Evolution of fly-ash bricks using industrial waste materials.

[1]Bhaumik Gandhi, [2]Pankti Bhatt, [3]Nisarg Fultariya, [4]Mahammadwasim Shaikh
[1]B E Student, [2]B E Student, [3]B E Student, [4]B E Student
[1]Department of Civil Engineering,
[1]A D Patel Institute of Technology, New V U Nagar, Gujarat, India

Abstract : Bricks are generally made from clay materials. It is high time to change from clay to such materials which are eco-friendly for production of bricks. This aim of the paper is to use eco-friendly waste materials like fly ash, marble waste, foundry sand, lime and stone dust for manufacturing of bricks. Such bricks will be manufactured through industrial support of Akira marbles situated at GIDC New V U Nagar. Properties of bricks like Water absorption, Compressive strength, Density will be tested for different mixes of above waste materials.

Index Terms **– Fly-ash, Foundry sand, Stone dust, Marble dust, Water absorption test, Compressive strength.**

I. INTRODUCTION

The conventional techniques for bricks making has brought irrefutable drawbacks. The ancient and conventional procedures of brick making were by mixing the raw materials, molding the bricks, and drying and firing them till they obtain a certain level of strength. The use of Fly Ash and other industrial wastes for making bricks is ecologically advantageous since apart from saving precious top agriculture soil, it meets the social objective of disposing industrial wastes otherwise are pollutants and nuisance

II. MATERIALS

1. FLY ASH: Fly-ash also known as “pulverized fuel ash” in the United Kingdom, is one of the coal combustion products, and is composed of the fine particles that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash. The chemical properties are taken as per the industry.

Table 1: Physical Properties of Fly-ash

Sr no.	Property	Value
1	Specific gravity	2.07
2	Fineness (m^2/kg)	290
3	Color (visual observation)	Light Grey

2. STONE DUST: Stone dust is a by-product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In stoning activities, the rock has been crushed into various sizes, during the process the dust generated is called stone dust and it is formed as waste.

Table 2: Physical Properties of Stone dust

Sr no	Property	Value	Test methods
1	Specific gravity	2.6	IS 2386 (Part 3) 1963
2	Bulk relative density	1750	IS 2386 (Part 3) 1963
3	Sieve analysis	Zone IV	IS 383- 1970
4	Moisture content (%)	Nil	IS 2386 (Part 3) 1963

3. MARBLE DUST: Marble dust is waste material formed during the production of marble. A large quantity of powder generated during cutting process. The result is that 25% marble mass is lost in the form of dust.

Table 3: physical Properties of Marble dust

4. FOUNDRY SAND:

Sr no.	Property	Value
1	Specific gravity	2.8
2	Color	Grey
3	Form	Powder

Molding sand, also known as foundry sand, is a sand that when moistened and compressed or oiled or heated tends to pack well and hold its shape. It is used in the process of sand casting for preparing the mold cavity.

Table 4: Physical Properties of Foundry sand

Sr no.	Property	Value
1	Specific Gravity	2.42
2	Bulk relative density kg/m^3 (lb/ft^3)	2500
3	Moisture content (%)	8

5. LIME: Lime is a white caustic alkaline substance consisting of calcium oxide, which is obtained by heating *limestone* and which combines with water with the production of much heat; quicklime.
6. WATER: Water is added to the materials for making strong and workable mix. Without water hydration will not take place. Adding water is necessary to make paste

III. METHODOLOGY

Total 108 modular bricks samples of size 230 mm × 110 mm × 80 (IS: 12894-2002) were cast at Akira marbles GIDC, New V U Nagar using Fly-ash, Stone dust, Foundry sand, Marble dust and Lime.

Table 5: Different proportions

Sr no	Mix design	No. of bricks	Fly-ash (%)	Lime (%)	Stone dust (%)	Marble dust (%)	Foundry sand (%)	Weight (kg)
1	Standard	18	60	10	30	-	-	2.992
2	Mix 1	18	50	10	10	28	2	2.541
3	Mix 2	18	50	10	10	26	4	2.720
4	Mix 3	18	50	10	10	24	6	2.523
5	Mix 4	18	50	10	10	22	8	2.654
6	Mix 5	18	50	10	10	20	10	2.648

IV. WORK FLOW

Mixing of waste materials: The different mix designs were prepared at A D Patel Institute of Technology with sufficient quantity of weight using weight method to obtain working capacity of molding. The below figure1 shows the

Figure 1: Mixing of raw materials

Adding water: The required amount of water for preparation of bricks is taken as per the guidelines given by manufacturer owner of Akira marbles GIDC, New V U Nagar.

Casting: The casting was done at Akira marbles. The mould size available was as per the standards. After casting, the molded brick was allowed to dry for two days, protecting from direct sun light as shown in Figure 2.

Figure 2: Casting at Akira marbles GIDC, New V U Nagar

Curing: The samples were brought in ADIT college after two days of casting and sprinkler curing method was used.

V. EXPERIMENTAL WORK

The various tests performed on the bricks were:

A. Water absorption test.
B. Compression test
C. Efflorescence test
D. Density

The samples were tested after 7 and 21 days respectively for compressive strength as per the provisions of IS: 3495 (Part 1)-1992. The water absorption of the bricks was tested as per the provisions contained in IS: 3495 (Part 2)-1992. Before testing, the frogs and voids of the specimen were filled up with cement sand mortar (1: 1).

IV.

A. WATER ABSORPTION TEST

We conducted water absorption test at the third day of the casting of brick. We weighted the bricks and keep the bricks in water for 24 hours. Total 5 bricks for various mixes we have taken and the comparison of dry and wet weight was carried out. The average weight of water absorption comes out to be less than 12%.

Table 6: Descriptive Statics

Sr no.	Proportion	Avg. Mass of dry brick (kg)	Avg. Mass of wet brick (kg)	Avg. Water absorption (%)
1	Standard	3.082	3.251	5.2
2	Mix 1	2.713	2.807	3.34
3	Mix 2	2.804	3.082	9.02
4	Mix 3	2.776	3.107	10.65
5	Mix 4	2.807	3.146	10.77
6	Mix 5	2.677	3.000	10.78

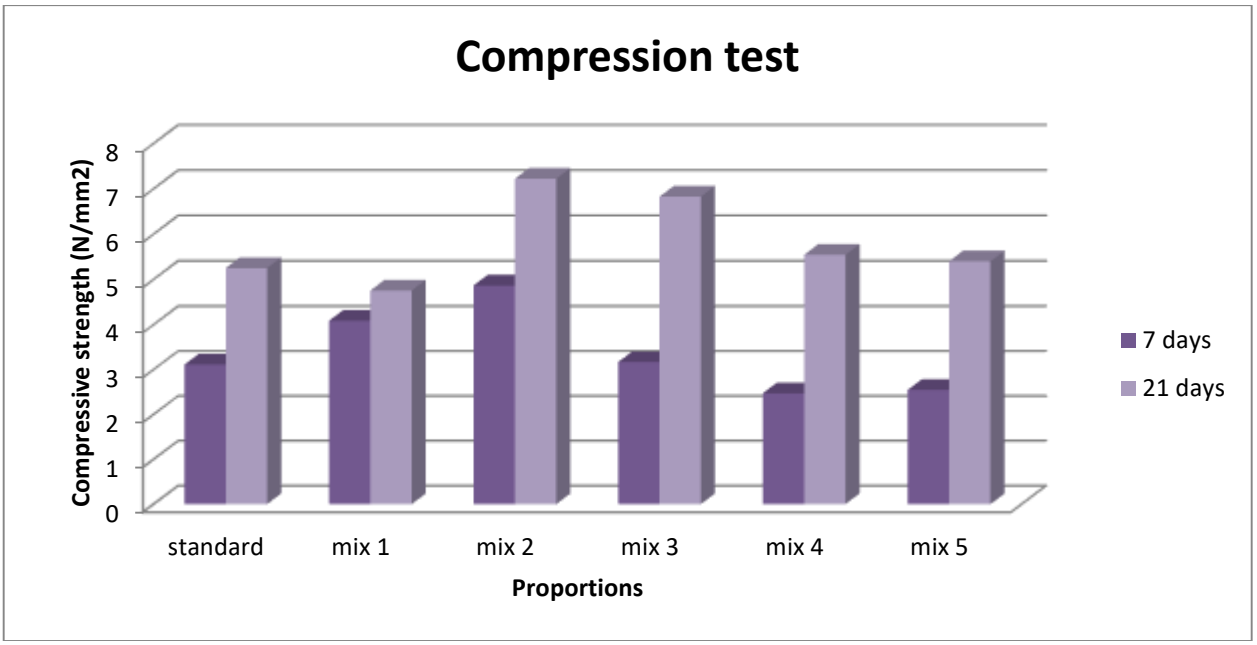

Figure 3: Graph of values of water absorption

B. COMPRESSION TEST

Compressive test was carried out using compression testing machine having a capacity of 2000 kN in ADIT college and the result of 7 days and 21 days was obtained as under shown in Table 7

Table 7: Descriptive Statics

Sr. no	Proportions	Avg. Compression on brick (7 days)		Avg. Compression on brick (21 days)	
		Load (kN)	Stress (N/mm^2)	Load (kN)	Stress (N/mm^2)
1	Standard	81.150	3.114	132.822	5.250
2	Mix 1	103.624	4.090	120.274	4.754
3	Mix 2	123.104	4.866	182.760	7.224
4	Mix 3	79.890	3.166	172.692	6.828
5	Mix 4	62.538	2.470	140.312	5.546
6	Mix 5	64.46	2.548	136.818	5.400

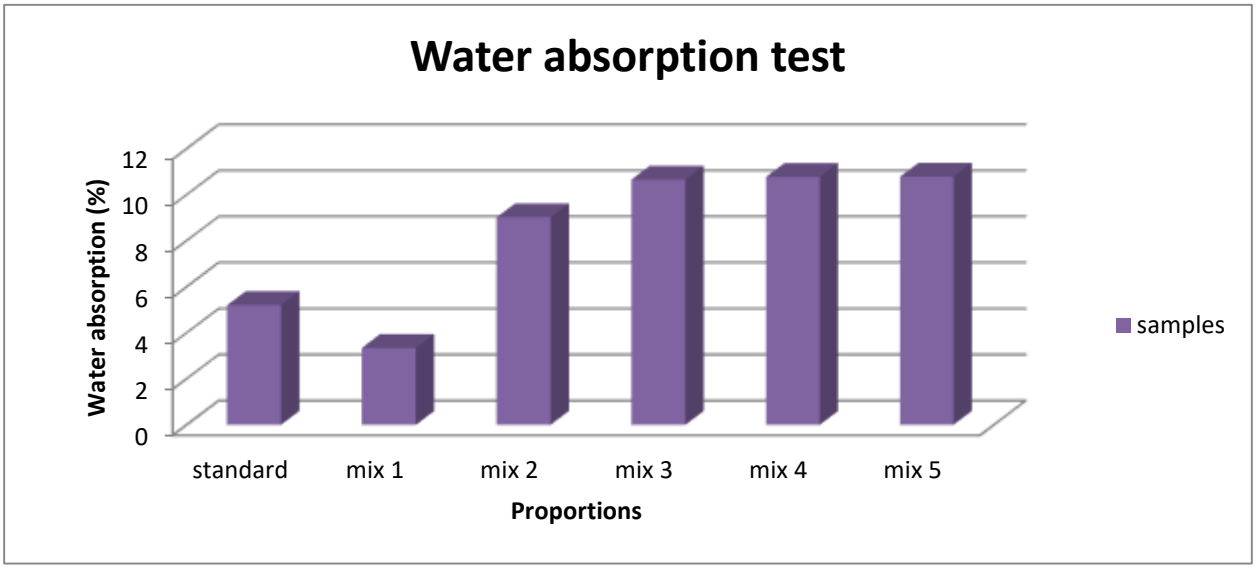

Figure 4: Graph of values of compression test for 7 and 21 days

C. EFFLORESCENCE

Bricks were placed vertically down in 2cm deep water. It was found that brick absorbs the water within a week and some soluble salts patches were observed as the content of furnace sand was increased, but it was under the Indian Standard recommendation. Hence, it is approved.

D. DENSITY

Brick density is an important parameter. Density indicates the weight of the brick work.

Table 8: Density calculations

Sr no	Material	Avg. Mass (kg)	Density (kg/m^3)
1	Standard	2.849	1407.608
2	Mix 1	2.696	1332.01
3	Mix 2	2.654	1311.26
4	Mix 3	2.609	1289.03
5	Mix 4	2.578	1273.71
6	Mix 5	2.529	1249.50

VI. RATE ANALYSIS

For calculation of costing of bricks, the cost of different industrial waste are obtained and final cost of brick was compared with the standard rate.

Rates of materials:

Fly ash :- 0.8 rupees/kg
Lime :- 5.5 rupees/kg
Stone dust :- 0.45 rupees/kg
Marble waste :- 0.5 rupees/kg
Labor charge :- 0.7 rupees
Electric charge :- 0.2 rupees
Supervision charge :- 0.3 rupees

Table 9: Rate of single unit of brick

Sr no	Property	Fly-ash (kg)	Lime (kg)	Stone dust (kg)	Marble dust (kg)	Foundry sand (kg)	Cost (rupees)
1	Standard	1.393	0.299	1.157	-	-	4.48
2	Mix 1	1.165	0.299	0.385	0.829	0.018	4.36
3	Mix 2	1.165	0.299	0.385	0.769	0.036	4.33
4	Mix 3	1.165	0.299	0.385	0.710	0.050	4.30
5	Mix 4	1.165	0.299	0.385	0.650	0.079	4.27
6	Mix 5	1.165	0.299	0.385	0.590	0.090	4.24

VII. DISCUSSION

- Compression strength of 21 days for mix design 2 and mix design 3 gives excellent result which are 6.48 kN/m^2 and 6.58 $kN/m^{2.}$
- As the proportion of stone dust increases the weight of brick increases.
- The water absorption is directly proportional to the proportion of foundry sand and stone dust, foundry sand in bricks increases water absorption increases.
- Efflorescence test done with mix 1, 2 and 3 give moderate grey or white deposits less than 10% on the surface area compared to mix 4 and 5.

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