Development of Lighter and Eco-Friendly Burnt Clay Bricks Incorporating Sugarcane Bagasse Ash

Syed Minhaj Saleem Kazmi [1, 2*], Muhammad Junaid Munir [1, 2], Safeer Abbas [3], Muhammad Azhar Saleem [3], Anwar Khitab [2], Muhammad Rizwan [2]

1. *School of Engineering, RMIT University, 376-392 Swanston St, Melbourne, Victoria-3001, Australia.*
2. *Department of Civil Engineering, Mirpur University of Science and Technology (MUST), Mirpur-10250 (AJK), Pakistan.*
3. *Department of Civil Engineering, University of Engineering & Technology, Lahore, Pakistan.*

* **Corresponding Author:** E-mail: minhajkazmi17@gmail.com

Abstract

Utilization of waste materials in the production of burnt clay bricks can be helpful in reducing the landfill burden. This study aims to develop lighter and eco-friendly burnt clay bricks incorporating sugarcane bagasse ash (SBA). Clay bricks were manufactured in a local brick manufacturing industrial kiln, incorporating SBA by weight of clay in different proportions. To study the properties of bricks, different mechanical and durability tests were performed as per ASTM C67. Results showed that SBA can be helpful in manufacturing of lighter bricks. Bricks incorporating SBA exhibit compressive strength lesser than traditional clay bricks; however, burnt clay bricks incorporating 5% SBA by clay weight fulfilled the minimum requirement for compressive strength according to the Building code of Pakistan. Moreover, efflorescence was improved after adding the SBA in burnt clay bricks. Therefore, lighter and sustainable bricks can be produced after utilization of small amount of SBA (i.e., 5%) in burnt clay bricks.

Key Words: Brick, Clay, Sugarcane bagasse ash.

1. Introduction

Burnt clay bricks are used widely for the construction purpose around the globe. Burnt clay products are produced after burning clay at high temperature. Temperature plays a significant role in developing the bond between clay particles. To lower down melting temperature and reduce the fuel consumption, additives are added in clay. Researchers have used different waste materials as additives in brick manufacturing (Kazmi et al., 2016a; Eliche-Quesada et al., 2012). Fly ash is one of the waste material that can be used as an additive. Addition of fly ash in burnt clay bricks improved the brick strength and water absorption (Kumar and Hooda, 2014; Shakir et al., 2013). Moreover, fly ash bricks were reported economical and environment friendly (Christy and Tensing, 2011).

Utilization of waste glass in burnt clay bricks resulted into higher compressive strength and lower porosity (Chidiac and Federico, 2007). Similarly, clay bricks can be produced using 15-20% marble powder in replacement of clay (Eliche-Quesada et al., 2012). Reduced porosity with high compressive strength was observed at high burning temperature (Saboya et al., 2007). Agricultural wastes like rice husk ash can also be helpful in producing lightweight bricks (Kazmi et al., 2016a). Improved compressive strength was observed after incorporating small amount of rice husk ash in clay bricks (i.e., 5% in replacement of clay) (Kazmi et al., 2016a). Waste generation is not only polluting the environment but also causing landfill burden (Munir et al., 2016a). Therefore, utilization of waste materials in clay brick production is an environment friendly option.

50 million tons of sugarcane is produced annually in Pakistan (Munir et al., 2016b). Bagasse is obtained after consuming sugarcane for sugar production. Bagasse is burned as a fuel source and as a result ash is obtained, which is termed as sugarcane bagasse ash (SBA). Approximately, 0.25 million tons of SBA is produced annually in Pakistan (Akram et al., 2009). There is no proper mechanism to get rid of SBA, which is a waste product. Therefore, it is not only polluting the environment but also leading towards a landfill burden.

Light weight bricks can be produced after incorporating SBA in burnt clay bricks (Kazmi et al., 2016b). This research focuses the utilization of SBA in brick manufacturing. Brick production after incorporating SBA can lead towards sustainable, economical, and environment friendly solution. Different brick properties were studied after replacing SBA with clay. Clay bricks incorporating SBA were prepared and burnt in an industrial brick kiln.

2. Methodology

To prepare clay bricks, SBA was collected from a sugar mill in Peshawar. Bricks were manufactured in a brick kiln. First dry materials (clay and SBA) were mixed manually in desired proportions (Table 1) and then water was added. Bricks were then prepared having size 228×114×76 mm. Bricks were sun-dried for a week and then burnt in a kiln for 2 days at approximately 800ºC. To avoid cracks due to sudden cooling, bricks were left in the kiln for 40 days and removed afterwards.

Table 1: Compositions of prepared brick specimens.

Raw Materials	Sample Code			
	C	SBA5	SBA10	SBA15
Clay (%)	100	95	90	85
SBA (%)	-	5	10	15

Chemical composition and particle size distribution of clay and SBA were determined through X-ray fluorescence (XRF) and ASTM D422, respectively. To study the properties of bricks, different tests (i.e., unit weight, compressive strength, modulus of rupture, water absorption and efflorescence) were performed as per ASTM C67.

3. Results and Discussion

Table 2 shows the results of XRF analysis. Silica was observed the main constituent of clay. Calcium oxide was observed greator than 6% whereas concentration of fluxing agents (MgO, CaO, Fe_2O_3, K_2O and TiO_2) was observed greator than 9%. On the basis of the chemical composition, clay can be termed as calcareous low refractory material (Musthafa et al., 2010). A prominent presence of silica was observed in SBA. Loss on ignition (LOI) was observed higher for SBA as compared to clay. This may be attributed to the presence of unburnt particles in SBA (Kazmi et al., 2017a).

Gradation curves of raw materials are shown in Figure 1. It was observed that particles were present in a wide range of sizes within raw materials.

Figure 2 shows the effect of SBA addition on weight per unit area results. It was observed that with the increased amount of SBA weight per unit area of the specimens reduced. For SBA15, brick specimens were observed 15% lighter than conventional clay bricks. Lighter weight may be attributed to the lower unit weight of SBA (279.4 kg/m^3) as compared to clay (1092 kg/m^3) (Abbas et al., 2017). Lighter bricks can be very useful in earthquake affected areas for construction purposes (Kazmi et al., 2017b).

Table 2: Chemical analysis of the raw materials.

Components (%)	Clay	SBA
SiO_2	57.11	86.77
Al_2O_3	11.89	1.79
Fe_2O_3	4.97	2.72
CaO	8.88	2.55
MgO	2.60	0.79
MnO	0.09	-
SO_3	-	0.12
P_2O_5	0.16	-
TiO_2	0.72	-
Na_2O	1.84	0.39
K_2O	2.19	0.46
LOI	9.29	10.12

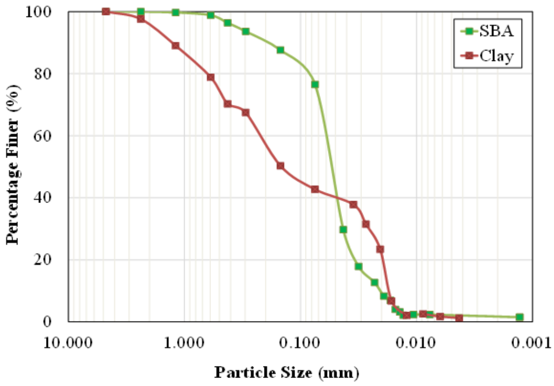

Figure 1: Gradation curves of SBA and clay.

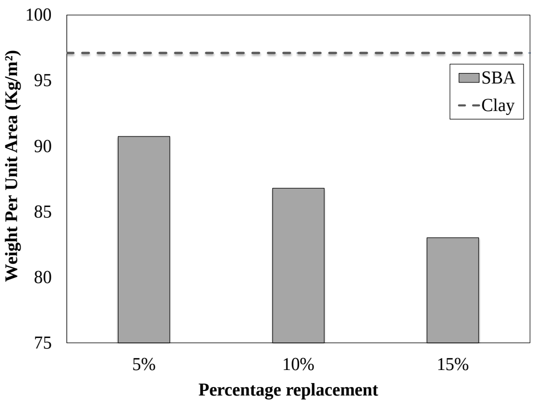

Figure 2: Effect of SBA addition on weight per unit area results.

Figure 3 shows the effect of SBA addition on the results of compressive strength of burnt clay bricks. It was observed that strength of the burnt clay bricks decreased with the addition of SBA. For SBA5, compressive strength reduced 14% as compared to traditional burnt clay bricks. Reduction in strength may be related to the porosity, which increases after addition of SBA (Kazmi et al., 2016a). However, SBA5 fulfilled the minimum requirement for compressive strength in accordance with the Building code of Pakistan.

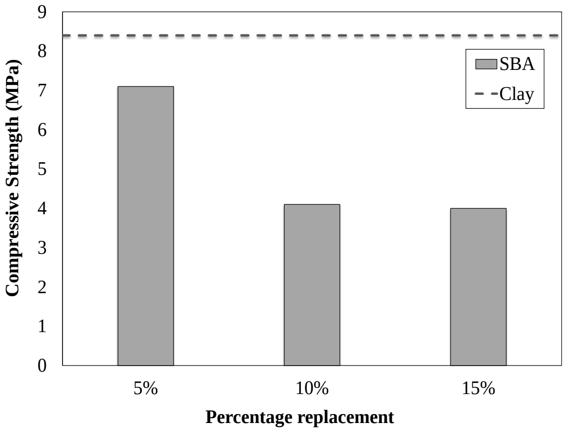

Figure 3: Compressive strength results of brick specimens incorporating SBA.

Figure 4 shows the effect of SBA addition on the modulus of rupture results. It was observed that flexural strength of the burnt clay brick decreased with the addition of SBA. SBA15 showed the minimum flexural strength. However, brick specimens incorporating SBA satisfied the minimum requirement for flexural strength in accordance with the ASTM C67 (i.e. 0.65 MPa). Porosity of burnt clay bricks incorporating SBA may be considered responsible for such trend (Kazmi et al., 2016a).

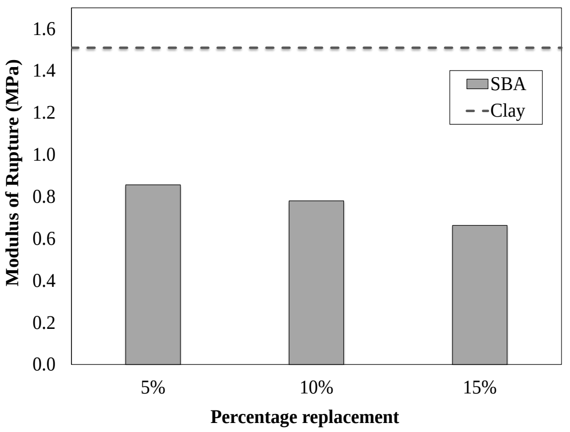

Figure 4: Effect of SBA addition on modulus of rupture.

Results of water absorption for burnt clay bricks incorporating SBA are shown in Figure 5. It was observed that addition of SBA resulted into increased water absorption of specimens. SBA10 showed water absorption of 24%. Increase in water absorption may be related to the porous structure of SBA (Madurwar et al., 2014). SBA5 can be used in areas having moderate weather according to ASTM C62.

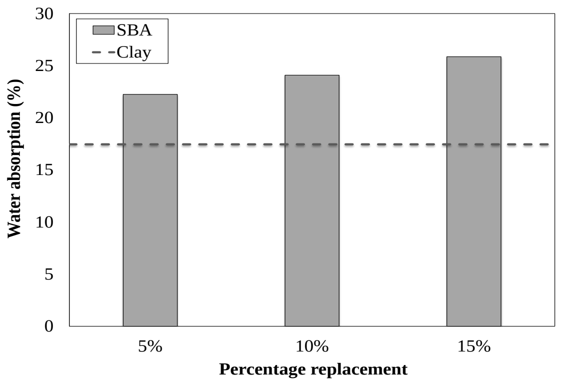

Figure 5: Water absorption results of brick specimens incorporating SBA.

Bricks with addition of SBA showed no signs of efflorescence after 7 days (Fig. 6). However, slight efflorescence was observed on the traditional burnt clay bricks. Presence of higher amount of calcium oxide was observed in clay (i.e., 9%) as compared to SBA (i.e., 2.55%). Reduction in amount of calcium oxide may be responsible to reduce efflorescence in SBA modified bricks (Netinger et al., 2014).

Figure 6: Brick specimens showing efflorescence results after 7 days.

4. Conclusions

Based on the discussion, it can be concluded that utilization of SBA can be helpful in manufacturing of lighter bricks. Bricks incorporating SBA exhibit lesser compressive strength than traditional clay bricks; however, burnt clay bricks with addition of 5% SBA by clay weight fulfilled the minimum requirement for compressive strength according to the Building code of Pakistan. Flexural strength was also observed higher than the specified minimum requirement of ASTM C67. Clay bricks incorporating SBA up to 5% by clay weight can be used in areas having moderate weather according to ASTM C62. Moreover, efflorescence was improved after adding the SBA in burnt clay bricks.

Therefore, lighter and sustainable bricks can be produced after utilization of small amount of SBA (i.e., 5%) in burnt clay bricks.

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6. References

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