ISSN:2348-2079

Volume-7 Issue-2

International Journal of Intellectual Advancements and Research in Engineering Computations

Experimental investigation on utilization of waste materials in fly ash brick

[*1]Mr.S.Elango, [2]Mr.K.Selvakumar, [3]Ms.S.Indhu

[*1]Assistant Professor, Department of Civil Engineering, K.S.R. College of Engineering, Tiruchengode.
[2]Assistant Professor, Department of Civil Engineering, K.S.R. College of Engineering, Tiruchengode.
[3]PG Student, Department of Civil Engineering, K.S.R. College of Engineering, Tiruchengode.

ABSTRACT

Fly ash is one of the major residues generated during combustion of coal in thermal power plants. Fly ash brick technology is the process of converting industrial waste materials into quality building material. Another issue in earth is dumping of the Bagasse ash, rice husk ash and copper slag waste. In a growing country like India a huge amount of fly ash waste materials are polluting the environment. The necessity of recycling the materials play a big role in the development of the safe and non- polluted earth. Fly ash, lime, gypsum and quarry dust are used as a replacement material for fly ash. The fly ash was replaced by the Bagasse ash and rice husk ash in the proportion of 2.5%, 5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20%, 22.5%, 25%27.5% and 30%. Two types of fly ash bricks were casted. One type is Bagasse ash replaced fly ash and another type is rice husk ash replaced fly ash bricks then copper slag are partially replaced in quarry dust. The prepared bricks are cured for 7 days and 28 days and dried in regular temperature. The mechanical and durability properties of optimum percentages of Bagasse ash and rice husk ash replaced fly ash bricks. The use of Bagasse ash and rice husk ash provides for considerable value – added utilization of Bagasse and rice husk in bricks and significant reductions in the production of greenhouse gases by the cement industry.

Keywords: Bagasse Ash, Rice husk ash, Fly ash, Bricks, Mechanical & Durability properties.

INTRODUCTION

Fly ash is the artificial pozzalona which is basically derived as the residue during combustion of pulverized coal used as fuel. During the combustion of coal, the products formed are classified into two categories viz. Bottom ash and fly ash. The bottom ash is the residue part, which are fused to become particles. The fly ash is that part of the ash which is entrained in the combustion gas leaving the boiler. Fly ash may be classified into two groups based on the nature of their ash constituents. One is the Lignite ash - class C fly ash and another one is bituminous ash - class F fly ash. Both class F and C fly ash react to cement in similar ways and undergo a “pozzolanic reaction” with the lime (calcium hydroxide) by the hydration (chemical reaction) of cement and water to form the calcium silicate hydrate which is the binder (i.e.)cement.

Fly Ash is used as a replacement for Portland cement due to its pozzolanic property. It will improve the workability of concrete. It is used for embankment construction. Fly ash has a large uniform coefficient and it consist of clay sized particles. Soil stabilization can be achieved by adding the fly ash with soil. It is used to increase the shear strength of a soil and to control the shrink - swell property of a soil. Fly ash is used to manufacture the construction bricks.

Fly ash is used in brick manufacturing process. Fly ash is used as a raw material instead of clay in manufacturing of bricks along with sand, lime and gypsum. This brick is compressed, cured and then toughened with air entrainment agent. In this

Author for correspondence:
Department of Civil Engineering, K.S.R. College of Engineering, Tiruchengode.

method pressure is used instead of heat. So that it saves energy, reduces mercury pollution and the cost is 20% less than the cost of traditional brick. The high pressure manufacturing technique of Fly ash bricks will produce high strength with good insulation property and environmental benefits.

PROBLEM AND ANALYSIS

Objective of work

In this project work, an attempt has been made to determine the compressive strength of brick which is partially replaced by bagasse ash and rice husk ash instead of fly ash. The main objectives are as follows:

- The present investigation is to make the bricks in an environmental friendly manner by utilization the waste material such as bagasse ash, rice husk ash, and copper slag.
- To investigate the optimum percentage of replacement of fly ash with bagasse ash and rice husk ash by considering the compressive strength of bricks.
- To study the Compressive strength of the brick is investigated with optimum percentage of bagasse ash and rice husk ash in bricks.
- To study the strength and durability properties of bricks with optimum replacement of fly ash by bagasse ash and rice husk ash.

MATERIALS USED

Fly ash

Class F fly ash is used in our study to prepare the test specimen as per IS `Nadu, India. The chemical composition of fly ash and its colour was given in table 2.1 & fig 2.1.

Quarry Dust

Locally available quarry dust passing through IS 4.76mm was used in this study as per IS 383: 1970. 20% of quarry dusts used in total mass of the specimen. The crusher dust contains elements of Silica, Alumina, Calcium, Magnesium, Sodium, etc. The specific gravity of quarry dust is 2.6. The physical property and chemical composition given in table 2.2 & 2.3.

Bagasse ash

Bagasse ash is used in our study to prepare the test specimen as per IS 3812- Part 1 – 2003. It was passing through 75µm sieve. It is collected from Ponni sugar factory, Erode, Tamil Nadu, India. The chemical composition of Bagasse ash was tabulated in table 2.4. Fig 2.2 shows bagasse waste.

Rice husk ash

Rice husk ash is locally available. It was passing through 75 µm sieve. It is collected from Krishna rice industry from Erode. The physical & chemical composition of rice husk ash was tabulated below in table 2.5 & 2.6 and rice husk ash shown in fig 2.3.

Copper slag

It was partially replaced material. It was collected from Arun associates from Coimbatore, Tamil Nadu, India. Specific gravity of copper slag is 3.03. Its chemical composition shown in table 2.7. Fig 2.4 shows copper ash.

Water

Water to be used for mixing and curing should be free from injurious or deleterious materials. Portable water is generally considered satisfactory. In the present study, available value within college campus is used for both mixing and curing with the value is 7.0.

Lime

It is used to obtain strength and hardness for the specimen as per IS: 712: 1984. 20% of lime is used in total mass of the specimen. Under the class C of Fat lime for finishing coat in plastering white and with addition of pozzolanic materials for masonry mortars is used to prepare the specimen.

Gypsum

The gypsum is taken from tuticorin, Tamil Nadu as per IS: 1288: 1982. The role of gypsum is to control the setting time. 5% of gypsum is used in total mass of the specimen.

Table 2.1 Chemical composition of Class F Fly Ash

S.No	Constituents	Observed Values (%)
1.	Silicon dioxide (SiO2)	46.8
2.	Aluminium oxide(Al2O3)	23.7
3.	Iron oxide(Fe2O3)	13.2
4.	Sulphur trioxide(SO3)	1.2
5.	Calcium oxide(CaO)	3.1
6.	Magnesium oxide(MgO)	1
7.	Moisture	0.1
8.	Loss on Ignition	7.9

Fig 2.1 Fly Ash

Table 2.2 Physical property of Quarry Dust

S.No.	Property	Observed Value (%)
1	Water absorption	6.0
2	Bulking of Sand	4.61
3	Fineness Modulus	1.20

Table 2.3 Chemical Property of Quarry Dust

S.No.	Chemical Compound	Proportion (%)
1	Silicon dioxide (SiO2)	67.62
2	Aluminium oxide(Al2O3)	15.43
3	Iron oxide(Fe2O3)	5.58
4	Calcium oxide (CaO)	3.25
5	Sodium oxide(Na2O)	4.01
6	Potassium oxide (K2O)	4.01

Table 2.4 Chemical composition of Bagasse Ash

S.No.	Components	Observed Values (%)
1	Silicon dioxide(SiO2)	78.34
2	Aluminium oxide(Al2O3)	8.55
3	Iron oxide(Fe2O3)	3.61
4	Calcium oxide(CaO)	2.15
5	Potassium oxide(K2O)	3.46
6	Magnesium oxide(MgO)	1.65
7	Sodium oxide(Na2O)	0.12
8	Manganese dioxide(MnO)	0.13
9	Titanium dioxide(TiO2)	0.50
10	Di phosphorus pentoxide (P_2O_5)	1.07
11	Loss on ignition	0.42

Fig 2.2 Bagasse Waste

Table 2.5 Physical properties of Rice husk Ash

S. No	Test for RHA	Relevant IS code	Result
1.	Specific gravity	IS:2386-1963(part I)	2.06
2.	Bulk density(kg/m3)	IS:2386-1963(part III)	700.00
3.	Water absorption	IS:2386-1963(part III)	15%

Table 2.6 Chemical Composition of Rice husk ash

S.No	Chemical Compound	Proportion (%)
1	Silicon dioxide(SiO2)	**86.94**
2	Aluminium oxide(Al2O3)	**0.2**
3	Iron oxide(Fe2O3)	**0.1**
4	Calcium oxide(CaO)	**0.3 – 2.2**
5	Magnesium oxide(MgO)	**0.2 – 0.6**
6	Sodium oxide(Na2O)	**0.1 – 0.8**
7	Potassium oxide(K2O)	**2.15 – 2.30**

Fig 2.3 Rice husk Ash

Table 2.7 Chemical Composition of Copper Slag

S.No	Chemical Composition	Proportion (%)
1	Iron oxide(Fe2O3)	55 – 60
2	Silicon dioxide	27 – 33
3	Calcium oxide(CaO)	1 – 3.5
4	Sulphur(S)	0.2 – 1.5
5	Copper(Cu)	1
6	Aluminium oxide(Al2O3)	3

Fig 2.4 Copper Slag

Mixing of raw materials

Raw materials like Fly Ash, GGBS, Bagasse ash, lime, Gypsum, Crusher dust are manually fed into a pan mixer a pan mixer where water is added in the required proportion for intimate mixing. Raw materials like Fly Ash, GGBS, Bagasse ash, lime, Gypsum, Crusher dust are manually fed into a pan mixer a pan mixer where water is added in the required proportion for intimate mixing. Conveyor is used to transfer the raw materials from mixer to Feeding hopper under Hydraulic control. Hydraulic press Compress the Raw Materials with required tonnage pressure of 36 mpa to produce the bricks. After Compaction, the Brick are de-moulded & the Pallet with Bricks is pushed out of the Press. After that the Pallet is stacked to the stacking area. The Bricks are air dried for 24 hours until it gets hard. The prepared bricks are cured for 7 days, 14 days and 21 days and dried in regular temperature. The curing of bricks is done by covering it with Gunny Bags. The moisture in the gunny bag is maintained regularly for the better curing. The brick after 7 days, 14days and 21 days curing is taken for compressive strength test, water absorption test, efflorescence test, bulk density test, hardness test, Initial rate of absorption, sorptivity test and masonry prism test. Moulded bricks and bricks after compaction shown in fig 2.5 & 2.6. Fig 2.7 & 2.8 shows the sample before and after compression.

Fig 2.5 Moulded Brick

Fig 2.6 Bricks after compaction

Fig 2.7 Sample before failure

Fig 2.8 Sample after failure

SOLUTION AND MECHANISM

Compressive strength test

Compressive strength test is done to determine the stress that the brick can withstand. The test is carried out using Universal Testing Machine. Table 3.1, 3.2 & Fig 3.1, 3.2 shows compressive strength test values.

Water absorption test

Water absorption test is used to determine the water absorbed by the Brick. Table 3.3, 3.4 & Fig 3.3, 3.4 shows water absorption percentage.

Efflorescence Test

The process of alkalis in brick is not desirable because they from patches of grey powder by absorbing moisture. So it is necessary to carryout Efflorescence test in Bricks.

Bulk Density Test

Fig 3.5, 3.6 & Table 3.5, 3.6 shows the observed bulk density values for different percentage mix. Bulk density is determined by calculating the mass of mortar contained in the known volume.

Hardness Test

The brick is scratched with nail. If no impression is marked on the surface, the brick is sufficiently hard.

Initial rate of Absorption

The weight of water absorbed when a brick is partially immersed for one minute usually expressed in grams or ounces per minute. The obtained values are shown in Table 3.7, 3.8 & Fig 3.7, 3.8.

Sorptivity test

Sorptivity is defined as a measure of the capacity of the medium to order-absorb liquid by capillarity. The test result are shown in table 3.9, 3.10 & in figure 3.9, 3.10.

Compressive Strength of Mortar

The compressive strength of Mortar ratio containing (1:6) are shown in fig 3.11 & Table 3.11.

Masonry Prism Test

The prism size of (230*110*410) mm was tested under UTM Machine. The obtained test results are shown in table 3.12.

Table 3.1 Compressive Strength Test

Percentage of Glass Powder replaced	After 7th day (N/mm2)	After 14th day (N/mm2)	After 28th day (N/mm2)
0%	2.104	2.737	4.839
2.5%	2.421	3.436	5.235
5%	2.625	3.213	5.438
7.5%	2.655	3.791	5.687
10%	2.683	4.028	5.971

Elango S et al., Inter. J. Int. Adv. & Res. In Engg. Comp., Vol.–07(02) 2019 [3043-3057]

12.5%	2.786	4.186	6.429
15%	2.81	4.206	6.015
17.5%	2.893	4.662	6.192
20%	2.923	4.772	6.223
22.5%	2.681	4.919	6.421
25%	2.359	4.397	5.426
27.5%	2.312	4.281	5.285
30%	2.235	3.804	5.141

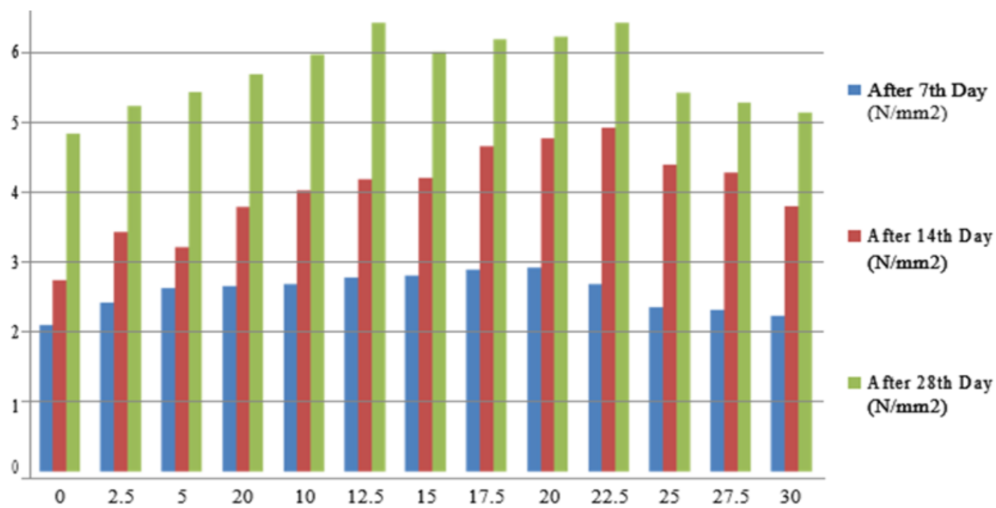

Fig 3.1 Compressive strength of Bagasse ash replaced Fly Ash Bricks

Table 3.2 Compressive Strength of Rice Husk Ash – GGBS replaced Fly Ash Bricks

Percentage of Glass Powder replaced	After 7th day (N/mm2)	After 14th day (N/mm2)	After 28th day (N/mm2)
0%	2.217	4.737	5.095
2.5%	2.538	4.804	5.721
5%	2.658	4.028	5.824
7.5%	2.862	4.180	5.845
10%	2.951	4.186	5.864
12.5%	2.970	4.206	5.876
15%	3.040	4.281	5.921
17.5%	3.255	4.397	5.939
20%	3.257	4.662	5.974
22.5%	3.832	4.991	6.038
25%	4.522	5.791	6.332
27.5%	3.593	5.241	6.215
30%	3.478	5.241	5.974

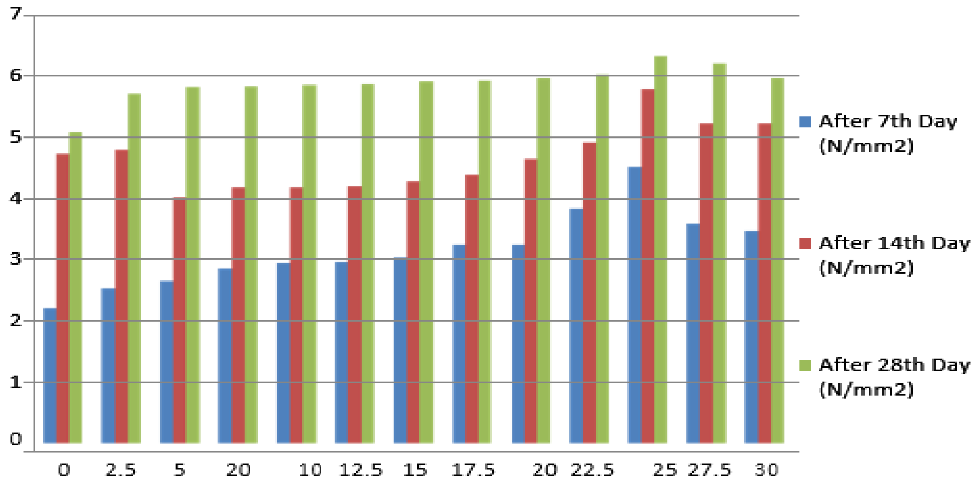

Fig 3.2 Compressive Strength of Rice Husk Ash – GGBS replaced Fly Ash Bricks

Table 3.3 Percentage of Water Absorbed Bagasse ash Replaced Fly Ash Bricks

Percentage of Glass Powder replaced	After 7th day %	After 14th day %	After 28th day %
0%	10.63	10.27	10.43
2.5%	10.53	10.73	10.42
5%	10.15	10.88	11.05
7.5%	11.43	11.18	11.62
10%	11.28	11.84	11.23
12.5%	11.12	12.15	12.1
15%	11.95	12.22	12.25
17.5%	10.76	12.45	12.93
20%	10.52	11.24	12.91
22.5%	11.04	11.42	10.89
25%	12.34	11.62	10.79
27.5%	12.79	11.70	12.05
30%	12.86	11.77	12.26

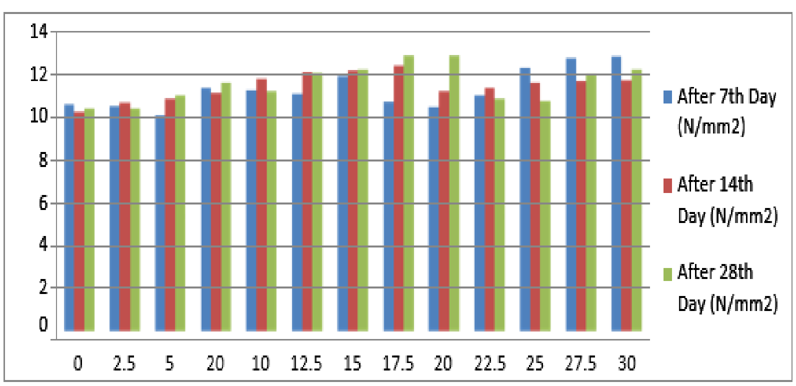

Fig 3.3 Percentage of Water Absorbed Bagasse ash Replaced Fly

Ash Bricks

Table 3.4 Percentage of water absorbed in Rice Husk Ash – GGBS replaced fly ash bricks

Percentage of Glass Powder replaced	After 7th day %	After 14th day %	After 28th day %
0%	13.64	14.18	13.43
2.5%	13.55	13.73	13.42
5%	13.16	13.38	12.05
7.5%	12.42	13.18	12.62
10%	12.29	12.83	11.23
12.5%	12.11	12.767	11.10
15%	11.96	12.31	11.93
17.5%	11.75	12.29	10.93
20%	11.51	12.27	10.91
22.5%	11.03	11.80	11.89
25%	10.33	11.45	11.79
27.5%	11.78	11.70	12.26
30%	11.85	11.77	12.58

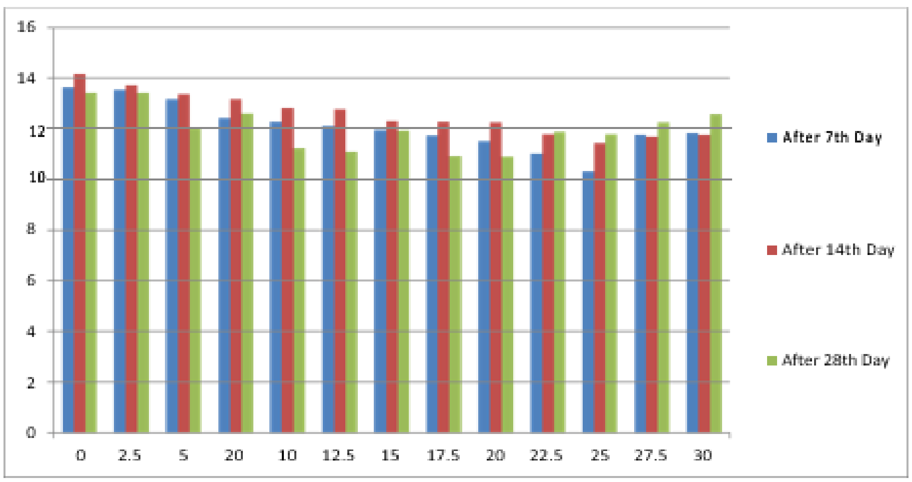

Fig 3.4 Percentage of Water Absorbed in Rice Husk Ash Replaced Fly Ash Bricks

Table 3.5 Bulk Density of Bagasse ash Replaced Fly Ash Bricks

Percentage of coloured Glass Powder replaced	After 7th day (Kg/m^3)	After 14th day (Kg/m^3)	After 28th day (Kg/m^3)
0%	1583.136	1556.258	1609.42
2.5%	1639.657	1600.132	1673.25
5%	1752.833	1752.174	1731.52
7.5%	1718.972	1710.013	1700.23
10%	1630.303	1675.758	1666.12
12.5%	1634.387	1689.987	1680.22
15%	1769.038	1734.783	1710.14
17.5%	1642.906	1612.253	1680.35
20%	1527.931	1536.364	1592.05
22.5%	1520.260	1637.945	1612.2
25%	1541.634	1677.497	1688.58

27.5%	1582.609	1614.756	1671.25
30%	1642.688	1683.794	1663.69

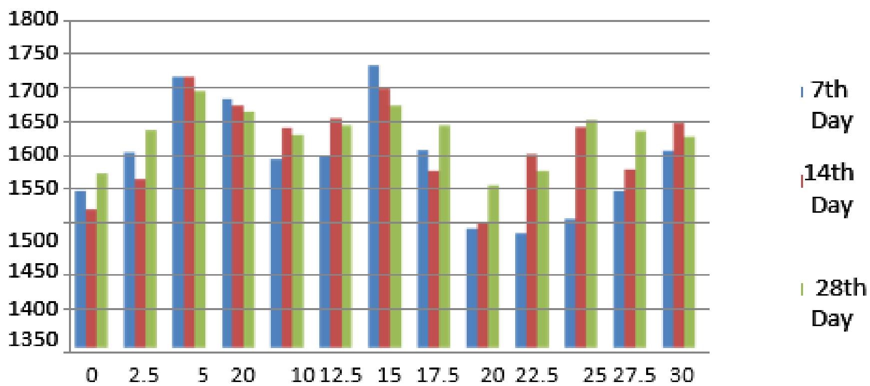

Fig 3.5 Bulk Density of Bagasse ash Replaced Fly Ash Bricks

Table 3.6 Bulk density of Rice husk ash- GGBS replaced Fly Ash Bricks

Percentage of coloured Glass Powder replaced	After 7th day (Kg/m^3)	After 14th day (Kg/m^3)	After 28th day (Kg/m^3)
0%	1583.13	1523.14	1609.42
2.5%	1659.65	1600.21	1615.14
5%	1663.93	1652.25	1671.23
7.5%	1676.20	1710.34	1702.41
10%	1701.30	1775.76	1712.33
12.5%	1724.38	1789.92	1774.13
15%	1644.03	1634.10	1738.56
17.5%	1621.90	1612.19	1680.63
20%	1507.93	1536.34	1635.82
22.5%	1512.02	1537.81	1523.98
25%	1541.63	1597.21	1588.44
27.5%	1582.60	1614.33	1571.18
30%	1642.68	1683.28	1663.27

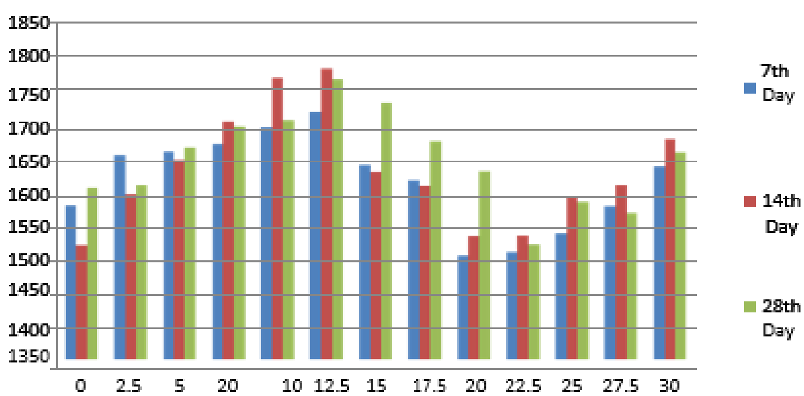

Fig 3.6 Bulk Density of Rice Husk Ash – GGBS Replaced Fly Ash

Table 3.7 Initial Rate of Bagasse ash Replaced Fly Ash Bricks

Percentage of coloured Glass Powder replaced	After 7th day ($Kg/cm^2/min$)	After 14th day ($Kg/cm^2/min$)	After 28th day ($Kg/cm^2/min$)
0%	0.0169	0.0214	0.0225
2.5%	0.0180	0.0168	0.0166
5%	0.0167	0.0157	0.0160
7.5%	0.0124	0.0142	0.0157
10%	0.0101	0.0143	0.0156
12.5%	0.0134	0.0144	0.0155
15%	0.0131	0.0142	0.0151
17.5%	0.0132	0.0123	0.0132
20%	0.0123	0.0118	0.0129
22.5%	0.0120	0.0116	0.0127
25%	0.0111	0.0114	0.0125
27.5%	0.0141	0.0158	0.0178
30%	0.0168	0.0186	0.0206

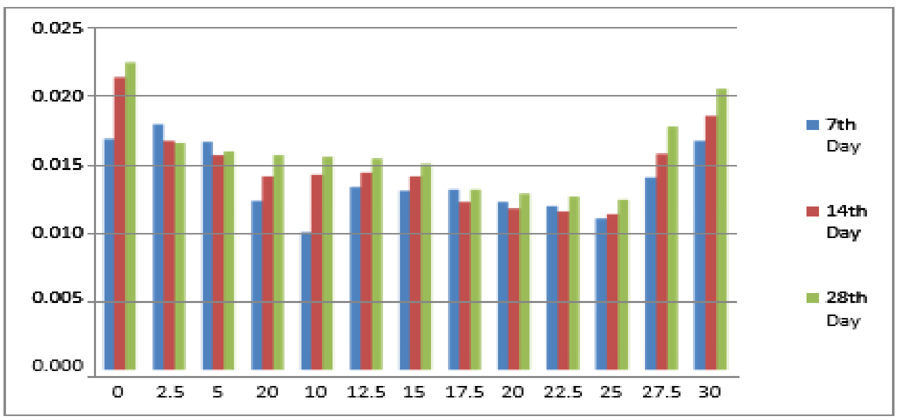

Fig 3.7 Initial rate of Bagasse ash Replaced Fly Ash Bricks

Table 3.8 Initial Absorption of Rice Husk Ash – GGBS Replaced Fly Ash Bricks

Percentage of coloured Glass Powder replaced	After 7th day ($Kg/cm^2/min$)	After 14th day ($Kg/cm^2/min$)	After 28th day ($Kg/cm^2/min$)
0%	0.0178	0.0225	0.0261
2.5%	0.0150	0.0166	0.0186
5%	0.0148	0.0160	0.0179
7.5%	0.0143	0.0157	0.0174
10%	0.0138	0.0156	0.0165
12.5%	0.0137	0.0155	0.0160
15%	0.0131	0.0151	0.0155
17.5%	0.0130	0.0132	0.0155
20%	0.0113	0.0129	0.0150
22.5%	0.0110	0.0127	0.0145
25%	0.0101	0.0125	0.0143
27.5%	0.0151	0.0178	0.0187
30%	0.0160	0.0206	0.0233

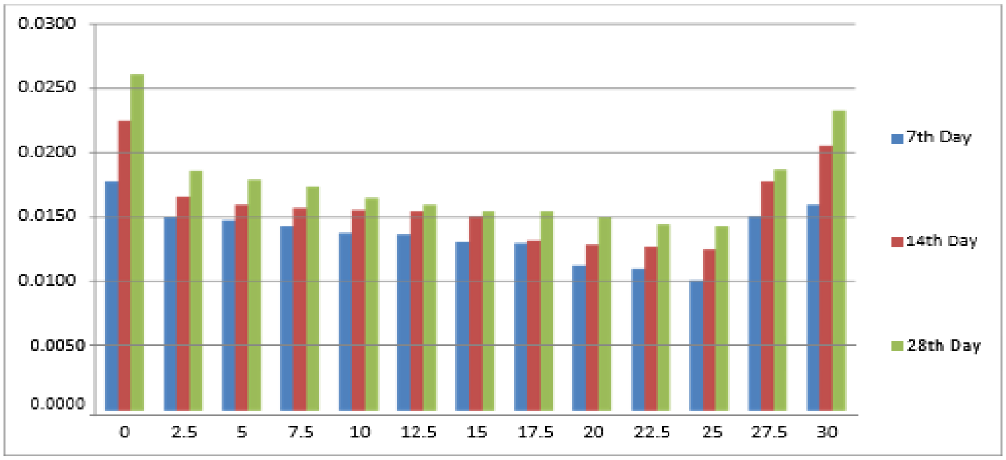

Fig 3.8 Initial Rate of absorption of Rice Husk Ash – GGBS Replaced Fly Ash Bricks

Table 3.9 Sorptivity of Bagasse ash Fly Ash Bricks

Percentage of coloured Glass Powder replaced	**Change in Weight (Kg)**				
	Initial Weight	**After 10 min**	**After 20 min**	**After 30 min**	**After 40 min**
0%	3.340	3.368	3.374	3.381	3.396
2.5%	3.320	3.352	3.364	3.370	3.384
5%	3.302	3.325	3.342	3.354	3.362
7.5%	3.256	3.275	3.284	3.289	3.296
10%	3.237	3.268	3.279	3.291	3.315
12.5%	3.235	3.268	3.274	3.282	3.294
15%	3.214	3.248	3.256	3.268	3.277
17.5%	3.210	3.235	3.244	3.259	3.265
20%	3.176	3.214	3.225	3.232	3.239
22.5%	3.152	3.186	3.215	3.220	3.228
25%	3.105	3.168	3.180	3.190	3.195
27.5%	3.295	3.250	3.325	3.420	3.220
30%	3.313	3.335	3.349	3.358	3.264

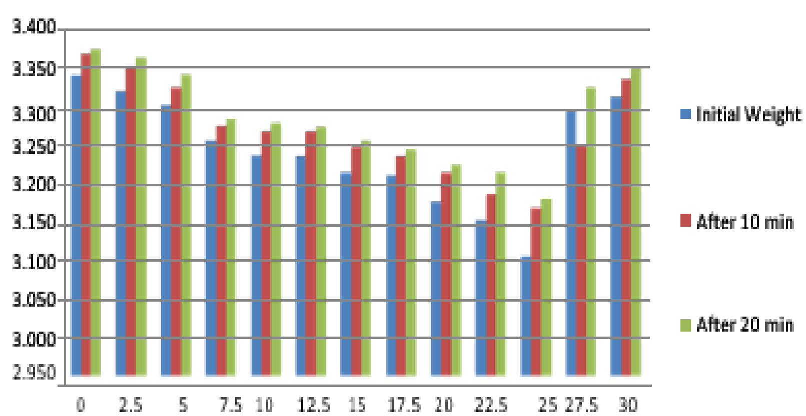

Fig 3.9 Sorptivity of Bagasse Ash replaced Fly Ash Bricks

Table 3.10 Sorptivity of Rice Husk Ash– GGBS replaced Fly Ash Bricks

Percentage of coloured Glass Powder replaced	Change in Weight (Kg)				
	Initial Weight	After 10 min	After 20 min	After 30 min	After 40 min
0%	3.250	3.368	3.174	3.122	3.141
2.5%	3.220	3.342	3.362	3.373	3.254
5%	3.202	3.355	3.343	3.354	3.263
7.5%	3.156	3.265	3.285	3.287	3.386
10%	3.137	3.278	3.278	3.299	3.425
12.5%	3.125	3.288	3.279	3.282	3.434
15%	3.012	3.298	3.255	3.261	3.257
17.5%	3.019	3.235	3.242	3.255	3.475
20%	3.276	3.234	3.221	3.236	3.318
22.5%	3.252	3.146	3.217	3.227	3.325
25%	3.050	3.168	3.184	3.193	3.120
27.5%	3.005	3.270	3.323	3.421	3.214
30%	3.200	3.385	3.341	3.350	3.297

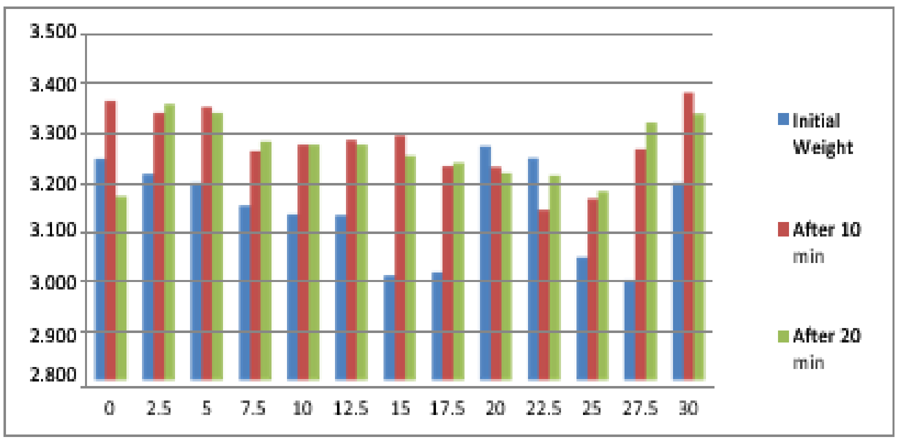

Fig. 3.10 Sorptivity of Rice Husk Ash – GGBS Replaced Fly Ash Bricks

Table 3.11 Compressive Strength of Mortar (1:6)

Cement Mortar	After 7th day (N/mm^2)	After 14th day (N/mm^2)	After 28th day (N/mm^2)
1:6	1.2	1.8	2.5

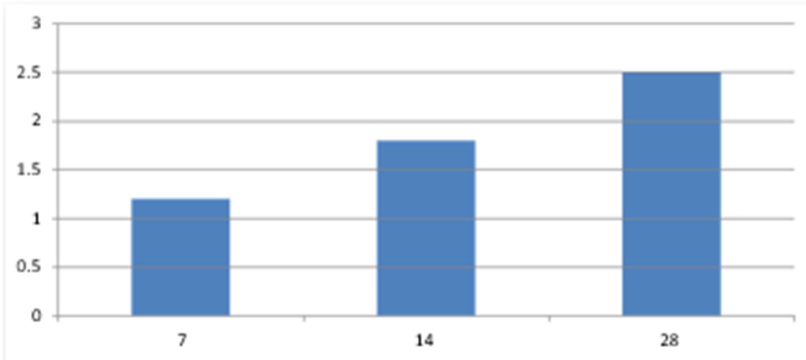

Fig.3.11 Compressive Strength of Mortar

Table 3.12 Compressive Strength on Masonry prism

Percentage of coloured Glass Powder replaced	Ultimate Load (kN)	Ultimate Stress (N/mm^2)
0%	36.68	1.45
2.5%	39.72	1.57
5%	42.50	1.68
7.5%	44.78	1.77
10%	47.05	1.86
12.5%	47.81	1.89
15%	48.82	1.93
17.5%	49.58	1.96
20%	50.34	1.99
22.5%	50.60	2.00
25%	53.63	2.12
27.5%	54.64	2.16
30%	62.24	2.46

RESULT AND CONCLUSION

From the above tests we conclude that Compressive strength of Bagasse ash and Rice Husk ash with GGBS replaced Fly ash bricks increased up to 20% and 22.5% replacement compared to ordinary Fly ash brick. Water absorption test, Hardness test, Efflorescence test, Bulk density and Initial rate of absorption are satisfying the requirements of provokes the good aspect in compare to the ordinary masonry prism. So we conclude that the Ash powder can be successfully replaced up to 20% and 22.5% respectively. Hence reduce the global impact by waste on environment can be reduced.

REFERENCE

[1]. A.Venkatesh, 'High Performance Bricks from Bagasse ash' - University of New south Wales at the Australian defence force academy, Canberra. 88, 2005, 42-50

[2]. Alaa A.Shakir, Ali Ahmed Mohammed, Kamal Nasharuddin Mustapha Properties of bricks made using fly ash, quarry dust and billet-International journal of engineering and advanced technology scale-Construction and Building Materials 41, 2013, 131-138.

[3]. Ambily.P.S 'Value-added utilisation of copper slag in brick' - Cement and Brick Research" CSIR structural Engineering Research Centre 34, 2015, 81-89

[4]. Cajiun shi “The Study of copper slag in Fly Ash Lime, Stone Dust Bricks ”Internatinal journal of Latest Research in Engineering and Computing.vol 101, 2015, 741-751
[5]. De Belie Magnel "Fly Ash Block Containing Limestone and Glass Powder Wastes KSCE Journal of Civil Engineering 11, 2011, 121-130
[6]. Jayakumar.R,Mahendran.N,Elangovan.R “studies on brick using fly ash ,rice husk ash.The Indian concrete journal, 3, 2004, 446-460
[7]. Kanagalakshmi & Vishnus - 'Properties of masonry blocks produced with waste sand dust and fly ash. Construction and Building materials 22, 1422-1427
[8]. K Meeravali1, K V G D Balaji, T. Santhosh Kumar, “The durability aspects of brick” International journal of Chem Tech Research. 55, 2012, 453-457.