PROPERTIES OF FAL-G MASONRY BLOCKS

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Abstract

Fly ash, Lime and gypsum are industrial wastes generated in millions of tones every year. Utilization of these materials is effective way of disposing the pollutants. In this research fly ash, lime, and gypsum were used in definite proportion along with quarry dust to produce FaL-G blocks. These blocks were tested for compressive strength, water absorption, IRA, density, flexure and modulus of elasticity. Masonry prisms were constructed using FaL-G blocks to determine shear bond strength, flexural bond strength, low rise masonry shear, modulus of elasticity, compressive strength and masonry efficiency. It was found that FaL-G masonry blocks can replace conventional masonry units.

Keywords: *Fly ash, Lime, Gypsum, FaL-G, Flexure bond strength, Shear bond strength and Masonry.*

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1. INTRODUCTION

Masonry is one of the oldest forms of construction. Combination of building units or materials like stone, brick, tiles, glass etc., with or without mortar forms masonry. Clay brick is one of the most popularly used masonry material. The clay available in river basins, water ponds and coastal areas is plastic in nature and suitable for proper moulding, drying and burning of bricks. But, soil that is less plastic or expansive, gritty or sandy cannot be used for brick manufacturing. In most of the central and south India, good quality soil for production of burnt clay brick is not available which result in higher cost of bricks due to transportation from long distances or use of low quality clay bricks manufactured with sub-standard clays. In such regions a substitute to burnt clay bricks is essential.

Chemical and agricultural industries are liberating large quantities of by-products every year. These materials have dual problems of disposal and health hazards. For example: fly ash from thermal power plants and phosphogypsum from fertilizer industries. With the more and more wastes being generated, the utilization of fly ash and phosphogypsum is important to save the environment from quick degradation [1, 2].

To replace conventional bricks and to safely dispose the toxic industrial wastes FaL-G is one among the best options available. FaL-G does not stand for any brand name; it only states the constituents [3, 4, 5, 6].

Current annual production of fly ash is 500 million tons worldwide. More than 160 million tons of fly ash is produced in India [7].For every 1 ton production of phosphoric acid 5 tons of phosphogypsum is produced. It has limited scope of utilization as building material. As per the recent records 280 million tons of phosphogypsum is produced every year [8, 9].Acetylene limes, lime sludge are by products of paper industry. Lime is also availed from mineral sources [10].

Strength development in lime pozzolanic reaction takes place in a slow pace in normal temperature conditions. Hence a long curing duration is required to achieve a meaningful strength. Thus there is a need to accelerate the reaction in this compact, which is achieved either by steam curing or by the addition of gypsum. [1, 5, 11,12,13].

2. MATERIALS AND METHODS

2.1 Procurement and Characterization of Materials

Fly ash was directly collected from the Raichur Thermal Power Plant (RTPS), India. Locally available commercial lime is used in the present investigation to obtain FaL-G composites. Gypsum was procured from a fertilizer company. The cement used in this investigation is ordinary Portland cement (OPC) of 53 grade as per IS 12269: 1987. Table 1 to 3 gives the physical and chemical properties of materials used. The values in these tables indicate that the fly ash samples conform to codal requirements as per IS 3812: 1981. Properties of lime show that it contains more than 90% of calcium oxide.

Table 1: Physical properties of materials

Materials	Specific gravity	Percentage particles (>45μ)	Surface area (m^2/kg)	Loss on ignition, (%)	Lime reactivity (MPa)	Bulk density (kg/m^3)
Fly ash	2.4	0.00	1134.1	0.9	8.2	-----
Lime	1.4	-----	-----	-----	-----	-----
Gypsum	1.2	-----	-----	-----	-----	-----
Cement	3.15	-----	1131.4	-----	-----	1865

Table 2: Chemical properties of fly ash

Chemical composition in percentage							
Al_2O_3	Fe_2O_3	SiO_2	MgO	SO_3	Na_2O	Total chlorides	CaO
31.23	1.50	61.12	0.75	0.53	1.35	0.06	3.20

Table 3: Chemical properties of lime, gypsum and cement

Materials	Chemical composition in percentage								
	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	CaO	Fe2O3	LoI
Lime	-----	1.23	0.56	1.23	-----	-----	94.3	0.2	-----
Gypsum	0.56	-----	0.56	0.86	1.23	53.2	34.6	0.05	8.9
Cement	1.50	2.32	6.95	16.3	1.67	1.99	60.8	5.38	-----

3. EXPERIMENTAL PROGRAMME

3.1 Methodology

Masonry units were cast using Fly ash, Lime and Gypsum as binder and quarry dust as aggregate. These units were tested for various properties like compressive strength, dry density, water absorption, Initial Rate of Absorption and Modulus of Elasticity at different ages. Two course masonry specimens were constructed to test for low rise masonry shear strength. FaL-G triplets were constructed and tested for bond shear strength. FaL-G masonry specimens were also constructed and tested for flexural bond strength. Masonry prisms were constructed using FaL-G masonry units and different types of mortar. These prisms were tested for masonry efficiency, compressive strength and modulus of elasticity. The results are recorded and detailed discussions are reported.

3.2 Preparation of FaL-G Blocks

FaL-G binder of proportion 50:40:10 and quarry dust (binder to aggregate ratio was 1:1) was dry mixed thoroughly, after which desired amount of water was added to the mix (water binder ratio was 0.2) and the binder was uniformly mixed such that there was no lump formation. Then this consistently mixed FaL-G binder was placed in mardini machine to prepare blocks.

The size of Mould is (190 X 230 X 100) mm. The machine is operated manually. The correct amount of wet mix is weighed which depends on the volume of finished block. The weighed mix is poured into the mardini and the lid is closed. It is pressed by operating the toggle lever and ejected by again using the lever. So formed block was carefully removed, after 24 hours of preparation of blocks these were wrapped thoroughly by gunny bag and small amount of water was sprinkled on the blocks twice a day, this was done for 28 days.

3.3 Testing of Blocks

Different tests were conducted on FaL-G blocks as per the procedure prescribed by the corresponding codes mentioned in Table 4, at different ages.

Table 4: Tests of FaL-G blocks and codes referred

Sl.no	Properties	Codes
1	Compressive strength	IS: 3495-1992
2	Water absorption	IS: 3495-1992
3	Initial Rate of Absorption (IRA)	ASTM C 67
5	Dry density	IS: 3495-1992
6	Flexure strength	-----
7	Modulus of elasticity	-----

3.4 Construction of Prisms

Three types of mortar were used to construct prisms:

1. Cement mortar of binder to aggregate ratio 1:6
2. FaL-G mortar of binder to aggregate ratio 1:1
3. Geopolymer mortar of binder to solution ratio 0.6

Cement mortar was prepared with cement as binder. FaL-G mix was used get FaL-G mortar. Clay based geopolymer mortar was also used as masonry mortar in this research. The preparation of masonry mortar was same in all the three cases except the ingredients used. Alkaline solution was prepared using Sodium hydroxide, Sodium silicate and water. Alkaline solution was added to the clay to get the masonry mortar of required consistency. The ratio of clay to alkali solution (molarity 14) was maintained at 0.6.

Details of tests conducted on masonry mortar were conforming to the codal provisions given in table 5. Masonry prisms were constructed using masonry mortar.

Table 5: Mortar used to construct prisms and codes referred

Tests	Mortars used to construct prisms	Codes referred
Bond shear test	Cement, FaL-G and geopolymer	------
Flexural bond test	Cement and geopolymer	ASTM C 1072
Low rise masonry shear test	Cement and geopolymer	------
Masonry efficiency, Modulus of elasticity, Compressive strength	FaL-G and geopolymer	IS 1905-1987

3.5 Testing of Prisms

Prisms were tested for Bond shear, Low rise masonry shear, Flexural bond test, Masonry efficiency, Modulus of elasticity. Codes referred to construct and test the prisms are given in Table 5.

Bond shear test: Shear load was applied to the middle portion of the masonry triplet and the load at which the bond fails was noted which gives bond shear strength.

Low rise masonry shear: Horizontal load was applied to the specimen consisting of two masonry courses. Due to the application of horizontal load the upper course slides over the lower course, providing value of the shear strength of the joint.

Flexural bond test: Prisms of approximate height 100cm were used to determine flexural bond strength. Frame was fitted to the topmost block. With the help of pulley and wire arrangement flexural load was applied gradually and gently to the prism. Load required for the failure of the mortar joint was noted and flexural bond strength was calculated [16].

Masonry efficiency: FaL-G masonry prism was placed in compression testing machine. Compressive force was applied on the prism. For every predetermined increment in load, deformation was noted using demec gauge. From the collected data, stress and strain was calculated and stress v/s strain curve was plotted. Modulus of elasticity was obtained from the stress v/s strain curve.

4. RESULTS AND DISCUSSION

FaL-G blocks were tested for different properties on 7th, 14th, 28th and 56th days of casting. The graphical representation of results of each test is given below. Figure 1 and 3 shows that compressive strength and dry density increases with age. It can be noticed that increment in compressive strength and dry density is rapid between 14th and 90th days. Figure 2 and 4 shows that IRA and water absorption decreases with age. Modulus of elasticity of FaL-G blocks was 5458 MPa, 9373MPa and 17038MPa on 28th (Figure 5), 56th(Figure 6) and 90th days (Figure 7)respectively. Flexural strength of FaL-G block was 1.58 MPa on 28thday.The stress-strain behavior could not be shown at higher stress values due to practical difficulty in noting down the strain values in the laboratory. Table 6 gives the masonry efficiency, modulus of elasticity and compressive strength of FaL-G prisms. Figures 8 to 11 shows stress v/s strain behavior of FaL-G masonry prism. Bond shear strength of prisms with cement and FaL-G mortar was 0.0149 MPa and 0.0134 MPa respectively. Low rise masonry shear strength was 0.019 MPa for geopolymer mortar and 0.01 MPa for cement mortar. Flexure bond strength for FaL-G prism with geopolymer mortar was found to be 0.052Mpa

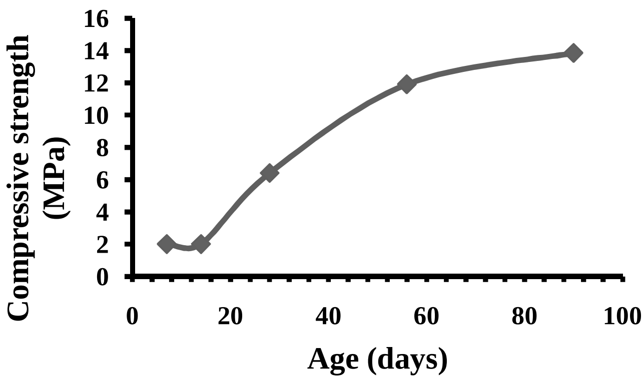

Figure 1: Variation of compressive strength with age

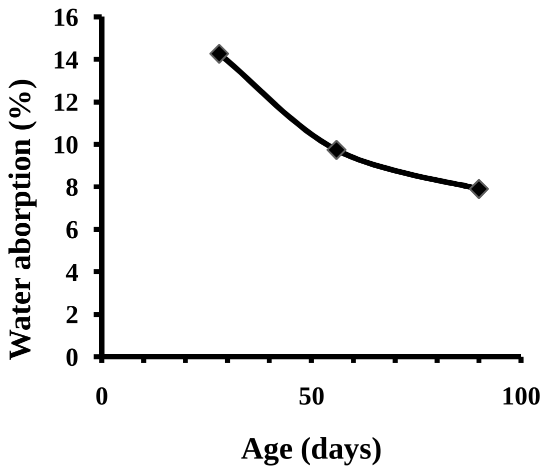

Figure 2: Variation of water absorption with age

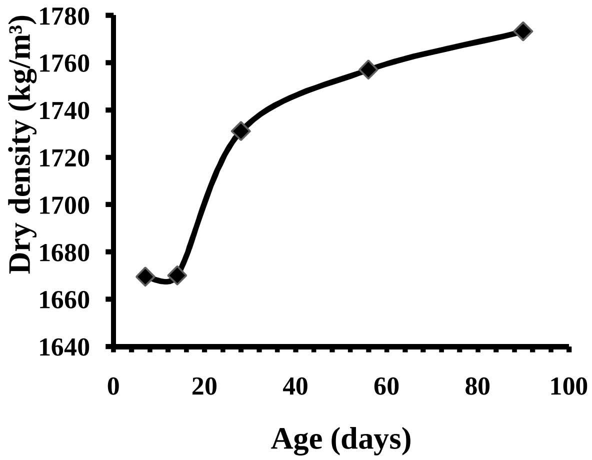

Figure 3: Variation of dry density with age

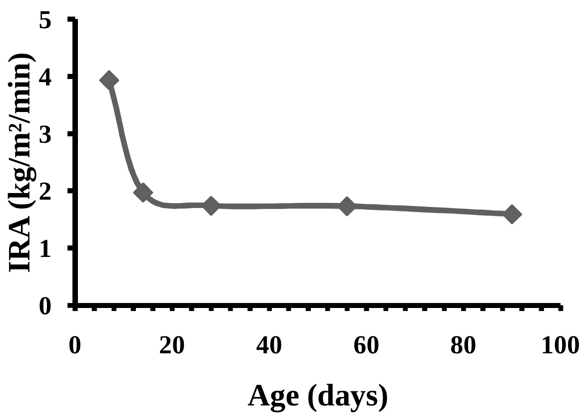

Figure 4: Variation of IRA with age

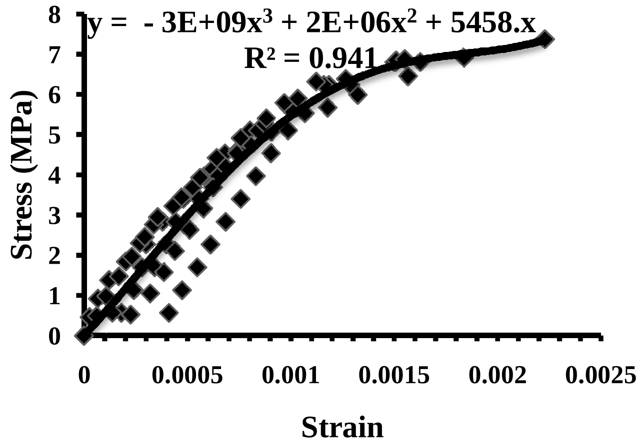

Figure 5: Stress v/s strain of FaL-G blocks (28th day)

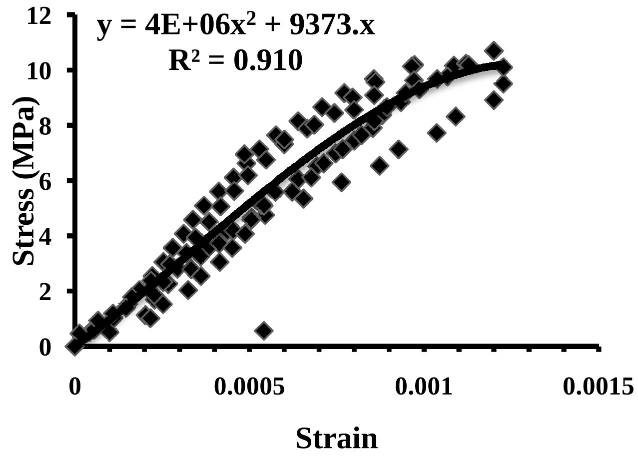

Figure 6: Stress v/s strain of FaL-G blocks (56th day)

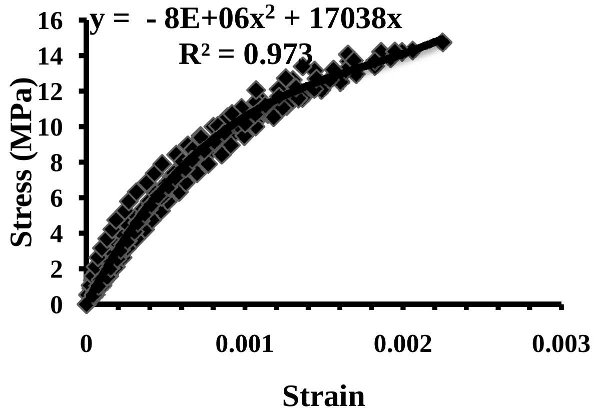

Figure 7: Stress v/s strain of FaL-G blocks (90th day)

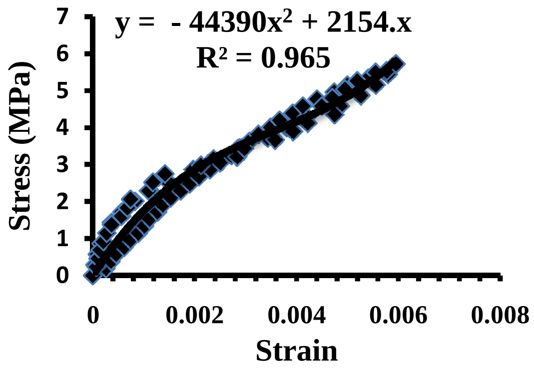

Figure 8: Stress v/s strain behaviour of FaL-G masonry prism of h/t 2.26 (FaL-G mortar)

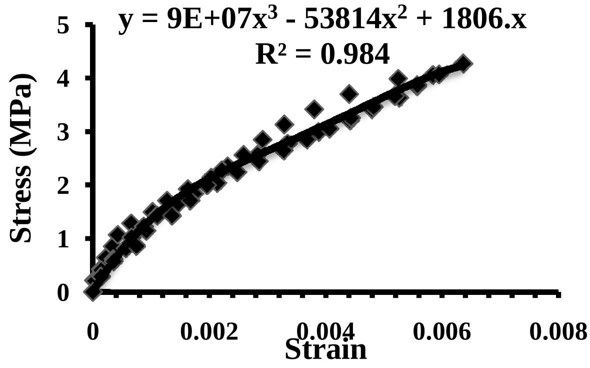

Figure 10: Stress v/s strain behaviour of FaL-G masonry prism of h/t 2.84 (FaL-G mortar)

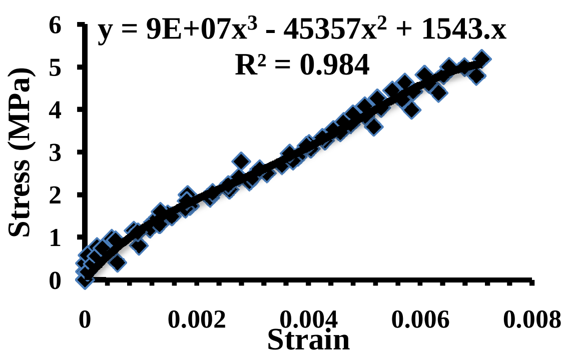

Figure 9: Stress v/s strain behaviour of FaL-G masonry prism of h/t 2.26 (Geopolymer mortar)

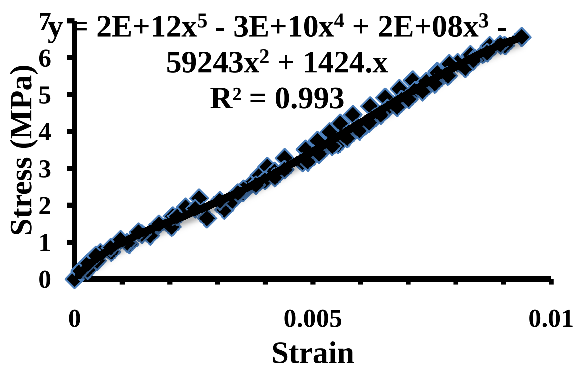

Figure 11: Stress v/s strain behaviour of FaL-G masonry prism of h/t 2.84 (Geopolymer mortar)

Table 6: Masonry efficiency, E and compressive strength of FaL-G prisms

Sl.No	FaL-G mortar				Geopolymer mortar			
	h/t	Masonry Efficiency, %	E (MPa)	Compressive strength (MPa)	h/t	Masonry Efficiency, %	E (MPa)	Compressive strength (MPa)
1	2.26	31.41	2154	4.35	2.18	28.1	1543	3.89
2	2.84	25.92	1806	3.59	2.74	39.33	1424	5.4

CONCLUSIONS

From this research it can be concluded that:

- Compressive strength increases with age, there is at least 70% increment in compressive strength between each age. It is noticed that compressive strength of FaL-G block is higher than the minimum compressive strength required as per IS 1077-1992.
- Dry density increases with age. There is 6% increment in density between 7th and 90th day.
- Water absorption and IRA decreases with age. There is more than 50% reduction in water absorption and IRA between 28th days to 90th day. Water absorption of FaL-G blocks are lesser than the maximum limit as per IS 1077-1992.
- Modulus of elasticity of FaL-G blocks increases with age. It is to be noted that there is at least 70% increment in Modulus of Elasticity between each age.
- Experimental results of bond shear test, flexural bond test, low rise masonry shear, showed that the combination of FaL-G block and geopolymer mortar performs well than other combinations.

- Variation of masonry efficiency with h/t ratio is found to be around 17% for prisms with FaL-G mortar and 40% for prisms with geopolymer mortar.
- Hence it can be concluded that FaL-G can effectively replace burnt clay bricks.Fly ash brick manufacturing is a potential field of application wherein large-scale utilization of fly ash is possible.

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