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Manufacturing of Fly Ash Brick and Finding the Optimal Mix of Materials with Replacement of Cement by Lime Sludge and Gypsum

Ramesh Raja M[1], Naresh Kumar A[2], Ranga Bashyam S[3], Sanjay Kumar M[4], Sathish Kumar M[5]

[1, 2, 3, 4] *Students, Dept. of Civil Engineering, Velammal College of Engineering and Technology, Tamilnadu, India*
[5]*Professor, Dept. of Civil Engineering, Velammal College of Engineering and Technology, Tamilnadu, India*

Abstract - *In construction industry, use of fly ash brick increased in the past ten years. Fly ash bricks are usually made by fly ash, sand and cement. Use of cement in fly ash makes the cost of the brick higher. And also cement production is a significant source of CO_2 emission. To reduce these problems, lime sludge and gypsum may be used in the place of cement. But manufacturers face problems since use of lime sludge and gypsum reduces the compressive strength of bricks. To solve these above problems we conducted this study to find out the optimal mix of materials of fly ash brick with replacement of cement by lime sludge and gypsum which gives greater compressive strength.*

Key Words: Fly ash brick, Gypsum and lime sludge, Optimal mix, Compressive strength, Quarry dust

1. INTRODUCTION

In the present scenario in the construction industry, use of economic and environmental friendly materials is of a great apprehension. One of the main ingredients used is cement. It is observed from various studies that the heat emitted from cement leads to a greater percentage in global warming. Cement industries account to a greater emission of CO2 and they also use high levels of energy resources in the manufacturing of cement. In order to reduce these effects, replacement of cement with lime sludge and gypsum can have an improving effect against these harmful factors. In addition to that, use of lime sludge and gypsum as a replacement of cement results in reduction in the cost of brick upto 45%. This is because the cost for the amount of cement used in a fly ash brick is higher than the cost of other materials used in that fly ash brick.

2. OBJECTIVES

In this work, we found the optimum mix of fly ash (major ingredients) generated at Thermal Power Plant, sand, hydrated lime and gypsum. Fly ash- 50%, sand- 20% and hydrated lime – 20% with gypsum-10% was identified to be the optimum mix. For the optimum mix calculated the compressive strength, water absorption test, Efflorescence and shape test were also examined.

3. RAW MATERIALS

Fly Ash: Fly Ash is the inorganic mineral residue generated after burning of coal or lignite in the boilers. Fly Ash is that portion of ash which is collected from the ash ponds. Bottom ash is that portion of ash which can be gathered from the bottom portion of the boilers. The characteristics of fly ash based upon the quality of lignite or coal and the efficiency of boilers. India depends primarily on coal for the power generation. Generation of power from bituminous sources is increasing every year. The generation of fly ash is also going to increase every year. The disposal of fly ash in the present method will be a big trouble to environment, especially when the quantity increases from the present level.

Lime: Lime is a significant binding material in building construction. It is mainly Calcium oxide (CaO) in natural association with magnesium oxide (MgO).Lime reacts with fly ash on ordinary temperature and results in a compound possessing binding properties. After reactions between lime and fly ash, calcium silicate hydrates are created which are responsible for the high strength of the compound.

Gypsum: Gypsum is a non- hydraulic binder taking place naturally as a soft crystalline rock or sand. Gypsum has valuable properties like small bulk density, good sound absorbing capacity, good fire resistance, rapid drying and hardening with negligible shrinkage, etc. In addition it can strengthen material or increase viscosity. It has a specific gravity of 2.31. The density of gypsum powder is 2.8 to 3 g/cc.

Quary dust: It is residue collected from granite quarry. Due to the cost of transportation of sand from natural sources, river sand is expensive. Also creates environmental problems of large-scale reduction of these sources. Use of river sand in construction becomes

expensive, a substitute or replacement product for concrete industry needs to be found. Whose continued use has begun posing serious problems with respect to its availability, cost and environmental impact.

4. COMPOSITION

Table -1: Composition of Brick 1

Composition of brick 1	
Fly ash	70%
M sand	15%
Lime sludge	10%
Gypsum	5%

Table -2: Composition of Brick 2

Composition of brick 2	
Fly ash	60%
M sand	20%
Lime sludge	15%
Gypsum	5%

Table -3: Composition of Brick 3

Composition of brick 3	
Fly ash	50%
M sand	20%
Lime sludge	20%
Gypsum	10%

5. MANUFACTURING

Fig -1: Compaction of brick by machineries

Fly ash (45-70%), Lime (10-25%), Gypsum (5-10%) and sand (10-25%) each mix proportion is manually feed into a pan mixer where water is added to the required proportion for homogeneous mixing. After mixing, the mixture is led to belt conveyor to feed in to automatic brick making machine were the bricks are pressed automatically. Then the bricks are placed on wooden pallets and set aside as it is for two days, there after they are water cured for 10 -15 days. The bricks are sorted and tested at 7^{th}, 14^{th} and 21^{st} day from the day of manufacturing. Each brick were casted for nominal size of 230mm×110mm×90mm.

6. TESTING

6.1 Water Absorption Test

Fly ash Bricks should not absorb water greater than 12%. The bricks to be tested should be dried in an oven at a temperature of 105˚C to 115˚C till it reaches constant weight, cool the bricks to room temperature and weight (W1). Submerge completely dried and weighed (W1) brick in clean water for 24 hours at a temperature of 27±20 Degree Celsius. Remove the bricks and wipe out all drops of water and weigh immediately (W2).Water absorption in % by weight = (W2 – W1/W1) x 100.The average of three bricks should be taken.

6.2 Compressive Strength Test

The compressive strength of fly ash brick is three times more than normal clay brick. The minimum compressive strength for clay brick is 3.5 N/mm^2. The compressive strength of fly ash brick varies from 7 to 12 N/mm^2. Bricks to be used for various works should not have compressive strength less than 3.5 N/mm2. The universal testing machine is used for testing the

compressive strength of bricks. After the curing period gets over bricks are set aside for testing. To test, 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 brick fails to produce any further increase in the indicator reading in the testing machine. In three numbers of bricks, one brick was tested for each mix proportion on 7^{th}, 14^{th} and 21^{st} day. Each brick may give different strength. The 21^{st} day compressive strength is taken as final value.

Fig -3: Compressive strength testing

6.3 Efflorescence Test

For this test, brick was immersed and kept for 24 hours. After 24 hours, the brick is taken out for inspection. Examine the brick after this and find out the amount of white spots to the surface area of brick. If any difference is detected because of presence of any salt deposit then the rating is reported as 'effloresced'. If no difference is observed, the rating is reported as 'not effloresced'. Percentage of white spot in the brick should be nil.

6.4 Shape Test

The brick should be perfectly rectangle and each side should be perfectly flat. The edges should be sharp.

7. RESULTS

7.1 Compressive Strength Test Result

Table -4: Compressive Strength Test Results

COMPOSITION	7 DAYS (N/mm^2)	14 DAYS (N/mm^2)	21 DAYS (N/mm^2)
1	1.34	2.62	4.3
2	1.03	1.97	5.04
3	1.98	3.95	8

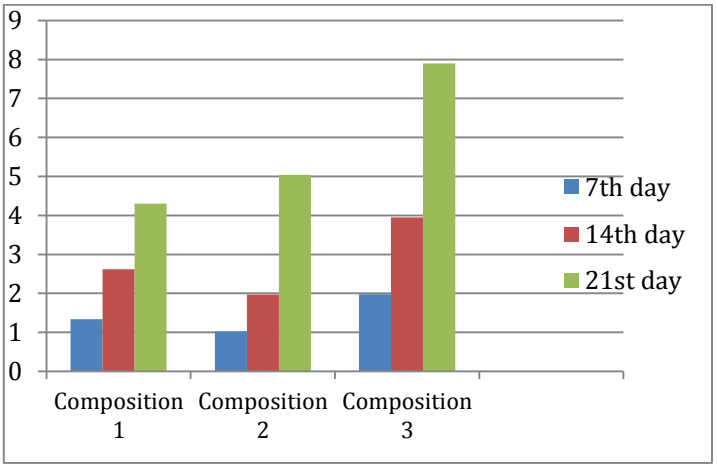

Chart -1: Graph Showing Compressive Strength of three Compositions of Bricks

7.2 Water Absorption Test Result

Table -5: Water Absorption Test Results

COMPOSITION	DRY WEIGHT W1	WET WEIGHT W2	WEIGHT OF WATER(W2-W1)	(W2-W1)/W1	WATER ABSORBED IN %
1	3.73	4.36	0.63	0.168	16.8
2	3.71	4.29	0.58	0.156	15.6
3	3.75	4.36	0.41	0.109	10.9

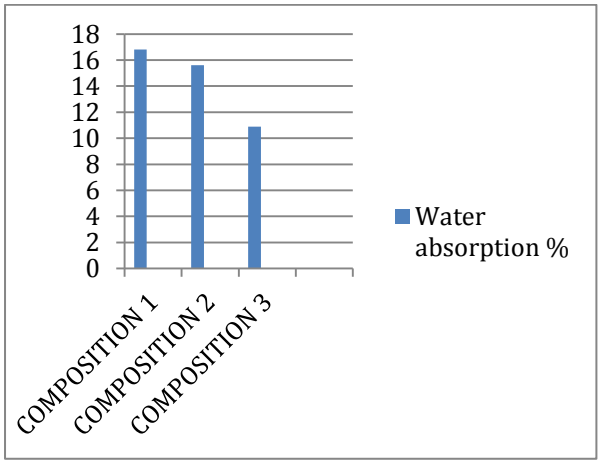

Chart-2: Showing Composition Based On Water Absorption

7.3 Efflorescence Test Result

No white spots are found in all three bricks of three different compositions.

7.4 Shape Test Result

All bricks have passed the shape test. All bricks satisfied these requirements. The bricks are perfectly rectangle and each side is perfectly flat. The edges are sharp.

8. CONCLUSION

Based on the experimental study, following conclusions can be drawn regarding the strength of fly ash bricks. The study was carried out to find the optimum mix percentage of fly ash brick. Hence, the brick specimen were cast for different mix percentage of Fly ash (45 to 70%), Gypsum (5-10%), Lime (10 to 25%) and Quarry dust (10 to 25%). The specimens have been tested for all three mix proportions. From the results it was concluded that among the three proportions, the maximum optimized compressive strength is obtained in optimal mix percentage of Fly ash-50%, Lime-20%, Gypsum-10%, Quarry dust-20% as 8 N/mm^2.

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