PROPERTIES OF FaL-G HOLLOW MASONRY BLOCKS

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Abstract

*FaL-G is the product name derived from a cementitious mixture composed of **F**ly **a**sh (Fa), **L**ime (L) and **G**ypsum (G). It is a low-cost and environmental-friendly material. FaL-G in certain proportions, as a building material is an outcome of innovation. It gains strength like any other hydraulic cement in the presence of water. It is water resistant too. This paper addresses the technology of making FaL-G mortar compressed hollow blocks with low-calcium (Class F) dry fly ash as the base material. The FaL-G masonry hollow blocks were prepared without the use of conventional cement. Quarry dust and sand were used as fine aggregates as sustainable materials. The properties of FaL-G masonry hollow blocks were determined for different parameters. The experimental results reveal that the FaL-G hollow blocks are suitable to be used for the construction of masonry structures.*

Keywords: *fly ash, lime, gypsum, quarry dust, sand, mortar, hollow blocks.*

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1. INTRODUCTION

Every moment the emission of carbon dioxide into the atmosphere is being increased gradually. Considerable amount of fossil fuel, coal and oil are burnt to satisfy the human needs. This weakens the heat–trapping blanket that surrounds the planet and causes global warming. different alternatives can be considered to protect the planet. The rapid increase in the capacity and number of thermal power generation has resulted in the production of a huge quantity of fly ash. The prevailing disposal methods are not free from environmental pollution and other hurdles. On the other hand, the production of each ton of cement releases equal amount of carbon dioxide to the atmosphere. The usage of cement can be reduced by using the other possible alternative cementing materials without compromising the properties.

The most basic building material for construction of houses is the usual burnt clay brick in many countries. A significant quantity of fuel is utilized in making these bricks. Also, continuous removal of topsoil, in producing conventional bricks creates lot of environmental problems. There is strong need to adopt cost effective sustainable technology using local materials . Different methods are adopted to produce the building blocks using cement, lime-fly ash, lime-slag bindings and other materials. There is a need to develop simple and effective technologies for producing the masonry units. The need to produce more building materials for various elements of construction and the role of alternative options would be in sharp focus. The possibility of using innovative building materials and technologies, using waste material like fly ash, lime and gypsum has been considered in this paper.

FaL-G in certain proportions, as a building material, is an outcome of innovation to promote the utilization of fly ash by Bhanumathidas and Kalidas [1]. It gains strength like any other hydraulic cement, in the presence of water, and is water resistant with time.

Large amounts of materials like gypsum and fly ash are available at phosphoric acid manufacturing plants and thermal power plants, respectively. These can be used to source sulphate and silica alumina. Gypsum contains impurities of phosphate, fluoride, organic matter and alkalies which prevent its direct use as building material. It is one of the calcium sulphate's rich residues. Phosphogypsum is an important by-product of phosphoric acid fertilizer industries. It consists of CaSO4.2H2O and contains some impurities such as phosphate, fluoride, organic matter and alkalies. Approximately 5 million tons of phosphogypsum is being produced each year in India [2]. Cementitious binder, FaL-G, finds extensive application in the manufacturing of building materials such as bricks, ,solid blocks ,hollow blocks and lean concrete. FaL-G technology enables production of hollow blocks with a simple process of mixing and water curing. Due to such appropriate technology, conservation of energy and pollution control are achieved [3].

It has been reported that FaL-G mortar can be used in making the masonry hollow block units by different combinations of fly ash, lime and phosphogypsum [4]. FaL-G technology contributes to the conservation of energy and reduces environmental degradation effectively [5]. Since it is manufactured using industrial wastes and marginal materails, the environmental impacts are mitigated. FaL-G units have the advantage of continuous year-wide operation and hence provide year-long employment opportunity to skilled artisans[6]. It creates self-help livelihood opportunities for the people in developing countries. In certain cases, where by-product lime is not available, ordinary Portland cement is used as the source of lime, producing the same quality of bricks and blocks [7,8].

2. SCOPE OF RESEARCH

FaL-G is relatively economical material derived from binders fly ash, lime and gypsum. The research reported till date speaks about the arbitrary use of the material without any rational approach. The report on proportioning, strength development in FaL-G is scarce. Also there is large scope for the development of FaL-G hollow blcoks made from mortar. In this research, FaL-G mortar hollow blocks were prepared and various properties were studied.

3. MATERIALS AND METHODS

Class F fly ash was procured from Raichur thermal power plant, Raichur,India. Commercially available lime was slaked and sieved through 1.18 mm sieve and stored in air tight container to maintain the freshness. Dry calcinated phosphogypsum was procured from a nearby fertilizer industry. The weighed quantity of class F fly ash and gypsum were mixed in dry condition. Lime was added to the mixture to obtain a uniform mix. This mixure was termed as FaL-G binder.

FaL-G mortar was prepared using FaL-G as binder and Quarry dust/sand/pond ash as fine aggregates. The procedure adopted was same as that of conventional cement mortar. Tap water was used to mix the ingredients. The ingredients were mixed thoroughly by kneading until the mass attained uniform consistency. FaL-G mortar was a dry frictional material at water/binder ratio of 0.2. FaL-G compressed hollow blocks were prepared using FaL-G mortar at various binder-fine aggregate ratios. The details of mix used for preparing FaL-G hollow blocks are indicated in Table 1. The FaL-G mixes were designated as H1 – H16 for convenience.

Table1: Mix proportions of FaL-G bricks

Mix designation	FaL-G Binder proportion			Fine aggregate	FaL-G Binder : Fine aggregate Ratio
	Fly ash	Lime	Gypsum		
H1	50	40	10	Stone dust	1:1
H2	50	40	10	Stone dust	1:1.5
H3	55	35	10	Stone dust	1:1
H4	55	35	10	Stone dust	1:1.5
H5	60	30	10	Stone dust	1:1
H6	60	30	10	Stone dust	1:1.5
H7	65	25	10	Stone dust	1:1
H8	65	25	10	Stone dust	1:1.5
H9	50	40	10	Sand	1:1
H10	50	40	10	Sand	1:1.5
H11	55	35	10	Sand	1:1
H12	55	35	10	Sand	1:1.5
H13	60	30	10	Sand	1:1
H14	60	30	10	Sand	1:1.5
H15	65	25	10	Sand	1:1
H16	65	25	10	Sand	1:1.5

Moulds of internal dimension 400 mm x150 mm x 200 mm were used for casting the compressed hollow blocks using FaL-G. The FaL-G mortar mix was placed in the moulds in two layers. Each layer was compacted and compressed using a vibrating table. The compressed brick was then de moulded and stored on the platform. They were cured in wet gunny bags for a day or two. Later they were cured by sprinkling water till the age of 28 days or date of testing whichever was earlier. The properties of FaL-G hollow blocks were studied like dry density, Initial rate of absorption, water absorption, Compressive strength of block and stress- strain characteristics.

4. RESULTS AND DISCUSSION

The properties of the FaL-G bricks are indicated in Table 2 for all the series H1-H16 considered. It was found that the density of FaL-G hollow blocks was in the range of 1.465 to1.654 g/cc for all the series. This density was marginally less compared to the conventional concrete hollow block available in the open market.

The initial rate of water absorption of the bricks varied from 3.92 to 4.4 kg/m2/min which is considered as less as per ASTM C-67 [9]. The percentage of water absorption was found to be less than 17.56% for all the series against the maximum limit of 20% as per IS 3495-1976[10].

Table2: Properties of hollow blocks of size 400mm x150mm x 200mm

Mix designation	Average Dry density in g/cc	Average Initial rate of absorption of brick in kg/m2/min	Average water absorption of brick in %
H1	1.635	3.960	15.786
H2	1.654	3.928	15.712
H3	1.622	3.981	15.924
H4	1.637	3.944	15.804
H5	1.597	4.040	16.159
H6	1.619	3.986	16.052
H7	1.585	4.072	16.287
H8	1.612	4.003	16.147
H9	1.535	4.197	16.788
H10	1.568	4.113	16.617
H11	1.507	4.273	17.089
H12	1.534	4.202	16.919
H13	1.492	4.348	17.262
H14	1.507	4.274	17.094
H15	1.465	4.408	17.564
H16	1.481	4.346	17.410

The following Parameters are varied to study various properties of FaL-G hollow blocks.

- Age: 7, 14, 28, 56, 72 and 90 days
- Binder-to-aggregate ratio: 1:1 and 1:1.5
- Quantity of fly ash : 50, 55, 60 and 65%
- Quantity of lime : 25, 30, 35 and 40%

Figures 1 and 2 show the variation of compressive strength of the FaL-G hollow blocks with age for quarry dust, and sand respectively. It is quite obvious that the strength increases with age in all the cases. It is due to continues reaction between the FaL-G binder and water as discussed in the introduction. The compressive strength was around 4 MPa at the age of 28days and around 5.5 MPa at the age of 90 days. The minimum strength at the age of 28 days is more than 3MPa in most of the cases. This strength would be sufficient to use them as masonry units as per IS 3495-1976 [10].

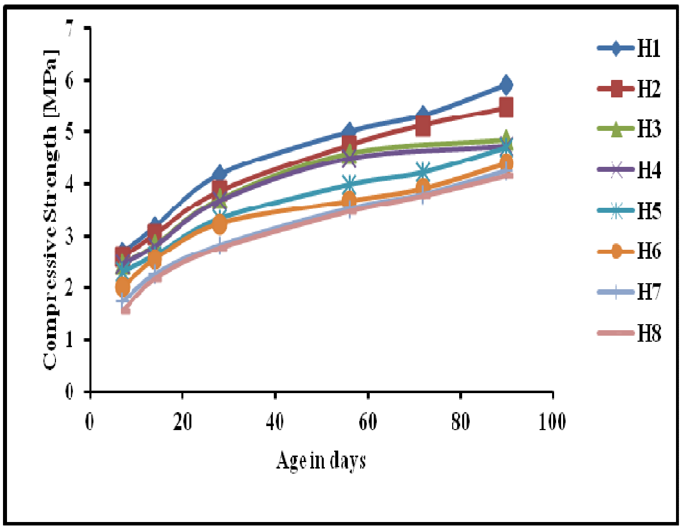

Fig. 1 Variation of Compressive Strength with age with Stone Dust as fine aggregate

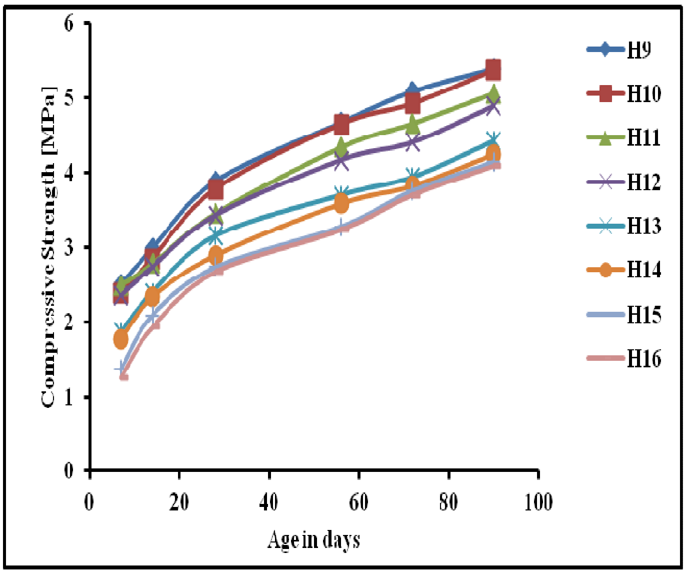

Fig. 2 Variation of Compressive Strength with age with Sand as fine aggregate

Figure 3 indicates the compressive strength of FaL-G bricks at the age of 7,14,28, 56, 72 and 90 days in order. The vertical bar in the graph indicates the strength of the brick having binder-to-aggregate ratio of 1:1 and 1:1.5 for different series H1to H8with quarry dust as fine aggregate. Similarly Figure 4 indicates for different series H9 to H16 with natural sand as fine aggregate. It can be observed that as the ratio of binder-to-aggregate increases the strength decreases in all the cases. It is due to less binder availability in the mortar.

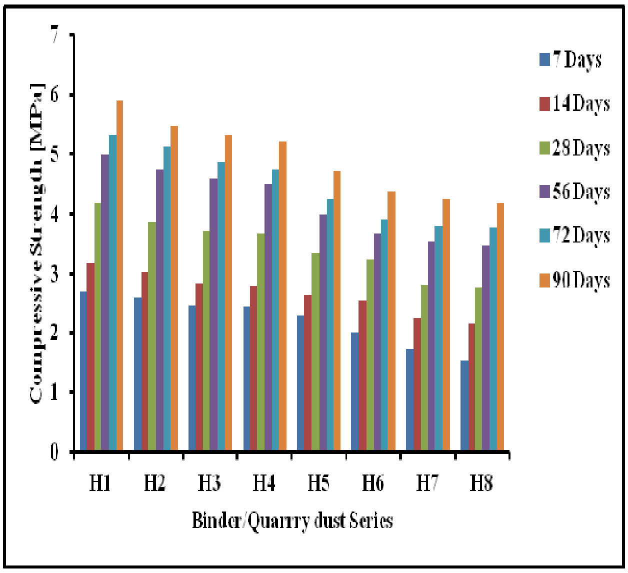

Fig. 3 Compressive Strength of H1 to H8 of Binder/Quarry dust Series for various ages

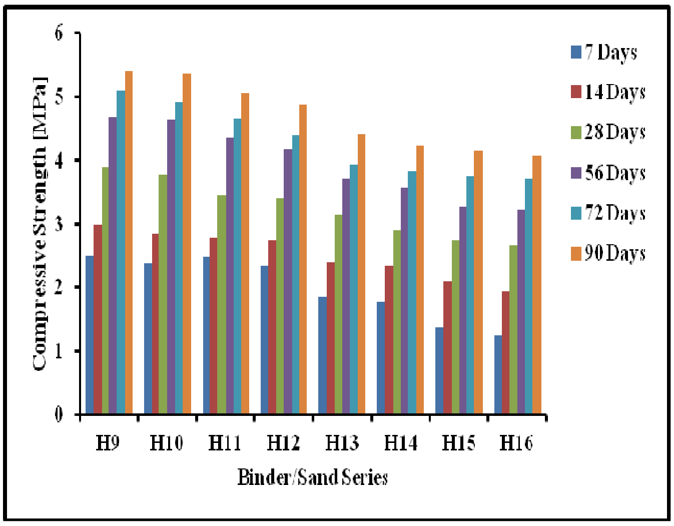

Fig. 4 Compressive Strength of H9 to H16 of Binder/Sand Series for various ages

The series considered for the variation of fly ash were H1 to H8 [binder/quarry dust series] and H9 to H16 [binder/Sand series] with 50,55,60 and 65% of fly ash respectively. For convenience, the age of the blocks was considered upto 90 days with quarry dust and sand as fine aggregates. Figure 5 indicates the variation of compressive strength with the percentage of fly ash beyond 50%. It was found that the compressive strength decreases with the increase in fly ash content, the optimum being 50%. Same observation was found in the research reported by Radhakrishna [4].

The series considered for the variation of lime were H1 to H16 series with 40 35, 30 and 25% of lime respectively. The variation of compressive strength with the lime content is shown in Figure 6. It can be noticed that the increase in lime content increases the strength. In FaL-G, as the fly ash content increases the lime content should decrease as the gypsum is maintained at 10%.

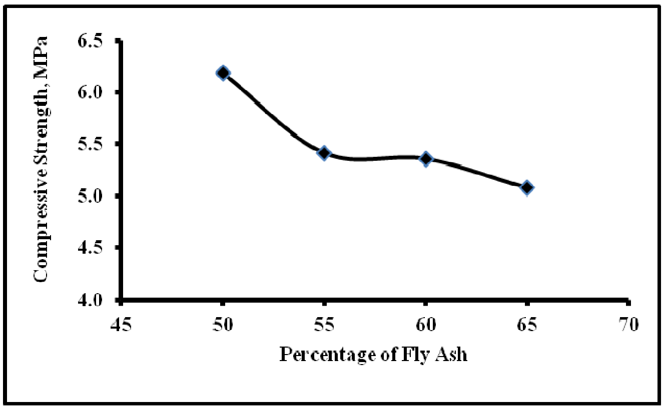

Fig. 5 Variation of Compressive Strength with fly ash content

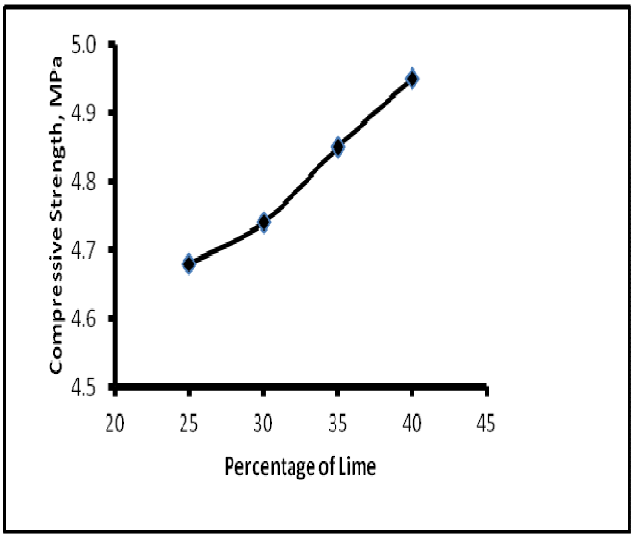

Fig. 6 Variation of Compressive Strength with lime content

Modulus of elasticity of hollow block were tested at 28 days for the series H1 [50:40:10], H3 [55:35:10] with quarry dust as fine aggregate, H9 [50:40:10], H11[55:35:10] with natural sand as fine aggregate. The modulus of elasticity was found to be 1768, 1666,1876 and 1527 MPa at the age of 28 days respectively. Figures 7, 8 9 and 10 indicate the stress-strain behaviour for different series of the hollow FaL-G blocks. This range of modulus of elasticity is quite satisfactory to use these bricks as masonry units.

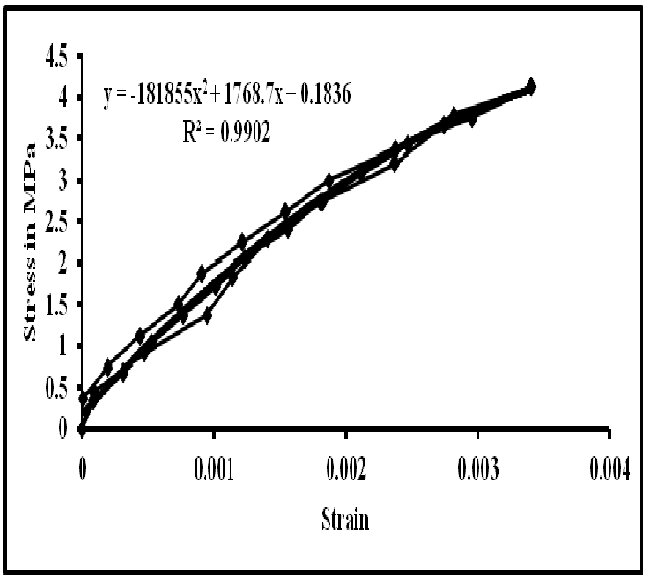

Fig. 7 Modulus of elasticity at 28 days of series H1[50:40:10][QD]

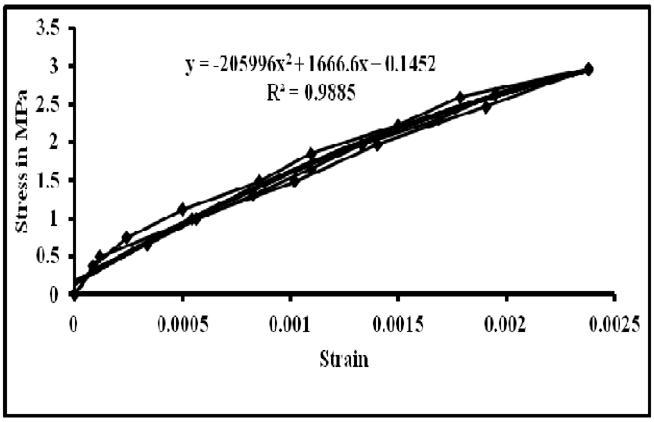

Fig. 8 Modulus of elasticity at 28 days of series H3[55:35:10][QD]

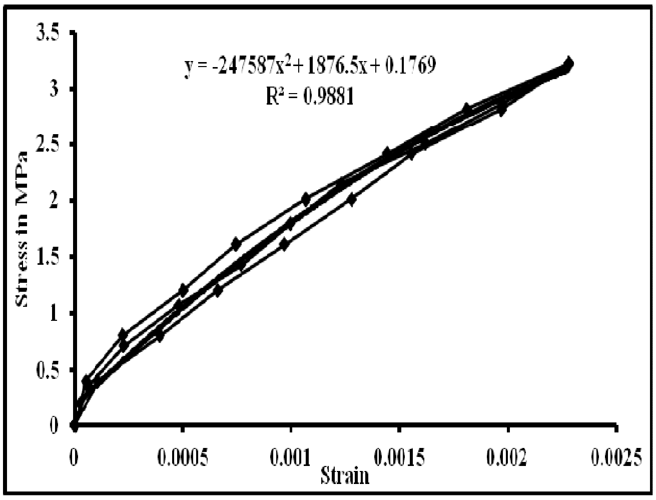

Fig. 9 Modulus of elasticity at 28 days of series H9[50:40:10][Sand]

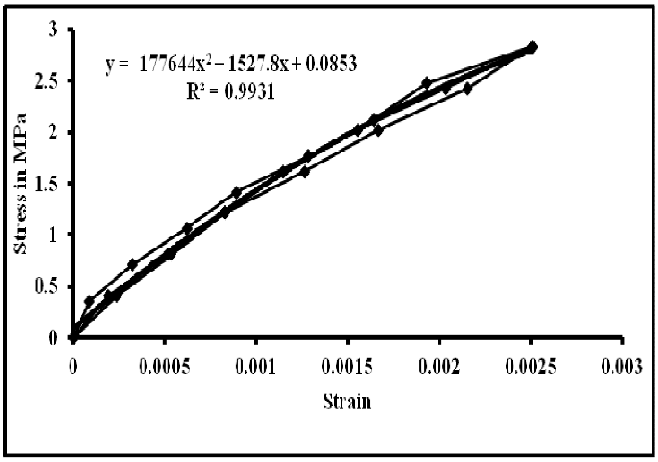

Fig. 7 Modulus of elasticity at 28 days of series H11 [55:35:10][Sand]

CONCLUDING REMARKS

- FaL-G compressed masonry hollow blocks can be conventionally prepared economically by using industrial wastes like fly ash, lime, gypsum, stone dust and Sand.
- It was found that the dry density, IRA and water absorption of FaL-G compressed bricks were in the range of 1.465 to1.654 g/cc., 3.92 to 4.4 $kg/m^2/min$ and less than 17.56 % respectively.
- FaL-G hollow blocks attained considerable strength around 4MPa at the age of 28 days to use them as masonry units with adequate modulus of elasticity.
- In view of the above, it can be concluded that FaL-G masonry units can effectively replace conventional masonry units.

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