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A EXPERIMENTAL STUDY ON THE FESIBILITY OF FaL-G BRICKS

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Abstract: Safe disposal of remaining fly-ash and Quarry dust has become a challenging problem. The utilization of fly ash in cement and other related industries is comparatively less. It therefore becomes necessary to utilize fly-ash in structural elements due to the deficiency in demand of construction materials. The most basic building material for construction is the usual burnt clay brick. A significant quantity of fuel is utilized in making these bricks, this burning of fossil fuels liberate green house gases and causes depletion of ozone layer. Continuous removal of topsoil, in producing conventional clay bricks creates environmental problems. This paper presents a feasibility study made on the Fly ash - Lime - Gypsum (FaL-G) bricks. This solves the problems of shortage of bricks and at the same time it is manufactured economically by utilizing industrial wastes. In this study, for conducting the experiments 120 FaL-G bricks of various mix proportions M1, M2, M3 and M4 were casted. Bricks were casted to study the effect of Compressive strength, Resistance to Sulphate intrusion and Water absorption of FaL-G with respect to aging.

Keywords:- industrial waste, Fly ash, building material, Bricks, FaL-G.

I. INTRODUCTION

In addition one of the major problems arising from continuous technological and industrial development is the disposal of waste materials. These materials can be used to make durable bricks which can replace the conventional burnt clay brick. One such industrial waste that can be used for recycling of industrial waste is the Fly ash [1]. To use Fly ash as a major constituent, a binder is required to produce Durable bricks. Lime can be chosen as the binder because lime is produced from acetylene industry in the form of calcium hydroxide sludge. Hence it is also a waste material. So it is chosen as the binder for Bricks [3-5]. The mixture of Fly ash and Lime attains strength in a slower rate, so to get a rapid hardening and to contribute to the early strength to the brick an accelerator is required. Gypsum can be used here, as Gypsum is a by-product of aluminium fluoride industry, generated in the form of anhydrite [7-8]. An attempt is made to develop bats bricks as an alternative building material to the traditional burnt clay bricks and is a substitute to the traditional burnt bricks used for construction. Production process of FaL-G bricks does not involve sintering. Thus, by substituting the burnt clay bricks, FaL-G bricks completely eliminate the burning of fossil fuels required in the clay brick production process and ultimately contribute to the reduction of greenhouse gas emissions [9, 10]. Since the FaL-G activity reduces green house gas emissions, it has the potential to benefit from the emerging carbon market.

II. MANUFACTURING PROCESS OF FAL-G BRICK

The Fig 1 shows the schematic flow diagram of FaL-G brick manufacturing process.

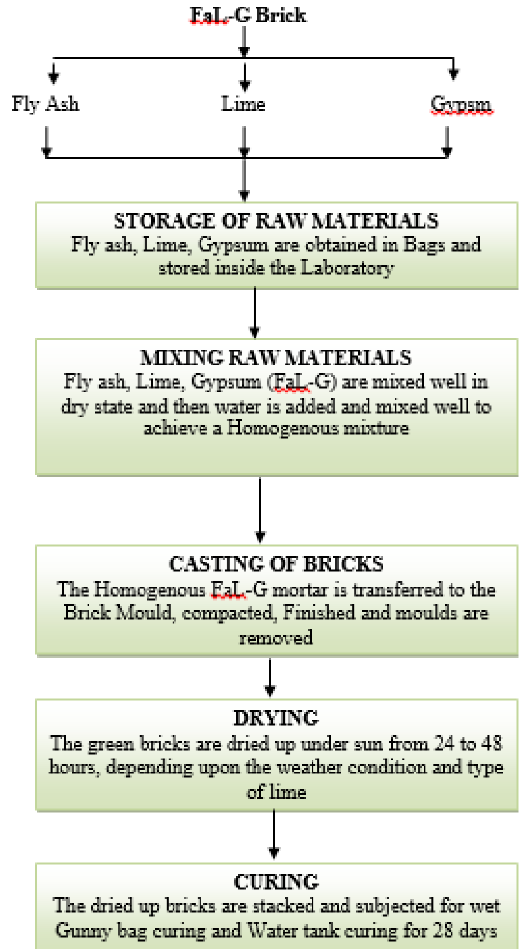

Fig 1 Schematic flow diagram

III. MIX RATIOS

The mix ratios used to study the properties of FaL-G bricks are casted by varying the proportions of Fly-ash, Lime and Gypsum. The Mix ratios, Symbols used and the number of bricks casted are given in the Table 1

SYMBOLS USED	MIX PERCENTAGE			NUMBER OF SPECIMENS REQUIRED										TOTAL NO BRICKS
	FLY ASH (%)	LIME (%)	GYPSUM (%)	COMPRESSION STRENGTH			SULPHATE INTRUSION			WATER ABSIORPTION			MISCELLANEOUS	
				7	14	28	7	14	28	7	14	28		
M1	75	15	10	3	3	3	3	3	3	3	3	3	3	30
M2	70	20	10	3	3	3	3	3	3	3	3	3	3	30
M3	65	25	10	3	3	3	3	3	3	3	3	3	3	30
M4	60	30	10	3	3	3	3	3	3	3	3	3	3	30
TOTAL NO OF BRICKS = 120														

Table.1 The Mix ratios and the number of bricks casted

IV. EXPERIMENTAL PROCEDURE

4.1 COMPRESSIVE STRENGTH

The compressive strength of FaL-G bricks are determined by placing the horizontal flat faces of the brick between two 3-ply plywood sheets each of 3mm thickness and carefully centered between the plates of the compression testing machine. Load is axially applied at a uniform rate of 14N/mm^2 per minute until the failure occurs. The load at which failure occur is the maximum load. This is similar to the compression test conducted on burnt clay bricks to determine their compression strength as recommended in Indian codes of practice for normal burnt clay bricks [IS 3495 (Part 1 - Determination of Compressive strength): 1992].

The Compressive strength of the Brick is determined using the following Formula:

Compressive strength in N/mm^2 (kg/cm^2) =

$$\frac{\text{Maximum Load at Failure in N (kg)}}{\text{Average net area of the two faces under compression in mm}^2\ (\text{cm}^2)}$$

4.2 WATER ABSORPTION

The water absorption of FaL-G bricks is determined by immersing it completely in the clean water at a temperature of 27 ± 2 degree for 24 hours. The specimen is removed from water and left to dry for 3 minutes, the traces of water are wiped out with a damp cloth and weighed. The difference in weight of the tested brick and dry brick is considered to be the water absorption of the brick. This is similar to the Water absorption test conducted on common burnt clay bricks to determine their water absorption as recommended in Indian codes of practice for normal burnt clay bricks [IS 3495 (Part 2 - Determination of Water absorption): 1992]. The water absorption, percent of mass, after 24-hour immersion in cold water is given by the following formula:

Water absorption is given in % : Water absorption = $\frac{M_2 - M_1}{M_1} \times 100$

Where,

M1 = Dry weight of the Specimen

M2 = Weight of the specimen after immersion in water

4.3 SULPHATE INTRUSION

The FaL-G bricks were taken out from the moulds and are covered with wet gunny bags for a week. After one week, when the specimens had attained sufficient strength for handling, these bricks were transferred to the Sulphate solution filled curing tanks at a temperature of 27 ± 2 degree. The sulfate solution having sulphate (SO_4) concentration equal to 10,000 ppm was prepared in the laboratory by mixing 14.79 gm of Na_2SO_4 in 1 liter of water. The durability of FaL-G bricks is investigated by curing these bricks in an aggressive environment of sulphate solution.

The compressive strength of FaL-G bricks subjected to sulphate intrusion are determined by placing the horizontal flat faces of the brick between two 3-ply plywood sheets each of 3mm thickness and carefully centered between the plates of the compression testing machine. The load is axially applied at a uniform rate of 14N/mm^2 per minute till the failure occurs. The load at which failure occur is the maximum load. This is similar to the compression test conducted on burnt clay bricks to determine their compression

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strength as recommended in Indian codes of practice for normal burnt clay bricks [IS 3495 (Part 1 - Determination of Compressive strength): 1992].

The Compressive strength of the Brick after curing them under sulphate environment is determined using the following Formula:
Compressive strength in N/mm^2 (kg/cm^2) =

$$\frac{\text{Maximum Load at Failure in N (kg)}}{\text{Average net area of the two faces under compression in mm}^2\ (\text{cm}^2)}$$

V. RESULTS AND DISCUSSIONS OF FaL-G BRICKS

5.1 COMPRESSIVE STRENGTH

The compressive strength of Fal-G bricks with various mix proportion are used to study the effect of aging and is determined as per IS 3495 (Part 1): 1992 and provided in the Table.2

SYMBOLS	COMPRESSIVE STRENGTH OF FaL-G BRICK (N/mm2)											
	7th DAY				14th DAY				28th DAY			
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean
M1	5.5	5.4	5.6	5.6	6.9	6.9	7.0	6.9	9.5	9.4	9.5	9.5
M2	4.6	4.4	4.5	4.5	5.7	5.8	5.7	5.8	8.4	8.2	8.6	8.6
M3	4.1	4.5	4.3	4.3	5.5	5.6	5.4	5.5	8.6	8.4	8.2	8.4
M4	4.5	4.4	4.3	4.4	5.6	5.5	5.5	5.5	8.2	8.4	8.3	8.3

Table 2 – Compressive strength of FaL-G Bricks

From the test results it is observed that the compressive strength of mix M1 is increasing with an increase in age as shown in fig.2. For the Mix ratio M1 there is an increase in compressive strength from 7days to 14 days and 14 days to 28 days are 23% and 37% respectively from the Fig.3. it is also observed that the mix ratio M2, M3 and M4 also exhibits the similar property. From the Fig.3 it is also observed that the strength is increasing for the mixes M1, M2 and M3 for 7 to 14th and 7 to 28th days but it is decreasing for M4 when compare to M3, this shows that the increase in compressive strength is increasing with increase in the number of days. The increase in compressive strength for the mixes M1, M2, M3 and M4 at 28 days when compared to 7days is 70%, 92%, 95% and 88% respectively. Thus it clearly indicates that the brick manufactured with fly-ash gains its strength more during later ages of curing.

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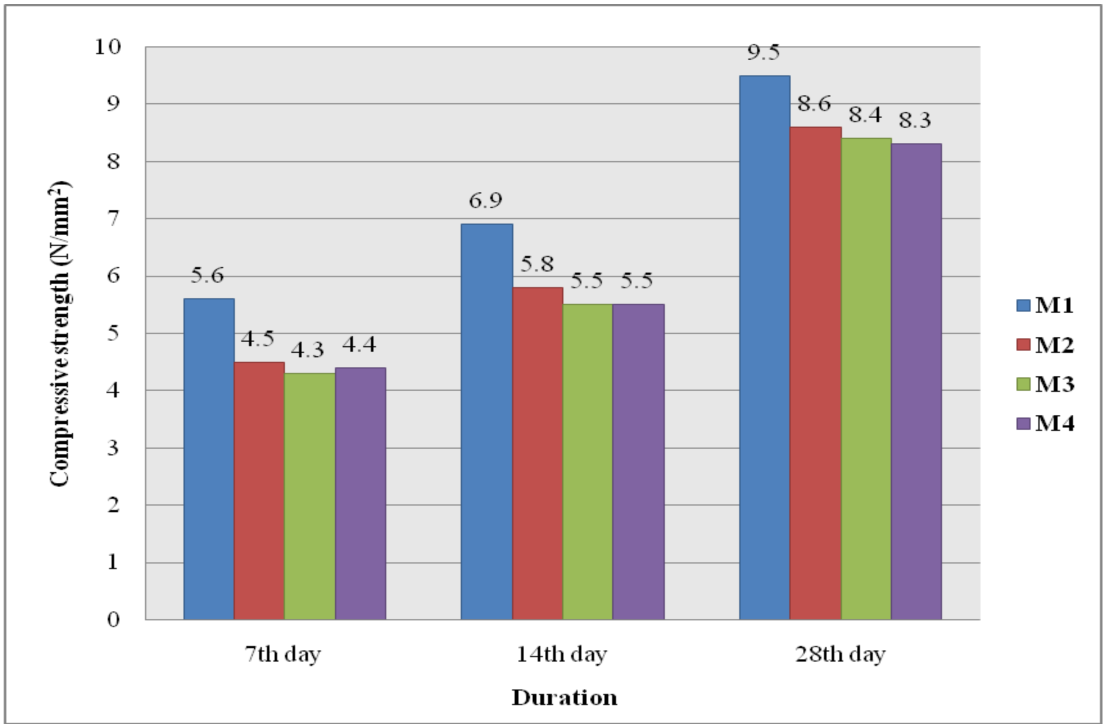

Fig.2 – Compressive strength of FaL-G Bricks

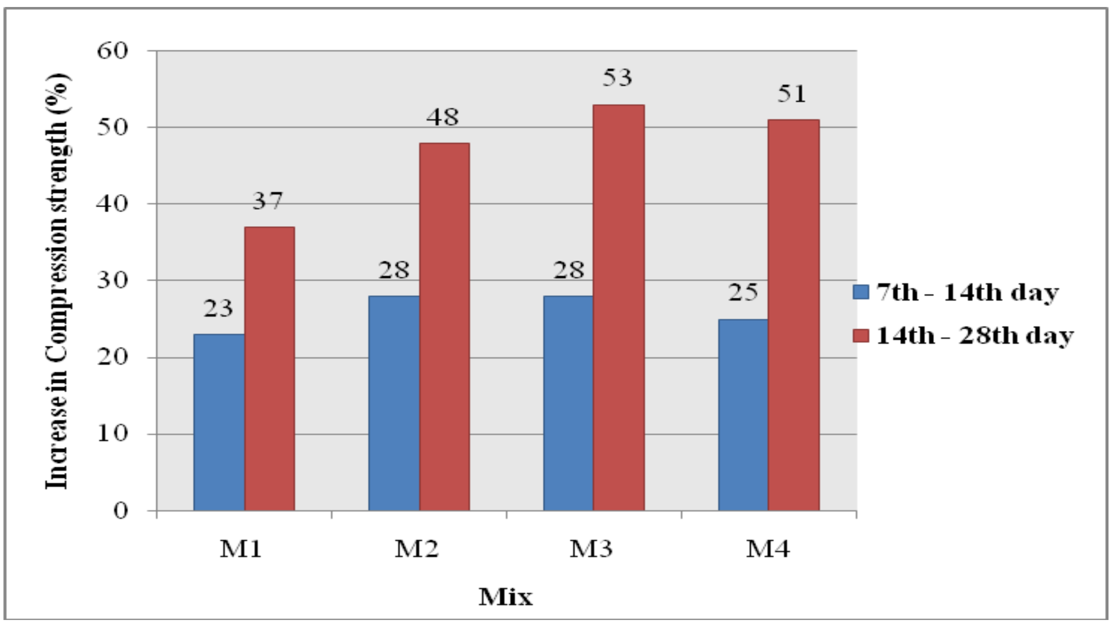

Fig.3 – Compressive strength comparison of FaL-G bricks with aging

For all the mixes used in this study the gypsum content is limited to 10%. The remaining portions are mixed with different proportions of fly-ash and lime. Analyzing from the results it is observed that if the lime proportions are increased beyond 25%, it does not produce any significance in the strength point of view. The results shows that, the compressive strength of the FaL-G bricks for all the mixes used in this study gives higher strength at the age of 7 days when compared to normal burnt clay brick (>3.5N/mm^2).

5.2 SULPHATE INTRUSION

The behaviour of various mix proportions of the Fal-G brick after sulphate intrusion is determined in this study and the test results are furnished in Table 3.

SYMBOLS	COMPRESSIVE STRENGTH OF FaL-G BRICK (N/mm2)											
	7th DAY				14th DAY				28th DAY			
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean
M1	5.4	5.4	5.5	5.4	6.6	6.	6.5	6.6	9.1	9.0	9.1	9.1
M2	4.3	4.3	4.2	4.3	5.6	5.5	5.7	5.6	8.0	8.1	8.1	8.1
M3	4.1	4.2	4.2	4.2	5.4	5.4	5.3	5.4	8.2	8.1	8.0	8.0
M4	4.2	4.1	4.3	4.2	5.1	5.2	5.3	5.2	7.9	7.9	8.0	7.9

Table 3 – Compressive strength of FaL-G bricks after sulphate intrusion

The FaL-G bricks are subjected to sulphate intrusion by immersing it in sulphate solution under various durations. After the prescribed periods the bricks are tested for its compression strength. The test results are shown in fig.4

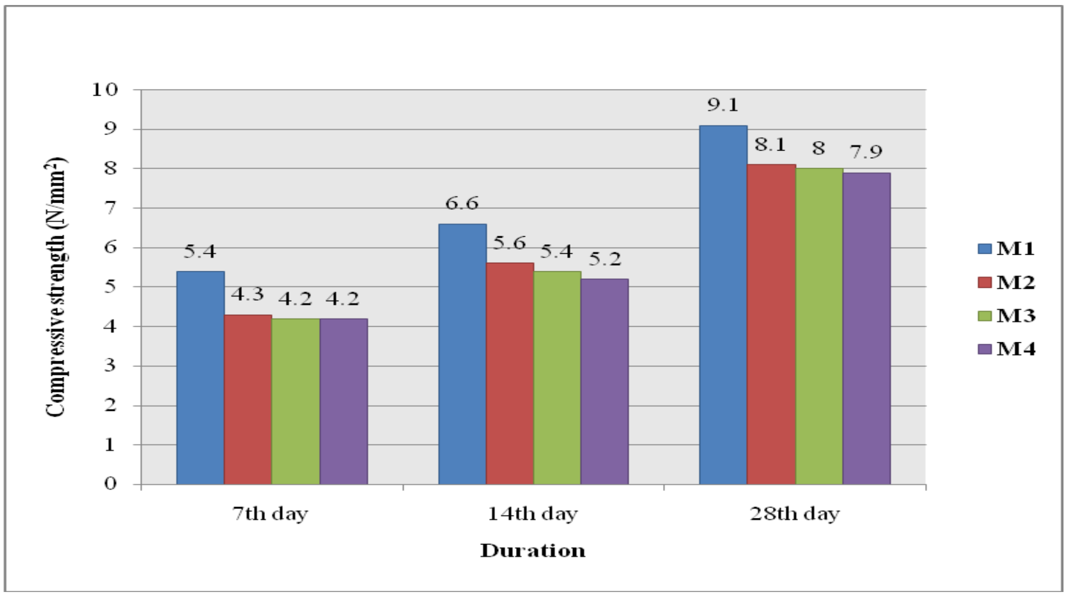

Fig.4 – Compressive strength of FaL-G Bricks after sulphate intrusion

It is observed that the compressive strength of Mix M1 increase from 7days to 14 days and 14 days to 28 days is 22% and 37% respectively. The mix ratio M2, M3 and M4 also exhibits similar increase in strength when subjected to sulphate attack. From the Fig.5 it is clearly observed that the strength is increasing for the mixes M1, M2 and M3 for 7 to 14th and 7 to 28th days but it decreases for M4 when compared to M3. The increase in compressive strength for the mixes M1, M2, M3 and M4 at 28 days when compared to 7days is 69%, 91%, 91% and 88% respectively. It indicates that the increase in

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compressive strength depends on the curing period. On observation, the increase in Compressive strength obtained from the bricks cured in water, gives a compressive strength of 70%, 92%, 95% and 88% on 28th day when compared to its 7th day strength. The decrease in compressive strength of brick for 28 days after sulphate intrusion is 1% for the mix M1, M2 and 4% for the mix M3 and there is no change in the compressive strength in the mix M4. These results are almost equal to the compressive strength of the brick that is subjected to sulphate intrusion.

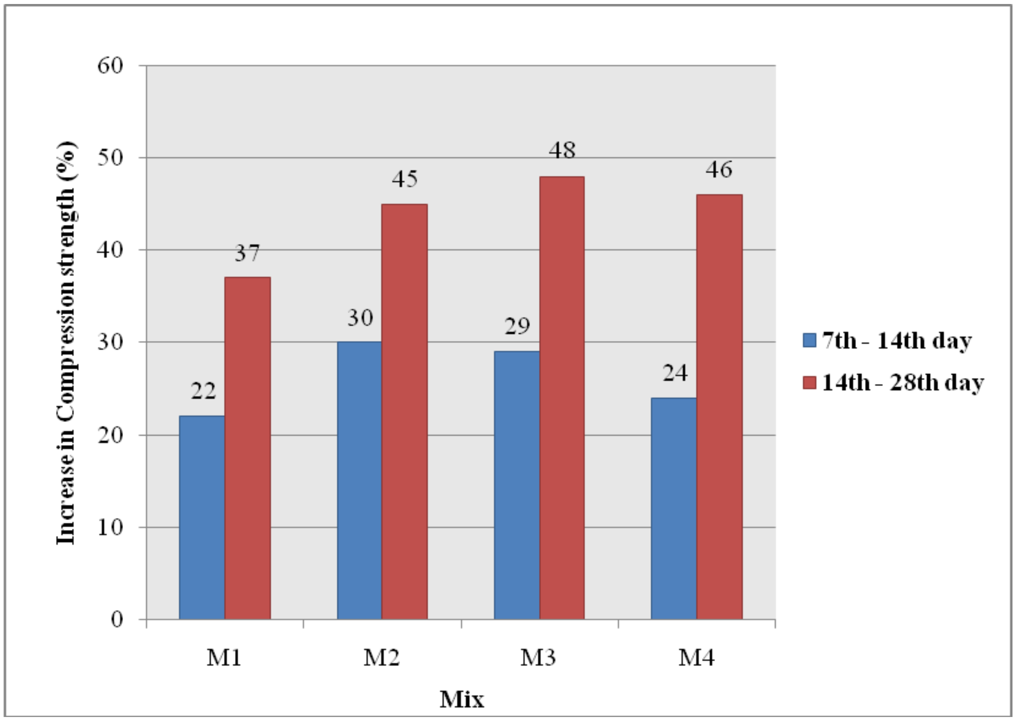

Fig.5 Compressive strength comparison of FaL-G bricks with aging after sulphate intrusion

In general the reduction in compressive strength of the FaL-G brick subjected to sulphate intrusion is marginal (0 – 4%) when compared to bricks cured under normal water. From the experimental results obtained from FaL-G bricks under normal and after sulphate intrusion the compressive strength is higher than the compressive strength of normal burnt clay brick.

5.3 WATER ABSORPTION

The Water absorption of FaL-G bricks for various mix proportions used in this study are determined as per IS 3495 (Part 2) : 1992 and provided in the Table 4

SYMBOLS	WATER ABSORPTION OF FaL-G BRICK (%)											
	7th DAY				14th DAY				28th DAY			
	S1	S2	S3	Mean	S1	S2	S3	Mean	S1	S2	S3	Mean
M1	11	13	12	12	12	13	13	13	14	15	15	15
M2	14	13	14	14	14	14	14	14	16	15	16	16
M3	13	13	13	13	14	14	13	14	15	16	16	16
M4	14	12	13	13	15	14	14	14	16	16	17	16

Table 4 - Water absorption of FaL-G Brick

From the test results, we can observe that the Mix proportion M1 shows 12%, 13% and 15 % absorption of water on the 7th, 14th and 28th day of test, this shows that there is a slow increase in water absorption with respect to the increase in days. The 7th day water absorption of the Mix proportion M2 is 14%, but the absorption is stabilised in the Mix M3 and M4. The 14th and 28th day water absorption of the mix M2, M3 and M4 are stabilised at 14% and 16%. The water absorption results are represented graphically in the Fig 6. This indicates that the water absorption does not show any great variations with respect to the variation in the fly-ash proportions used in this study. Hence more number of varying mix proportions are required in order to make a detailed analysis on the water absorption property of the FaL-G brick.

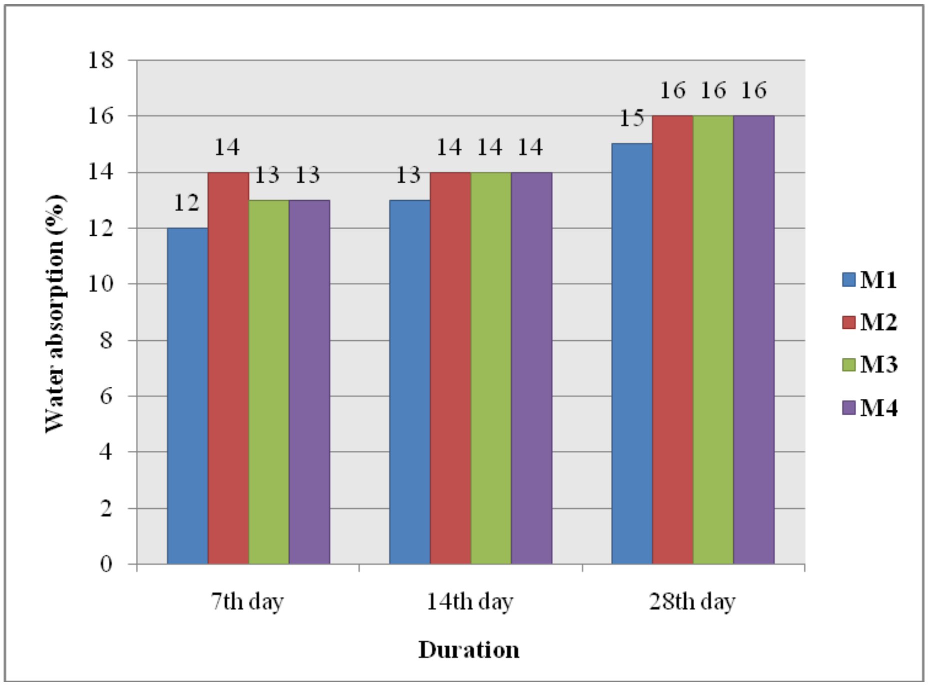

Fig.6 - Water absorption of FaL-G Bricks

In general the test results indicates that the water absorption property for all mix proportions (M1, M2, M3 & M4) of FaL-G brick does not exceed 16%, but the water absorption level of normal burnt clay brick is 20%. It shows that the FaL-G bricks absorb lesser water when compared with conventional clay bricks.

VI. CONCLUSION

The present study is made to find the effective way of utilizing waste materials such as Fly-ash in manufacturing brick. From the experiments conducted for this purpose, the following conclusions are suggested. It is observed that the FaL-G bricks have a high compressive strength in the range of 8.8 to 9.5 N/mm^2. Similarly, the bricks tested after sulphate intrusion shows a decrease in strength of about 0 to 4%. However the strength is higher than normal conventional bricks. In the water absorption test conducted, the FaL-G brick possess maximum water absorption of 16%. It is lesser than the ordinary burnt clay brick. FaL-G bricks have better resistance to strong sulfate environments. Hence the FaL-G brick are a good alternative and replacement for the burnt clay bricks. The FaL-G bricks can successfully replace conventional burnt clay bricks in the construction work after carrying out the water absorption for longer duration and cyclic environment conditions.

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