iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** XI **Month of publication:** November 2021

DOI: https://doi.org/10.22214/ijraset.2021.39034

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue XI Nov 2021- Available at www.ijraset.com

Mechanical and Durability Characteristics of Eco-Friendly Fly Ash Bricks

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Abstract: ***This paper presents an experimental investigation carried out on eco-friendly fly ash bricks having various percentage of fly ash, lime, gypsum, stone dust, coarse aggregate and boiler slag. Raw materials are added to the pan mixer with different mix proportions and are mixed thoroughly with water until a homogeneous mixture is formed. Prepared homogeneous mixture is fed into the press and moulded to a brick of size 200 x 200 x 300 mm using vibro-hydraulic press. Moulded bricks are air dried for 24 hours, arranged in stacks and are cured for a period of 28 days by sprinkling the water to achieve the optimum strength. Compressive strength, water absorption, efflorescence, dimension tolerance and density tests are conducted as per BIS codal provisions. Eco friendly fly ash bricks having varying proportions of industrial by-products with less content of stone dust satisfy compressive, water absorption, efflorescence, dimensional tolerance and density requirements as per BIS codal provisions and can be used in structures as a sustainable construction material.***

Keywords: Eco-friendly fly ash bricks, Compressive strength, Water absorption, Efflorescence, Dimension tolerance and Density

I. INTRODUCTION

In developing countries like India, disposal of solid waste is a serious problem. In order to overcome this threat, recycling and reuse of waste material is critically important for the conservation of environment as well as for sustainable development. Use of waste materials in the production of eco-friendly fly ash bricks as an alternative source reduces harmfulness to the environment. Bricks are the important and oldest construction materials because of their reliability, strength, durability and low cost. They are essential for the construction of super structures Bricks are often used for the reason of economy and speed, even in the areas where stones are abundantly available.

Use of solid wastes like fly ash, boiler slag in the manufacture of bricks not only ensures sustainable development but also have indirect benefits than the conventional clay bricks. Eco friendly fly ash bricks are commonly used for compound walls, non-load bearing structures. Additives like gypsum, stone dust coarse aggregate and stone dust are used for accelerating rate of strength gain in lime–fly ash compacts.

In the present investigation, an attempt has been made to study the physical characteristics of eco-friendly fly ash bricks having various percentage of fly ash, lime, gypsum, stone dust, coarse aggregate and boiler slag. Performance of eco-friendly fly ash bricks in terms of compressive strength, water absorption, efflorescence, dimension tolerance and density tests are conducted as per BIS codal provisions.

II. EXPERIMENTAL PROGRAM

A. *Materials Used*

1) *Fly Ash:* Fly ash is procured from Grasim Industries Limited, Harihara, Davangere district.
2) *Lime:* Lime is procured from Shree Sai Krupa Industries, Mudhol, Bagalkot district.
3) *Gypsum:* Gypsum is procured from a local fertilizer shop.
4) *Stone Dust:* Stone dust is procured from a local quarry which is free from impurities.
5) *Coarse Aggregate:* Coarse aggregate is procured from a local quarry which conforms to IS 383 (2016).
6) *Boiler Slag:* Boiler slag is procured from BMM Inspat Limited, Hospet, Vijayanagara district.

For the above materials, preliminary tests such as specific gravity and gradation is carried out as per BIS codal provisions viz. IS 2386–Part 1 (1963), IS 2386–Part 3 (1963), IS 4031–Part 11 (1999) and IS 1727 (1967). Table 1 shows the preliminary test results.

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Table 1: Preliminary test results

Sl. No.	Material	Specific gravity	Gradation
1	Fly Ash	1.93	–
2	Lime	2.20	–
3	Gypsum	2.32	–
4	Stone dust	2.48	4.75 mm down size
5	Coarse aggregate	2.7	12 mm down size
6	Boiler slag	2.6	4.75m down size

B. Mix Proportions of Eco-Friendly Fly Ash Bricks

Table 2 shows the mix proportions of eco-friendly fly ash bricks with varying percentage of fly ash, lime, gypsum, stone dust, coarse aggregate and boiler slag considered in the present study.

Table 2 : Proportions for various mixes of eco-friendly fly ash bricks

Mix ID	Fly ash (%)	Lime %	Gypsum (%)	Stone dust (%)	Coarse aggregate (%)	Boiler slag (%)
1	30	10	-	50	-	10
2	40	10	-	30	20	-
3	50	10	-	40	-	-
4	60	10	-	20	10	-
5	65	10	5	-	20	-
6	70	10	5	15	-	-

C. Mixing

Raw materials are added to the pan mixer with different mix proportions and are mixed thoroughly with water until a homogeneous mixture is formed. Raw materials should be free from lumps as they may cause cracks in bricks and reduce the strength. The same procedure is followed for different mix proportions.

D. Casting and Curing

Prepared homogeneous mixture is fed into the press for moulding through a conveyer belt. Moulding of bricks for a size of 200 x 200 x 300 mm is done using vibro-hydraulic press. The moulded bricks are kept on a level ground and air dried for 24 hours. Curing is done for a period of 28 days to achieve the optimum strength by sprinkling the water manually.

E. Tests on Eco-Friendly Fly Ash Bricks

Table 3 shows the various physical tests conducted on eco-friendly fly ash bricks as per BIS codal provisions.

Table 3 : Tests conducted on eco-friendly fly ash bricks

Sl. No.	Test	Remarks
1	Compression	IS 3495–Part 1 (2019)
2	Water absorption	IS 3495–Part 2 (2019)
3	Efflorescence	IS 3495–Part 3 (2019)
4	Dimension tolerance	Comparing the actual dimensions of length, width and height of blocks with that of mould
5	Density	Ratio of dry weight and volume of block

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III. RESULTS AND DISCUSSION

A. Compressive Strength Test Results

The compressive strength of eco-friendly blocks after 28 days of curing is graphically represented in Fig. 1.

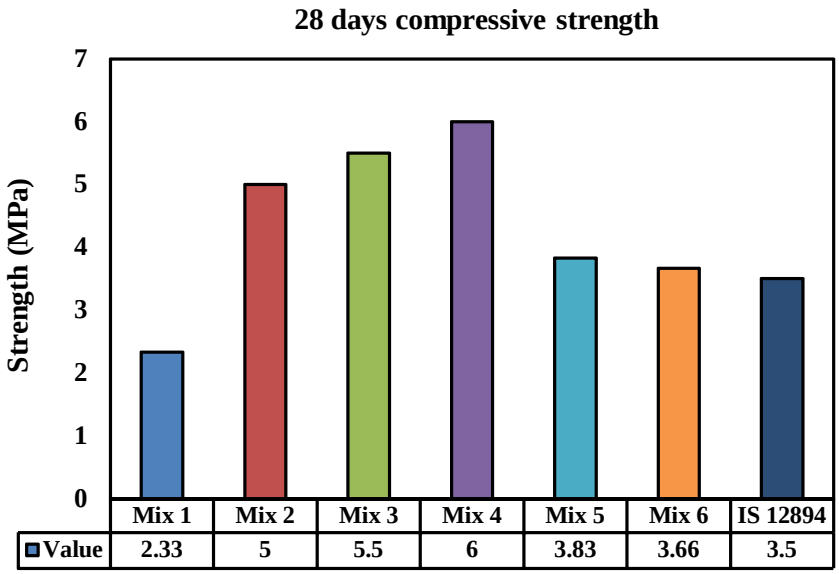

Fig. 1 : 28 days Compressive strength of eco-friendly fly ash bricks

Mix 1 having 30% fly ash, 10% lime, 50% stone dust and 10% boiler slag shows less compressive strength and does not conform to IS 12894 (2002). Other Mixes viz. 2, 3, 4, 5 and 6 having varying content of fly ash, lime, gypsum, stone dust, coarse aggregate and boiler slag conform to compressive strength requirements as per IS 12894 (2002).

B. Water Absorption Test Results

Water absorption results of eco-friendly fly ash bricks after 28 days of curing is graphically represented in Fig. 2.

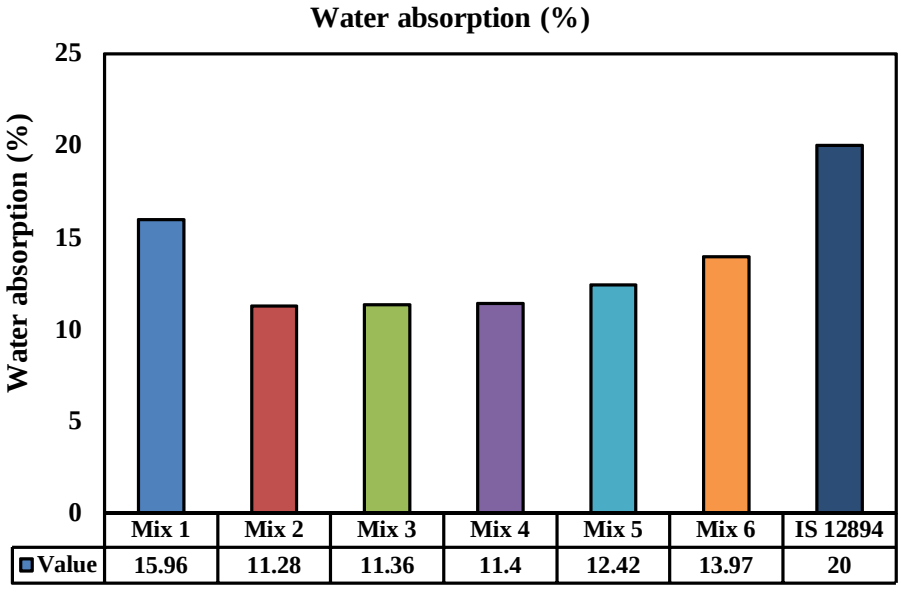

Fig. 2: Water absorption of eco-friendly fly ash bricks

Water absorption values of all the mixes is observed to be less than 20% thus conforming to IS 12894 (2002) codal specifications.

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C. Efflorescence Test Results

Efflorescence test results of eco-friendly fly ash bricks after 28 days of curing is shown in Table 4.

Table 4 : Efflorescence test results on eco-friendly fly ash bricks

Mix ID	Rating as per IS 3495 – Part 3 (2019)	Remarks
1	Slight	A per IS 12894 (2002), rating of efflorescence should not be more than "moderate"
2	Nil	
3	Slight	
4	Slight	
5	Slight	
6	Slight	

All the mixes conform to IS 12894 (2002) specification as the rating of efflorescence is observed to be not more than "Moderate".

D. Dimension Tolerance Test Results

Table 5 shows the dimensions of eco-friendly fly ash bricks which are cured for 28 days.

Table 5: Dimensions of eco-friendly fly ash bricks

Mix ID	Length (mm)	Width (mm)	Height (mm)	Remarks
1	300	199.7	199.8	As per IS 2185–Part 1 (2005), the variation in length should not be more than ± 5 mm and variation in width and height should not be more than ± 3 mm.
2	300	199.9	200	
3	299.7	200	200	
4	300	199.8	200	
5	300	200	199.8	
6	300	199.7	199.9	
Mean (≈)	299.94	199.86	199.93	

All mixes having various proportion of fly ash, lime, gypsum, stone dust, coarse aggregate and boiler slag satisfy the limits specified in IS 2185–Part 1 (2005).

E. Density Test Results

Density of Eco-friendly fly ash bricks after 28 days of curing is graphically represented in Fig. 3.

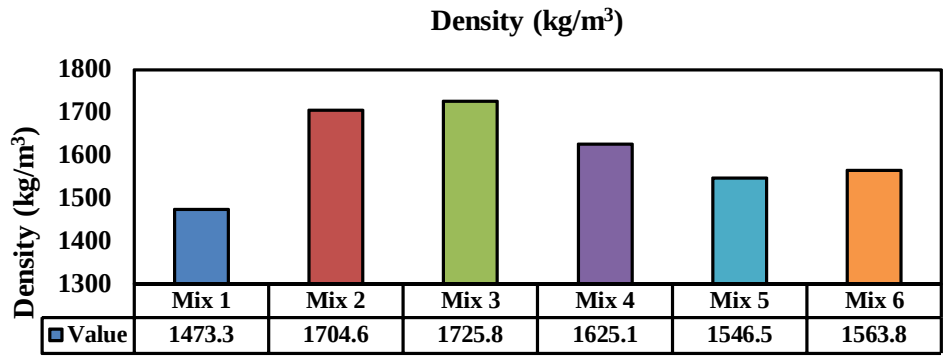

Fig. 3: Density

From the density test results, Mix 1 having 30% fly ash, 10% lime, 50% stone dust and 10% boiler slag shows minimum density of 1473.3 kg/m^3. Whereas Mix 3 having 50% fly ash, 10% lime and 40% stone dust shows maximum density of 1725.8 kg/m^3.

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IV. CONCLUSIONS

The present study reports the mechanical and durability characteristics of eco-friendly fly ash bricks having various percentage of fly ash, lime, gypsum, stone dust, coarse aggregate and boiler slag. Important conclusions drawn are as follows.

1) Mix 1 having 30% fly ash, 10% lime, 50% stone dust and 10% boiler slag shows less compressive strength and does not conform to IS 12894 (2002). Whereas all the other mixes having varying content of fly ash, lime, gypsum, stone dust, coarse aggregate and boiler slag conform to compressive strength requirements as per IS 12894 (2002).
2) Water absorption values of all the mixes is observed to be less than 20% thus conforming to IS 12894 (2002) codal specifications.
3) All the mixes conform to IS 12894 (2002) specification as the rating of efflorescence is observed to be not more than "Moderate".
4) All the mixes satisfy dimension tolerance limits as specified in IS 2185–Part 1 (2005).
5) Mix 1 shows minimum density of 1473.3 kg/m^3 and Mix 3 having 50% fly ash, 10% lime and 40% stone dust shows maximum density of 1725.8 kg/m^3.

A. Concluding Remarks

Eco friendly fly ash bricks having varying proportions of industrial by-products with less content of stone dust satisfy compressive, water absorption, efflorescence, dimensional tolerance and density requirements as per BIS codal provisions and can be used in structures as a sustainable construction material.

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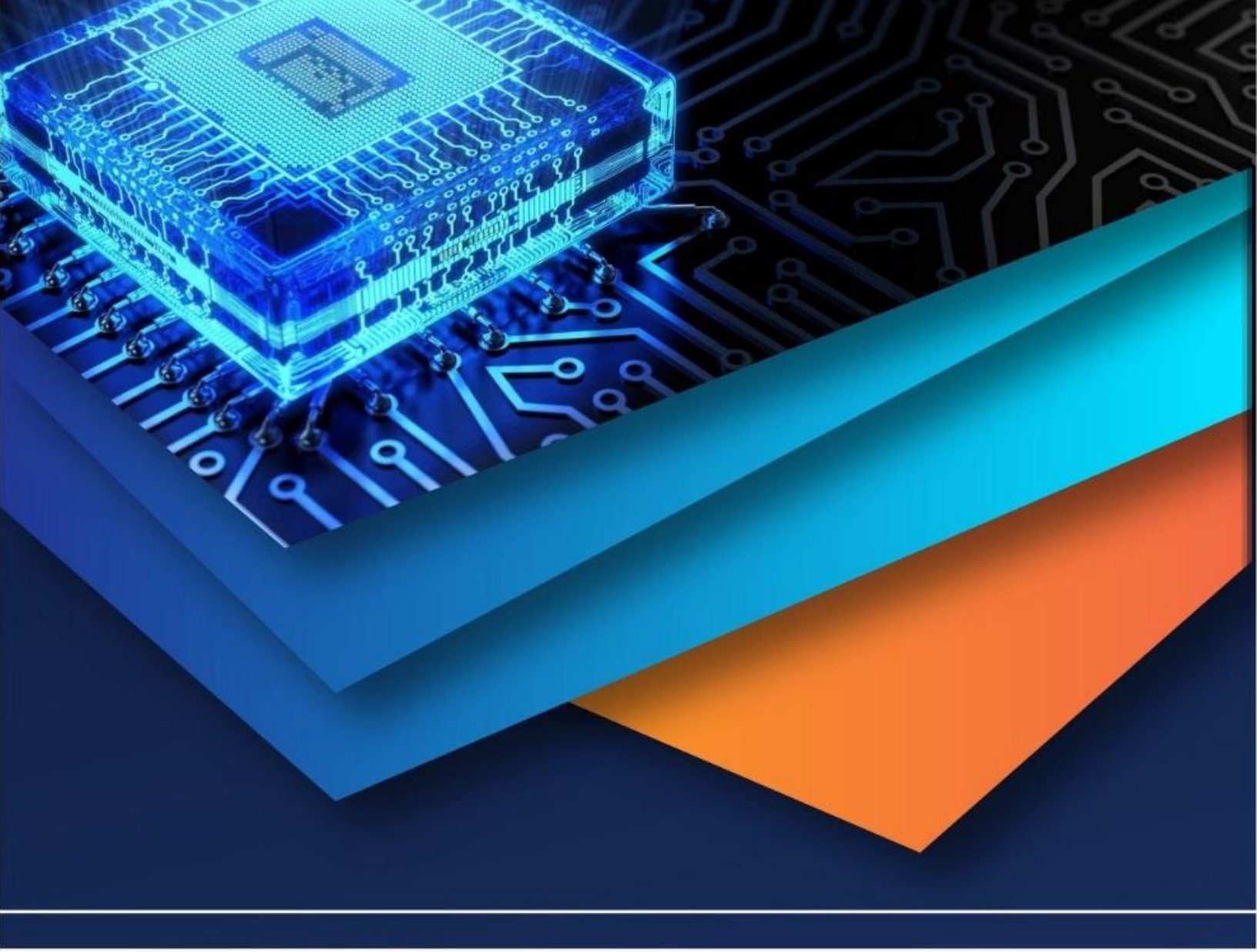

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