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AN EXPERIMENTAL STUDY ON DIFFERENT MATERIAL PROPERTIES REQUIRED FOR MAKING OF FLY ASH BRICK

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Abstract

Bricks are such an element which takes part an important role to construct a house. Usually, burnt clay bricks are using to meet the ambition but to do so, a large amount of soil is removing for the production of clay bricks. This paper reveals the material properties of fly ash bricks taking different proportions of fly-ash, gypsum, sand, quarry dust, lime and a fixed amount of cement. Different tests were conducted to find material properties i.e., moisture content, specific gravity, grain size distribution, consistency, bulking of sand, silt test, water absorption in the laboratory. Ingredients were being used to produce the bricks at four proportions of using fly-ash, gypsum, sand/stone dust, lime and small amount of cement replacing gypsum in three proportions. All the materials were tested before preparation of brick mould. Then the mortar was placed to a mold as per specification. ASTM code of practice was followed to conduct the tests of this research.

Keywords: *Fly ash, Lime, Gypsum, Quarry dust, Sand, Cement, Material properties.*

INTRODUCTION

In order to achieve the project objectives a series of tasks were identified and included literature reviews, collection of experiences from other research work, review of other state specifications, laboratory evaluation of fly ash brick samples and material properties. The fly ash bricks being lighter and stronger than ordinary burnt clay bricks can be easily used for the purposes of construction. Fly ash brick is a building material, specifically masonry units, containing class C and class F fly ash and water. Fly ash is generally evaluated in cement and concrete production as an inexpensive pozzolanic blending material, Pei-wei et al. (2007). Gourav and Reddy (2018) tried to reveal the causes behind the clay-fly ash-gypsum-lime masonry. Cultrone and Sebastian (2008) conducted a research to develop strength of solid bricks using fly ash in five proportions. Henry et.al (2005) intended to provide a solution to the fly ash disposal problem by utilizing the fly ash produced from different sources. The cement industry emits a huge amount of CO2 along with high energy consumption produce cement. To reduce these effects, the pozzolanic materials such as fly ash may be used by replacing lime. In this current work the attempt has made toward find the optimum mix proportions so as to obtain highest compressive strength of latest fly-ash brick. These bricks made with fly-ash are prepared for different ratios of ingredients using hydride lime or slug lime and Gypsum/cement as binder material and 28 days compressive strengths are calculated. Obadakayaliet.al (2005) compared the properties of fly ash bricks to the clay bricks. The produced fly-ash bricks were not only 28% lighter than clay bricks although it possess 40MPa or higher compressive strength.

Sieve analysis is carried out to determine the grain size distribution of the sand. Sand has been tested for its bulking properties and it was found that the volume of the sand has increased by 3% after 1 hour as well as 24 hours. Average moisture content of fly ash by oven dry method was 0.3. The consistency was determined using the Vicat apparatus. A mixture of 400 gm cement and 136 ml of water determined the initial and final setting time of the cement. Different proportions of materials are mixed together to prepare different grades of bricks and their strength is checked.

2. INGREDIENTS OF FLY ASH BRICK

Fly ash

Fly Ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electrostatic precipitator. ASTM broadly classify fly ash into two classes Class F: Fly ash normally produced by burning anthracite or bituminous coal, usually has less than 5% CaO. Class F fly ash has pozzolanic properties only. Class C Fly ash normally produced by burning lignite or sub-bituminous coal. Some class C fly ash may have CaO content in excess of 10%.

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 cementations properties.

Gypsum

Hydrated Calcium Sulphate is called Gypsum ($CaSO_4$: $2H_2O$). Gypsum is a non- hydraulic binder occurring naturally as a soft crystalline rock or sand. Gypsum have a valuable properties like small bulk density, incombustibility, good sound absorbing capacity, good fire resistance, rapid drying and hardening with negligible shrinkage, superior surface finish, etc.

Quarry dust

It is residue taken from granite quarry. Due to excessive cost of transportation from natural sources locally available river sand is expensive. Also creates environmental problems of large-scale depletion of these sources. In such a case the Quarry rock dust can be an economic alternative to the river sand.

Sand

Optimum properties are achieved when selecting the most suitable raw material. The sand is mostly preferred from river, which is washed and should be with minimum20% fines. Dust in sand increases the demand for water and cement, without adding to the properties. It also increases shrinkage.

Cement

Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete, which is a combination of cement and an aggregate to form a strong building material.

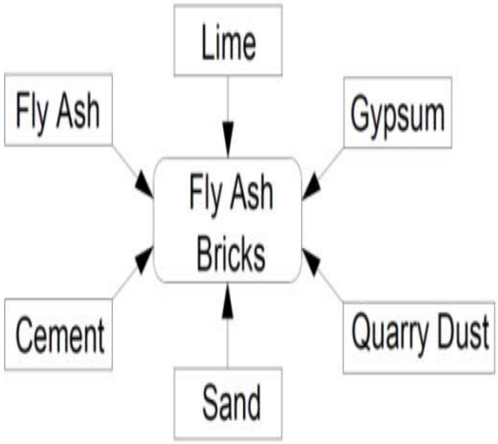

Figure 1: Flowchart representing the composition of Fly Ash brick

3. EXPERIMENT RESULT

Specific gravity of fly ash:

Determine the specific gravity of fly ash grains (Gs) using the following equation.

Gs = (W2-W1) / {(W2-W1)-(W3-W4)}

Where,

W_1 = empty weight of pycnometer

W_2 = weight of pycnometer + oven dry fly ash

W_3 = weight of pycnometer + oven dry fly ash + water

W_4 = weight of pycnometer + water full

Here, w_1 = 0.595kg; w_2= 0.646kg; w_3= 1.526kg; w_4 = 1.499kg;

We know that

Specific gravity of fly ash

$(G_s)= \frac{(W_2-W_1)}{(W_2-W_1)-(W_3-W_4)}$

Gs = (0.646 - 0.595) / {(0.646 - 0.595) – (1.526 – 1.499)}

Gs = 0.051 / (0.051 – 0.027)

Gs = 0.051kg / 0.024kg , Gs = 2.125.

Figure 2: Specific gravity test of fly ash

Moisture content of fly ash by oven dry method:

For many fly ash, the water content may be an extremely important index used for establishing the relationship between the way a fly ash behaves and its properties. The consistency of a fine-grained fly ash largely depends on its water content. The water content is also used in expressing the phase relationships of air, water, and solids in a given volume of fly ash. Calculated moisture content is described in Table 1.

Figure 3: Moisture content test of fly ash

Table 1

Observation and calculation of moisture content of fly ash

Container No.	Mass of empty container with lid (M_1), (KG)	Mass of the container with wet fly ash and lid (M_2) (KG)	Mass of the container with dry fly ash and lid (M_3) (KG)	Mass of Water Mw (LITRE)	Mass of fly ashMs (KG)	Water Content w = $(Mw/Ms) \times 100$
W_1	0.0218	0.0788	0.0786	0.0002	0.0568	0.352
W_2	0.0226	0.0726	0.0724	0.0002	0.0498	0.402
W_3	0.0232	0.0820	0.0819	0.0001	0.0587	0.170

Determination of grain size distribution of fly ash by hydrometer analysis:

Take about 50g in case of clayey fly ash and 100g in case of sandy fly ash and weight it correctly to 0.1g.

Sodium hexa Meta phosphate (s.h.m.p.) = 33g

Sodium carbonate (s.c) = 07g

Take total materials (s.h.m.p. + s.c) = 40gsolution

40g total materials with 1000ml water mixed goodly.

Then 1000ml mixed solution from we will take only 100ml solution.

Again 100ml solution with 50g fly ash materials mixed goodly.

This mixed 100ml + 50g solution put in 1000ml capacity glass jar.

Then 10ml + 50g solutions with distilled water add up to 250±2ml.

Figure 4: Observation and calculation of hydrometer Analysis (Fly ash)

Determination of consistency of cement:

Ordinary Portland cement (opc), grade 53 for star cement

Weight of cement taken (g) = 400 g

Initial percentage of water added to cement = 34%

Quantity of water added to cement =136 ml

Table 2

Observation and calculation of consistency of cement

Sl. No.	Quantity Of Water Added (ml)	Depth Of Penetration (ml)
1	136	6

Determination of initial and final setting time of cement:

Weight of cement taken (g) = 400 g

Initial percentage of water added to cement = 35%

Quantity of water added to cement =140 ml

Consistency of cement = 35%, Amount of water = 0.85p = (0.85   140) ml   = 119 ml

Initial setting time = 87 min

Final setting time = 3 h 5min

Table 3
Observation of initial and final setting time of cement

Sl. No.	Quantity Of Water Added (ml)	Depth Of Penetration (ml)
1	140	7

Specific gravity of cement:

Determine the specific gravity of cement (G_s) using the following equation

$$Gs = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

- W_1 = Empty weight of Pycnometer = 0.596 Kg
- W_2 = Weight of Pycnometer + Oven dry sand = 0.646 Kg
- W_3 = Weight of Pycnometer + Oven dry sand + Water = 1.537 Kg
- W_4 = Weight of Pycnometer + Water = 1.502 Kg

Specific gravity of cement (G_s)= $\frac{(W_2-W_1)}{(W_2-W_1)-(W_3-W_4)}$

$$= \frac{(0.646 - 0.596)}{(0.646 - 0.596) - (1.537 - 1.502)} = 3.3$$

Specific gravity of sand:

Determine the specific gravity of sand (G_s) using the following equation

$$Gs = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

- W_1 = Empty weight of Pycnometer = 0.596 Kg
- W_2 = Weight of Pycnometer + Oven dry sand = 0.795 Kg
- W_3 = Weight of Pycnometer + Oven dry sand + Water = 1.626 Kg
- W_4 = Weight of Pycnometer + Water = 1.502 Kg

Specific gravity of sand (G_s) = $\frac{(W_2-W_1)}{(W_2-W_1)-(W_3-W_4)}$

$$= \frac{(0.795 - 0.596)}{(0.795 - 0.596) - (1.626 - 1.502)} = 2.7$$

Determination of grain size distribution of sand by sieve analysis:

Sieve analysis of sand determined by sieve set of size 4.75 m, 2.36mm, 1.18mm, 600mic, 425mic, 300mic, 150mic, 75mic.

- Percentage of coarse sand (4.75mm−2.36mm) = (99−83.6)% = 15.4%
- Percentage of medium sand (2.36m−0.425mm) = (83.6−56.2)% = 27.4%
- Percentage of fine sand (0.425mm−0.075mm) = (56.2−3)% = 53.2%
- Percentage of silt clay fraction (< 0.075mm) = 3%

Table 4
Observation and calculation for grain size distribution of sand

IS Sieve Size	Diameter of Grain (mm)	Wt. Retained (g)	Cumulative Wt. Retained (g)	% Retained	% Finer Than
2.36 mm	2.36	77	82	16.4	83.6
1.18 mm	1.18	57	139	27.8	72.2
600 µ	.600	45	184	36.8	63.2
425 µ	.425	35	219	43.8	56.2
300 µ	.300	20	239	47.8	52.2
150 µ	.150	206	445	89	11
75 µ	.075	40	485	97	3

Determination of quantity of silt test of Fine aggregate sand:

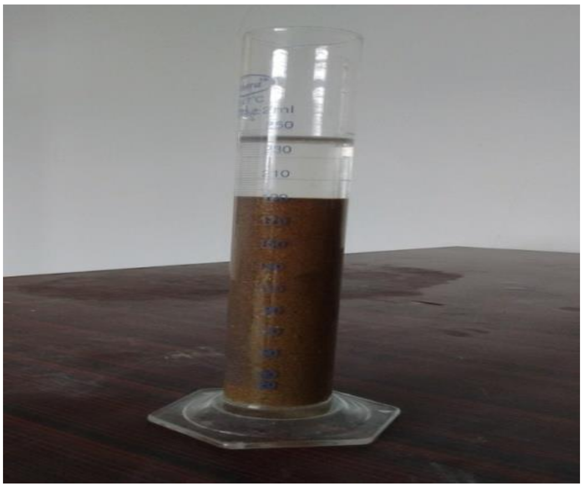

Figure 5: Silt test of the sand

Determine the amount of the silt (in percentage) by volume in fine aggregates.

- Dissolve 2 pinches of salt in about 200ml of water in the measuring.
- Fill it with sand till the level is about 2cms from the top of the cylinder.
- Shake the cylinder rigorously and take the reading after 10mins and af

Table 5

Observation and calculation of Silt content in sand

Sl. No.	Volume of sample X (ml)	Volume of sample Y (ml)	% Silt content =(X/Y)×100%
1	3	90	3.33

Bulking of sand:

At first we will take 200ml of sand 1.18mm sieve sand. Then 200ml dry sand within 250±2ml (1pc biker or jar) Water will add, then 20-30 minutes after setting and taking final result.

After 1hour result:

Volume of dry sand (H) = 200ml

Volume of saturated sand (h) = 194ml

Reduced volume of sand

(H – h) = (200 -194) ml = 6ml

Percentage of bulking = ((H-h)/H)×100

= ((200-194)/200)× 100 = 3%

After 24 hours result:

Volume of dry sand (H) = 200ml

Volume of saturated sand (h) = 194ml

Reduced volume of sand

(H – h) = (200 -194) ml = 6ml

Percentage of bulking =

((H-h)/H)×100

= 3%

Figure 6: Laboratory set up for testing Bulking of sand

Specific gravity of hydride lime:

Determine the specific gravity of Hydride Lime(G_s) using the following equation

$$Gs = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

i. W_1 = Empty weight of Pycnometer = 0.5976 Kg
ii. W_2 = Weight of Pycnometer + Oven dry H.Lime = 0.6510 Kg
iii. W_3 = Weight of Pycnometer + Oven dry H.Lime + Water = 1.5350Kg
iv. W_4 = Weight of Pycnometer + Water = 1.5036 Kg

Specific gravity of Hydride Lime (G_s) = $\frac{(W_2-W_1)}{(W_2-W_1)-(W_3-W_4)}$ = $\frac{(= 0.6510 - 0.5976)}{(0.6510 - 0.5976) - (1.5350 - 1.5036)}$

= 2.427

Figure 7: Specific gravity test of hydride lime

Specific gravity of gypsum

Determine the specific gravity of gypsum (G_s) using the following equation

$$Gs = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

i. W_1 = Empty weight of Pycnometer = 0.5990 Kg
ii. W_2 = Weight of Pycnometer + Oven dry gypsum = 0.6490 Kg
iii. W_3 = Weight of Pycnometer + Oven dry gypsum+ Water = 1.5370 Kg
iv. W_4 = Weight of Pycnometer + Water = 1.5042Kg

Specific gravity of gypsum (G_s) = $\frac{(W_2-W_1)}{(W_2-W_1)-(W_3-W_4)}$

$$= \frac{(0.6490 - 0.5990)}{(0.6490 - 0.5990) - (1.5370 - 1.502)} = 2.7$$

4. CONCLUSION

Here is an attempt has been done to study the behavior of fly ash based bricks using the lime, gypsum, sand, cement and stone dust. The experimental investigation was carried out to find the optimum mix percentage of fly ash brick. Based on these materials required data can be obtained from the experimental study and concluded that, during preparation of Fly ash brick all material sample need to be examined. Fly ash bricks are prepared using seven different proportions. However the brick specimen of size 200mm x 100mm x 100mm were cast for different mix percentage of Flyash (45 to 60%), Gypsum (5%), Lime (10 to 20%), Quarry dust (25 to 40%), and cement (8 to 10%). Compressive strength were studied for different mix proportions. For different trial ratios it is observed that fly ash based bricks achieve more strength for slug lime than hydride lime even if using fifty percent of fly ash (further detail experiment result described in reference 7).

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