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Effect of Soil Type in Compressed Earth Brick (CEB) with Uncontrolled Burnt Rice Husk Ash (RHA)

Fetra Venny Riza[1, a], Ismail Abdul Rahman[1,b], Ahmad Mujahid Ahmad Zaidi[2, c] Lee Yee Loo[1,d]

[1]Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia (UTHM)
[2]Faculty of Engineering, Universiti Pertahanan Nasional Malaysia (UPNM) [3]

[a]fetravenny@gmail.com, [b]ismailar@uthm.edu,my, [c]mujahid80s@yahoo.com, ahloon@uthm.edu.my

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Abstract. Compressed Earth Brick (CEB) as building material has many advantages compared to conventional fired clay brick in the view of sustainability, moreover if incorporated uncontrolled burnt RHA waste that usually dumped off since it has no commercial value. This paper tried to assess the effect of soil types of clay and laterite in CEB properties which abundantly available in Malaysia. The result showed that the compressive strength of CEB with 20% RHA using clay at 5.5 MPa is better than that of laterite 4.9 MPa, and both exceed that of commercial unfired clay brick from UK.

1. Introduction

In 2011, the FAO report stated the world rice production up to 721 million tones or 3% larger from previous year [1]. And Malaysia's rice production will be projected to increase every year, and the potential of its ash will increase considerably. From 100 kg paddy plant will produce 25 kg of rice husk, and after undergone incineration or combustion process –where rice husk used as fuel for the boiler to generate electricity in the rice mill- 4 kg of will be obtained [2-3].

Rice husk can be used as an alternative energy source i.e. as a fuel in the boiler of rice milling kiln to generate electricity where heating value of the husk could ranging from 15.7 to 17 MJ/kg of which 18.8% is carbon, 62.8% is volatile materials, and 9.3% is moisture content [4-6].

RHA has very little or no commercial value and usually damped into the river or just left abandoned so the RHA will be spread when the wind blew, which will caused environmental and health problems to the inhabitants mainly because RHA contains high contents of silica that is not biodegrade easily [7-8]. Silica contents in RHA is the highest compared to other plant residue [3, 9-10].

Previous researchers have confirmed that RHA which has good pozzolanicity is the one that undergone controlled combustion with certain temperature. To produce amorphous silica, various researchers have had suggested different temperature ranging from the 500°C to 700°C [3, 7, 11-15]. However, the RHA resulted from uncontrolled burning temperature in the rice milling combustion is in crystallite form which the consequences has poor pozzolanicity.

On the other hand, the tendency to minimize the negative impact of construction to the environment has lead to the reduction of cement used and the process of producing construction material that used heat, such as furnace or kiln. Most of the commercialized clay brick in the market are fired clay brick, as well as commercialized compressed earth brick (CEB) also utilizing cement as a binder.

CEB has many advantages compares to the conventional fired clay brick like low cost material and production since the materials are locally available and the technology only need moderate to low skilled worker, can be made in situ, environmental friendly since no need firing process, has good thermal properties where the CEB can keep the house warm during the winter and cool during the summer, fire resistant, good for health of the occupants because the CEB can absorb the CO_2. In all, CEB is ultimately greener, eco friendly and comparable in term of strength, durability and thermal properties [16].

This paper tried to observe the effect of soil type in the compressed earth brick that utilized uncontrolled burnt RHA where the clay and laterite soil is used since these two types of soils are available abundantly in Malaysia.

2. Materials

Uncontrolled burnt RHA from rice milling in Muar and hydrated lime LT 204/09 which certified to MS 918:93 were used as binder in CEB and analyzed using XRF to examine the chemical content. Loss on ignition of RHA also calculated as shown in table 1. RHA from uncontrolled combustion in the boiler of rice milling is black in color and of particular interest is the high silica content of RHA (91.20 %) and low loss on ignition (1.19). It stated that the higher the temperature used to incinerate the RHA, the higher the content of silica, [3]. It is showed that the rice husk was burnt above 700°C in the boiler.

Table 1. Chemical properties of RHA and lime.

	SiO_2	K_2O	CaO	P_2O_5	MgO	Fe_2O_3	Al_2O_3	SO_3	LOI
RHA	91.20	4.17	1.18	1.51	0.66	0.20	0.47	0.36	1.19
Lime	1.45	-	92.70	-	3.68	0.43	0.92	0.57	-

Particle size of RHA and lime were analyzed using CILAS diffraction particle size analyzer and the result is showed in the table 2 below. The value of particle size is as a result of calculation from mean particle diameter as determined by laser diffraction. It is obvious that lime much finer than sieve RHA.

Table 2. Physical properties of RHA and lime.

	Particle size diameter at 50% of cumulative value [μm]	Range [μm]	Specific surface [m^2/kg]	Specific Gravity
RHA	12.77	0.1 - 75	1537.45	2.07
Lime	6.52	0 - 75	3956.30	2.28

RHA crystallography graphic was examined using Bruker D8 Advance to find out whether it in amorphous or crystalline state as shown in figure 1. The XRD pattern was recorded with diffraction angle of 6-85° 2Θ at a scan rate 0.018° per scan using Cu Kα radiation and filtered by Ni. From the graphic can be seen the distinctive peak at 22° and 36.5° 2Θ where cristobalite presence was detected, which shown the crystalline nature of the ash. It is possible that the rice husk was burnt above 900°C in the boiler since that the amorphous silica will change into cristobalite form if heated above 700°C. And this will explain the low loss on ignition value.

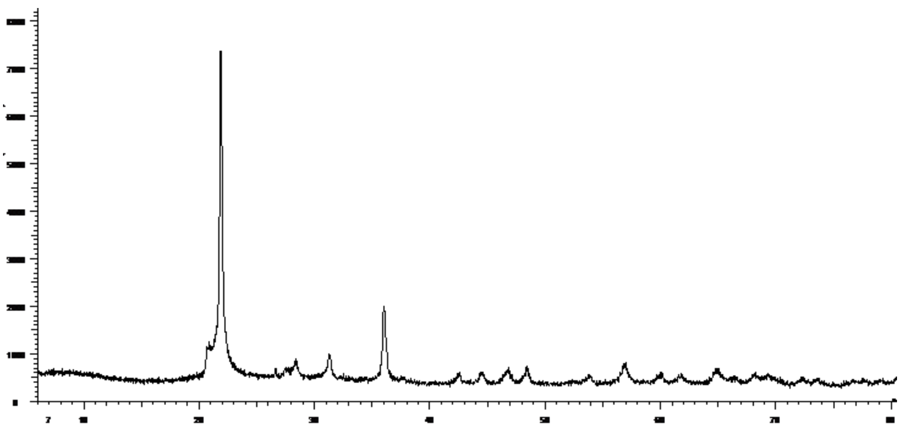

Figure 1. X-ray diffraction pattern of RHA from Muar.

Chemical composition of clay and laterite were examined as well as specific gravity and plasticity index as shown in table 3. It is noted that laterite is rich with iron and aluminium oxide where its silica content less than clay. This confirms that laterite soil showed typical increase of iron and frequently aluminium and decrease of silica. And according to Schellmann [17], from the table of oxide composition of laterite that were collected from many tropical countries by him, the parent rock of laterite used in this project was granite. Also the higher the specific gravity, then the higher the laterization occurs in the soil [18].

Table 3. Properties of clay and laterite soil.

	SiO_2	K_2O	CaO	MgO	Fe_2O_3	Al_2O_3	SO_3	TiO_2	Na_2O	SG	PI
Clay	59.20	1.80	0.24	0.38	5.81	27.9	3.40	0.97	-	2.58	30.1
Laterite	42.00	1.80	0.29	0.21	19.00	35.00	-	1.01	0.27	2.61	21.2

Other materials were river sand that passing 2 mm sieve and water from tap water with pH 6.0068 which indicates the water is neutral.

3. Methods

Uncontrolled burnt RHA from rice milling was sieved passing 200 µm sieve. The ratio of binder:soil:sand was 1:8:2 where binder consisted of lime and RHA. The composition of binder change gradually every 20%, that make the ratio like 20% lime:80% RHA, 40% lime:60% RHA, 60% lime:40% RHA and 80% lime:20% RHA. Dimension and shape of bricks used in this project is a small scale solid brick with size 100 X 50 x 28 mm, emphasizing the standard brick in US 8” x 4” x 2 $^1/_4$" (203 x 102 x 57 mm) by National Concrete Masonry Association (NCMA) [19]. These samples were then compressed using manual compaction with compression rate 2000 psi.

Water content was 15% from total weight of soil and sand. Mix of binder + soil + sand which has added by water was squeezed by hand and then dropped from I meter height and the trace of fallen mixture were observed for its suitability. If the mix broken to many pieces, it’s too friable and need more water, but if the mix only split into 2 or 3 large pieces, it’s too damp. The just right water content would result in several pieces with moderate size.

After compression, samples then cured in the open air for several hours then cured with low pressure water sprayed using manual hand sprayer and immediately cover by terpauline plastic. This curing method was done by spraying the brick samples on daily basis prior to the compression test for 7 and 28 days.The compressive strength of the bricks was determined by using Universal Testing Machine (UTM). The bricks were tested at 7 and 28 days for compressive strength and water absorption.

4. Results and Discussion

4.1 Compressive Strength

The effect of soil types in CEB utilizing uncontrolled burnt RHA were examined for 7, 14 and 28 days respectively as can be seen in figure 2. Increasing trend can be seen in both soils. Almost for every ratio, the compressive strength at 14 days is the highest compare to 28 days except for the 80% of clay and 20% of laterite.

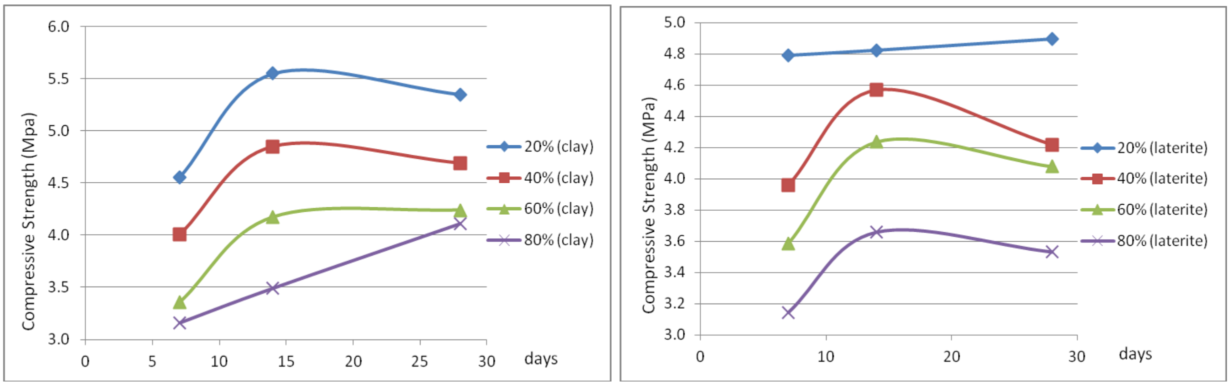

Figure 2. Effect of soil types in CEB compressive strength.

The maximum strength achieved at 20% RHA with clay soil at 14 days which reach 5.55 MPa where it strength at 28 days is slightly decrease at 3.35 MPa. For laterite, maximum strength was obtained at 28 days stretched to 4.9 MPa. In general, clay soil compressive strength showed slightly higher value than laterite. This is possibly due to its higher plasticity index and flaky particles which resulted in higher compressibility and eventually lead to higher compressive strength. Also some particles of laterite tend to crush easily under impact and thus disintegrate.

4.2 Water Absorption

Figure 3 give some insight on how soil types effect in water absorption of CEB where the values were assessed at 7, 14 and 28 days respectively. From the graphic it is noted that clay soil absorbs more water than laterite.

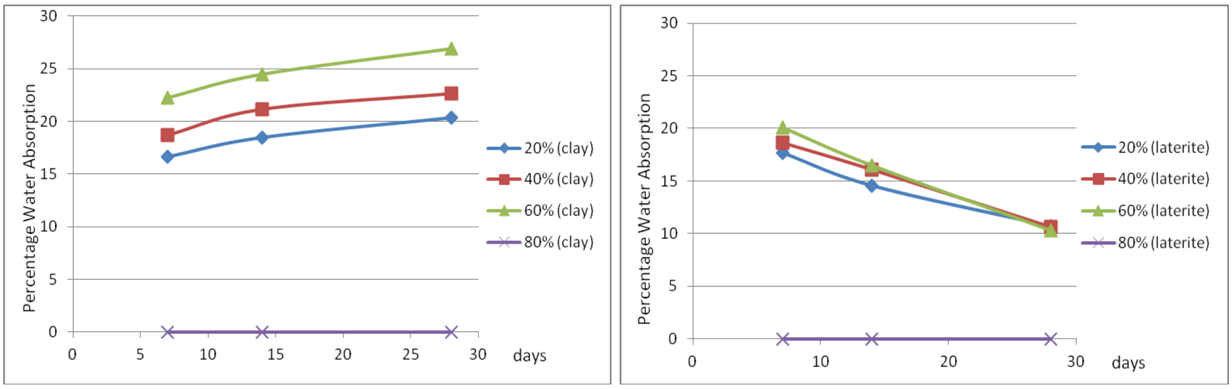

Figure 3. Effect of soil types in water absorption of CEB.

Striking contrast between clay and laterite is the ability to absorb water of laterite is lower than clay. Even the ability to absorb water with the function of time from these two soils is inversely proportional for the ratio of 20%, 40% and 60%. However, for the ratio 80% RHA, both soils cannot hold the form of CEB even since the 7 days due to excessive silica and deficit in calcium hydroxide as the agent to change the silica into cementitious material.

Hypothetically, the inversely proportional phenomenon of CEB water absorption using clay and laterite due to their plasticity index, which as the same way works for the compressive strength. Clay soil can absorb and hold more water because it plastic nature, and for the laterite, it lack of plasticity.

5. Conclusions

CEB with laterite showed better properties with higher compressive strength and lower water absorption rather than clay, however both compressive strength of clay and laterite CEB utilized uncontrolled burnt RHA did not conform to Malaysian Standard (MS) 76:1972 for load bearing brick which required minimum strength 7 MPa and not stated about water absorption, however MS 76 was regulated for the fired clay brick. As for the CEB itself, until today no standard has been issued for the purpose.

Nevertheless, UK and US has been commercialized CEB since few years back. One of the commercialized CEB in UK (http://www.jjsharpe.co.uk/material.html) is stated that the brick has compressive strength 3 MPa. Based on its compressive strength, 20% RHA using both types of soil can be applied to the production of CEB since the maximum strength achieved 5 MPa.

References

[1]. Monitor, F.R.M., *FAO Rice Market Monitor, January 2012, Volume XV - Issue No. 1*. 2012.

[2]. Ash, R.H. *Rice Husk Ash*. 2010 [cited 2010; Available from: http://www.ricehuskash.com/.

[3]. Siddique, R., *Waste Materials and By-Products in Concrete*. 2008, Berlin: Springer-Verlag Berlin Heidelberg.

[4]. Ekasilp, W., S. Soponronnarit, and A. Therdyothin, *Energy analysis in white rice and par-boiled mills for cogeneration in Thailand.* RERIC International Energy Journal, 1995. **17**(2): p. 83-92.

[5]. Ferraro, R.M., et al., *Carbon Neutral Off-White Rice Husk Ash as a Partial White Cement Replacement.* ASCE (American Society of Civil Engineers), 2010. **22**(10): p. 1078-1083.

[6]. Thorburn, C., *Rice Husk as a Fuel*. 1982, Indonesia: Tekton Books.

[7]. Sensale, G.R.d., *Strength development of concrete with rice-husk ash.* Cement and Concrete Composites, 2006. **28**(2): p. 158-160.

[8]. Beagle, E.C., *Rice-husk conversion to energy.* FAO Agricultural Services Bulletin, 1978. **31**.

[9]. Xu, W., T.Y. Lo, and S.A. Memon, *Microstructure and reactivity of rich husk ash.* Construction and Building Materials, 2012. **29**(0): p. 541-547.

[10]. Yalçin, N. and V. Sevinç, *Studies on silica obtained from rice husk.* Ceramics International, 2001. **27**(2): p. 219-224.

[11]. Ramezanianpour, A.A., M.M. Khani, and G. Ahmadibeni, *The effect of rice husk ash on mechanical properties and durability of sustainable concrete.* International Journal of Civil Engineering, 2009. **7**(2): p. 83-91.

[12]. Nehdi, M., J. Duquette, and A. El Damatty, *Performance of rice husk ash produced using a new technology as a mineral admixture in concrete.* Cement and Concrete Research, 2003. **33**(8): p. 1203-1210.

[13]. Mehta, P.K. *Rice husk ash - a unique supplementary cementing material*. in *International Symposium on Advances in Concrete Technology*. 1992. Athens, Greece.

[14]. Nair, D.G., et al., *A structural investigation to the pozzolanic activity of rice husk ashes.* Cement and Concrete Research, 2008. **38**: p. 861-869.

[15]. Chindaprasirt, P., S. Homwuttiwong, and C. Jaturapitakkul, *Strength and water permeability of concrete containing palm oil fuel ash and rice husk-bark ash.* Construction and Building Materials, 2007. **21**(7): p. 1492-1499.

[16]. Riza, F.V., *Preliminary Study of Compressed Stabilized Earth Brick (CSEB).* Australian Journal of Basic and Applied Science, 2011. **5**(9): p. 6-12.

[17]. Shellmann, W. *An Introduction in Laterite*. 2008 [cited 2010; Available from: http://www.laterite.de/.

[18]. Badmus, B.S., *Plasticity and Compressibility Characteristics of Lateritic Soil from Southwestern Nigeria.* Research Journal of Soil and Water Management, 2010. **1**(1): p. 10-14.

[19]. Taubert, D.H. and J.T. Conway, *Masonry: Esthetics, Engineering, and Economy, Issue 1246*. 1996.