An Experimental Study on Fal-G Brick

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Abstract- Although the use of fly ash has many advantages, its low hydration at early stage causes the strength to be low. In this study, the experimental investigation was carried out to find the optimum mix percentage of fal-g brick. However the brick specimen of size 230mm x 110mm x 90mm were cast for different mix percentage of Flyash (15 to 40%), Gypsum (2%), Lime (5 to 30%) and Quarry dust (48 to 53%), compressive strength were studied for different mix proportions. The results shows the variation of compressive strength for different mix proportions of materials mentioned earlier at different curing ages. From the results it was inferred that, the maximum optimized compressive strength is obtained for optimal mix percentage of Flyash-15% Lime-30% Gypsum-2% Quarry dust-53%.

Keywords – fly ash,lime,gypsum,quarry dust, Compressive Strength

I. INTRODUCTION

In the present scenario in the construction industry, use of economic and environmental friendly material is of a great concern. One of the main ingredients used is cement. It is observed from various studies that the heat emitted from cement accounts to a great percentage in global warming. Cement industries account to a greater emission of CO2 and they also use high levels of energy resources in the production of cement. In order to minimize these effects, replacement of cement with some pozzolanic materials such as fly ash, can have an improving effect against these harmful factors. In each country utilization of fly ash depends on the local condition and has much to do with the fact that fly ash is multi functional material and can be used for various purposes. FaL-G Flyash-lime-gypsum bricks/blocks technology has been developed successfully by National Thermal Power Corporation (NTPC), Bhanu International and Ahmadabad Electricity Company (AEC) for manufacturing bricks/blocks which can replace burnt clay bricks as walling material. It is also known as FlyAsh-Lime-Gypsum **(**FaL-G) bricks. It is not a brand name but it is duct name, christened to the mix for easy identification of its ingredients. Fal-G is a technological renaissance of the age old pozzolanic chemistry proven for its strength and durability . FaL-G is a ground blend of fly ash (Fa), lime (L) and gypsum (G) in suitable proportions which, upon hydration, yields strengths in the range of 6-40 MPa, rendering a highly water impervious hard matrix, with the formation of mineralogical phases during hydration similar to those of ordinary Portland Cement (OPC) .The proportions of lime and gypsum are dependent upon the chemical constituents and the behaviour of fly ash

II. MATERIALS AND METHODS

A. Materials and methods

Fly ash was directly collected from Tuticorin Thermal Power Plant,India. The other ingredients lime, sand and gypsum were collected from the local market. The major ingredients in fly-ash are presented in Table 1.

Si.No	Chemical composition	Class F type Fly Ash
1	$Si O_2$	59.90
2	$Al O_2$	25.80
3	$Fe_2 O_5$	6.90
4	Ca O	8.70
5	Mg O	1.80
6	SO_3	0.60
7	Na_2O & $k_2 O$	0.60

Fig .1 class F type Fly Ash

Lime

Lime is an important binding material in building construction. It is basically Calcium oxide (CaO) in natural association with magnesium oxide (MgO). Lime reacts with fly ash at ordinary temperature and forms a compound possessing cementitious properties. After reactions between lime and fly ash, calcium silicate hydrates are produced which are responsible for the high strength of the compound.

Gypsum

Gypsum is a non- hydraulic binder occurring naturally as a soft crystalline rock or sand. Gypsum is a common mineral, with thick and extensive evaporite beds in association with sedimentary rocks. Deposits are known to occur in strata from as far back as the Archaeaneon. Gypsum is deposited from lake and sea water, as well as in hot springs, from volcanic vapors, and sulfate solutions in veins

Quarry dust

Quarry rock dust can be an economic alternative to the river sand. It is residue taken from granite quarry

First Arriving mix percentage of flyash bricks for Flyash (15 to 50%), Lime (5 to 30%), Gypsum (2%) and Quarry dust (45 to 55%).Standard flyash brick size of 230 mm x 110mm x 90 mm are used to cast the bricks. For each proportion 12 number of bricks are casting in that nine bricks are used to determine the compressive strength of brick in N/mm² at 7days,14days,21days curing time and three bricks are used to determine the water absorption. Compressive Stress is determined using Compression Testing Machine (CTM) of 3000 kN capacity.The following Flow chart describes the methodology of this study

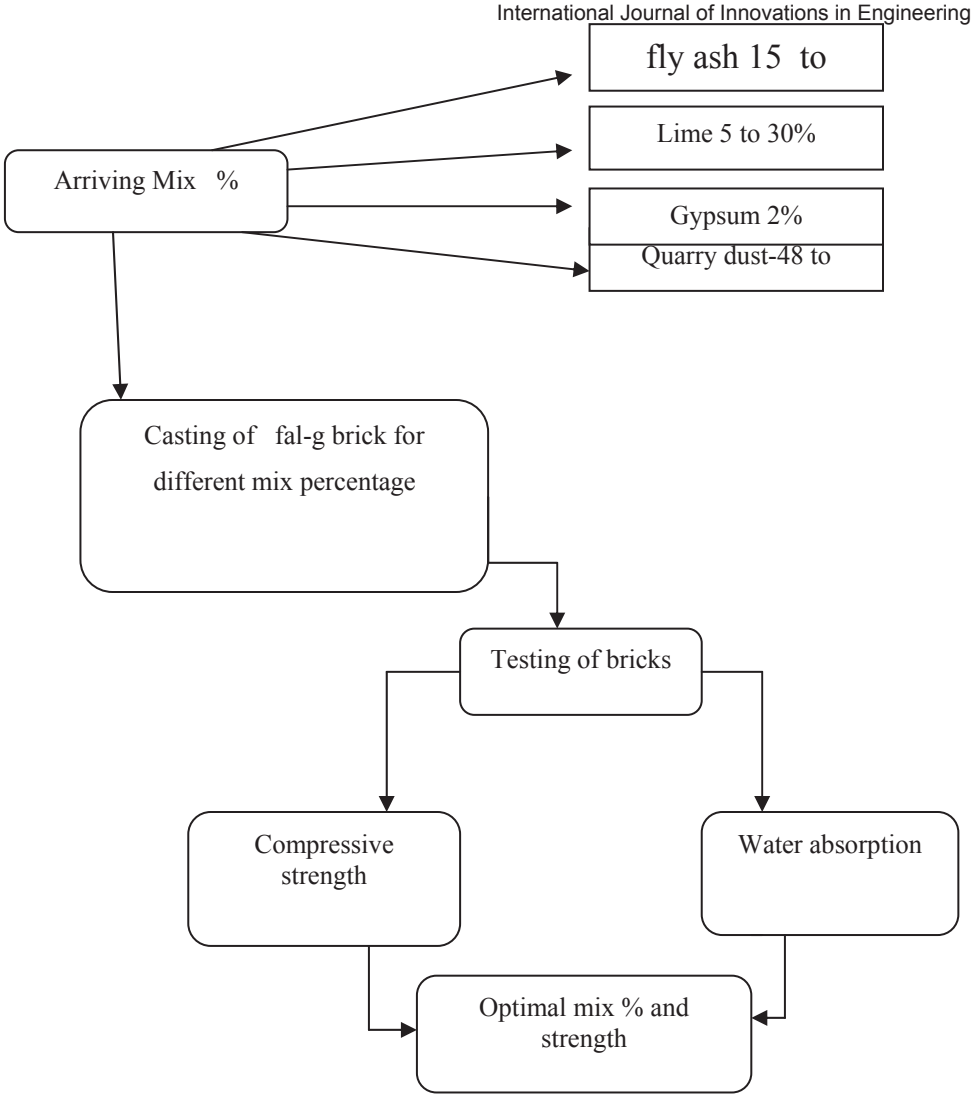

Fig.2 Flow chart shows the methodology

Mix Proportion

To make the fal-g brick following mix proportions are arrived by trial and error method.The Table 1 shows the various mix proportions

Table.2 various mix proportions.

proportions	Fly ash(%)	Lime(%)	Gypsum (%)	Quarry dust(%)
I	15	30	02	53
II	20	25	02	53
III	20	30	02	48
IV	25	20	02	53
V	30	15	02	53
VI	35	10	02	53
VII	40	05	02	53

The quantity of materials required to cast a single brick is arrived by taking a brick weight of 3.5 kg is given in the Table.2

Table.3 Quantity of materials used

Proportions	Fly ash(kg)	Lime(kg)	Gypsum(kg)	Quarry dust(kg)
I	0.525	1.050	0.2	1.855
II	0.700	0.875	0.2	1.855
III	0.700	1.050	0.2	1.680
IV	0.875	0.700	0.2	1.855
V	1.050	0.525	0.2	1.855
VI	1.225	0.350	0.2	1.855
VII	1.400	0.175	0.2	1.855

Water-binder ratio

Water-binder ratio is calculated based on fly ash and weight of lime to total weight of the brick. It also plays the significant role on the compressive strength of the brick. Considering the water content or water to binder ratio is an indirect approach to sizing the volume, thus ensuring greater durability in the mixture proportions for bricks made .Thus Water-binder ratio used for various proportions is given in the Table.3

Table. 4 Water-binder ratio(%)

proportions	Water-Binder ratio(%)
I	0.45
II	0.43
III	0.50
IV	0.45
V	0.45
VI	0.45
VII	0.45

B. PREPARATION AND TESTING OF SPECIMENS

Testing of Specimens Casting of bricks

The normal hand mould is used to cast the bricks with the standard size of 230mm x 110mm x90mm.They were cast according to the standard procedure with various mix proportions arrived. The required quantity of Fly ash, Lime, Gypsum, Quarry dust is calculated previously, according to that the materials mixed properly. Then required quantity of water was added. Then they mixed thoroughly. Then the prepared mix was poured in to the mould and it is compacted. After compacting gets over then the mould is removed. Then the wet brick was kept under air curing for 2 days and then bricks were water cured for a period of 7,14,21 days.

The following figures shows the materials and mixing of materials to cast the brick

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Fig.3 Brick Hand Mould

Fig.4 Fly Ash

Fig.5 Quarry Dust

Fig.6 Lime

Fig.7 Gypsum

Fig.8 Casted brick kept for Air curing

III. RESULTS AND DISCUSSIONS

. The investigation was carried out to determine the optimal mix percentage of fly ash brick admixed with lime, gypsum, and quarry dust and also to determine the water absorption.

Arriving proportions

Mix proportions are arrived by referring the articles and data collecting from local manufacturing companies. For the various proportions arrived bricks are casted and the following tests were conducted

Tests are applied to bricks

Compressive Strength test

Water Absorption test

Efflorescence

Compressive strength test

The compressive strength of fal-g brick is three times greater than the normal clay brick. The minimum compressive strength of clay brick is 3.5 N/mm².So as the fal-g brick has compressive strength of 10-12 N/mm². Bricks to be used for different works should not have compressive strength less than as mentioned above. The universal testing machine is used for testing the compressive strengt**h** of bricks. After the curing period gets over bricks are kept for testing. To test the specimens the bricks are placed in the calibrated Compression testing machine of capacity 3000 kN applied a load uniform at the rate of 2.9 kN/min. The load at failure is the maximum load at which specimen fails to produce any further increase in the indicator reading on the testing machine. In that three numbers of bricks were tested for each mix proportion. Each brick may give different strength. Hence, average of three bricks was taken.

Water absorption

Fly ash Bricks should not absorb water more than 12%. The bricks to be tested should be dried in an oven at a temperature of 105 to 115^{o} C till attains constant weight cool the bricks to room temperature and weight (W1). Immerse completely dried and weighed W1 brick in clean water for 24 hrs at a temperature of 27±20 Degree Celsius. Remove the bricks and wipe out any traces of water and weigh immediately (W2). Water absorption in % by weight = (W2 – W1/W1) x 100

Efflorescence

For this test, brick was placed vertically in water with one end immersed. The depth of immersion in water being 2.5 cm, then this whole arrangement should be kept in a warm-well-ventilated room temperature of 20-30 ^{o}C until all evaporates. When the water in the dish is absorbed by the brick and surplus water evaporates. When the water is completely absorbed and evaporated place similar quantity of water in dish and allows it to absorb and evaporate as before. Examine the brick after this and find out the percentage of white spots to the surface area of brick. If any difference is observed because of presence of any salt deposit then the rating is reported as 'effloresced'. If no difference is noted, the rating is reported as 'not effloresced'.Percentage of white spot in the brick = Nil

Optimal Mix Percentage

Table. 5 Mean values of Compressive Strength (N/mm²)

Proportions	7 days(N/mm^2)	14 days(N/mm^2)	21 days(N/mm^2)
I	1.98	3.89	7.82
II	1.68	3.37	6.78
III	1.82	3.37	6.97
IV	1.43	3.08	5.78
V	1.22	2.43	5.36
VI	1.03	1.97	5.04
VII	1.12	2.23	5.14

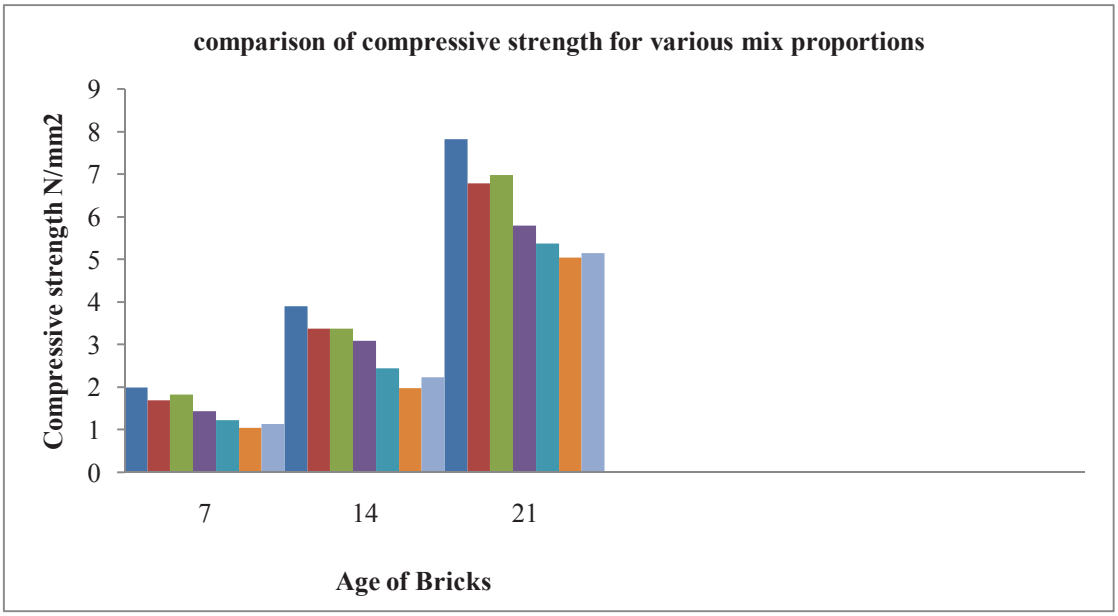

Fig.9 Compressive strength for various proportions at 7, 14, 21 days curing

From the experimental results proportion-1 shows the maximum compressive strength value. So that proportion-1 was taken as a optimal mix percentage of fly ash brick (Fly ash-15% Lime-30% Gypsum-2% Quarry dust-53%).The compressive strength decreases with increases of fly ash content.The fig shows the compressive strength decreases with increases of fly ash

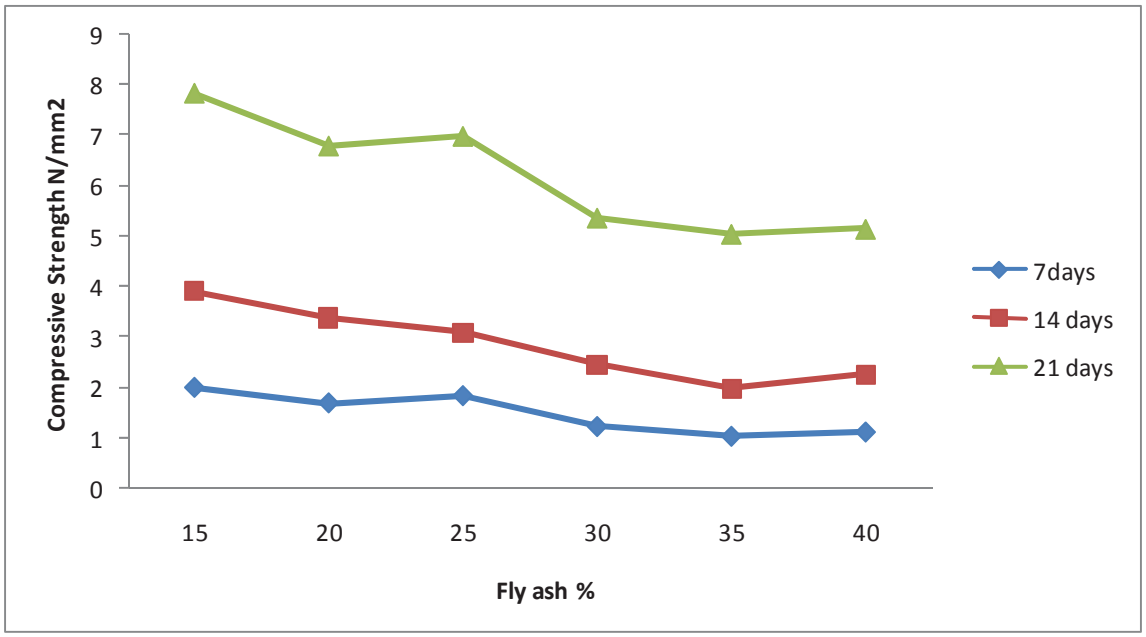

Fig.10 Variation of Compressive Strength with increase of Fly Ash

Table.6 Calculation of Water Absorption value (%)

proportions	W_1(kg)	W_2(kg)	W_2-W_1	(W_2-W_1)/W_1	(W_2-W_1)/W1X100%
I	3.75	4.16	0.41	0.109	10.9
II	3.69	4.15	0.46	0.124	12.4
III	3.71	4.18	0.47	0.126	12.6
IV	3.75	4.25	0.50	0.133	13.3
V	3.69	4.25	0.56	0.151	15.1
VI	3.71	4.29	0.58	0.156	15.6
VII	373	4.34	0.59	0.157	15.7

Water absorption = (W2-W1)/W1x100

= [(4.16-3.75)/3.75]x100

= 0.109x100

= 10.9%

From the results obtained water absorption for optimal mix percentage is 10.9%.It is lesser then the standard value of 12%.And also observed that for maximum strength only a good water absorption obtained. The following figure shows the variation of water absorption with compressive strength of brick

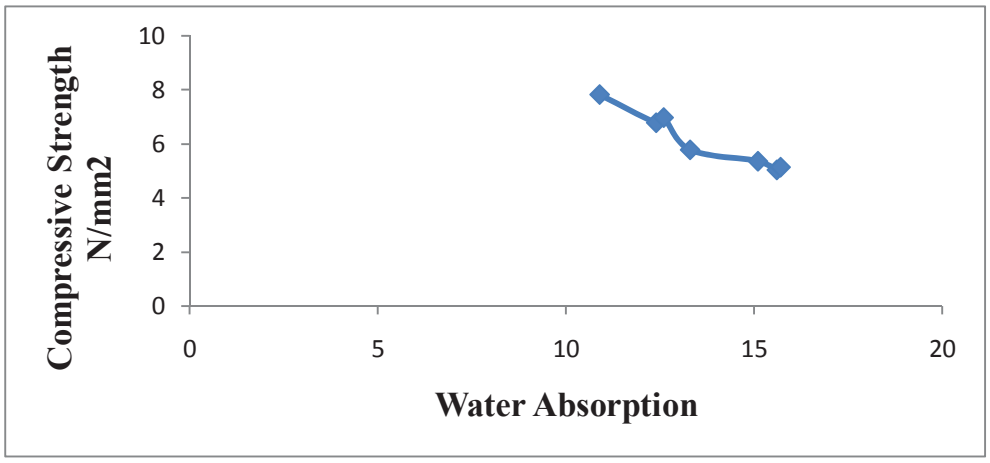

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Fig.11 Comparison between strength Vs water absorption

IV.CONCLUSION

Based on the experimental study, following conclusions can be drawn regarding the strength behavior of fal-g brick; The study was conducted to find the optimum mix percentage of fal-g brick. However the brick specimen of size 230mm x 110mm x 90mm were cast for different mix percentage of Flyash (15 to 40%), Gypsum (2%), Lime (5 to 30%) and Quarry dust (48 to 53%). However the specimens have been tested for seven mix proportions. The mechanical properties such as compressive strength were studied for different mix proportions, at different curing ages. From the results it was inferred that, among the seven proportions the maximum optimized compressive strength is obtained for optimal mix percentage of Flyash-15% Lime-30% Gypsum-2% Quarry dust-53% as 7.91 N/mm². Water absorption for optimal mix percentage is 10.9%. It is lesser then the standard value of 12%. And also observed that for maximum strength only a good water absorption obtained

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