DURABILITY STUDIES ON COAL RESIDUE AND SUGARCANE RESIDUE BASED GEOPOLYMER BRICKS

G.Saravanan

Assistant Professor, Government college of Engineering, Bargur-635104

Abstract: This study elucidates the alkali activation of bagasse ash blended class - F fly ash. This concept of geopolymer concrete was derived from the motive of utilizing the waste material or by product from the sugarcane industry called bagasse ash. This material is available in abundance in India and faces disposal issues. The current study blends the class F fly ash with bagasse ash for different proportions and investigates their effectiveness for alkali activation; and their effect on fresh and hardened properties. The study revealed that blending of bagasse ash results in reduction in flow properties and compressive strength. The partial replacement of cement by Fly Ash (FA) and Bagasse Ash (BA) in combine proportion started from 90%, FA and 10%, (BA) and the design mix ratio 1:1.3 was adopted. The durability study was extended from Fly ash and Bagasse based geopolymer concrete and the Molar concentrations are 5M, 10M and 12M.

1. GEOPOLYMER BRICKS

The fundamentals of brick manufacturing have not changed over time. However, technological advancements have made contemporary brick plants substantially more efficient and have improved the overall quality of the products. A more complete knowledge of raw materials and their properties, better control of firing, improved kiln designs and more advanced mechanization have all contributed to advancing the brick industry.

1.1 Preparation of specimen

The solid constituents of the fly ash and bagasse ash based geopolymer mortar, i.e. the fine aggregates and the fly ash & bagasse ash, were dry mixed in the pan mixer for about three minutes. The alkali-activator solution (i.e. liquid sodium silicate and sodium hydroxide which are premixed), is added to the solids. The wet mixing usually continued for another five minutes. The fresh fly ash and bagasse ash based geopolymer mortar was blackish white in colour and shiny in appearance. The mixtures were usually cohesive. The geopolymer mix is prepared in 1:1.3 ratio and Alkali – Activator Solution (AAS) to Fly ash (FA) ratio utilized was 0.40.

1.2 Steam Curing of Fly ash and Bagasse ash based Geopolymer Bricks

Fly ash and bagasse ash based Geopolymer bricks were prepared, tested and compared with country bricks. The compressive strength of geopolymer mortar cubes is influenced (1) by the wet-mixing time. The size of the bricks cast was 230 x 110 x70 mm and were steam-cured at 60^0C for 24 hours (Fig. 1). Totally 100 bricks were cast for 1: 1.3 ratios, with 10 and 12 molarities. Later, bricks with 5M were added as the strength of 10M and 12M bricks are very high.

Fig.1 Steam curing of Geopolymer Bricks

2. STRENGTH TESTS ON BRICKS

Strength tests such as compressive strength, tensile strength and flexural strength were conducted on geopoloymer bricks. For comparison purpose, the commercially available country bricks and fly ash bricks of same size were also tested. The test specimens were kept in chamber and steam-cured at 60^0C for 24 hours and allowed the rest period for 3 days.

2.1 Test Procedure

The compressive strength of country bricks, fly ash bricks and fly ash & bagasse ash based geopolymer bricks with 12M, 10M and 5M is presented in Table 1. The compressive strength of geopolymer bricks is more when compared to other types of commercial bricks.

Table 1 Compressive Strength of different types of bricks

Sl. No.	Type of Brick		Density kg/m^3	Average compressive strength (MPa)
1.	Country Bricks		1562.5	10.2
2.	Fly ash Bricks		1496.8	12.8
3.	Geopolymer Bricks	12 M	1918.0	13.4
		10 M	1875.0	14.5
		5 M	1871.3	15.6

The comparison of flexural strength of country bricks, fly ash bricks and flyash and bagasse ash based geopolymer bricks with 6M is presented in Table 2.

The 5M geopolymer brick gives better result than other types of bricks.

Table 2 Flexural Strength of different types of bricks

Sl. No.	Type of Brick		Average flexural strength (MPa)
1.	Country Bricks		10.6
2.	Fly ash Bricks		12.5
3.	Fly ash and Bagasse ash based Geopolymer Bricks	12 M	13.6
		10 M	14.2
		5 M	15.8

The comparison of compressive and flexural strength of country bricks, fly ash bricks and geopolymer bricks with 5M is presented in Table 3. The 5M fly ash and bagasse ash based geopolymer bricks gives better result than other types of bricks.

Table 3 Strength test results of different types of Bricks-a comparison

Sl.No.	Type of Test conducted	Country Brick	Fly ash Brick	Flyash and Bagasse ash based Geopolymer Brick (5M)
1.	Compressive strength (MPa)	10.2	12.8	15.6
3.	Flexural strength (MPa)	10.6	12.5	15.8

The comparison of compressive strength of country bricks, fly ash bricks and geopolymer bricks is presented in Fig.2. The compressive strength of geopolymer bricks is more than fly ash bricks and country bricks.

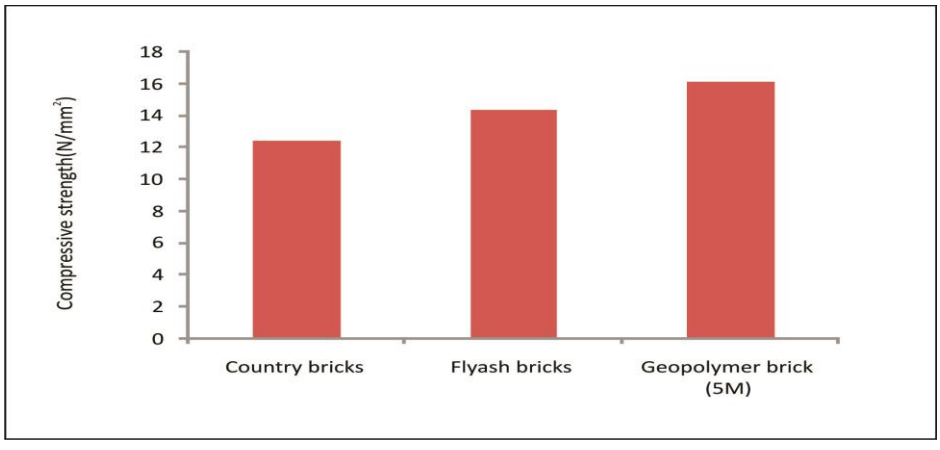

Fig. 2 Compressive Strength of different types of Bricks

The comparison of the flexural strength of geopolymer bricks, fly ash bricks and country bricks are presented in Fig.3. Flexural strength results of the geopolymer bricks are much better than other types of bricks.

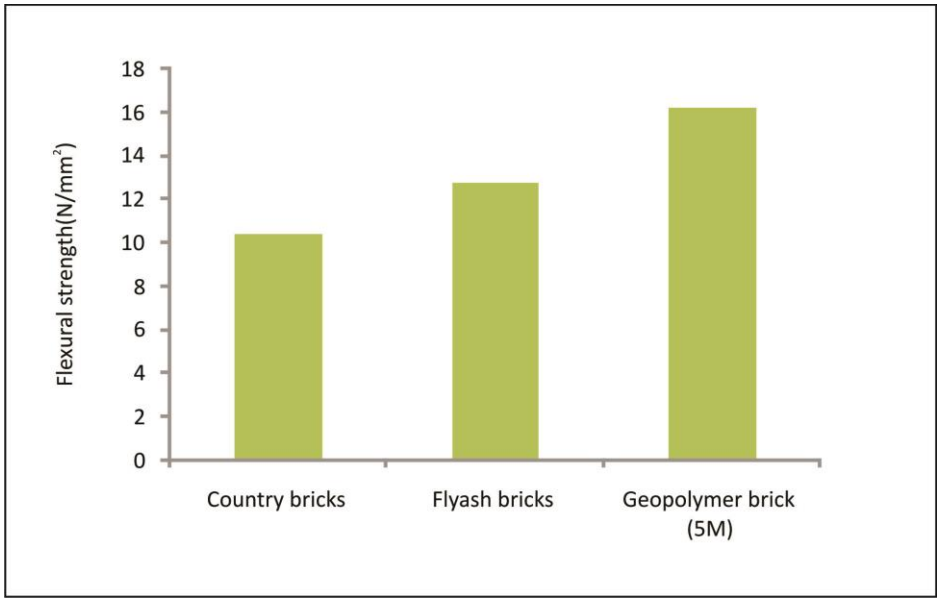

Fig. 3 Flexural Strength of different types of Bricks

3. WATER ABSORPTION TEST ON BRICKS

To study the character of Fly ash and Bagasse ash based geopolymer bricks, the cast specimens are subjected to water absorption test. After the curing period is completed, the specimens are immersed in the water tank (3) and kept 24 hours in water (Fig.4). The weight of the specimen was noted.

Fig. 4 Different types of Bricks immersed in water

The specimen was placed in an oven at 105°C temperature, and then the weight of the specimen was recorded. From these two values, the water absorbed by the entire specimen was calculated using Eqn.4.1 and presented in Table 4.

Table 4 Water absorption of different types of bricks

Sl. No.	Type of Brick		Percentage increase in weight
1	Country Bricks		10.8
2	Fly ash Bricks		6.4
3	Flyash and Bagasse ash based Geopolymer Bricks	10 M	1.4
		12 M	1.6
		5 M	1.8

When compared with country and fly ash bricks, geopolymer bricks absorbed only 1.8 percent of water and it should be appreciable for non-porous structures. The flyash and bagasee ash based geopolymer bricks gives ringing sound while clashing with each other and has resistivity against nail scratching and there is no powder formation. When it is dropped from one meter height it does not break. Thus the fly ash and bagasse ash based geopolymer bricks (4) satisfies all the requirements. The water absorption of fly ash and bagasse ash based geopolymer bricks, fly ash bricks and country bricks is presented in
Fig. 5.

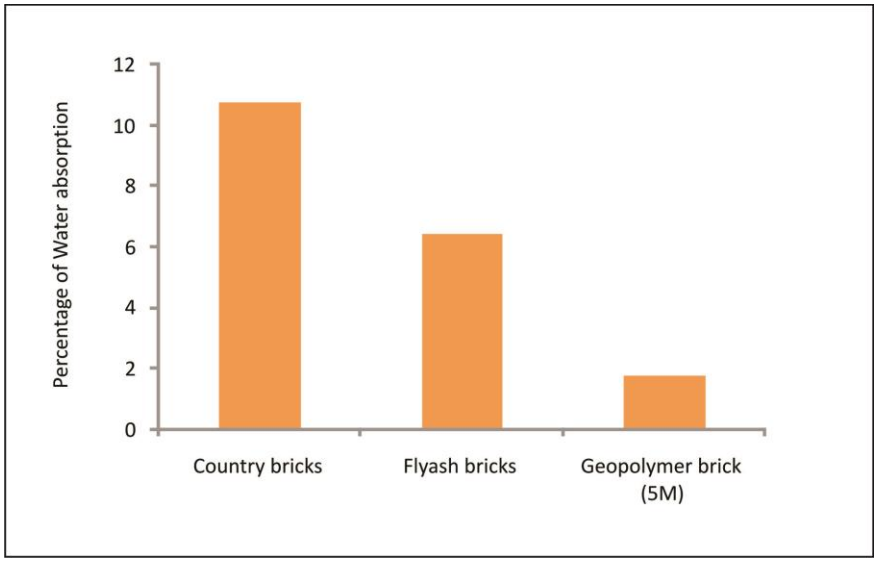

Fig. 5 Water Absorption Test

3. ACID RESISTANCE TEST ON BRICKS

As Fly ash and Bagasse ash based geopolymer bricks (5M) is considered to be alkali resistive in nature, acid resistance tests were conducted for various concentrations of HCl and H_2SO_4, the percentage of solution prepared using 1 percent, 2 percent and 3 percent of diluted acids were used. The bricks are immersed in acids as shown in Fig. 6.

Fig.6 Different types of Bricks immersed in acids

The test results have been tabulated in Table 5. The results reveal that geopolymer brick was found to be good alkali resistive in nature.

Table 5. Acid resistance test results of different types of bricks (H_2SO_4)

Sl.No.	Types of Bricks	Percentage of decrease in weight after 24 hours of immersion (H_2SO_4)		
		1percent	2percent	3percent
1.	Country bricks	2.7	2.9	3.4
2.	Fly ash bricks	1.1	2.7	2.6
3.	Flyash and Bagasse ash based Geopolymer Bricks	0.1	0.3	0.4

The geopolymer bricks specimens were immersed in 1 percent, 2 percent and 3 percent H_2SO_4 solution and the percentage of decrease in weight is shown in Fig.7. The rate of penetration into geopolymer bricks specimens (5) was less than other bricks specimens.

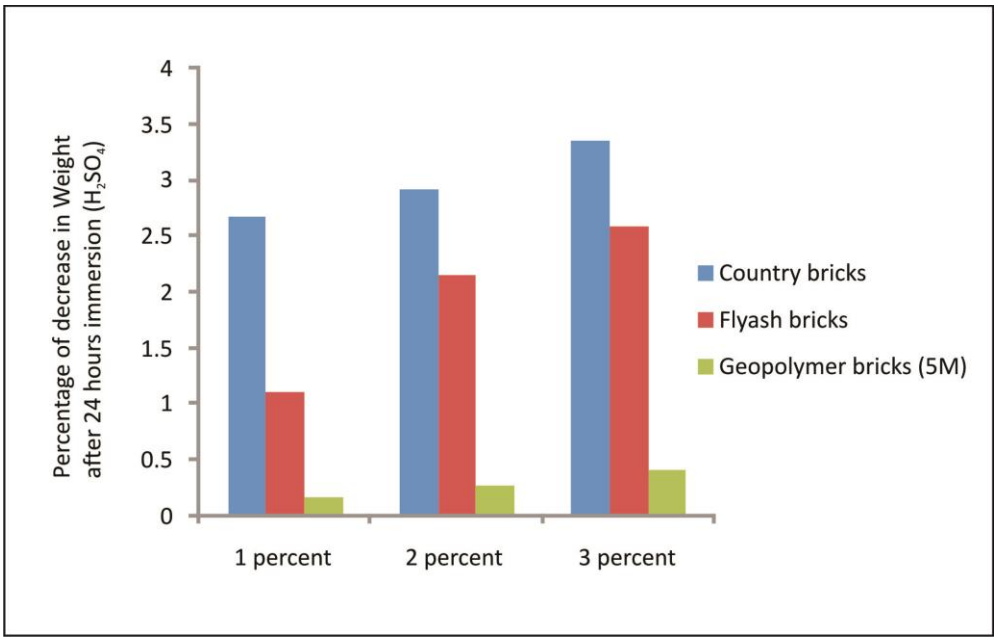

Fig.7 Bricks immersed in H_2SO_4 solution

The Fly ash and Bagasse ash based geopolymer bricks specimens were immersed in 1 percent, 2 percent and 3 percent HCl solution and the percentage of decrease in weight is shown in Fig.8. The rate of penetration into geopolymer bricks specimens was less than other bricks specimens.

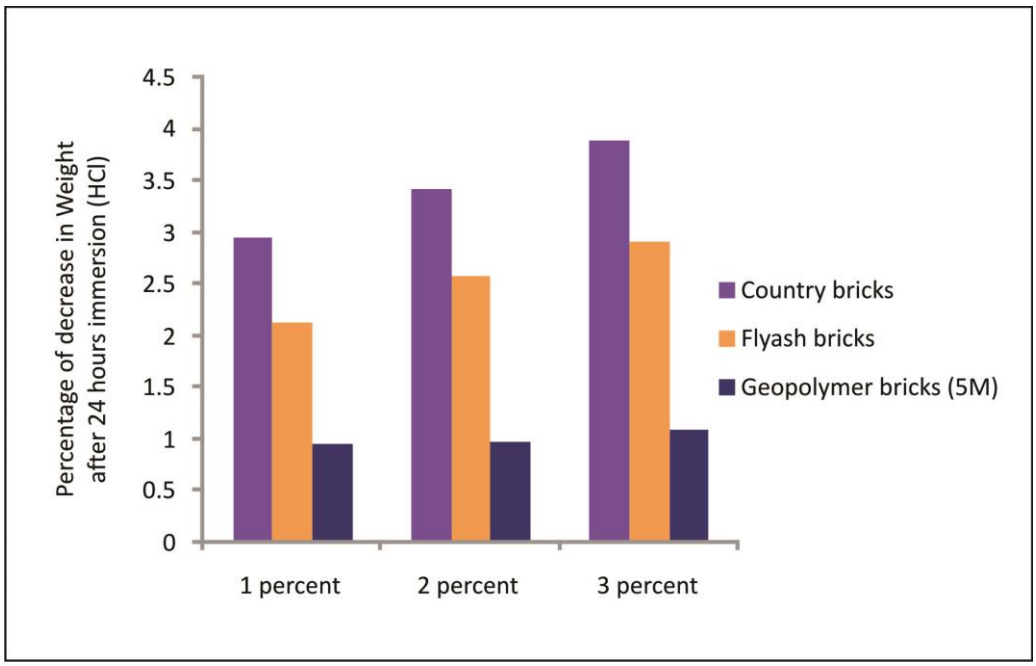

Fig. 8 Acid Resistance Test (HCl)

Table 6 reveals a comparison of the strength of the country bricks, fly ash bricks and 5 mole fly ash and bagasse ash based geopolymer bricks. Based on the obtained average results, 5M fly ash and bagasse ash based geopolymer bricks have more compressive strength and it satisfies the durability requirements when compared with all other commercial bricks.

Table 6 Acid resistance test results of different types of bricks (HCl)

Sl.No.	Types of Bricks	Percentage of decrease in weight after 24 hours of immersion (HCl)		
		1percent	2percent	3percent
1.	Country bricks	2.96	3.43	3.89
2.	Fly ash bricks	2.13	2.58	2.91
3.	Flyash and Bagasse ash based Geopolymer Bricks (5M)	0.95	0.98	1.09

5. CONCLUSIONS

Fly ash and Bagasse ash based Geopolymer bricks were prepared, tested and compared with fly ash bricks and country bricks. From the experimental results it is found that the compressive and flexural strength of the Fly ash and Bagasse ash based geopolymer bricks are much better than other types of bricks. The durability properties of Fly ash and Bagasse ash based geopolymer bricks is also very good when compared to that of other types of bricks.

REFERENCES

1. Anjan Chatterjee, K. Indian Fly Ashes: Their Characteristics and Potential for Mechanochemical Activation for Enhanced Usability, Journal of Materials in Civil Engineering, Vol. 23, No. 6, pp.783-788, 2011.

2. Anuradha, R., Sreevidya, V., Venkatasubramani, R. and Rangan, B.V. Modified guidelines for geopolymer concrete mix design using Indian standard, Asian Journal of Civil Engineering (Building and Housing) Vol. 13, No. 3, pp. 353-364, 2012.

3. Anurag Mishra, Deepika Choudhary, Namrata Jain and Manish, Effect of concentration of alkaline liquid and curing time on strength and water absorption of geopolymer concrete, ARPN Journal of Engineering and Applied Sciences, Vol. 3, No. 1, pp.14-18,2008

4. Bakharev, T. Geopolymeric materials prepared using Class F fly ash and elevated temperature curing, Cement and Concrete Research, Vol.35, pp.1224-1232, 2006.

5. Buchwald, A. and Schulz, M. Alkali-activated binders by use of industrial by - products, Cement Concrete Research, Vol. 35, pp. 968- 973, 2005.