EXPERIMENTAL INVESTIGATION ONPARTIAL REPLACEMENT OF FLYASH INSTEAD OF CEMENT IN INTERLOCKING BRICKS WITH STEEL FIBER

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ABSTRACT
Cement is a significant material that is used in building. The manufacture of cement emits high levels of carbon dioxide due to combustion. This study aims to investigate the use of fly ash as a partial replacement for cement in interlocking bricks.This study is part of a research project in which the production of interlocking mortar-free bricks.The mix ratio is 1:6with different water-cement ratios such as 0.41, 0.43, and 0.45and the addition of 1% of steel fibers.The cement is replaced by fly ash in different percentages such as 5%, 10%, 15%, and 20% respectively. It is a good binding material for the replacement of cement on the interlocking bricks.The major focus of this investigation to develop manually compressed interlocking bricks. The interlocking bricks are tested atthe age of 7 days and 28 days for compressive strength, water absorption, and bulk density and physical tests such as hardness test and efflorescence test.

Keywords–*Interlocking bricks, Fly ash, steel fiber, Compression strength test, Mortar free joints.*

1. INTRODUCTION

Due to the high demand for simple, high-performance, and cost-effective building systems, significant changes have occurred to the traditional masonry system over the last few decades.Brick manufacturing required the use of coal to burn bricks [1].The use of coal in the combustion of bricks releases greenhouse gases, which pollute the atmosphere [2].The rapid growth of the building industry has necessitated the use of eco-friendly materials and waste disposal to manufacture long-lasting goods [3].Because of the rapid growth and development in the construction industry, Civil Engineers are looking for a new building material that is economical, durable, and effective [4, 5].Because of the recent pattern over the last two decades, bricks have been classified into two types: solid brick and interlocking brick [6].Interlocking brick is a type of wall material used in homebuilding.Many aspects affect the consistency of interconnected brick goods, including the ratio of the forming materials' mixture [8].A compressive strength test was performed to determine the strength and failure pattern of interlocking bricks [9].The control bricks have shrinkage cracks, but the specimens with fiber had no symptoms of shrinkage cracking [10, 11].Since interlocking blocks are constructed with an interlocking structure that allows the blocks to be placed securely on top of each other, block-laying work is possible without the use of any mortar layers to bind the blocks around each other [13].In comparison to masonry structures, there is no mortar joint between the units in this method.The mortar-less brick method requires fewer skills and saves time during construction [14, 15]. Efforts have been made by researchers to evaluate the behaviour of bricks made from a variety of by-products and waste materials [16]. They realized that these bricks can be used as a replacement material for their research.Such bricks can be produced at a cheaper cost while also having a high compressive strength [17].Fly ash interlocking bricks are an alternative to conventional bricks and can be used to easily replace conventional bricks [18, 19].Furthermore, the interlocking structure improves the stability of the brick assembly, allowing the built wall to be horizontally and vertically balanced to accommodate loads equal to a non-skinned wall frame [20].Water absorption is lower in interlocking blocks than in control specimens [21].Steel fiber with a hook on one end is used to improve the post-crack arresting mechanism of bricks [22, 23].The overall aim of this study is to find alternative materials for bricks.Find the physical and strength tests for interlocking bricks and compare the findings to the control specimen.

2. EXPERIMENTAL WORK

The cement used is Ordinary Portland Cement (OPC) grade 53. The cement test was carried out under IS 12269:1987. Table 2.1 displays the physical properties of cement as determined by the test. M-sand is used in the manufacture of bricks. It's made by grinding down a rough granite block. The fine aggregate test was carried out under IS 2386 (Part 1-6):1963. Table 2.2 displays the physical properties of the M-sand as determined by the test. IS 3812(Part-1):2013 coding is used to test Class F fly ash. Mettur thermal power station provided the fly ash. Table 2.3 shows the physical properties of fly ash as determined by the measurement. In this process, steel fiber with a hooked end is used.The steel fiber test was performed under ISO 13270:2013.Post-curingcan prevent the formation of cracks. They have hooks on both ends and are capable of filling air voids. Table 2.1 displays the physical properties of the fly ash obtained from the test.

Table 2.1 Properties of Cement

S.No	Properties	Value
1.	Initial setting time	30 min
2.	Final Setting time	500 min
3.	Consistency	32%
4.	Specific Gravity	3.17
5.	Fineness	1%

Table 2.2 Properties of Fine aggregate

S.No	Properties	Value
1.	Specific Gravity	2.7
2.	Water Absorption	0.74%

3.	Fineness	3.75
4.	Bulk density	1419.5 kg/m^3
5.	Zone	II

Table 2.3 Properties of Fly Ash

S.No	Properties	Value
1.	Specific Gravity	2.14
2.	Bulk density	580.5 kg/m^3
3.	Grade	Class F

Table 2.4 Properties of Steel Fiber

S.No	Properties	Value
1.	Length	30 mm
2.	Diameter	0.5 mm
3.	Aspect ratio (l/d)	60
4.	Bulk density	7850 kg/m^3
5.	Shape	Hooked at ends

3. SPECIMEN PREPARATION

Bricks were made by measuring the exact amount of cement, fine aggregate, fly ash, water, and steel fiber required while keeping the necessary mix pattern and water-cement ratio in mind. The cement, fine aggregate, and fly ash were combined dry first, and then the steel fiber was attached. Water is eventually applied to the dry mix, which is then blended with a shovel. The cement and sand mix ratio would be 1:6. The fly ash for cement replacement is added at 5%, 10%, 15%, and 20% in the various water-cement ratios such as 0.41, 0.43, and 0.45 respectively. Steel fiber is added to the brick at 1% to improve the post-crack arresting mechanism of bricks.The A0, B0, and C0 signify the normal mix of water-cement ratios such as 0.41, 0.43, and 0.45with the addition of 1% steel fiber.A1, A2, A3, and A4, B1, B2,B3, and B4, and C1, C2, C3, and C4 signify the replacement of fly ash with cement in 5, 10, 15, and 20 percentages.The bricks were cast in the dimensions 300*230*150mm. These specimens were extracted from the moulds after 24 hours and cured in a water tank for 7 and 28 days, respectively.

4. RESULT AND DISCUSSIONS

4.1 Testing of Bricks

Interlocking bricks are tested for compressive strength, water absorption, and bulk density, and also physical tests such as hardness and efflorescence.

4.2 Compression Strength Test

The IS 2185 (Part-1):2005is used to refer to the compressive strength test.The maximum compressive strength is achieved by mix B3, which has a compressive strength that is 28.2% higher than the control specimen,a compressive strength 28.18% higher in a mix A3thancontrol specimen,and a compressive strength 19% higher in a mix C3thancontrol specimen.In comparison to the A3& C3, B3 has a 38% higher compressive strength in interlocking bricks.Figures 1, 2,and 3 display the compressive strength results of interlocking bricks.

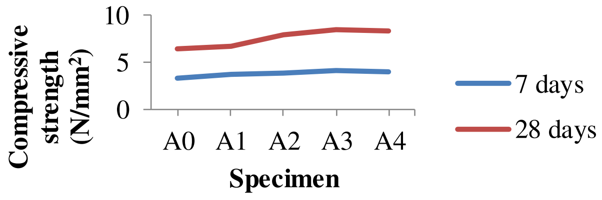

Fig.1 Compressive strength test for specimen A

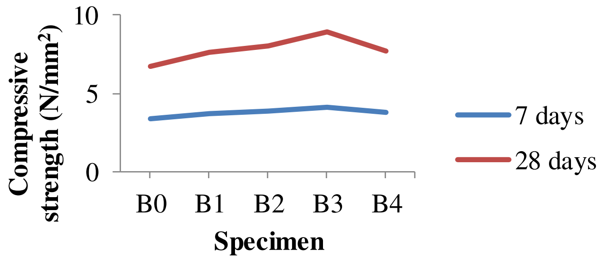

Fig.2 Compressive strength test for specimen B

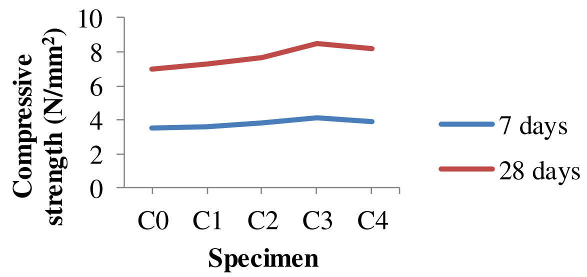

Fig.3 Compressive strength test for specimen C

4.3. Water Absorption test

An absorption test on brick is performed to determine the amount of moisture content absorbed by brick under acute conditions.The IS 2185 (Part-1):2005 is used to refer to the water absorption test.The graph represents the different sample water absorption percentages of the bricksThe water absorption percentage of mix A4, which is 14% lower than control specimens, the water absorption percentage of mix C4, which is 11.2% lower than controlspecimens, and the water absorption percentage of mix B3, which is 6% lower than control specimens.In interlocking bricks, the A4 has 23% less water absorption than the B3 andC4.Figure4, 5, and 6 show the results of water absorption of interlocking bricks.

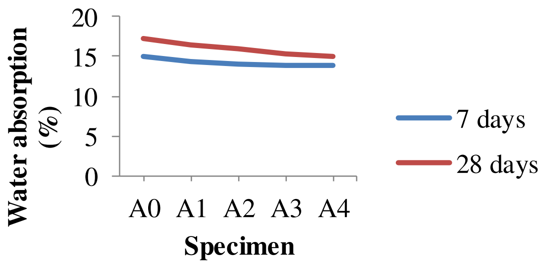

Fig.4 Water absorption test forspecimen A

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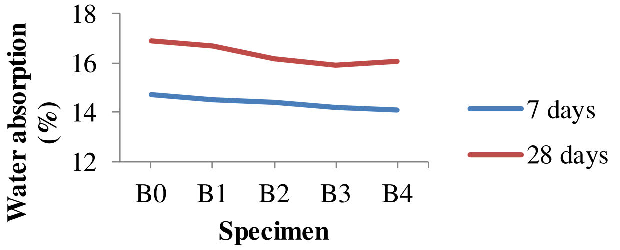

Fig.5 Water absorption test for specimen B

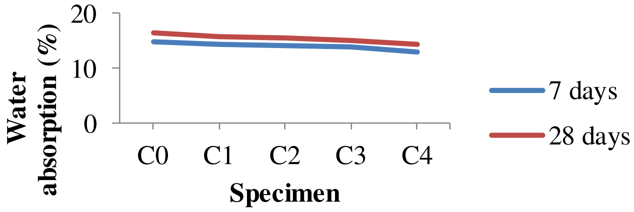

Fig.6 Water absorption test for specimen C

4.4 Bulk density test

The mass of mortar contained in a known volume is used to calculate bulk density. The IS 2185 (Part-1):2005 is used to refer to the bulk density test. Mix B4 achieves the maximum bulk density, which is 10.78% higher than control specimens, mix A4 achieves a bulk density that is 7.85% higher than control specimens, and mix C2 achieves a bulk density that is 3.5% higher than control specimens. In interlocking bricks, the B4 has a 31.45% higher bulk density than the A4 and C2.Figure 7, 8, and 9 show the results of the bulk densityfor interlocking bricks.

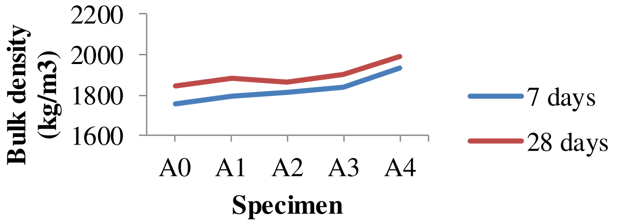

Fig.7 Bulk Density test for specimen A

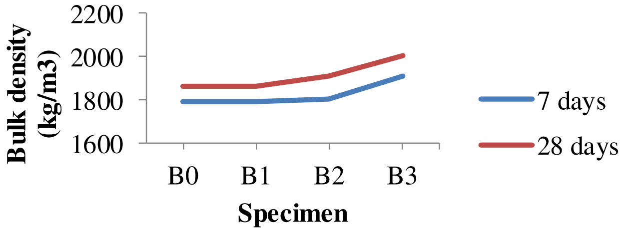

Fig.8 Bulk Density test for specimen B

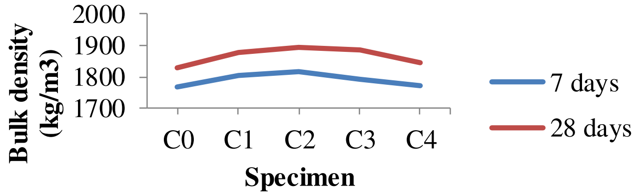

Fig.9 Bulk Density test for specimen C

4.5 Efflorescence test

The efflorescence test was carried out underIS 2185 (Part-1):2005. Using an efflorescence test, it was discovered that only a small percentage of the area of the specimen is coated with alkalis in interlocking bricks. The presence of soluble salts is very minimal in this interlocking brick with a sophisticated appearance.Figure 7 shows the efflorescencefor interlocking bricks.

Fig.10 Efflorescence Test

4.6 Hardness test

In the hardness test, no reflection was found on the surface of the bricks when scratched with a nail, indicating that it is suitable for building.

4.7 Relationship between Mechanical properties of interlocking bricks

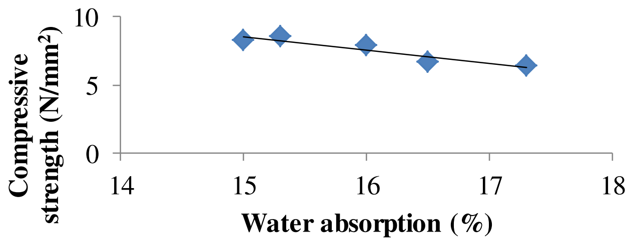

Fig.11 Relationship between compressive strength and Water absorption for specimen A

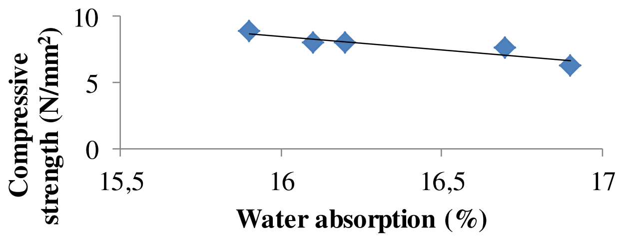

Fig.12 Relationship between compressive strength and Water absorption for specimen B

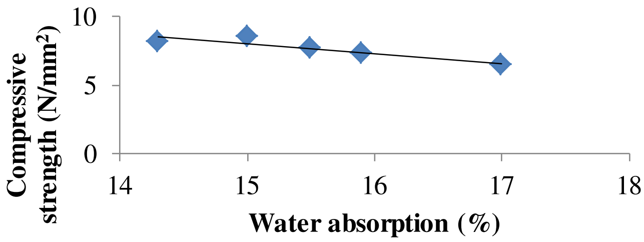

Fig.13 Relationship between compressive strength and Water absorption for specimen C

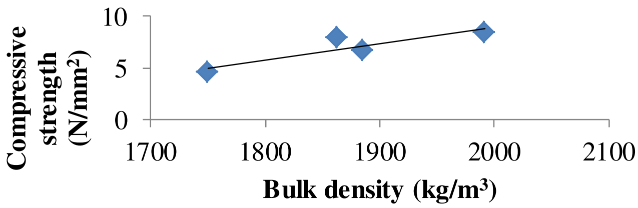

Fig.14 Relationship between compressive strength and Bulk density for specimen A

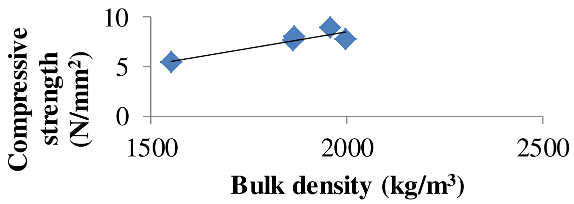

Fig.15 Relationship between compressive strength and Bulk density for specimen B

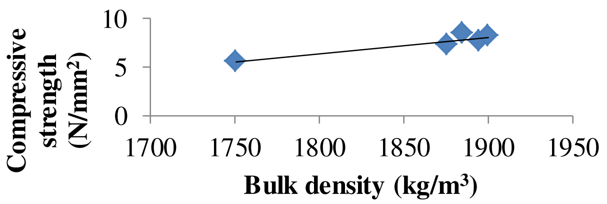

Fig.16 Relationship between compressive strength and Bulk density for specimen C

From figure 11, 12, and13,it was observed that the compressive strength and water absorption of interlocking bricks are closely related for specimens A, B&C. From figure 14,15,and 16 it was observed that the compressive strength and bulk density of interlocking bricks are closely related for specimens A, B&C. The relation is found to be

The Linear equation of ACW

$$Y = -0.9732x + 23.15 \quad (4.1)$$

$R^2 = 0.8939$

The Linear equation of BCW

$$Y = -2.0618x + 41.491 \quad (4.2)$$

$R^2 = 0.8473$

The Linear equation of CCW

$$Y = -0.7204x + 18.835 \quad (4.3)$$

$R^2 = 0.8592$

The Linear equation of ACB

$$Y = 0.0156x - 22.324 \quad (4.4)$$

$R^2 = 0.\ 8103$

The Linear equation of BCB

$$Y = 0.0066x - 4.7222 \quad (4.5)$$

$R^2 = 0.\ 8138$

The Linear equation of CCB

$$Y = 0.0.0176x - 25.391 \quad (4.6)$$

$R^2 = 0.\ 8767$

5. CONCLUSION

In this study, cement is replacedby fly ash in interlocking bricks, with the addition of 1% steel fibers in various water-cement ratios.The compressive strength, water absorption, bulk density, efflorescence test, and hardness test are all performed on the interlocking brick.

After 28 days, the replacement of 15% fly ash and the addition of 1% steel fiber increased the compressive strength of the interlocking brick by 28.2% in a 0.43 water-cement ratio compared to the control specimen.

As compared to the control specimen, the replacement of 20% fly ash in cement with the addition of 1% steel fiber reduced water absorption to 14.24 % in 0.41 water-cement ratio in interlocking bricks after 28 days.

As 15% fly ash was replaced in cement and 1% steel fiber was added, the bulk density of the interlocking brick increased to 10.78% in a 0.43 water-cement ratio at 28 days when compared to the control specimen.

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