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Evaluation of Properties of Fly Ash based on Geo Polymer Bricks

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***Abstract*: In ongoing years, the study focus on the sustainable construction development. As the effect of greenhouse gases is increased more due to high range of CO_2 emissions associated with manufacturing process of OPC. Hence, research studies the possibility of geo polymer manufacturing from fine fly ash (Class F) and Alkaline solution, then studied the hardened properties of fly ash bricks with addition of lime and gypsum. In this research, we have studied the composition of high-strength fly ash-lime bricks using a fine pulverized fuel ash Class-F. Main purpose of this research is to evaluate mechanical properties of pulverized fuel ash based geo polymer brick along with its durability, the size of the sample brick is adopted as 225 mm×100 mm×75 mm. The brick is casted with different percentages of Fly ash (55-65%), M-sand (25-35%), Hydrated lime (5-15%) and Gypsum (up to 5%). According to the various research, the optimum w/b ratio is to be taken as 0.35 and the temperature for curing is to be selected as normal room temperature. The tests on specimen to be conducted are a compressive strength, water absorption test, efflorescence test, impact test for various mixing proportions on respective curing period of 7 days,14 days and 28 days. From the results, the maximum optimized results are obtained for optimum mixing proportion of Fly ash-60%, Hydrated lime-12%, Gypsum-3%, M-sand-30%.**

***Keywords*: Evaluate, Properties, pulverized fuel ash, hydrated lime, gypsum, m-sand, geopolymer bricks.**

1. Introduction

Bricks are the most ancient and simplest form among all types of building materials. The making of conventional building bricks requires a lot of thermal energy and it causes environmental pollution as air pollution, water pollution and depletion of the land. Disposal of solid waste produced from agricultural and industrial production activity is the leading issue in the Developing countries. The accumulation of wastes is the main problem ahead to the industry as adversely affects surrounding environment. Hence, the development of new technique or theory to reuse, recycle the industrial waste and to convert such waste into reusable materials is severally essential for the protection of the Earth environment and sustainable development of the Society. Reuse of these type of wastes as a sustainable construction material reflects a good remedial measures not only for the pollution problem, but also for the depletion of the land and more cost of building materials. An incremental increase in population causes rapid urbanization and the rising standard of living due to technological innovations which contributes to increase in quantity and types of solid waste generated by an industrial, mining, domestic as well as agricultural activities. The research shows that, in all over Asian countries round about 4.6 billion tonnes of solid waste get produced at every year

2. Related work

In work done by M. Chester et.al [3**]** Bricks containing fly-ash/sand in the ratio of 70/30 with addition of 5% lime and 15% Na_2SiO_3 are good in compression, easy to mold and less water absorption properties as per the research paper. Apart from this, the weight of such brick is less as compare with the clay bricks fired in kiln.

3. Objective of proposed work

1. To achieve the desired strength of fly ash based geopolymer bricks by addin optimum percentage of hydrated lime and gypsum.
2. To optimize the mechanical properties and find the optimum mix proportion of fly ash and crushed sand having good compressive strength.
3. To find mechanical properties of bricks, when materials are mixed by using ratio of an alkaline solution (Na_2SiO_3/NaOH).

4. Experimental material used

A. Fly ash

A waste material is collected in electrostatic precipitators or filter bags. The particle size may vary from 0.5 µ to 100 consist of spherical shape.

B. Hydrated lime

The Lime is a solid composite material having specific gravity 2.7 and bulk density 1425 kg/m^3. It has an average particle size of 25 microns while particle size varies between ranges of 10 µ to 70µ.

C. Gypsum

The specific gravity is observed of about 2.3 gm/cc. While the density is about 2.7 to 3.1 gm/cc.

D. Alkaline solution

The chemical composition of the sodium silicate solution was NaO = 15.012 %, SiO = 34.08 % and water =50.8 % by

mass. The other characteristics of the sodium silicate solution were specific gravity = 1.53g/cc and viscosity at 20C = 400cp.

E. M-sand

Getting good quality of M-sand which should be free from organic impurities. While adding the M-sand to the mix, it should be in uniform size i.e. all the M-sand particles should be fine.

F. Cement

A cement is a binder substance used in construction that say and harden and can bind other material together.

5. Mix design

Table 1
Mix design

Proportions	Fly ash %	Hydrated lime %	Gypsum %	M-sand %
I	55	8	3	32
II	55	10	3	32
III	60	10	3	30
IV	60	12	3	30
V	65	12	3	25

6. Methodology

1. Selection of materials.
2. Basic test performed on cement and aggregate.
3. Prepare mix design for M40 grade of concrete.
4. Prepare conventional concrete sample for bricks.
5. Curing of specimens.
6. Testing on conventional concrete specimens.
7. Results of conventional concrete.
8. Comparison between conventional fly bricks and conventional clay bricks.

7. Experimental investigation

A. Compressive strength test

Compression testing machine is used for compressive strength test. Brick size of 225 x 100 x 75 mm was used. Five bricks of each batch tested.

Fig. 1. Compressive strength test

B. Water absorption

The ware absorption test procedure is adopted from IS 3495-1992 Part-II. The water absorption gives the quantity of water being absorbed by ponding bricks into cold water for 24 hrs.

Fig. 2. Water absorption

C. Efflorescence

The Efflorescence test procedure is adopted from IS 3495:1992 Part-III. The Efflorescence test results indicate that the percentage of white spots on the surface of brick.

Fig. 3. Efflorescence

8. Test results

A. Compressive strength

Prepared brick samples with various mix proportion are tested for the various test after 7 days, 14 days and 28 days of curing. The various tests have been conducted as per the IS 3495-1992 to find the mechanical properties of the bricks.

Table 2
Compressive strength after 7 Days for geopolymer bricks

Proportion	Load (KN)	Average Load (KN)	Area (mm^2)	Compressive strength (N/mm^2)
I	90	91.60	225×100 =22500	4.07
	100			
	85			
II	100	101.60	225×100 =22500	4.51
	110			
	95			
III	110	115	225×100 =22500	5.11
	130			
	105			
IV	120	120	225×100 =22500	5.33
	110			
	130			
V	125	115	225×100 =22500	5.11
	105			
	115			

Table 3
Compressive strength after 14 Days for geopolymer bricks

Proportion	Load (KN)	Average Load (KN)	Area (mm^2)	Compressive strength (N/mm^2)
I	125	120	225×100 =22500	5.33
	105			
	130			
II	140	130	225×100 =22500	5.77
	120			
	130			
III	124	141.63	225×100 =22500	6.37
	160			
	140			
IV	165	150	225×100 =22500	6.67
	130			
	155			
V	130	146.67	225×100 =22500	6.52
	165			
	145			

Table 4
Compressive strength after 28 Days for geopolymer bricks

Proportion	Load (KN)	Average Load (KN)	Area (mm^2)	Compressive strength (N/mm^2)
I	205	218.33	225×100 =22500	9.70
	235			
	215			
II	230	230	225×100 =22500	10.22
	215			
	245			
III	235	248.33	225×100 =22500	11.04
	260			
	250			
IV	285	266.6	225×100 =22500	11.85
	265			
	250			
V	245	240	225×100 =22500	10.67
	250			
	225			

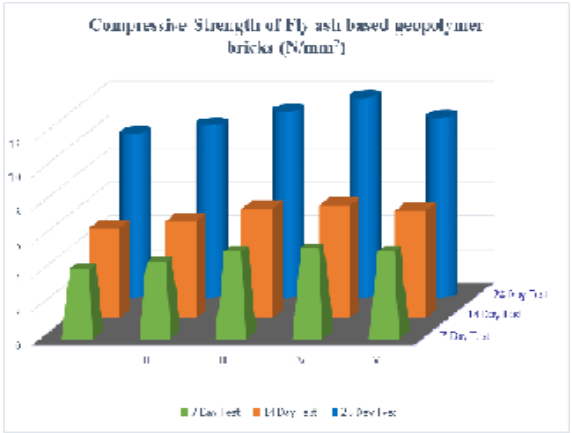

Fig. 4. Chart 1: Compressive strength of fly ash based geopolymer bricks

B. Water Absorption Test

Table 5
Water absorption after 7 Days

Proportion	Dry Weight (Kg)	Wet Weight (Kg)	Average Dry Weight M_1 (Kg)	Average Wet Weight M_2 (Kg)	Water Absorption $=\frac{M2-M1}{M1}X100$ (%)
I	2.721	2.940	2.722	3.034	9.46
	2.782	5.051			
	2.864	3.115			
II	2.681	2.894	2.751	3.012	9.45
	2.762	3.042			
	2.811	3.101			
III	2.806	3.121	2.855	3.152	10.53
	2.884	3.190			
	2.917	3.145			
IV	2.815	3.141	2.875	3.173	10.45
	2.905	3.209			
	2.896	3.160			
V	2.809	3.103	2.826	3.104	9.92
	2.834	3.114			
	2.817	3.106			

Table 6
Water absorption after 14 Days for geopolymer bricks

Proportion	**Dry Weight (Kg)**	**Wet Weight (Kg)**	**Average Dry Weight M_1 (Kg)**	**Average Wet Weight M_2 (Kg)**	**Water Absorption $=\frac{M2-M1}{M1}X100$ (%)**
I	2.641	2.923	2.691	2.955	9.52
	2.683	2.891			
	2.751	2.955			
II	2.681	2.923	2.673	2.923	9.35
	2.602	2.821			
	2.741	3.025			
III	2.792	3.079	2.796	3.077	10.05
	2.764	3.128			
	2.833	3.030			
IV	2.803	3.103	2.831	3.11	9.89
	2.829	3.205			
	2.863	3.025			
V	2.783	3.068	2.787	3.068	10.09
	2.779	3.125			
	2.801	3.011			

Table 7
Water absorption after 28 Days for geopolymer bricks

Proportion	Dry Weight (Kg)	Wet Weight (Kg)	Average Dry Weight M_1 (Kg)	Average Wet Weight M_2 (Kg)	Water Absorption $=\frac{M2-M1}{M1}X100$ (%)
I	2.631	2.881	2.651	2.881	8.68
	2.670	2.869			
	2.652	2.893			
II	2.856	2.729	2.633	2.856	8.48
	2.806	2.983			
	2.906	2.856			
III	2.904	2.927	2.736	2.986	9.201
	2.943	2.986			
	3.111	3.045			
IV	3.025	3.074	2.772	3.025	9.149
	3.128	2.976			
	2.922	3.025			
V	2.903	2.969	2.729	2.969	8.794
	2.986	2.923			
	3.018	3.015			

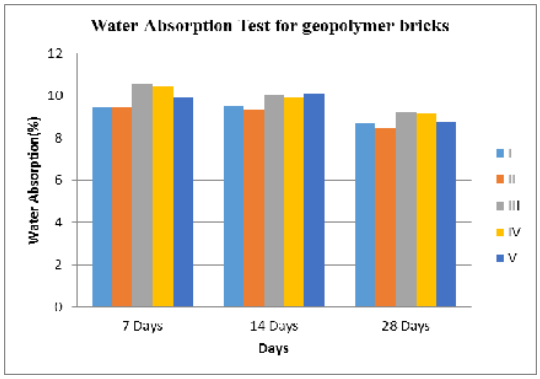

Fig. 4. Chart 2: Water absorption for geopolymer bricks

C. *Efflorescence test*

The Efflorescence test procedure is adopted from IS 3495:1992 Part-III. The Efflorescence test results indicate that the percentage of white spots on the surface of brick. The prepared samples of fly ash based geopolymer bricks are tested after the rest period of 28 Days.

Table 8
Result of Efflorescence Test on geopolymer bricks

Proportions	Efflorescence
I	Nil
II	Nil
III	Nil
IV	Nil
V	Nil

9. Conclusion

1. Addition of hydrated lime up to 12% in geo polymer bricks can gives better results at normal temperature without heating to geo polymer.
2. The ratio of Na_2SiO_3 to NaOH is an important parameter in polymerization of geopolymer. The tested ratio gives better results for geopolymer bricks.
3. The fineness of a fly ash gives better results in compression for geopolymer brick as it plays an important role in polymerization process and bind all ingredients.
4. Geopolymer brick shows good compressive strength at mix proportion of Fly ash 60%, lime 12%, M-sand 30%.
5. The fly ash also contains pozolanic properties which gives equal results as compared with cement.
6. The moulded bricks are light in weight. Due to machine moulding, it is well compacted and having perfect rectangular shape.

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