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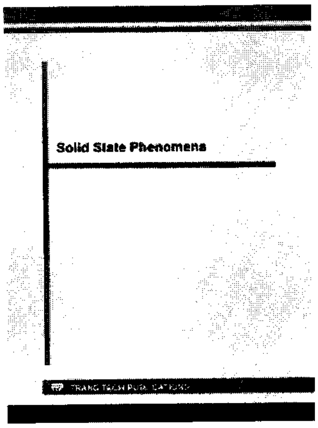

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Investigate the Properties of Solid Waste Bottom Ash (SBA) and Lime Reinforced in Composite Bricks

W. Namboonruang[1,a], N. Suphadon[2,b] and P. Yong-amnuai[1,c]

[1]Department of Civil Technology and Architecture, Faculty of Industrial Technology, Muban Chombueng Rajabhat University, MCRU 70150, Thailand

[2]National Metal and Materials Technology Center 12120, Thailand

[a]bannork_civil@hotmail.com , [b]nutthans@mtec.or.th, [c]ajanyoon@hotmail.com

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Abstract. This research studies on the possibility of producing a more sustainable lightweight brick. Solid waste bottom ash (SBA) and lime found in area of Ratchaburi province of Thailand were mixed into the composite brick for the replacement of fine aggregates and Portland cement contents, respectively. Effects of varied amount of SBA and local lime contents typically (10, 20, 30, 40 and 50% by weight) on mechanical and physical properties of bricks were studied. Results showed that with the replacement cement and fine aggregate of 20% by weight with SBA and local lime, respectively showed the maximum values. Similarly, the thermal conductivity and density and product weight showed the maximum values at the same replacement contents. By conclusion, this application may be an interesting solution in order to improve sustainability and energy efficiency of the low cost house in local area of Thailand.

Introduction

Nowadays, researchers are finding solution to reduce environmental problem, according using solid waste come from coal power plant [1]. A large volume of bottom ash and fly ash generated from coal fired thermal power plants are currently dumped to landfill. Bottom ash is produced from the burning coal in a dry bottom pulverized coal boiler which is considerable harmful. In order to solve the problem, the bottom ash has been utilized in many applications [1-3]. Mixing with concrete brick is another possibility. The main purposes are to find suitable materials for minimizing cement contents and improving some properties such as the thermal conductivity and density of bricks. It has been reported that various types of material such as local fly ash wasted from power plant or wasted from agriculture have been tested by blending with other common compounds (cement, sand and water) to produce composite construction materials [1-16].

This work focuses on the replacement of fine aggregate and Portland cement by SBA and local lime. All materials used in this work can be found in Ratchaburi province, Thailand. The effects of varied SBA and local lime contents to the mechanical properties are investigated for optimising mixing ratio. The main aim of this work is to find the new low cost brick which can be exactly used in low cost building in local area of Thailand. Also, the use of Portland cement will be minimized. That means, we can reduce the CO_2 emission generated by cement process resulting in the global warming effect.

Methodology

This work, SBA and lime (L) were reinforced in composite bricks. The chemical and mechanical properties were investigated as follows: density, compressive strength (ASTM C67)[17], flexural strength (ASTM C293)[18], and thermal conductivity (ASTM C177)[19]. All materials used in this research were found in Ratchaburi province, Thailand. The material dimensions used in this work are 150 mm in width x 600 mm in length x 200 mm in thickness. For the mixing, fine aggregate and Portland cement type 1 were replaced by varying contents of SBA and Lime of 0, 10, 20, 30, 40 and

50% respectively. All formulations were minimized the total water to binder ratio (w/b) given results as follows: 0.615, 0.633, 0.670, 0.764 and 0.876 respectively shown in Fig.1 Also the cured times were varied at the age of 3, 7, 14, 28, 60, 90 and 120 days, respectively to investigate the effect of cured time to the compressive strength and flexural strength.

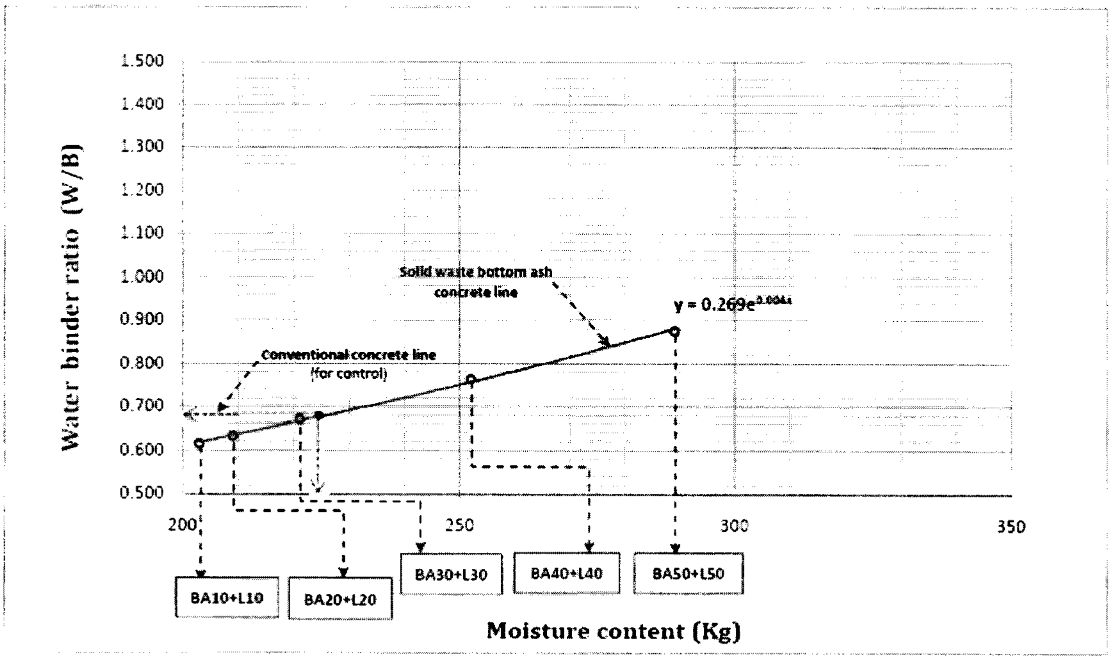

Fig. 1: The water binder ratio (w/b)

Results and Discussions

The chemical property of SBA and Local lime. The chemical properties of SBA and lime were observed by using the X-Ray Fluorescence method (XRF). Results showed that the total main oxides which can have an influence on the chemical reaction such as SiO_2, CaO and Al_2O_3 are given as follows: 68.48% for SBA and 54.73 % for local lime, respectively as shown in Table 1 and 2. This shows that these materials have enough quality to be produced as cement brick composites.

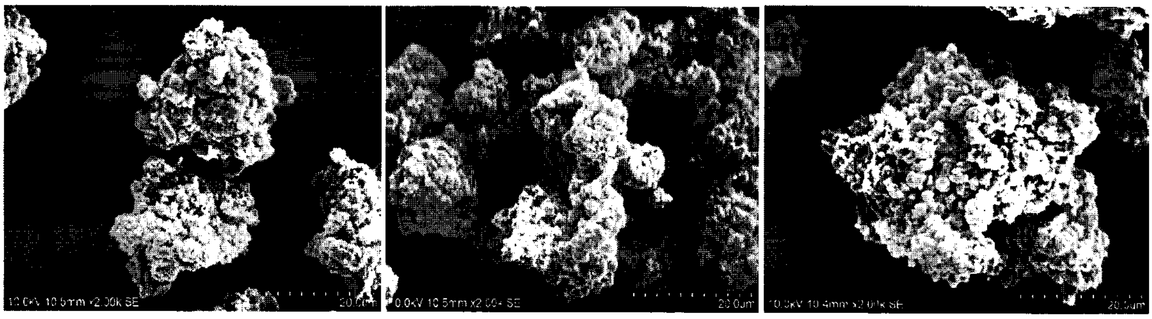

Fig. 2: The scanning electron microscopy (SEM) of Local lime

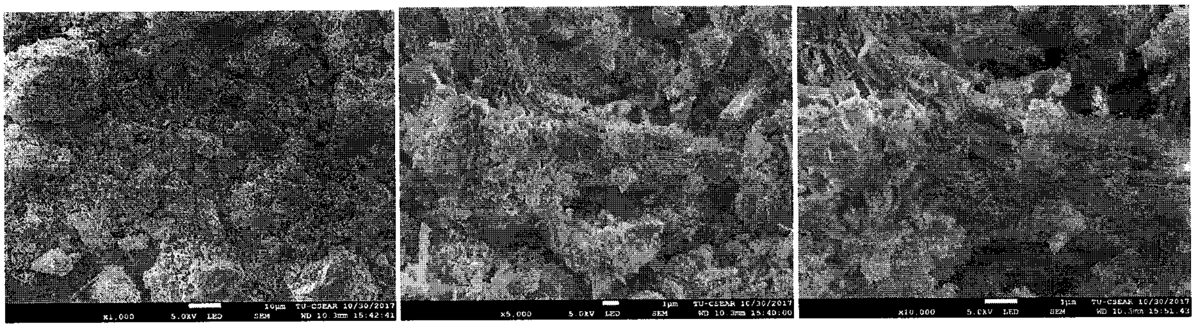

Fig. 3: The scanning electron microscopy (SEM) of Solid waste bottom ash (SBA)

Table 1: Shows the chemical compositions of SBA analyzed by X-Ray Fluorescence (XRF)

Component	Result	Unit	Component (Org)	Result (Org)	Unit
Na	1.6546	Mass %	Na_2O	2.2304	Mass %
Mg	1.0084	Mass %	MgO	1.6721	Mass %
Al	1.4232	Mass %	Al_2O_3	2.6980	Mass %
Si	4.3965	Mass %	SiO_2	9.4056	Mass %
P	1.3529	Mass %	P_2O_5	3.0999	Mass %
S	2.9462	Mass %	SiO_3	7.3565	Mass %
Cl	5.5597	Mass %	-	-	Mass %
K	1.9198	Mass %	K_2O	2.3125	Mass %
Ca	40.2966	Mass %	CaO	56.3824	Mass %
Ti	1.3312	Mass %	TiO_2	2.2206	Mass %
Cr	0.1355	Mass %	Cr_2O_3	0.1980	Mass %
Mn	0.1355	Mass %	MnO	0.1749	Mass %
Fe	3.1357	Mass %	Fe_2O_3	4.4832	Mass %
Ni	0.0199	Mass %	NiO	0.0253	Mass %
Cu	0.2306	Mass %	CuO	0.2886	Mass %
Zn	08380	Mass %	ZnO	1.0431	Mass %
Br	0.0118	Mass %	-	-	Mass %
Rb	0.0061	Mass %	Rb_2O	0.0067	Mass %
Sr	0.0856	Mass %	SrO	0.1013	Mass %
Zr	0.0263	Mass %	ZrO_2	0.0355	Mass %
Cd	0.0190	Mass %	CdO	0.0217	Mass %
Sn	0.0520	Mass %	SnO_2	0.0660	Mass %
Sb	0.0414	Mass %	Sb_2O_3	0.0496	Mass %
I	0.2256	Mass %	-	-	Mass %
bA	0.2198	Mass %	BaO	0.2454	Mass %
Pb	0.0880	Mass %	PbO	0.0948	Mass %

The physical property of SBCBC. The weight and density of SBCBC were tested with varying SBA and local lime contents of 0, 10, 20, 30, 40 and 50% by weight as shown in Fig 4 and 5. Results show that the weight of SBCBC increase with increasing SWA and local lime contents up to 20%. The maximum value is 1,990 kg.m^{-3} and 2,385 kg.m^{-3} at cured time of 120 days. Comparing with 0% SWA and local lime at 60 days, the density values of SBACBC of 10, 20, 30, 40 and 50% are given as 0.5, 1.57,-2.72, -3.83 and -5.36% respectively.

Table 2: Shows the chemical compositions of Local lime analyzed by X-Ray Fluorescence (XRF)

Component (Org)	Result (Org)	Unit
Na_2O	0.74	Mass %
MgO	0.73	Mass %
Al_2O_3	0.11	Mass %
SiO_2	0.24	Mass %
P_2O_5	0.10	Mass %
SO_3	0.04	Mass %
Cl	0.04	Mass %
K_2O	0.11	Mass %
CaO	54.58	Mass %
Fe_2O_3	0.08	Mass %
SrO	0.03	Mass %
LOI	43.19	Mass %

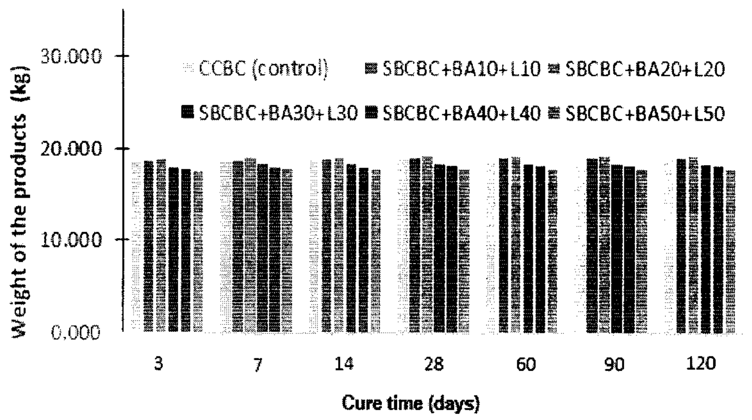

Fig. 4: The product weight of SBCBC varied by cure time

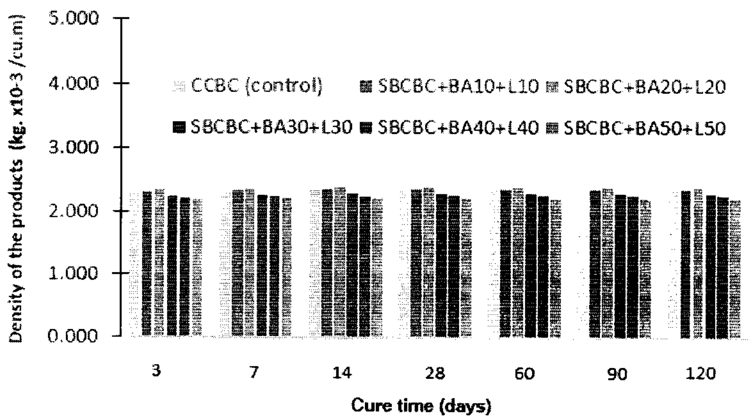

Fig. 5: The density of SBCBC varied by cure time

Fig. 6 shows the compressive strength of SBCBC at varied SBA and local lime contents at cured time of 3, 7, 14, 28, 60, 90 and 120days. Results show that the compressive strength of SBCBCincreases with increasing cellulose contents up to 20%. Then, it decreases dramatically. At cure time of 120 days, the maximum values is 75.97 kg/cm^2. at SBA and local lime of 20% and minimum value is 85.20 kg/cm^2. at SBA and local lime of 50%. It is clearly seen that's BA and local lime with content up to 20% can insist the higher load compared to those of control composite brick cement(CCBC). That means the chemical reaction between Portland cement-SBA-lime composite materials can promote the strength of materials. However, adding more SBA and local lime deteriorate the strength of the materials due to less cement content which is directly effecting to the less chemical reaction and also increasing of the void in the brick. This work also investigates the effect of cured time to the compressive strength of materials. Results show that the compressive strength of all SBCBC combinations sharply increase with cured time until 28 days, after 28 days they slightly increase. This can explain that at the first stage the reaction between cement and water (hydration reaction) dominate. After 28 days calcium hydroxide which is the production of hydration reaction will react with silicon dioxide (SiO_2) and generate the product as calcium silicate hydrates (C-S-H). This is the reason why the compressive strength still gradually increases with time. Following by ASTM standard, it shows that the compressive strength of SBCBC with 50% of SBA and local lime passes the standard and can be used as the non-load bearing brick materials.

Then, Fig 7. shows the modulus of rupture plotted with curing times. Similar to compressive strength, the flexural strength sharply increase up to 28 days, after that the decreasing rate is slower. Results show that the flexural strength increase with times at all compositions. Replacement the cement and fine aggregate by lime and SBA contents, the flexural strength trend is agreement with the compressive strength. The maximum value occurs at content of 20%with value of 23.13 kg/cm^{2}and minimum value is 8.37 kg/cm^2 occurred at the replacement of 50% by weight. Similar to compressive strength, the flexural strength sharply increase up to 28 days, after that the increasing rate is slower.

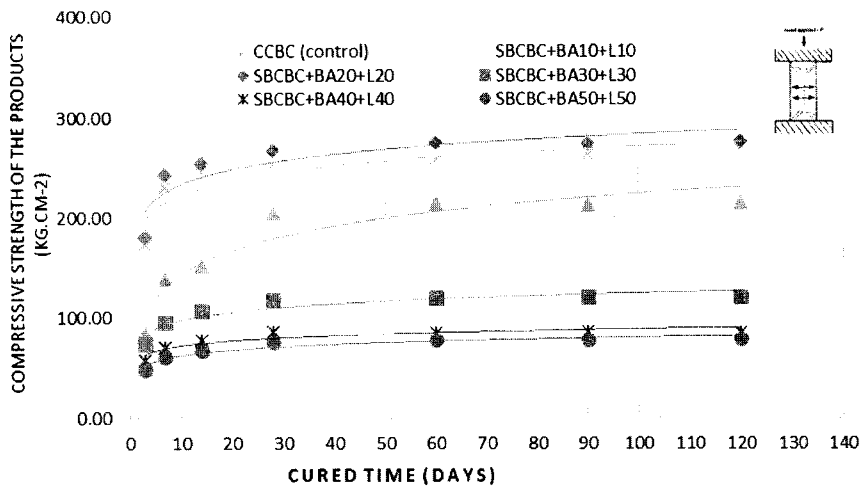

Fig. 6: Shows the compressive strength of SBCBC mixed with SBA and Local lime

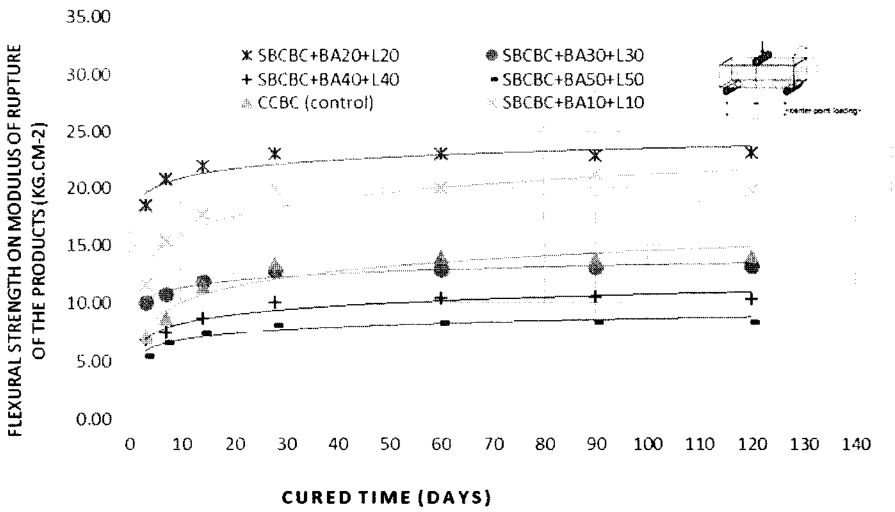

Fig. 7: Shows the flexural strength of SBCBC mixed with SBA and Local lime

Thermal conductivities of SBCBC were investigated at different amount of SBA and local lime contents. The purpose of this test is to evaluate the possibility the use of SBACBC as the low thermal conductivity and light weight brick in local house of Thailand. Results show that with increasing SBA and local lime contents, the thermal conductivity increase at contents of 10 and 20% replacement by weight. However, the thermal conductivity decrease at content of SBA and local lime of 30, 40 and 50%. From these results, it can be explained that with replacement Portland cement type 1 and fine aggregate of 10 and 20% by local lime and SBA, the chemical reaction of composition is highly activated resulting to the higher density of the brick. On the other hand, adding higher contents of SBA and lime can decrease the density of the brick due to the low density of lime and increasing of voids resulting to the decline of the thermal conductivity shown in Fig 8. According to Thailand industrial Standard (TIS), the conventional lightweight concrete should have a limited thermal conductivity value in the range of 0.303-0.476 W/mK [16]. However, in this study, the thermal conductivity value of SBCBC+BA20+L20 is in the allowable range of those specified by TIS.

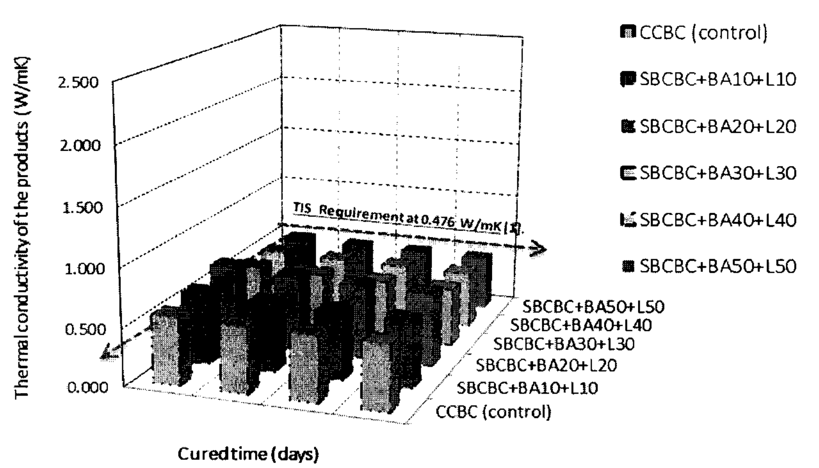

Fig. 8: Shows the thermal conductivity of SBCBC mixed with SBA and Local lime

Conclusion

The purpose of this work is to develop the waste and local materials as the low cost and sustainable construction material in local area of Thailand. Thus, the solid waste bottom ash composite cement brick (SBCBC) with various contents of SBA and lime were successfully developed. Chemical and mechanical properties were investigated. Results show that the strength of SBCBC is highest at replaced content of 20% by weight, they could only be used as non-load bearing concrete masonry units (2.45 MPa) [20]. The thermal conductivity, product weight and density of SCBCB show the increasing at similar trend. All results of this study indicate that SBA and local lime reinforced composite cement brick are light weight, economical and possess good thermal insulating. Hence, the newly developed composite brick can be used to produce as the commercial brick in the local area.

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