houses. Compressive strength and peak load of the brick can be improved by increasing the amount of binder and lime. But the cost of production of each brick will be increased and it will not be feasible. Optimum amount of binder and lime can be increased to improve the compressive strength of the brick. It is also important to study the behavior of this brick for long term exposure with environment.

Further study can be extended to analyze the exposure behavior with different environment parameters like rain, humidity, sunlight, gaseous composition of air etc. The price of each brick from the raw material is $0.03.

Acknowledgements

The authors showed their deep gratitude at first towards the authority of BCSIR for allotting the fund to carry out the research. They are also grateful to Md. Latiful Khabir, Md. Masrul Huda, Dr. Ruhul Amin of Department of Chemical Engineering, Bangladesh University of Engineering & Technology for their support in carrying out the research.

REFERENCES

[1] Samarendu Mohanty, 'Trends in Global rice consumption', Rice Today, January-March 2013

[2] Dashan I. I. and Kamang E. E. I., Some characteristics of RHA/OPC concretes: A preliminary assessment, Nigerian Journal of Construction Technology and management, 2(1), p.22-28, 1999.

[3] Michael K .O., Rice husk as stabilizing agents in clay bricks, higher national diploma project, Department of civil engineering, Federal polytechnic Bida, Nigeria, 1994.

[4] Ajay kumar, Kalyani Mohanta, Devendra Kumar and Om Parkash, 'Properties and Industrial Applications of Rice husk: A review ', Accepted in International Journal of Emerging technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008 certified journal, Volume2, Issue 10, October 2012

[5] Md.Latiful Khabir, Md.Masrul Huda, Dr.Ruhul Amin and Sarker kamruzzaman, 'Energy Saving Brick from Rice Husk Ash', International Conference Mechanical, Industrial and Materials Engineering 2013 (ICMIME2013), RUET, Rajshahi, Bangladesh, p.222-226.

[6] Prof. R. Sathish Kumar, 'Experimental study on the properties of concrete made with alternate construction materials', International Journal of Modern Engineering Research (IJMER) www.ijmer.com Vol. 2, Issue. 5, Sept.-Oct. 2012 pp-3006-3012 ISSN: 2249-6645.

[7] 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), 39 (2) (2011) 175-188.

Fig. I: Rice husk and Rice husk ash.

Fig. II: RHA bricks

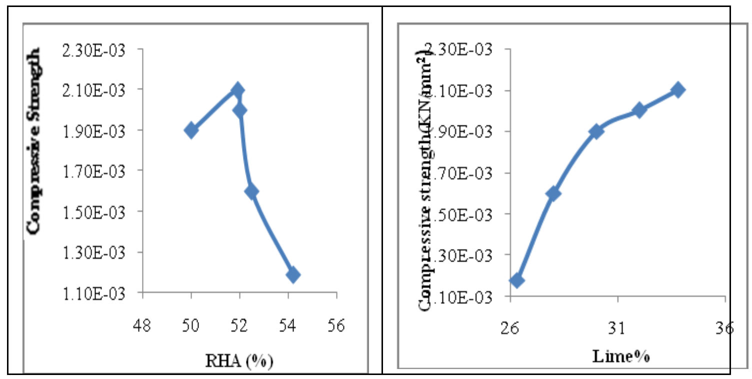

Fig. III: Compressive Strength vs RHA and Lime

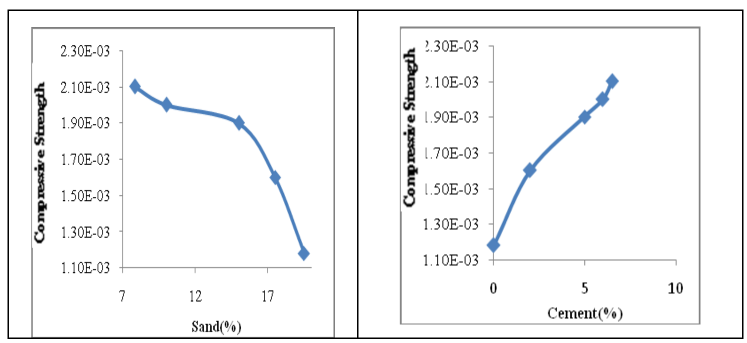

Fig. IV: Compressive Strength vs Sand and Cement

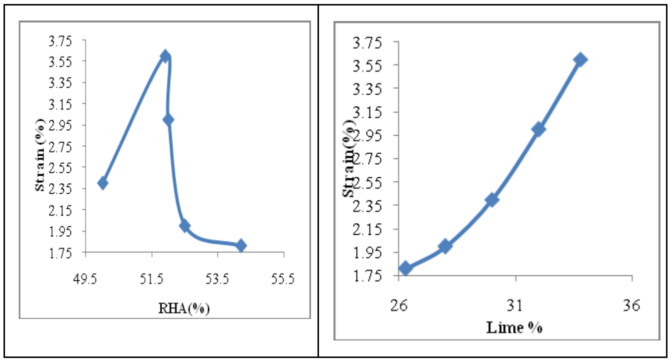

Fig. V: Strain vs RHA and Lime

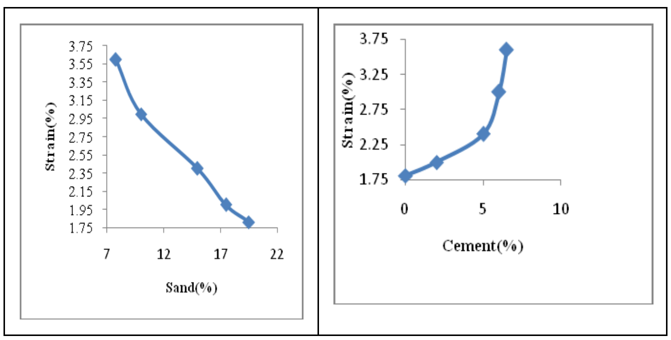

Fig. VI: Strain vs Sand and Cement

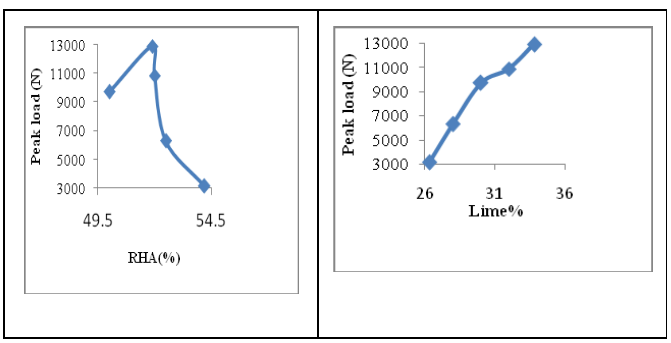

Fig. VII: Peak Load vs RHA and Lime

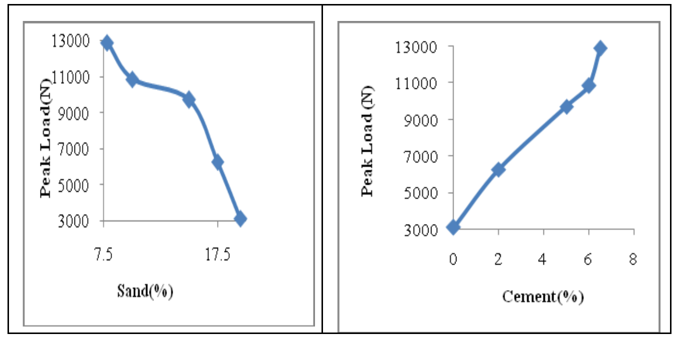

Fig. VIII: Peak Load vs Sand and Cement

Table I
Chemical Properties of RHA [7]

Constituent %	Composition
Fe_2O_3	1.38
SiO_2	90.20
Al_2O_3	0.85
CaO	1.18
MgO	1.21
Loss on ignition	3.95

Table II
Physical Properties of RHA [5]

Specific Gravity	2.05 – 2.3
Bulk Density	1.86 g/cm^3
Colour	Grey
Odour	Odourless
Particle Size	25 microns- mean
Appearance	Very fore

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 11, November 2015)

Table III
Experimental result

Components	1st Batch	2nd Batch	3rd Batch	4th Batch	5th Batch
RHA (%)	54.2	52.5	50	52	51.9
Sand (%)	19.5	17.5	15	10	7.8
Lime (%)	26.3	28	30	32	33.8
Cement (%)	0	2	5	6	6.5
Parameters	**1st Batch**	**2nd Batch**	**3rd Batch**	**4th Batch**	**5th Batch**
Compressive strength (KN/mm^2)	$1.18x10^{-3}$	$1.6x10^{-3}$	$1.9x10^{-3}$	$2x10^{-3}$	$2.1x10^{-3}$
Peak load (N)	3126	6280	9722	10850	12883
Strain @ brick (%)	1.81	2	2.4	3	3.6

Corresponding Author: nahid_pppdc@yahoo.com