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An Experimental Study on the Strength Properties of Geopolymer Bricks

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Abstract- This paper presents the experimental investigation by partial replacement of fly ash by GGBS on geopolymer bricks. The bricks were of a standard size of 190 mm x 90 mm x 90 mm. In this investigation, a geopolymer brick was prepared by the partial replacement of fly ash by GGBS (50:50), fine aggregates, and six molar concentrations of sodium hydroxide and sodium silicate (Na_2SiO_3) solution were used as an alkaline solution with a mass ratio of Na_2SiO_3/NaOH of 2.5. The geopolymer bricks were kept open to the atmosphere for 24 hours. The geopolymer brick specimen was tested for water absorption and compressive strength. The strength of the masonry depends on the strength of the component of the masonry such as bricks and cement mortar. Triplet shear bond and Single shear bond strengths was calculated. The test results showed that the compressive strength increases with 100% replacement of GGBS with fly ash. Since the minimum compressive strength of brick is limited to 3.5 N /mm^2, a 50% replacement of GGBS with fly ash was studied for all the tests.

Keywords: *alkali solution, fly ash, GGBS, geo-polymer, sodium hydroxide, sodium silicate.*

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Abstract- This paper presents the experimental investigation by partial replacement of fly ash by GGBS on geopolymer bricks. The bricks were of a standard size of 190 mm x 90 mm x 90 mm. In this investigation, a geopolymer brick was prepared by the partial replacement of fly ash by GGBS (50:50), fine aggregates, and six molar concentrations of sodium hydroxide and sodium silicate (Na_2SiO_3) solution were used as an alkaline solution with a mass ratio of Na_2SiO_3/NaOH of 2.5. The geopolymer bricks were kept open to the atmosphere for 24 hours. The geopolymer brick specimen was tested for water absorption and compressive strength. The strength of the masonry depends on the strength of the component of the masonry such as bricks and cement mortar. Triplet shear bond and Single shear bond strengths was calculated. The test results showed that the compressive strength increases with 100% replacement of GGBS with fly ash. Since the minimum compressive strength of brick is limited to 3.5 N /mm^2, a 50% replacement of GGBS with fly ash was studied for all the tests.

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I. Introduction

Masonry is constructed with bricks and mortar. Masonry walls are cheap, and have good sound and insulation properties. The surface characteristics of the brick may not influence the bond between the bricks. Venumadhava Rao et al. 1995 made a preliminary study on the influence of bond strength on the compressive strength of masonry. Goodwin and West (1992) McGinley (1990) suggested that both the mortar quality and the surface absorption criteria of the masonry unit are the most significant parameters in developing good bond strength.

II. Objectives

This experimental study has aimed at following objectives

- To produce Geopolymer bricks with partial replacement of Fly ash by GGBS (50:50)
- To determine the percentage of water absorption and compressive strength of Geopolymer bricks (Fly ash to GGBS, 50:50) and compared with the locally available burnt clay bricks.
- To determine Triplet shear and shear bond strength of Geopolymer bricks (Fly ash to GGBS, 50:50) and compared with the locally available burnt clay bricks.

III. Methodology

- Geopolymer bricks were prepared with partial replacement of Fly ash by GGBS varying from 0 to 100%.
- Compressive strength was determined for all replacement for Fly ash - GGBS (50:50). The minimum compressive strength of burnt clay bricks (3.5 N / mm^2) was taken as the base for further tests.
- The water absorption test is carried out for burnt clay and Geopolymer bricks Fly ash- GGBS (50:50).
- Triplet shear and Shear bond strength is carried out for burnt clay and Geopolymer bricks, Fly ash by GGBS (50:50).

IV. Material Properties

Clay bricks and a Geopolymer fly ash brick partially replaced by GGBS was used to study the strength properties of the masonry unit. The compressive strength of burnt clay brick and Geopolymer bricks (varying percentage of GGBS replaced to fly ash), are being presented in Table 1 & 2, The water absorption of burnt clay brick and Geopolymer bricks (Fly ash: GGBS, 50:50) are shown in Table 3 & 4. Comparison of water absorption of burnt clay bricks and Geo-polymer bricks (Fly ash: GGBS, 50:50) are shown in Fig 1, Triplet shear bond strength with 1:6 cement mortar of burnt clay brick and Geopolymer bricks (Fly ash: GGBS, 50:50) are tabulated in Table 5 & 6, Comparison of triplet shear bond strength of burnt clay bricks are shown in Fig 2 and Shear bond strength with 1:6 cement mortar of burnt clay brick and Geopolymer bricks (Fly ash: GGBS, 50:50) are being presented in Table 7 & 8. Comparison of Shear bond strength of burnt clay bricks and Geopolymer bricks (Fly ash: GGBS, 50:50) are revealed in Fig 3.

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V. Tables and Figures

Table 1: Compressive strength- Burnt clay bricks

Sl. No.	Size of burnt clay bricks (mm)	Area (mm^2)	Load (KN)	Compressive strength (N / mm^2)	Average compressive Strength (N/mm^2)
1	(220 x 100 x 75)	22000	112	5.09	5.25
2			126	5.72	
3			098	4.45	
4			126	5.73	
5			116	5.27	

Table 2: Compressive strength- Geopolymer bricks (Fly ash: GGBS, 50:50)

Sl. No.	Fly ash: GGBS	Average compressive strength (N / mm^2)
1	100 : 00	00.87
2	90 : 10	01.35
3	80 : 20	02.04
4	70 : 30	02.45
5	60 : 40	03.50
6	50 : 50	03.97
7	40 : 60	04.50
8	30 : 70	04.93
9	20 : 80	06.04
10	10 : 90	06.60
11	0 : 100	07.45

Table 3: Water absorption test - Burnt clay bricks

Sl. No.	Dry weight (Kg)	Wet weight (Kg)	Water absorption (%)	Avg. water absorption (%)
1	3.48	3.15	10.47	9.69
2	3.43	3.11	10.28	
3	3.40	3.12	08.97	
4	3.45	3.15	09.52	
5	3.41	3.12	09.23	

Table 4: Water absorption test - Geopolymer bricks (Fly ash: GGBS, 50:50)

Sl. No.	Dry weight (Kg)	Wet weight (Kg)	Water absorption (%)	Avg. water absorption (%)
1	3.01	3.28	8.97	9.11
2	3.00	3.24	9.66	
3	2.96	3.24	9.66	
4	3.02	3.32	9.93	
5	2.97	3.26	8.89	

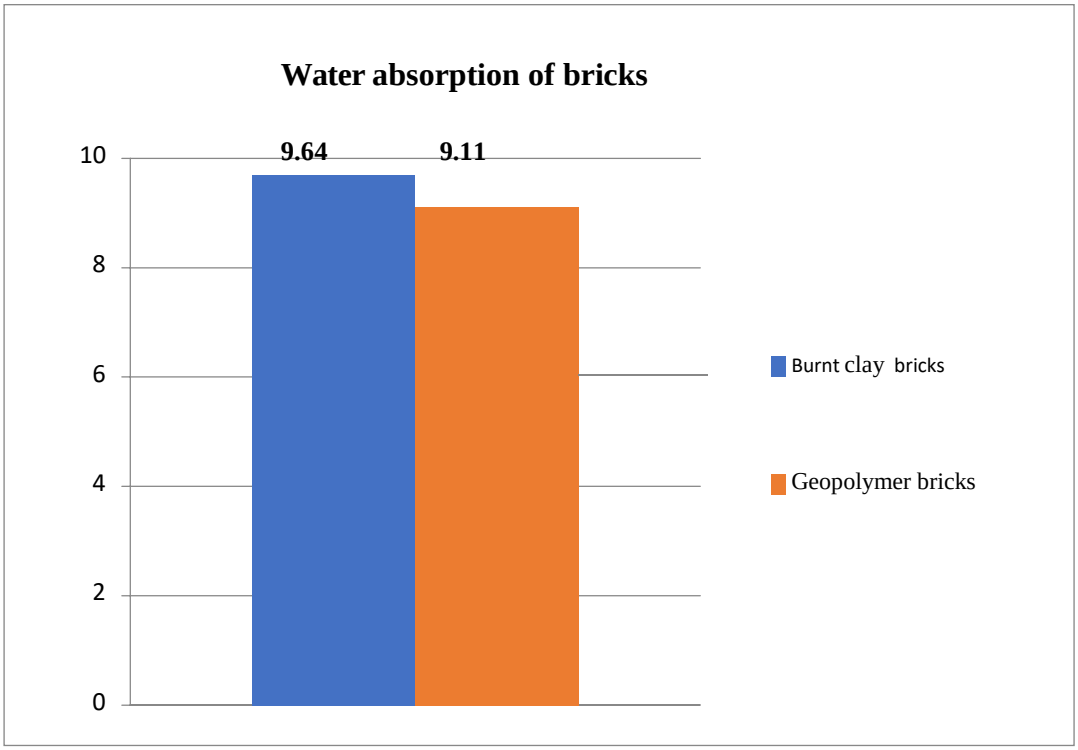

Fig. 1: Comparison of water absorption of burnt clay bricks and Geo-polymer bricks (Fly ash:GGBS, 50:50)

Table 5: Triplet shear bond strength – Burnt clay bricks

Sl. No.	Load (KN)	Size of brick (mm)	Area of brick (mm^2)	Shear bond strength	Avg. shear bond strength (N/mm^2)
1	2.80	(220 x 100 x 75)	22000	0.063	0.064
2	3.00			0.068	
3	2.90			0.065	
4	2.80			0.063	
5	2.79			0.063	

Table 6: Triplet shear bond strength of Geopolymer bricks (Fly ash: GGBS, 50:50)

Sl. No.	Load (KN)	Size of brick (mm)	Area of brick (mm^2)	Shear bond strength	Avg. shear bond strength (N/mm^2)
1	3.8	(220 x 100 x 75)	22000	0.172	0.168
2	3.7			0.168	
3	3.6			0.163	
4	3.7			0.168	
5	3.8			0.172	

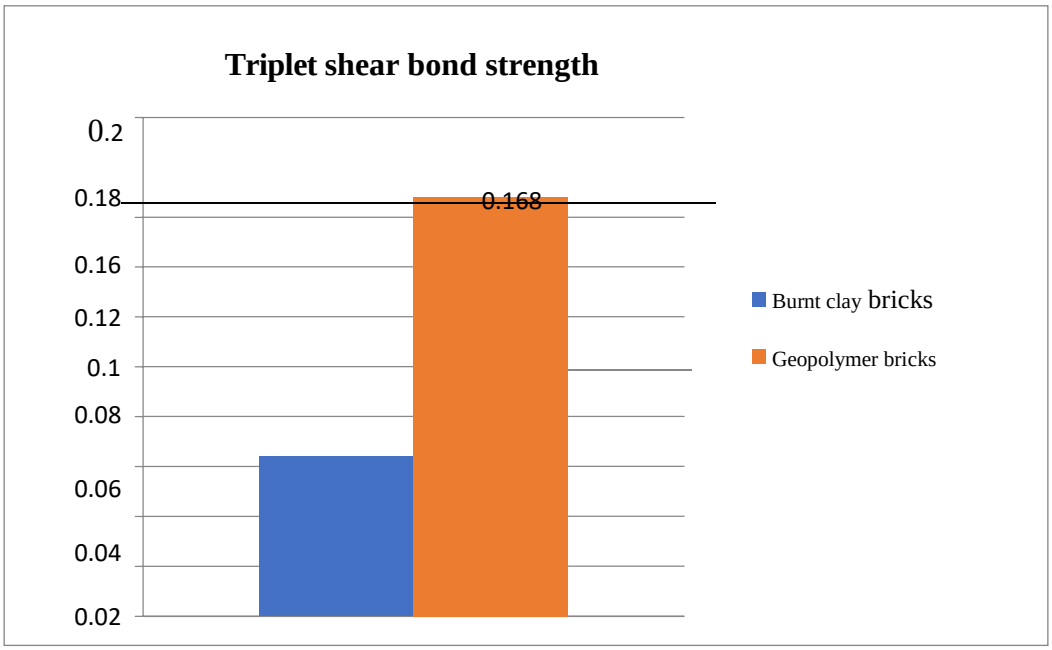

Fig. 2: Comparison of Triplet shear bond strength of Burnt clay bricks and Geo-polymer bricks (Fly ash: GGBS, 50:50)

Table 7: Shear bond strength – Burnt clay bricks

Sl. No.	Load (KN)	Size of brick (mm)	Area of brick (mm^2)	Shear bond strength	Avg. shear bond strength (N/mm^2)
1	0.8	(220 x 100 x 75)	22000	0.106	0.114
2	0.8			0.106	
3	0.9			0.120	
4	0.9			0.120	
5	0.9			0.120	

Table 8: Shear bond strength of Geopolymer bricks (Fly ash: GGBS, 50:50)

Sl. No.	Load (KN)	Size of brick (mm)	Area of brick (mm^2)	Shear bond strength	Avg. shear bond strength (N/mm^2)
1	3.8	(220 x 100 x 75)	22000	0.222	0.217
2	3.7			0.216	
3	3.6			0.210	
4	3.7			0.216	
5	3.8			0.222	

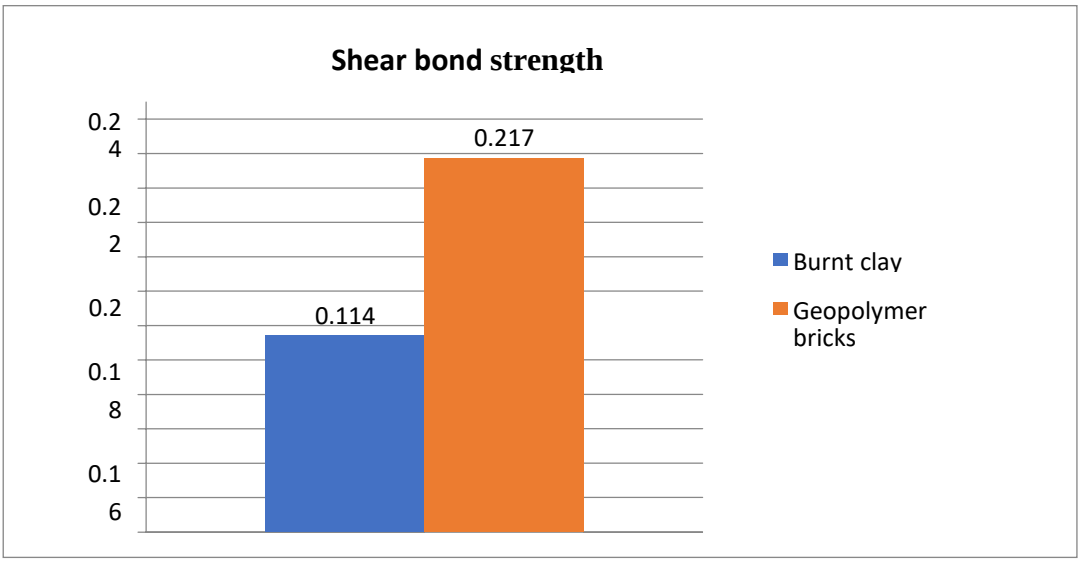

Fig. 3: Comparison of Single shear bond strength of Burnt clay bricks and Geo-polymer bricks (Fly ash: GGBS, 50:50)

VI. Conclusions

- It was observed that the compressive strength of Geopolymer bricks with partial replacement of Fly ash with GGBS increases up to 100%. The compressive strength of burnt clay brick is 3.5 N/ mm^2; the substitute of fly ash to GGBS is (50:50).
- It was observed that the percentage of water absorption of Geopolymer bricks is 5.90% less than the ordinary burnt clay bricks.
- It was observed that the triplet shear bond strength, with 1:6 cement mortar, strength of Geopolymer bricks was 62% greater than ordinary burnt clay bricks.
- It was observed that the shear bond strength with 1:6 cement mortar, Geopolymer bricks are 48% greater than ordinary burnt clay bricks.
- Incorporation of GGBS as partial replacement to Fly ash in the preparation of Geopolymer bricks resulted in the reaction of pozzolana with calcium hydrate which produced calcium silicate hydrate, thus enhancing the compressive strength and shear bond strength of the brick masonry with the modification of the microstructure of the mortar – brick unit interface.

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