EXPERIMENTAL STUDY ON BOND SHEAR STRENGTH OF BRICK MASONRY TRIPLET BY PARTIALLY REPLACING OF CEMENT BY BAGASSE ASH

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ABSTRACT:

Brick Masonry is a material built with brick units and mortar. Brick masonry is the most used masonry and it is a conventional type. Brick masonry is very good at taking compressive load but very weak in taking lateral loads. Masonry is a material built with brick units and mortar. Behaviour of masonry greatly depends on the characteristics of masonry units, mortar and the bond between them. Bond strength is dependent on many interrelated factors that can directly affect bond development or indirectly affect bond strength. The resistance of masonry to tensile or shear loads depends on the bond between mortar and masonry units.

The bond between brick and mortar plays an important role in the ability of masonry to resist loads. One of the most important properties of mortar is bond strength, and it is critical that this bond be complete, strong, and durable. This paper presents an outcome of a study conducted on shear bond strength of masonry. It was also investigated to develop a possible relationship between shear and tensile bond strength. An experimental program was conducted to determine the impact of bond strength on compressive strength of masonry. Bond shear strength was determined by testing brick triplets and shear bond strength by testing triplets as recommended in relevant standards.

Since the bagasse ash has the pozzolanic property it can be used as cementitious material. The bond strength of masonry may increase by partially replacing of cement bagasse ash as compared to bond strength of conventional masonry. The deformation characteristics of individual brick and mortar can be determined and found to be different due to the composite action between the brick and mortar joint. The outcome of this research will have a higher benefit to the construction industry where masonry structures form a substantial portion.

Index Terms **– Brick Masonry, pozzolanic, Triplet.**

1. INTRODUCTION

In the history of construction, brick masonry contributes the major portion in the development of eminent historical masonry structures. Since it was most economical and sustainable method of construction gained more importance and started emerging everywhere. Brick Masonry is a material built with brick units and mortar.

Brick masonry is the most used masonry and it is a conventional type. Brick masonry is very good at taking compressive load but very weak in taking lateral loads

But many ancient masonry structures failed due to their inadequate design against structural durability and strength. This facilitates the importance to study on the brick masonry in order to predict their behaviour and properties. Many researches have been carried out in the past to stipulate the nature of brick masonry and their constituent materials under different circumstances. Further research in this field is necessary to understand their heterogeneous material properties and to gain an in-depth knowledge about their behaviour.

The strength of masonry structure mainly depends on the strength of bonding between the bricks. Interface between the mortar and brick plays a vital role in enhancing the strength of masonry. Hence, the interface behaviour of masonry is also discussed in this paper. Further studies are also proposed to identify the interface model and bond-slip relation of brick triplet prism for different mortar ratio based on the experimental results which is useful for numerical studies on brick masonry. The bond between the mortar and the masonry units is one of the most important properties of masonry construction, particularly when it is load bearing such as in low-rise buildings. Poor bond and low bond strength are a major weakness of brickwork. The function of mortar in masonry wall is to bind the individual bricks or blocks together to form a single element to resist the movement and stress; and (in external walls) provide as a weather proof barrier.

2. Materials Used

a. CEMENT

Ordinary Portland cement of 53 grade is used in our experimentation. It has been tested as per Indian standard specification IS: 1489 PART-1 1991. The cement mortar is prepared using this OPC and fine aggregate with suitable water-cement ratio which is further used to cast triplet brick prisms.

b. FINE AGGREGATE

M Sand is used for experimental program. It has been tested as per Indian standard specification IS: 383-1970.

c. BRICKS

The bricks used in the research are the handmade burnt clay bricks of uniform shape and size. The dimension of the bricks is measured using measuring scale. The average dimension was found to be 210mmx105mmx75mm. The quality of brick is ensured by its appearance and the good bricks are selected from the brick stack as per the requirements.

d. BAGASSE ASH

The sugarcane bagasse ash was collected during the cleaning operation of boiler operating in the sugar factory, located in Koppa, Mandya District, Karnataka.

Figure 1.1: Bagasse Ash

Table 2.1 Chemical Composition of Bagasse Ash

Composition Property	Bagasse Ash
SiO_2	87.40
Al_2O_3	3.60
Fe_2O_3	4.90
CaO	2.56
MgO	0.69
Na_2O	0.15
K_2O	0.47
SO_3	0.11
LOI	8.25

3. Methodology

Following methodology was adopted

- Materials were procured for the study such as Cement, Bagasse Ash, M-Sand and Bricks of good quality
- Material characterizations was done by conducting the tests on each material.
- Totally 24 brick triplets were prepared for different mix proportions (i.e. 1:4 & 1:6) with 0%, 10%, 20% and 30% replacement of cement by Bagasse Ash.

- Bond shear strength was determined by testing the brick triplets in compression Testing Machine.

4. Test on brick triplets

4.1 Preparation of a brick triplet

- Brick triplets were prepared using three burnt clay bricks for different mortar proportion of 1:4 and 1:6.
- The partial replacement of bagasse ash in place of cement were done in the percentages of 10%, 20%, and 30% for both 1:4 and 1:6 ratio of cement mortar.


Fig 2.1 Preparation of a brick triplet

4.2 Curing of brick triplets

- Curing of the brick triplet were done by using wet gunny bags.
- Curing of brick triplets were done for 28 days.


Fig 2.2 Curing of brick triplets **Fig 2.3 Covering of brick triplet with gunny bag**

4.3 Test on brick triplet

- After curing the brick triplets for 28 days, it is placed in compression testing machine as shown in figure 2.3.
- The top and bottom of the triplet is made level using the fine sand, so that the load is distributed uniformly on the top capping of brick triplet.
- The load is applied at the minimum pace rate.
  When the load is applied on top capping of the triplet the shearing action will take place along the bond between brick and mortar.
- Note down the ultimate load and failure pattern when triplets fail.
- Find out the bond strength by using the formula given below.

Fig 2.3 Experimental set up for Shear Testing

4. Modes of Failure

There are three modes of failure:

I. Bond failure.
When compressive strength of mortar is less than the compressive strength of brick, the bond failure takes place. Usually it is observed in 1:6 mortar proportion as shown in fig 3.1

II. Brick failure.
When compressive strength of brick is less than the compressive strength of mortar, then the failure of brick takes place as shown in fig 3.2. It is usually observed in 1:4 mortar proportion.

III. Partial bond and partial brick failure.
When compressive strength of brick is less than the compressive strength of mortar, then the failure of brick takes place, it is usually observed in 1:4 mortar proportion.

Fig 3.1 Bond failure.

Fig 3.2 Brick failure

Fig 3.3 Partial bond and partial brick failure.

5. Results

- The Bond shear strength results of 1:4 proportion Brick triplet after 28 days curing are tabulated in table 4.1.

Table 4.1 Bond Shear Strength of Brick Masonry Triplet of 1:4 Proportion

% replacement of Cement by Bagasse ash	Average Bond Strength (1:4 proportion) Mpa	Modes of Failure
0%	0.130	Partial brick & bond failure
10%	0.180	Partial brick & bond failure
20%`	0.201	Brick failure
30%	0.150	Bond failure

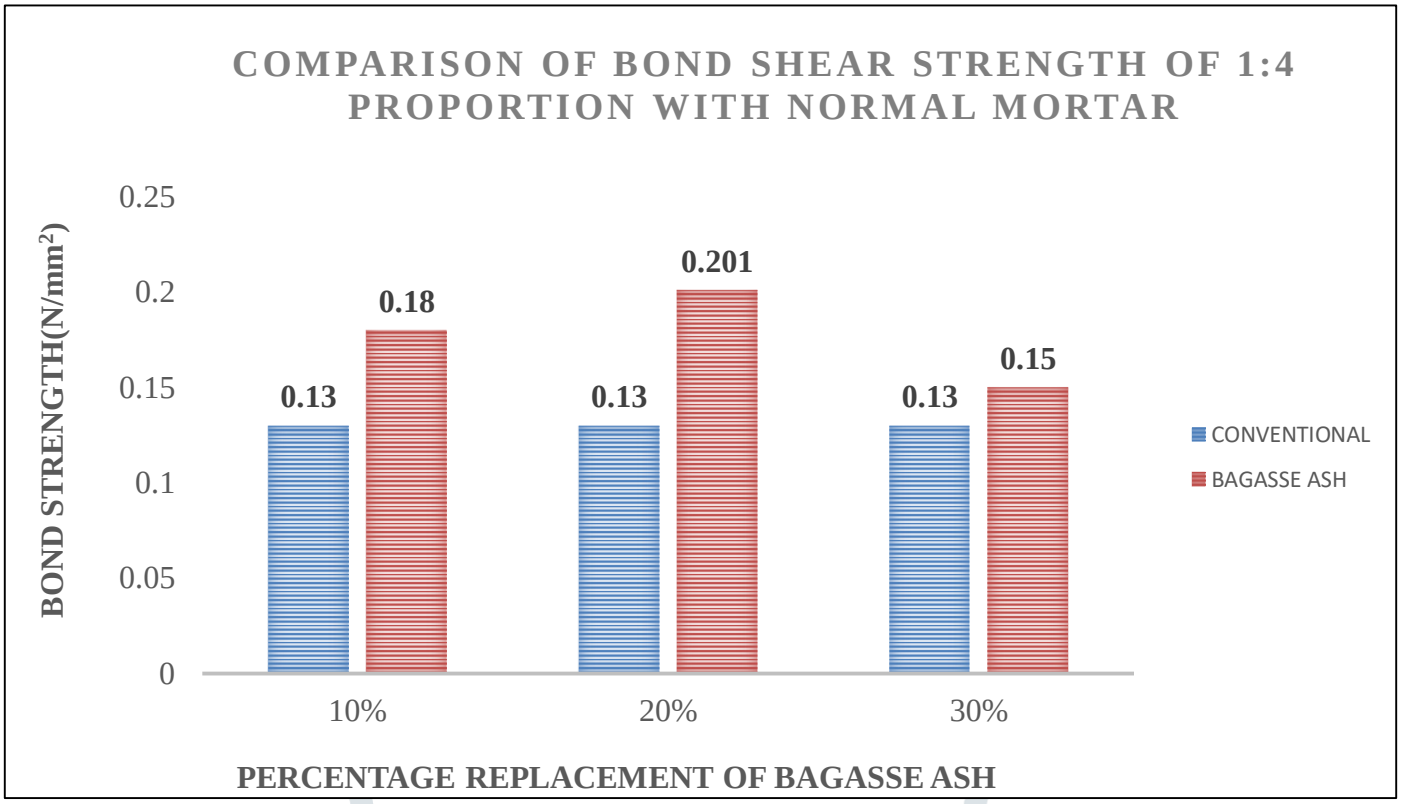

Fig 4.1 Comparison of Bond Shear Strength of 1:4 Mortar Proportion with conventional mortar and different Percentage Replacement of bagasse ash after 28 days of curing

- The Bond shear strength results of 1:6 proportion Brick triplet prism of 28th day are tested and results are represented graphically as shown in table 4.2

Table 4.2 Bond Shear Strength of Brick Masonry Triplet of 1:6 Proportion

% replacement of Cement by Bagasse ash	Average Bond Strength (1:6 proportion) Mpa	Modes of Failure
0%	0.101	Partial brick & bond failure
10%	0.139	Partial brick & bond failure
20%`	0.170	Brick failure
30%	0.1	Bond failure

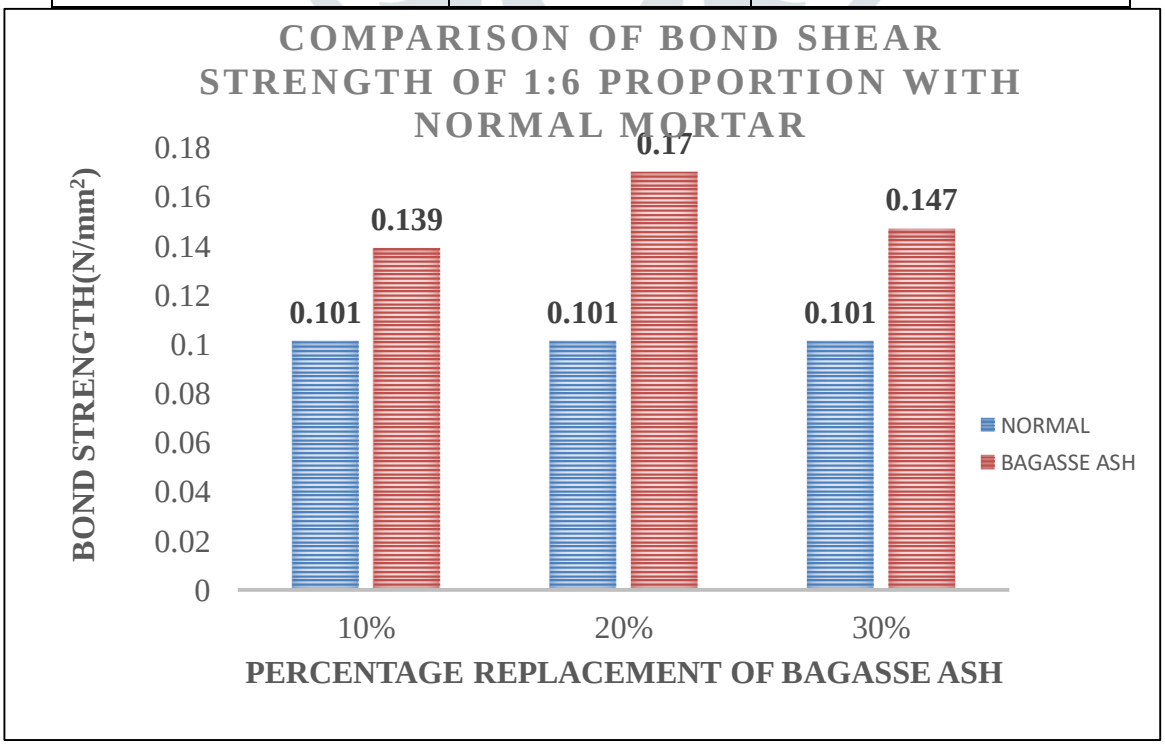

Fig 4.2 Comparison of Bond Shear Strength of 1:6 Mortar Proportion with conventional mortar and different Percentage Replacement of bagasse ash after 28 days of curing

- The comparison Bond shear strength results of 1:4 proportion and 1:6 Brick triplet prism of 28th day are tested and results are tabulated as shown in table 4.4

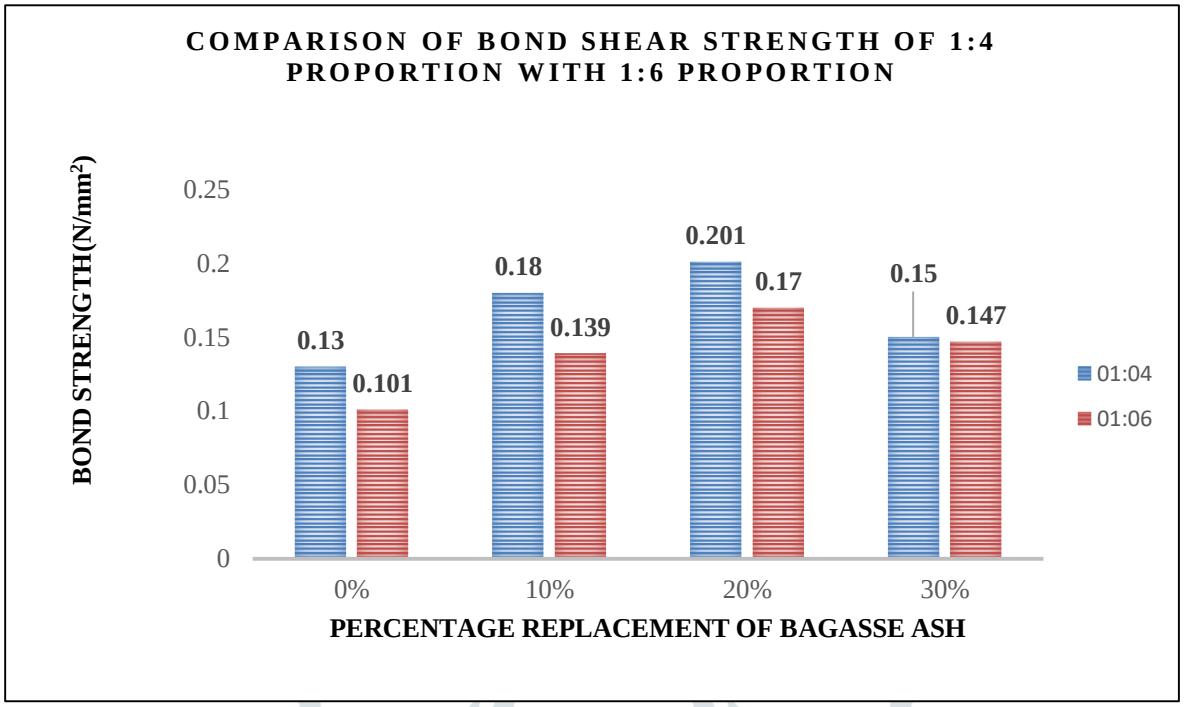

Fig. 4.3 Comparison of Bond Shear Strength of 1:4 Proportion with 1:6 Proportion Percentage Replacement of bagasse ash after 28 days

6. Discussions

- From the results tabulated above, it is observed the partial replacement of bagasse ash in place of cement acts as a cementitious material which intern increases the bond strength.
- From fig 4.1, it is observed that for 1:4 cement mortar, the bond strength of brick triplet with replacement of bagasse ash had increased 1.38 times for 10% replacement, 1.55 times for 20% replacement, 1.15 times for 30% replacement when compared to conventional brick triplet.
- Similarly From fig 4.2, it is observed that for 1:6 cement mortar, the bond strength of brick triplet with replacement of bagasse ash had increased 1.37 times for 10% replacement, 1.68 times for 20% replacement, 1.45 times for 30% replacement when compared to conventional brick triplet.

7. CONCLUSIONS

- The result obtained from basic material testing are within the limit and satisfactory.
- The bond strength of the 1:4 cement mortar proportion is increased by 38.46% for 10% replacement of bagasse ash, 54.61% for 20% replacement of bagasse ash, 15.38% for 30% of replacement of bagasse ash.
- The bond strength of the 1:6 cement mortar proportion is increased by 37.62% for 10% replacement of bagasse ash, 68.31% for 20% replacement of bagasse ash, 45.54% for 30% of replacement of bagasse ash.
- By observing the above results, we can conclude that up to 20% of bagasse ash can be replaced to cement to obtain the desired bond strength and further increase in percentage of bagasse ash the bond strength decreased.

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