International Journal of Engineering &Technology, 7 (3.12) (2018) 576-578

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper



Feasibility of Replacement of Cement with Copper Slag in Flyash Based Bricks

Harish S[1], Karthik S[2*], Saravana Raja Mohan K[3]

School of Civil Engineering, SASTRA Deemed University, Thanjavur, India
**Corresponding Author E-mail: [2]karthik@civil.sastra.edu*

Abstract

Cement manufacturing industry has been a great contributor to global warming which poses global threat. This novel paper investigates the possibilities of reducing the amount of cement used in a conventional flyash brick by replacing the cement with copper slag in various proportions to make way for substantial construction. Flyash bricks contribute less to global warming compared to chamber bricks, which involves lot of burning. Further substitution of cement with copper slag would significantly reduce its damage potential as copper slag itself is a by-product from copper manufacturing. A conventional flyash brick contains 5% of the entire mix as cement. This paper aims to replace the cement in flyash bricks in successive percentages of the entire mix i.e 1%, 2%, 3%, 4% and 5% with copper slag. The brick samples are then subjected to mechanical tests and durability tests as per IS 3495:1992 and IS 13757:1993. These data of the samples are compared with the normal flyash bricks to find the best proportion. The greatest advantage is the economic factor involved as 1kg of copper slag costs only 16% of that of cement, providing a greater scope for the implementation of this research in reality.

1. Introduction

Brick manufacturing industry is one of the largest thriving industry because the brick has high mechanical properties. [1]. like fire resistance, specific gravity, corrosion resistance and durability, and the ease in which it can be manufactured. Besides the above advantages, the raw materials required for its manufacture are putting a great strain in the resources available.[2,3] thus urging the need for a replacement using suitable materials.[4] that can provide reliable results. Several alternatives are now proposed for chamber bricks with materials like coal flyash [5], saline soil [6]etc and several methods are also being proposed to increase their efficiency [7]. Chamber bricks have been the most widely used variety of brick in India but flyash bricks are gaining importance in the construction industry. This is because of the need for the usage and recycling of by products from various other manufacturing processes such as smelting[9] which can be toxic. Flyash based bricks also have higher potential compared to chamber bricks in almost all characteristics and hence are currently being accepted well in the society. On the other hand, Cement manufacturing industry contributes in great measures to global warming and hence necessary measures must be taken to reduce its usage in construction industry. The cement is the second-most consumed product after water and thus, this industrial sector alone accounts for about 5% of the global CO_2 emissions [8]. A single flyash brick contains about 200 grams of cement which is a large volume when taken into consideration the total number of bricks that is used in an actual construction. Hence to find a solution to both the problems involving reduction in usage of cement and maintaining the standards of a flyash brick this experimental study aims to reduce the usage of cement in flyash based brick by replacing it with copper slag.

A single flyash brick contains about 200grams of cement which makes up for about 6% of the entire weight of the brick.
This paper aims to replace the 6% of cement in a flyash brick by copper slag 1%, 2%, 3%, 4% and 5% respectively of the entire weight of the brick. The optimum mix of copper slag is then found by subjecting the brick samples to mechanical and durability tests like compression test, water absorption and efflorescence test. All the tests are done according to the standard Indian code books for namely IS 13757 which is specifically for fly ash based bricks and IS 1395 which specifies the various test procedures to be followed for finding the characteristics of the copper slag incorporated flyash based bricks.

2. Experimental Investigations

Flyash

Flyash used in the casting of the proposed brick samples is of class C. Class C type flyash have higher pozzolonicactitivity due to presence of higher lime content. The flyash is bought from the neyveli lignite mines, Tamilnadu. The properties of the flyash used are listed in Table 1.

Cement

The cement used for the manufacture of the brick samples is of grade 53 and compiles with IS 12269:2013. The physical properties of the cement are listed in table 1 and the chemical properties of the cement are listed in table 2.

Gypsum

Gypsum is used as a non-hydraulic binder[9]. It has a specific gravity of 2.3 and provides the brickwith essential properties like good resistance against fire, sound absorbant, hardening with reduced shrinkage, smooth surface finish etc.

Copyright © 2018 Authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Quarry Dust
The dust material used is taken from a granite quarry. The quarry dust are fine grinded particles than are less than 4.5mm size. They are used as a substitute for river sand nowadays and are utilized in large scale in highway construction sector for the preparation of hollow bricks etc.

Copper Slag
The copper slag used for the manufacture of the brick samples is from Tuticorin, Tamilnadu. The copper slag is a by-product that is released during the manufacture of copper metal by smelting process. The chemical properties of the copper slag are listed in table 2.

Table 1: Physical properties of cement

S.No	Properties of Cement	Results
1.	Specific Gravity	3.15
2.	Soundness by Le Chatelier (mm)	7
3.	Initial Setting Time	35
4.	Final Setting Time	450

Table 2: Chemical composition of cement, fly ash and copper slag:

Parameter	Cement (%)	Fly ash (%)	Copper Slag (%)
SiO_2	20.12	54.62	9.54
Al_2O_3	6.30	23.38	4.43
Fe_2O_3	3.60	5.28	57.56
TiO_2	-	1.80	-
K_2O	1.30	1.55	-
CaO	63.00	12.45	22.25
MgO	2.40	0.65	0.93
P_2O_5	-	0.58	-
SO_3	1.78	0.21	-
Na_2O	0.30	0.13	1.49
BaO	-	0.08	0.23
MnO	-	0.04	0.62
Cr_2O_3	-	0.04	0.11
Cl	-	0.04	-
PbO	-	0.03	0.59
ZrO_2	-	0.03	-
ZnO	-	0.02	0.89
SrO	-	0.01	-
CuO	-	0.01	1.42

3. Methodology

Brick manufacturing process
The brick samples were manufactured in a flyash brick factory called RRR tiles. The Columbia machine of model SPM 20 is used to manufacture these flyash bricks. These machines can be used to manufacture a variety of bricks from a hollow brick to a retaining wall block. This machine has the capability to mould about 30,000 bricks in a span of 8 hours. The proposed brick samples were manufactured in this machine by replacing the cement that was feeded into the machine by the required amount of copper slag. The cement in the brick was replaced by copper slag by 1%, 2%, 3%, 4% and 5% respectively of the entire weight of the brick. The mix were prepared by manual labour and then feeded directly into the hopper. The brick samples were then prepared by high pressure moulding. They were then cured by pouring water over them at regular intervals for 7,14 and 21 days. After curing the bricks were taken for testing.



Fig. 1: Columbia flyash brick manufacturing machinealong with the feeder

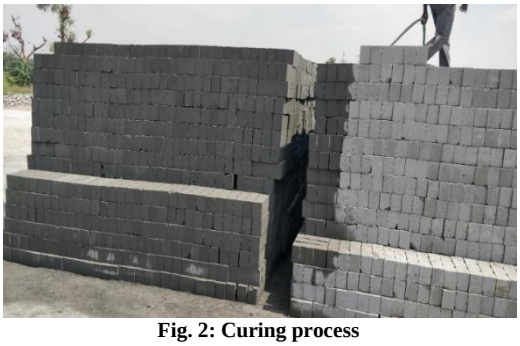

Fig. 2: Curing process

4. Testing of Specimens

Compressive strength test
The flyash based brick samples were cured for 7 days for achieving its optimum strength. The compression test for each sample is done according to IS standard code book IS: 13757 and IS: 1395 according to which a standard brick of size 230 x 110 x 70 mm. The compressive testing machine used has a maximum capacity of 3000 KN. For each proportion three brick samples were tested and the average value was taken to reduce the error. A clay brick has a compressive strength of 3.5 N/mm^2. Thus, an average value of compressive strength greater than that of a clay brick would be beneficial.



Fig. 3: Compression test of the brick sample

Water Absorption Test
The water absorption test is done according to the Indian standard code IS:13757 which states that a flyash brick must not absorb more than 12% of water by its weight. The samples were oven dried for 2 hours and then submerged in water for a period of 24 hours. The loss in weight of the samples were then noted. The water absorption values of the samples are found using the formula

Loss in weight = $W_2 – W_1 / W_1$ x 100

Where W_1 – Weight of the sample before dipping in water

W_2 – Weight of the sample after taken from the water

Efflorescence Test

The efflorescence test was carried out by placing the brick sample vertically in a water tub immersed at one end by 2.5cm. It was kept at a well-ventilated room at temperature ranging from 21-30 ^{0}C. The process is done until the entire water is absorbed or evaporated. The brick are then taken out and checked for any white spots. The total percentage of surface area covered by the white spots gives the values for this test. For all the brick samples no white spots were spotted and henceit is said to be –NIL.

5. Results and Discussion

Compressive strength

The compression tests done on the samples yielded better results. The test was done on the Universal Testing machine. The brick was placed within the forks and was subjected to gradual loading. Two samples were tested for each percentage replacement of cement with copper slag. The results of the compressive strength are provided in Table 3

Table 3: Compressive Test Results

Percentage replacement	7	14	21
0	8.36	9.36	10.72
1	8.41	9.68	10.95
2	8.92	10.41	11.26
3	9.58	11.03	12.52
4	7.81	9.94	10.09
5	7.15	8.62	9.25

The compressive strength of the brick samples keeps increasing with increase in the copper slag content up to 3% of copper slag which exhibits the highest value of 12.52 MPa at the end of 21 days. The value then decreases with further increase in copper slag content. This compression strength value of the optimum brick sample was about 2 times as much as a normal chamber brick.

The main strength contributing factors for the fly ash brick is the pozzolonic activity involved by the fly ash and copper slag with calcium hydroxide and the porosity present in the bricks. Upto 3% the pozzolonic activity parameter contributes a greater factor after which the porosity factor contributes to the loss in compressive strength on further addition of copper slag. The porosity factor increases with increase in copper slag content as the particle size of copper slag is less than 4mm while that of cement is less than 90µm. The pozzolonic factor increases the compressive strength while the porosity decreases the compressive strength.

Water absorption Test

A flyash brick must not absorb more than 12 % of water by its weight. The samples were oven dried to get a constant weight (taken as W_1) and then immersed in clean water for 24 hours. The samples were then wiped clean and weighed immediately (taken as W_2). The values obtained from the water absorption test are listed in Table 3.

Table 3: Water absorption values

Percentage replacement	7	14	21
0	9.40	9.62	9.61
1	10.52	10.47	10.79
2	11.05	11.23	10.98
3	10.84	11.24	11.29
4	11.08	11.28	11.31
5	11.67	11.72	11.68

The values for the water absorption test are all under 12% which is the upper limit value for the water absorption test. Thus acceptable values are exhibited by the brick samples. It can be seen from the Table 3 that the water absorption values does not differ by much as the number of days increases but rather the water absorption values increases with the increase in replacement of cement with copper slag. This can be attributed to the porosity of the brick samples which increases with increase in copper slag content.

6. Conclusion

From the results of various tests conducted, the detailed conclusions were presented as follows,

- The cement in the flyash brick when replaced by copper slag at about 3% of the entire weight of the brick exhibits a maximum compressive strength value of about 12.52 MPa. This is as much greater than the value of the compressive stress of a normal chamber brick and that of a normal flyash brick.
- The water absorption values of the all the brick samples is less than 12 % which is the upper limit of water to be absorbed by a flyash brick.
- The efflorescence test yielded the result NIL for all the brick samples indicating that there is movement of water within the brick. Thus the brick can be pronounced safely in the construction of building in places with high ground water level and saline water.
- The greatest advantage of this study is the economic cost involved for the manufacture of this type of copperslag incorporated flyash bricks. This paper when implemented can reduce the cost of a brick by about one Indian rupee. Thus these samples not only provide the desired results on par with the normal flyash bricks but greatly reduce its costs thereby indicating its necessity in implementation in the construction industry.

7. Acknowledgements

The authors would like to thank the Vice Chancellor of SASTRA Deemed University for having provided experimental facilities in the School of Civil Engineering to undertake this research work. The authors also thank the anonymous reviewers for their valuable suggestions and comments, which resulted in a more accurate and complete presentation of the present work.

References

[1] X. Lingling, G.Wei, W.Tao, Y.Nanru, Study on fired brick by replacing clay with flyash in high volume ratio, Construction of Building Materials.19 (2004) 243–247.

[2] C. Leiva, C.Arenas, B.Alonso-fariñas, L.F.Vilches, B.Peceño, M.Rodriguez-galán, F.Baena, Characteristicsof firedbrickswithco-combustion fly ashes, Journal of Building Engineering 5 (2016) 114–118.

[3] Gaurav Goel, Ajay S. Kalamdhad, Degraded municipal solid waste as a partial substitute for manufacturing fired bricks, Construction and Building Materials 155 (2017) 259–266.

[4] D. Eliche-Quesadaa, J.A. Sandalio-Péreza, S. Martínez-Martíneza, L. Pérez-Villarejob, P.J. Sánchez-Soto, Investigation of use of coal fly ash in eco-friendly construction materials:fired clay bricks and silica-calcareous non fired bricks Ceramics International, 44 (2018) 4400–4412.

[5] Tung-Chai Ling, Kim Hung Moc, Lie Qud, Jiujun Yang, Lei Guo, Mechanical strength and durability performance of autoclavedlime-saline soil brick,Construction and Building Materials 146 (2017) 403–409.

[6] Danuta Barnat-Hunek a, Piotr Smarzewski b, Zbigniew Suchorab, Effect of hydrophobisation on durability related properties of ceramic brick Construction and Building Materials 111 (2016) 275–285.

[7] Murugesan T, Bahurudeen A, Sakthivel M, Vijay R, Sakthivel S, Performance evaluation of Burnt Clay-Fly Ash Unburnt Bricks and precast paver blocks,Materials Today: Proceedings 4 (2017) 9673–9679.

[8] http://blogs.ei.columbia.edu/2012/05/09/emissions-from-the-cement-industry.

[9] Tayfun Çiçek, Yasin Çinçin, Use of fly ash in production of light-weight building bricks, Construction and Building Materials 94 (2015) 521–527.

[10] A. Sumathi, K. Saravana Raja Mohan**,** Compressive Strength of Fly Ash Brick with Addition of Lime, Gypsum and Quarry Dust, International Journal of ChemTech ResearchVol.7 (2015), pp 28-36.