J. Appl. Environ. Biol. Sci., 8(4)109-114, 2018

ISSN: 2090-4274
Journal of Applied Environmental *and Biological Sciences*
www.textroad.com

Influence of Bottom-Ash Mixed with Gypsum as Concrete Bricks for Wall Construction Material

Mochammad Qomaruddin[1*]; Sudarno[2]

[1]Civil Engineering Study Program, Faculty of Science & Technology, Islamic University of Nahdlatul Ulama Jln Taman Siswa (Pekeng) Tahunan Jepara Central Java Indonesia.
[2]Department of Civil Engineering, Faculty of Engineering, Tidar University, Jalan Suparman No 39, Potrobangsan Magelang Utara 56116 Central Java Indonesia.

Received: October 3, 2017
Accepted: February 7, 2018

ABSTRACT

There had been environmental issues regarding the storage management of coal combustion residuals (CCR) disposed by the PLTU Tanjung Jati B power plant in Jepara Indonesia where the abundant bottom-ash compounds are particularly unprocessable. In preparation of further projects responding to study the environmental effects, this experiment was to determine the compressive strength of bottom-ash as primary material used for a set concrete bricks tested with addition of gypsum in several portion of mixtures; 0 Gp, 2 Gp, 4 Gp, 6 Gp, 8 Gp, & 10 Gp. The compressive tests was conducted in accordance with SNI 03-0691-1996 standard. The result shows that the average of maximum strength was 158 kg/cm^2 (15.4945 Mpa) and 67 kg/cm^2 (6.57046 Mpa) at the lowest average which met the concrete brick standard required by the SNI on C and D types. The experiment also conluded that with more gypsum exercised in the mixture, although resulting in fairly lighter weight, they are less capable of withstanding the pressure.
KEYWORDS: concrete brick, bottom ash, gypsum.

INTRODUCTION

Coal combustion waste, comprising Bottom-ash and Fly-ash, contain a variety of hazardous chemicals such as; *Sulphur*, *Mercury* (Hg), *Hydrogen cyanide*/prussic acid (HCN), *Manganese* (Mn), *Sulfuric Acid* (H_2SO_4) that are harmful for human health. There are also issues of radioactive and air pollution. Concrete brick manufacturing which produce from the waste for building and construction material is a way to tackle the issue, reducing the negative environmental impact [1]. The use of environment-friendly materials in the construction industry is very alarming. One of the primary material used, in building constructions, is cement that contributes to global warming. Cement productions release a number of considerable *Carbon dioxide* (CO_2) emissions and are large consumer of energies. The replacement of cement with some pozzolanic materials such as fly-ash and bottom-ash will minimize the impact of making this dangerous cement [2: 15].

Electric Steam Power Plant Tanjung Jati B is a steam power plant located in Tubanan village, Jepara, Indonesia. It has four incenerator units which disposing coal combustion residuals of fly-ash and bottom-ash in continous operation. The waste is not processable and unwanted, except for the fly-ash compounds which are reliable for cement manufacturers. The bottom-ash compounds are stored on an open field, mounting in piles, creating dusty environment. The novelty of this study is to make use of neglected bottom-ash compounds, by which replacing sand material and cement as fine aggregates [3]. Portions of gypsum is added in certain amount of mix for casting a set of concrete brick samples,. The gypsums acquired were from the waste of limes used in neutralizing the acidic steam at the Tanjung Jati B power plant. The use of bottom-ash and gypsum, is a mixture of waste materials used for research on concrete bricks [4]. The purpose of this research is to disclose the behavior of adjustable gypsum's proportions mixed with bottom-ash to a number of compressive load tests that will provide the ideal amount of mixtures proposed for wall constructions as an alternative material.

MATERIAL AND METHOD

The materials used are acquired from Tanjung Jati B power plant. The test specimens are made from a mixture of cement, bottom-ash, and gypsum compounds. The method of this study is implementing six portions of gypsum varied in; 0 Gp, 2 Gp, 4 Gp, 6 Gp, 8 Gp, and 10 Gp. The compressive test of each concrete brick samples proceed after 28 days from castings [5; 16].

Gypsum is a mineral dominated by calcium. The most commonly known type is calcium sulfate hydrate with the formula $CaSO_4.2H_2O$. One of the mineral materials from chemical process that vaporized is gypsum. When in

***Corresponding Author:** Mochammad Qomaruddin; Civil Engineering Study Program, Faculty of Science & Technology, Islamic University of Nahdlatul Ulama, Jln Taman Siswa (Pekeng) Tahunan Jepara Central Java Indonesia. Email: qomar@unisnu.ac.id

hot water or in any water that has a high salt content, the gypsum turns into *Basanite* ($CaSO_4.H_2O$) or also becomes *Anhydride* ($CaSO_4$). In a balanced state, gypsum which over 108° F or 42° C in pure water will turn into anhydride [6].

Bottom-ash formed from the combustion of pulverized coal in the steam generator, which is larger in size and heavier compared to fly-ash. The bottom-ash gets fall off to the bottom of the boiler and collected in the ash hopper. It then taken out from the furnace by jet pumps or conveyors onto ash yard/storages through clinker grinders. Because of its physical resemblance to fine sand and/to coarse with a gradation of the size of various particles [7].

The casting of samples conducted in "dry concrete" mix method, the water-cement factor (ratio) decided at 0,3 (1:4) of the cement volume. The primary material used is bottom-ash mixed with volume of proportion; 1 PC : 5 BA : *n* Gp. Portions of gypsum to add is at 0 Gp, 2 Gp, 4 Gp, 6 Gp, 8 Gp, and 10 Gp for each sample accordingly [8; 9]. The following table will explain the proportion for each samples (table 1).

Table 1. Composition of concrete brick samples

No.	*Mix Design*
1	1Pc : 5 Ba : 0 Gp
2	1Pc : 5 Ba : 2 Gp
3	1Pc : 5 Ba : 4 Gp
4	1Pc : 5 Ba : 6 Gp
5	1Pc : 5 Ba : 8 Gp
6	1Pc : 5 Ba : 10 Gp

Equipments are; 4.76 mm sized sieve, 200 x 100 x 60 mm steel concrete brick molds, measuring cups, a concrete mixer and a 10 HP hydraulic compassion machine. After mixing all the ingredients and left for about 24 hours, concrete samples are treated with water to maintain a slow pace but steady dry, this will help to prevent a dryout that will result in a compressive failure. The pressure tests conducted after 28 days of treatment using the hydraulic compassion device capable of pressing up to 1000 psi load strength. The result estimation based on the Indonesian National Standard.

RESULTS AND DISCUSSIONS

The actual image of a concrete brick sample before the compression test is shown in Figure 1 below:

Figure 1. The concrete brick sample

In general, the brick samples are grayish and tend to have spotty surface, with white spots being the gypsums and the darker ones are the bottom-ashes. Figure 2 shows the compression apparatus compression apparatus 3000 KN and the testing mechanism.

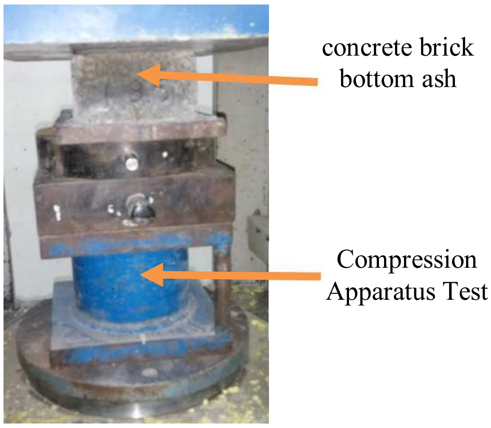

Figure 2. Setup of compressive strength testing

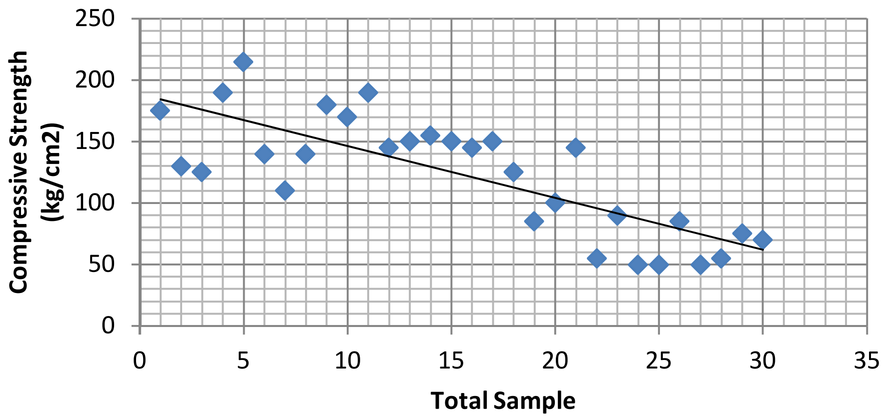

Figure 3. Samples testing result by increased gypsum mixture

The statistic shows the behavior of which the brick samples are tested. It indicates a comparable results of concrete bricks with less mixture of gypsum than those of more gypsum added. With the absence of gypsum, the mixture resulted in maximum strength compared to the others with gypsum added [10]. The highest compressive strength reach up to 215 kg/cm^2 with 1 Pc: 5 Ba: 0 Gp recipe. While the lowest is 50 kg/cm^2 with the proportion of 1 Pc: 5 Ba: 10 Gp. Table 4 illustrates the average of each recipe tested with the 163 kg/cm^2 at the highest (1 Pc: 5 Ba: 0 Gp) as the 67 kg/cm^2 is the lowest (1 Pc: 5 Ba: 10 Gp).

The addition of gypsum to the mixture is likely lowering the compressive quality and so it's capability to withstand any pressure than the others which are not at all. Gypsum fragility is that the elements consisted in it do not bind completely with bottom-ash, although it has been reacted (mixed) with cement and so does the hydraulic pressure [11]. The binding of the material is only due to the pressure between the bottom ash and gypsum particles during hydraulic compaction [12]. It seems that chemical bonding reaction occurs only between cement and bottom ash.

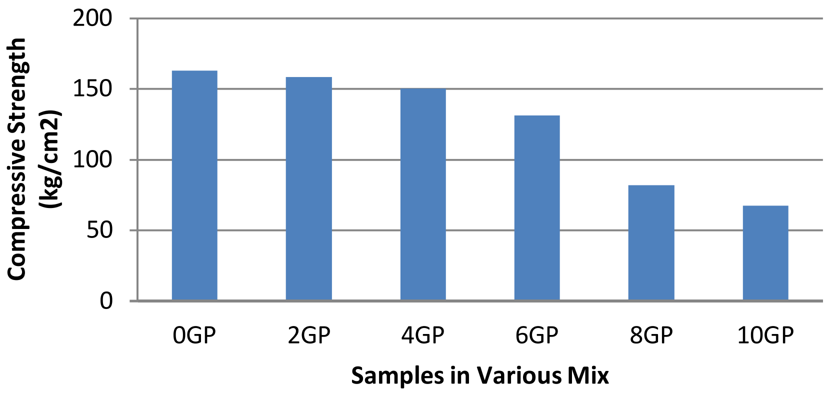

Figure 4. Average compressed strength against mix design

Figure 4 shows each mix design on the compressive strength. The more gypsum added in the mixture, the lesser quality of the concrete brick can get. Although the compressive behavior is deteriorating with more gypsum added, the samples shows different results in terms of content weights of each sample [13]. All samples of concrete bricks content weight with gypsum are identified in the Figure 5 below:

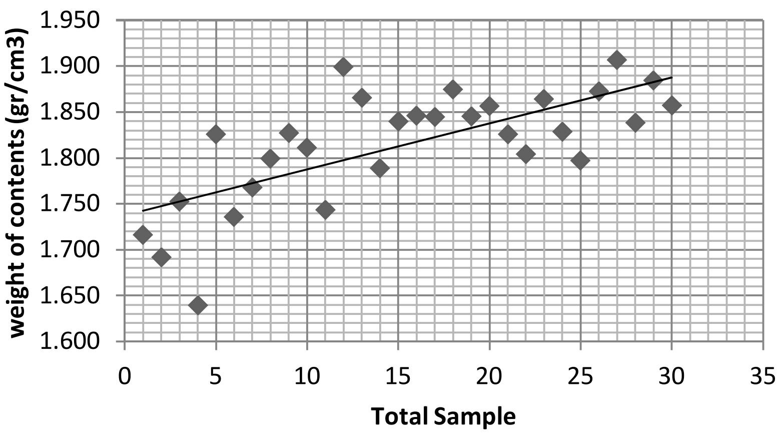

Figure 5. The content weight of samples comprised with portions of gypsum

Explanation as per graphic of the Figure 5 is that in each progress of the samples added with more portion of gypsum resulting in increasing value of it's content weight[14; 15]. This was affected by the smoothness nature and scale of the gypsum materials which able to fill the void fraction/porosity of bottom-ash compounds when pressed with hydraulic machine.

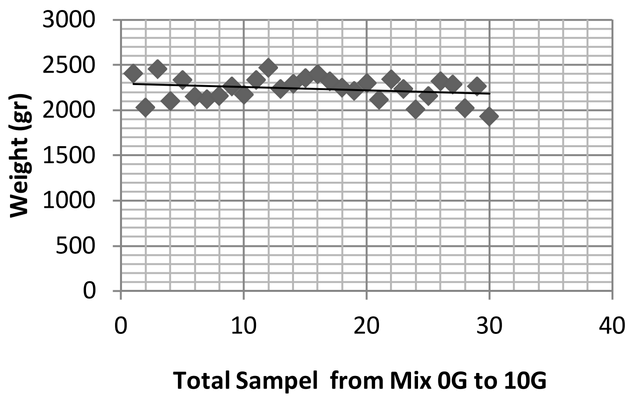

Figure 6. The weight of concrete brick against mix designs

In Figure 6, the scatter graph shows the tendency of the volume weight of each brick samples. It indicates that the bricks which containing more of gypsum are relatively lighter compared with the ones with smaller amount.

CONCLUSION

This study concludes:

a) The average of maximum compressive strength in which gypsum was exercised calculated at 158 kg/cm^2 make up a proportional mix of 1 Pc: 5 Ba: 2 Gp.
b) The compressive strength value of concrete brick samples tested ranging from 158 kg/cm^2 to 131 kg/cm^2 met the SNI C standard for concrete brick.
c) The more gypsum contained the more fragile the brick to withstand the pressure. Therefore is not suitable for floor filler, rather concrete brick or *batako*.
d) The compaction load with hydraulic engine power has an effect on the compressive strength of the concrete brick.
e) The mixture of gypsum in concrete bricks and *batako* can be applied and used for wall construction based on SNI.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to The Indonesian Ministry of Higher Education, Technology and Research for granting us a beneficial funding conducting this study through *skim*'s Research Partnership between Nahdlatul Ulama Islamic University Jepara and Diponegoro University Semarang in 2016/2017 Budget Year.

REFERENCES

1. Sumathi A, Mohan, K.S.R. 2015. Compressive Strength of Fly Ash Brick with Addition of Lime, Gypsum and Quarry Dust, International Journal of ChemTech Research CODEN (USA); 7 (1): pp 28-36.

2. Oruji S, Nicholas A., Brake, Nalluri L., Ramesh K. 2017. Guduru Strength Activity and Microstructure of Blended Ultra-fine Coal Bottom Ash-Cement Mortar, Construction and Building Materials; 153: 317–326, www.elsevier.com/locate/conbuildmat.

3. Naganathan N.S. Subramaniam and K. Nasharuddin Bin Mustapha. 2012. Development of Brick Using Thermal Power Plant Bottomash And Flyash, Asian Journal of Civil Engineering; 13 (1): 275-287.

4. Pan J.R., Huang C, Kuo J.J., Lin H.S. 2008. Recycling MSWI Bottom and Fly Ash as Raw Materials for Portland Cement, Waste Management; 28: 1113–1118.

5. Naik S.N., Bahadure B.M., Jejurkar C.L. 2014. Strength and Durability of Fly Ash, Cement and Gypsum Bricks, International Journal of Computational Engineering Research (IJCER); 4: 42250 – 3005.

6. Surender K. Verma, Deepankar K. Ashish, Singh J. 2016. Performance Of Bricks And Brick Masonry Prism Made Using Coal Fly Ash And Coal Bottom Ash, Advances in Concrete Construction; 4 (4): 231-242.

7. VidhyaK., Kandasamy S, Malaimagal U.S., KarthikeyanS.R., Basha G.S., H. Tariq Junaid. 2013. Experimental Studies on Pond Ash Brick, International Journal of Engineering Research and Development; 6 (5): 06-11.

8. Hanjitsuwan S., Ngernkham P.T., Damrongwiriyanupap N. 2017. Comparative Study Using Portland Cement and Calcium Carbide Residue as a Promoter in Bottom Ash Geopolymer Mortar, Construction and Building Materials; 133: 128–134.

9. Lessard M.J., Omran A., Hamou T.A., Gagne R. 2017. Feasibility of Using Biomass Fly and Bottom Ashes in Dry-Cast Concrete Production, Construction and Building Materials; 132: 565–577, journal home page:www. elsevier.com/locate/conbuildmat

10. Raghavendra T., Udayashankar C.B. 2015. Engineering Properties of Controlled Low Strength Materials Using Flyash and Waste Gypsum Wall Boards, Construction and Building Materials; 101: 548–557, www.elsevier.com/locate/conbuildmat

11. Sata V., Sathonsaowaphak A., Chindaprasirt P. 2012. Resistance of Lignite Bottom Ash Geopolymer Mortar to Sulfate and Sulfuric Acid Attack, Cement & Concrete Composites; 34 700–708, journal homepage: www.elsevier.com/locate/cemconcomp

12. Song Y., Li B., Yang H.E., Liu Y., Tian Ding T. 2015. Feasibility Study on Utilization of Municipal Solid Waste Incineration Bottom Ash as Aerating Agent for The Production of Autoclaved Aerated Concrete, Cement & Concrete Composites; 56: 51–58, journal homepage:www.elsevier.com/locate/cemconcomp

13. Tsakiridis E.P., Samouhos M., Peppas, N.S.A., Katsiotis, Velissariou D., Katsiotis S.M., Beazi M. 2016. Silico-Aluminous Bottom Ash Valorisation in Cement Clinker Production: Synthesis, Characterization and Hydration Properties, Construction and Building Materials; 126: 673–681, journal homepage: www.elsevier.com/locate/conbuildmat

14. Wu B., Zhang S., Yang Y. 2015. Compressive Behaviors of Cubes and Cylinders Made of Normal-Strength Demolished Concrete Blocks and High-Strength Fresh Concrete, Construction and Building Materials;78342–353,journal homepage:www.elsevier.com/locate/conbuildmat.

15. Singh H, bG.S.Brar G.S, Mudahar G.S. 2016. Evaluation of the Characteristics of Masonry Bricks Containing Waste Fly Ash, Journal of Applied Environmental and Biological Sciences; 6(6) :1-7.