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Research Article

Utilization of fly ash, m-sand, lime and cement for eco friendly interlocking bricks: an experimental approach

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The use of agricultural and industrial waste materials within the industry has been the main target of research for financial, ecological and technical reasons. The aim of this experiment is to create cost-effective and ecofriendly bricks to sustain environmental balance and avoid problems of ash discarding and M-sand. In this lime, cement and red oxide are used for replacing fly ash and M-sand. Size of trial brick [190 x 90 x 90] mm were tested in different proportions of 52%, 50%, and 48% as a replacement for fly ash with lime and cement and 42%, 40%, and 38% addition of M- sand. Even though the M-sand and fly ash have a lot of merits, but the strength will get low due to their lower hydration process at an early stage. These bricks were tested in a universal testing machine (UTM) and water absorption as per the Indian standard. This project is based on an idea that gives more economic value to today's world and it is ecofriendly material. This can be used in future construction techniques for better and economic construction.

Keywords: Interlocking bricks, Eco friendly, fly ash, m-sand, lime, waste management.

1. Introduction

In the construction industry, the use of cost-effective and eco friendly products is of excellent concern. It is noticed from the literature studies, amount of heat released from cement counts to a higher percentage in global warming. Cement production plays a major role in the release of CO_2. To attenuate those effects, cement is partially or fully replaced with substitute pozzolanic materials like fly ash, M-Sand which enhance the effect against those ill factors. In this experiment, the optimum mix of fly ash generated at NLC India Limited, Cement, red oxide, hydrated lime, M-Sand and optimum brick forming pressure were identified.

55% of Fly ash, 30% of M-sand and 15% of hydrated lime with 14% of cement were identified as the optimum mix. To find out the optimum mix investigation was done on microstructure, shrinkage behaviour, unit weight (volume), rate of absorption, porosity, compressive strength of modified brick which made under different pressures. In this experiment, the fly ash bricks of different mixes were examined by the Taguchi method [1]. The projected most favourable values of the process are based on water/Pozzolanic material ratio - 0.4, 39% of fly ash, 24% of M-Sand with 30% of cement.

In this experiment, various trials have been done to find out the optimum mix % to attain higher compressive strength of modified brick at different mixes. Bricks are produced in different sizes, using different materials and of various classes. Fly ash bricks are normally made using C – class type fly ash. The fly ash brick is manufactured with C – class type fly ash which is generally self-cementing. Due to its outstanding

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engineering property and durability, the fly ash brick widens its scope for application in developing infrastructure, building construction, irrigation, underwater construction etc. On the other hand, M-Sand is used, due to rapid developments in infrastructure, the demand for natural river sand has increased tremendously thereby causing deficiency in most part of the world.

2. Objectives and Methodology

The objective of this experiment work is to manufacture environment friendly interlocking bricks [2] with fine strength as a replacement for normal clay with fly ash, M-Sand, lime and cement in 20% to 60% and 15% to 55% to increase the use of waste materials like M-Sand and fly ash to create the sustainable environment [3].

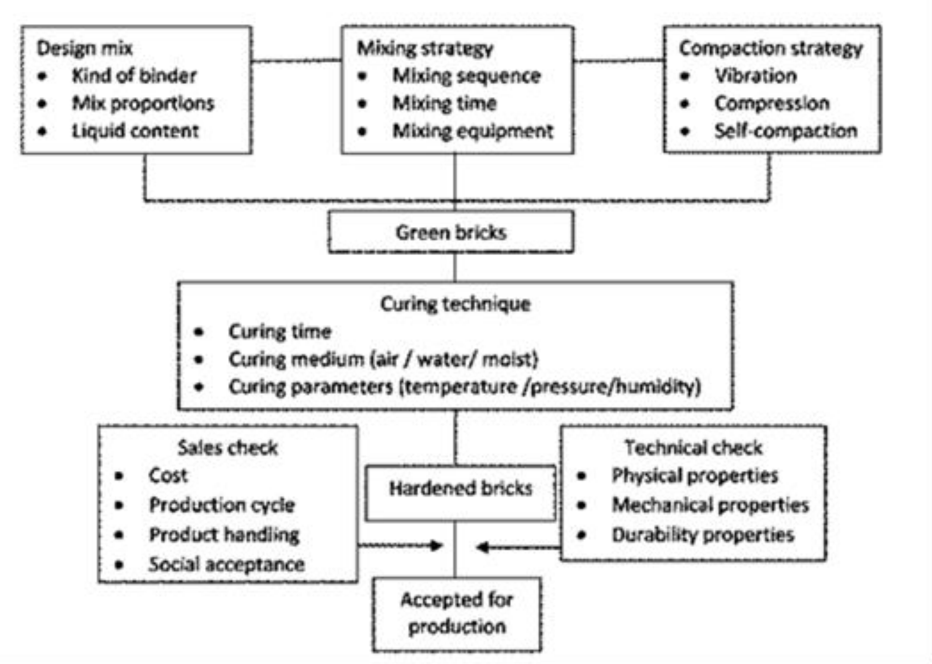

Fig. 1 General methodology followed for alternate brick production[4]

3. Materials and Methods

The required materials are Fly Ash, M-Sand, Lime, Cement, Red Oxide.

In this method of interlocking bricks, the mix proportion in the ratio of 20%, 40% and 60%. And in which red oxide is acting as a colouring agent.

3.1. Fly ash and m-sand + (Red oxide)

Fig. 2 Mix proportion – R1M1, R2M2 & R3M3

Ratio R1

R1M1- 1 : 1 + (Red oxide)
R1M2- 1 : 1 (½) + (Red oxide)
R1M3- 1 (½) : 1 + (Red oxide)

Table 1 Mix proportion of fly ash and M-Sand

Proportions	Fly Ash (%)	M -Sand (%)
R1M1	50	50
R1M2	25	75
R1M3	65	35

3.2. Fly ash, m-sand, and lime + (Red oxide)

Ratio R2

R2M1- 1 : 1 : (½) + (Red oxide)
R2M2- 1 : 1 (½) : (½) + (Red oxide)
R2M3- 1 (½) : 1 : (½) + (Red oxide)

Fig. 3 Mix proportion – R2M1, R2M2 & R3M3

Table 2 Mix proportion of fly ash, M-Sand and Lime

Proportion	Fly Ash (%)	M-Sand (%)	Lime (%)
R2M1	40	40	20
R2M2	30	50	20
R2M3	50	30	20

3.3. Fly ash, m-sand, lime and cement + (Red oxide)

Fig 4 Mix proportion of R3M1, R3M2 & R3M3

Ratio R3
R3M1- 1 : 1 : (½) : (¼) + (Red oxide)
R3M2- 1 : 1 (½) : (½) : (¼) + (Red oxide)
R3M3- 1 (½) : 1 : (½) : (¼) + (Red oxide)

Table 3 Mix proportion of fly ash, M-Sand, lime and cement

Proportion	Fly Ash (%)	M-Sand (%)	Lime (%)	Cement (%)
R3M1	35	35	20	10
R3M2	25	45	20	10
R3M3	45	25	20	10

4. Experimental work

4.1. Manufacturing of bricks

The common self-made die is to form the interlocking brick with the size of 190 mm x 90 mm x 90 mm[5].

Fig. 5 Interlocking hand mould

Various mix bricks are cast into the interlocking hand mould[6]. Based on the optimum mix ratio, materials were mixed. Then the mix was filled into the mould and packed together. After the compaction got over the mould is dismantled. Next, the wet bricks were placed into curing for the time of twenty-one days.

Table 4 Various mix proportions

Proportion	Fly Ash (%)	M-Sand (%)	Lime (%)	Cement (%)
R1M1	50	50	0	0
R1M2	25	75	0	0
R1M3	65	35	0	0
R2M1	40	40	20	0
R2M2	30	50	20	0
R3M3	50	30	20	0
R3M1	35	35	20	10
R3M2	25	45	20	10
R3M3	45	25	20	10

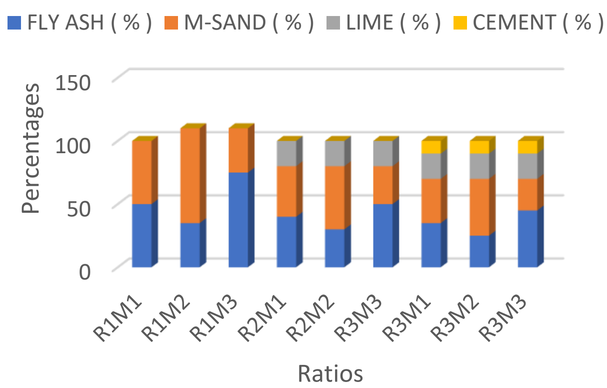

Fig. 6 Various mix proportions

5. Test and results

Test on Compressive strength, test on Water absorption and test on Hardness was taken to find out the results[7].

5.1. Compressive strength of interlocking bricks

Compressive strength of interlocking brick made from M-Sand and fly ash

R1M1- 3.2 KN (1:1)
R1M2- 2.4KN (1:1(1/2))
R1M3- 3.2KN (1(1/2):1)

Compressive strength of the bricks made from M-Sand, fly ash and lime

R2M1- 5.6KN (1:1:1/2)
R2M2- 7.6KN (1:1(1/2):1/2)
R2M3- 12.8KN (1(1/2):1:1/2)

Compressive strength of the bricks made from M-Sand, fly ash, lime and cement

R3M1- 17.8KN (1:1:1/2:1/4)
R3M2- 16.8KN (1:1(1/2):1/2:1/4)
R3M3- 20.8KN (1(1/2):1:1/2:1/4)

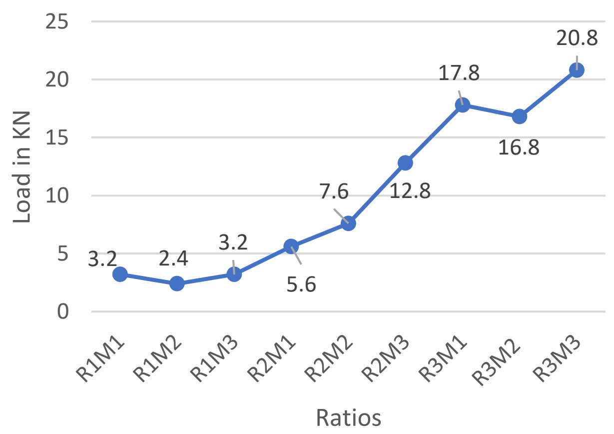

Fig. 7 Compression test results

This exhibits the load carrying ability of various proportions of the interlocking bricks, the brick which gives the highest compressive strength will be taken for the construction purpose.

5.1.1. Result of compression test

The proportion of the brick which gives more compression value will be taken as a good quality brick suitable for the construction, the greatest compression value of the brick exhibited in the compression test is given by the proportion of (M-Sand, lime, cement and fly ash) and compressive value of interlocking brick is 20.8 KN. The compression value of the brick is high because the lime and cement added to the bricks provide better bonding strength to the bricks.

5.2. Water absorption test of interlocking bricks

The water absorption capacity of the bricks made by M-Sand and fly ash

R1M1- 833gm (1:1)
R1M2- 801gm (1:1(1/2))
R1M3- 788gm. (1(1/2):1)

The water absorption capacity of the bricks made by M-Sand, fly ash and lime

R2M1- 747gm (1:1:1/2)
R2M2- 729gm (1:1(1/2):1/2)
R2M3- 689gm (1(1/2):1:1/2)

The water absorption capacity of the bricks made by M-Sand, Fly Ash, Lime and cement

R3M1- 684gm (1:1:1/2:1/4)
R3M2- 612gm. (1:1(1/2):1/2:1/4)
R3M3- 500gm (1(1/2):1:1/2:1/4)

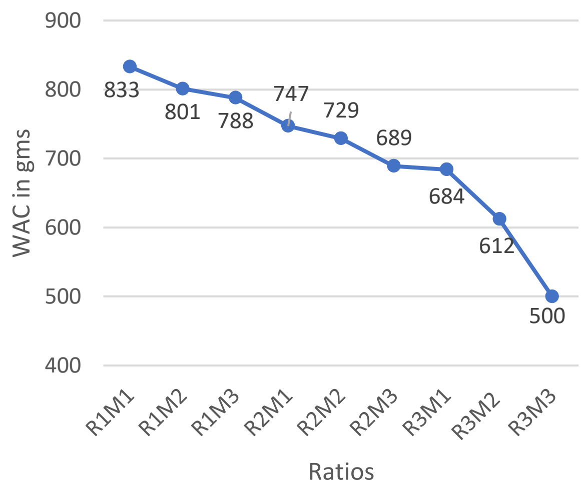

Fig. 8 Water absorption test results

This shows the different water absorption capacities of the different bricks of different proportions.

5.2.1. Result of water absorption test

The brick which has more pores in it absorbs more water than the other bricks, the water absorption should be in a limited range, and the average absorption of water should not exceed be 20% of its brick weight. The bricks which have good quality properties will absorb only a required amount of water which is said to be good quality bricks suitable for construction The average water absorption value of the brick is 500 gm.

5.3. Hardness test on interlocking bricks

In this test on hardness, a brick should defend scratches over the razor-sharp things to conduct this test a sharp or pointed tool or human nails can be utilized to create scratches on the bricks. If scratch impression was not seen on the surface of bricks, then it is a hard brick. The hardness test of the bricks does not contain any values. The brick which exists scratches on the surface is not a hard brick and it does not contain any hardness properties.

5.3.1. Result of hardness test

The hardness test conducted on each brick gives different results according to the hardness of the bricks, the bricks which exhibit more scratches has less hardness, and it is not a good quality brick.

The brick which gives more hardness among all bricks is taken as a good quality brick that is suitable for construction. The brick made of 12% proportion exhibits more hardness and it is suitable for construction.

5.4. Cost of interlocking bricks

Quantity: 320 square feet
Low: Rs71,568
High: Rs142,366

6. Conclusion

The work conducted on the interlocking bricks had provided a better output to today's construction. The different tests were conducted on the bricks and the results are provided according to the mix proportion of the bricks, the result of each brick varies according to the proportion of the bricks, behalf of the results provided in the accordance with the bricks the better and suitable brick which can be used for the construction is of ratio R3M3 proportion (11/2:1:1/2:1/4). This shows the bricks of this proportion are stable, suitable and better for construction purposes. The R3M3 bricks exhibit good quality as much as that of other bricks, this project concludes that the interlocking bricks can be used and suitable for the construction of the buildings. We think that it gives a change in the building materials. These bricks can only be used in the temporary buildings which are demolished within a short period of time, so these bricks can be used for the construction instead of the bricks which are used nowadays respectively.

REFERENCE

[1] P.K. Chaulia, R. Das, Process parameter optimization for fly ash brick by Taguchi method, Mater. Res. 11 (2008) 159–164. https://doi.org/10.1590/S1516-14392008000200008.

[2] A.A. Shakir, M.H. Wan Ibrahim, N.H. Othman, A. Ahmed Mohammed, M.K. Burhanudin, Production of eco-friendly hybrid blocks, Constr. Build. Mater. 257 (2020) 119536. https://doi.org/10.1016/j.conbuildmat.2020.119536.

[3] A. Al-Fakih, B.S. Mohammed, M.S. Liew, E. Nikbakht, Incorporation of waste materials in the manufacture of masonry bricks: An update review, J. Build. Eng. 21 (2019) 37–54. https://doi.org/10.1016/j.jobe.2018.09.023.

[4] V. Gupta, H.K. Chai, Y. Lu, S. Chaudhary, A state of the art review to enhance the industrial scale waste utilization in sustainable unfired bricks, Constr. Build. Mater. 254 (2020) 119220. https://doi.org/10.1016/j.conbuildmat.2020.119220.

[5] Indian Standard, IS 1725: Specification for soil based blocks used in general building constructuion, Indian Stand. Inst. (1982) 13.

[6] L. Fay, P. Cooper, H.F. De Morais, Innovative interlocked soil-cement block for the construction of masonry to eliminate the settling mortar, Constr. Build. Mater. 52 (2014) 391–395. https://doi.org/10.1016/j.conbuildmat.2013.11.030.

[7] A.L. Murmu, A. Patel, Towards sustainable bricks production: An overview, Constr. Build. Mater. 165 (2018) 112–125. https://doi.org/10.1016/j.conbuildmat.2018.01.038.

[8] M.M. El-Attar, D.M. Sadek, A.M. Salah, Recycling of high volumes of cement kiln dust in bricks industry, J. Clean. Prod. 143 (2017) 506–515. https://doi.org/10.1016/j.jclepro.2016.12.082.