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HIGH PERFORMANCE FLYASH BRICKS

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Abstract - *The coal field thermal power station generates large volume of fly ash every year. In India, bricks are mainly composed up of clay, and are generally produced in traditional, unorganized small-scale industries. Using of red clay bricks in larger amount leads to land degradation and top removal of soil. Large areas of lands are destroyed every year especially in developed countries due to collection of soil from a depth of about 1 to 2 m from agricultural land. Even though the red brick is strong and solid, brick is porous and absorbs moisture. The clay bricks undergo long – term shrinkage. When large amount of clay is taken from the agricultural land this leads to loss of good fertile soil .These particles of fly ash led to a reduction in the density of bricks and a substantial improvement in their durability. Use of this additive could have practical implications as a means of recycling and for achieving cost and savings in brick production. The absorption coefficient, shape and size and compressive strength of fly ash bricks compare with normal clay bricks that produce good results. The cost-effective building materials otherwise low-cost building materials are the materials used in building construction with appropriate technology to reduce overall construction cost compared to conventional type of building. Now-a- days the quality of materials used in conventional type is not in desired standards.*

Key Words: Fly ash, Recycling, Cost- effective, Lime, Gypsum.

1. INTRODUCTION

Fly ash is a by- product of the combustion of pulverized coal in thermal power plants. A brick is a building material used to make walls, pavements and other elements in masonry construction. Traditionally, the term brick referred to a unit composed of clay, but it is now used to denote rectangular units of clay -bearing soil, sand, and lime, or concrete materials. Bricks are most generally used as a substitute for stone when the stone is not available. Though a common structural material, till now brick is the cheapest one. Clay bricks fall under the category of heavy clay products. All kiln units are operating in cluster and cause substantial level of air pollution and land degradation in locality. some environmental issues related with such activities as availability of good fertile alluvial land which is one of the most important conditions for establishing a brick industry that initiates the process of land degradation. Ministry of Agriculture, Government of India has admitted tha2t more than half of the total area of India is suffering from serious land degradation due to some man, made activities. To overcome this, fly ash bricks is used now-a-days in construction. The project deals with the "High Performance Fly Ash Bricks".

Fly ash arising from the combustion of coal is being accumulated as waste material in large quantities. Fly ash has pozzolanic properties creates large serious environmental pollution problems and poses serious operational constraint as a recognized environmental pollutant. By using fly ash as a raw material to produce building elements will be a good solution to handle such a hugely polluting material raising environmental and economic concerns. Fly ash brick is a building material, specifically masonry units, containing class C or class F fly ash and water. Compressed at 28MPa and cured at natural temperature. Owing to high concentration of calcium oxide in class C fly ash, the brick is described as "self-compacting". The manufacturing method saves energy, reduces mercury pollution, and costs 20% less than traditional clay brick manufacturing. Fly ash bricks are lighter and stronger than the clay bricks. Some properties set it apart from other lightweight concrete materials. The finished product is lighter block, less than 40% the weight of conventional bricks, while providing the similar strengths. Using these blocks in building reduces the dead load.

1.2 MATERIALS USED

1.2.1 Fly ash

Fly ash or flue ash, also known as pulverized fuel ash, is a coal combustion product that is composed of fine particles of burned fuel that are driven out of coal- fired boilers together with the flue gases. Ash that falls to the bottom of the boiler's combustion chamber is called as bottom ash. Depending upon the source and composition of the coal being burned, the component of fly ash varies. In past, fly ash was generally released into the atmosphere, but air pollution standards now require that it is captured prior to release by fitting pollution control equipment. Fly ash is generally stored at coal power plants or placed in landfills. About 43% is recycled, often used as a pozzolan to produce hydraulic cement or hydraulic plaster and a replacement or partial replacement for Portland cement in concrete production.

1.2.2 Lime

Lime is a truly versatile material widely used in the construction of buildings. It can be utilized in masonry applications as a component of mortar or of the masonry unit. It provides benefits to mortar and plaster in both the plastic and the hardened state. It can react with pozzolanic materials in mortar or plaster to produce a cement like product. Since initial strength is needed in most applications, additives such as gypsum, cement are mixed with lime in construction applications. This is particularly beneficial in restoration applications, where low strengths and high vapor permeability is required.

1.2.3 Cement

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Raw materials employed in the manufacture of cement are extracted by quarrying in the case of hard rocks such as limestones, slates, and some shales, with the aid of blasting when necessary. Some deposits are mined by underground methods. Bricks that are manufactured from cement are typically cheaper than clay bricks. It is cheaper to manufacture and build cement bricks. At the same time they are much stronger than ordinary bricks. It is available in three grades: Grade 33, Grade 43, and Grade 53. Because of their hydrating properties, constructional cements, which will even set and harden under water, are often called hydraulic cements. A material was obtained by burning a naturally occurring substance called “cement rock”. These materials belong to a class known as natural cement, allied to Portland cement but more lightly burned and not of controlled composition. The cement used for manufacturing of fly ash brick is OPC grade 53.

1.2.4 Quarry Dust

Quarrying is the process of removing rock, sand, gravel or other minerals from the ground in order to use them to produce materials for construction or other uses. So, a quarry is any such working on the surface of the earth where minerals are extracted. Stone quarry is a light, neutral, sandy white with a brick undertaken. Quarry dust is a byproduct of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes, during the process the dust generated is called quarry dust and it is formed as waste. It is cost effective, easily available, consumption reduces the pollution in environment and effectively used as a replacement material for river sand.

1.2.5 Gypsum

Gypsum is made up of oxygen, sulfur, calcium and water. As evaporation occurs the sulfur is not protected by water and oxygen contacts sulfur bonding with it to form a sulfate. The sulfate then bonds with calcium and water to create gypsum. Gypsum is a soft sulfate mineral composed of calcium sulfate dihydrate. It is widely mined and is used as a fertilizer and as the main constituent in many forms of plaster and dry wall. Its crystal habit is of massive, flat. it is also elongated and generally prismatic crystals. Varieties of gypsum known as “satin spar” and “alabaster” are used for a variety of purposes, however, their low hardness limits their durability. This plays a very important role in controlling the rate of hardening of the cement. During the cement manufacturing process, upon the cooling of clinker, a small amount of gypsum introduced during the final grinding process.

1.2.6 M -Sand

M- Sand is a substitute of river sand, used in construction industry mainly for concrete production and mortar mix. It is produced from hard granite stone by crushing. The crushed stone is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand is less than 4.75mm. This is mainly crushed fine aggregate produced from a source material with suitable strength, durability and shape characteristics. These particles should have a higher crushing value. The surface texture of M- Sand particles should be smooth and even. These particles should have a rounded shape. It should not contain any organic impurities.

1.3 SCOPE

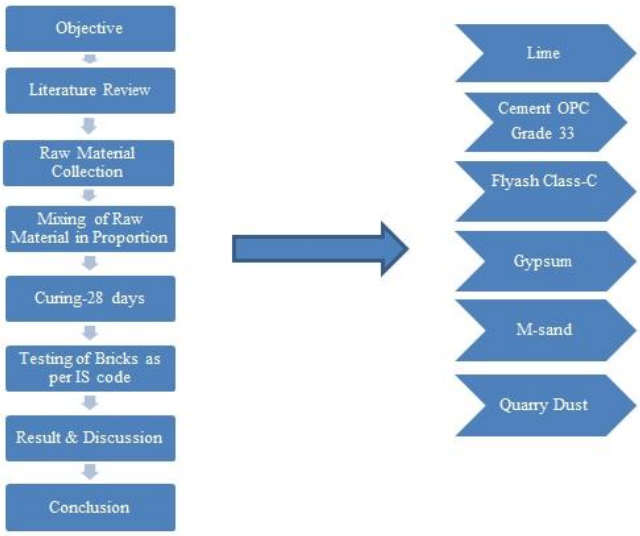
- To explore the strength of0 the brick using different proportions.
- To compare the bricks of different proportions by testing the water absorption, compressive strength and efflorescence.

1.4 OBJECTIVE

- To manufacture an economical and quality fly ash brick comparing to existing one (Presently manufacturing at Everest Fly ash Bricks, Tirupur).
- To compare three different material proportion and find the optimum proportion.
- To conduct various test on fly ash bricks as per IS code and compare the result.
- To compare burnt clay bricks with the optimum - proportion fly ash bricks for market use.

2. METHODOLOGY

The manufacturing process of fly ash brick requires fly ash, sand/stone dust, lime and gypsum to be mixed in a suitable proportion. Lime and gypsum are first ground in pan-mixture with optimum water. Ash and sand/stone dust are then added into the pan-mixture to from a uniform mixture. Fly ash brick are lighter and stronger than clay bricks. Main ingredients include fly ash, water, quicklime or lime sludge, cement, aluminium power and gypsum. Autoclaving increases the hardness of the block by promoting quick curing of the cement.



3. EXPERIMENTAL INVESTIGATION

3.1 SHAPE AND SIZE TEST

Table 1 Shape and size of FQ 1

FQ 1				
S.NO	L(mm)	B(mm)	H(mm)	W(kg)
1.	230	110	75	3.350
2.	230	110	75	3.540
3.	230	110	75	3.630
4.	230	110	75	3.623
5.	230	110	75	3.320

Table 2 Shape and size of FQ 2

FQ 2				
S.NO	L(mm)	B(mm)	H(mm)	W(kg)
1.	230	110	75	3.452
2.	230	110	75	3.524
3.	230	110	75	3.765
4.	230	110	75	3.634
5.	230	110	75	3.369

Table 3 Shape and size of FQ 3

FQ 3				
S.NO	L(mm)	B(mm)	H(mm)	W(kg)
1.	230	110	75	3.650
2.	230	110	75	3.600
3.	230	110	75	3.327
4.	230	110	75	3.574
5.	230	110	75	3.423

Table 4 Shape and size of FQ 4

FQ 4				
S.NO	L(mm)	B(mm)	H(mm)	W(kg)
1.	230	110	75	3.570
2.	230	110	75	3.640
3.	230	110	75	3.355
4.	230	110	75	3.734
5.	230	110	75	3.592

Table 5 Shape and size of FQ 5

FQ 5				
S.NO	L(mm)	B(mm)	H(mm)	W(kg)
1.	230	110	75	3.236

2.	230	110	75	3.671
3.	230	110	75	3.553
4.	230	110	75	3.679
5.	230	110	75	3.546

Table 6 Shape and size of FQ 6

FQ 6				
S.NO	L(mm)	B(mm)	H(mm)	W(kg)
1.	230	110	75	3.376
2.	230	110	75	3.350
3.	230	110	75	3.476
4.	230	110	75	3.595
5.	230	110	75	3.357

Table 7 Shape and size of FM 1

FM 1				
S.NO	L(mm)	B(mm)	H(mm)	W(kg)
1.	230	110	75	3.249
2.	230	110	75	3.273
3.	230	110	75	3.624
4.	230	110	75	3.271
5.	230	110	75	3.463

Table 8 Shape and size of FM 2

FM 2				
S.NO	L(mm)	B(mm)	H(mm)	W(kg)
1.	230	110	75	3.543
2.	230	110	75	3.641
3.	230	110	75	3.676
4.	230	110	75	3.435
5.	230	110	75	3.362

Table 9 Shape and size of FM 3

FM 3				
S.NO	L(mm)	B(mm)	H(mm)	W(kg)
1.	230	110	75	3.542
2.	230	110	75	3.628
3.	230	110	75	3.461
4.	230	110	75	3.712
5.	230	110	75	3.839

Table 10 Shape and size of FM 4

FM 4				
S.NO	L(mm)	B(mm)	H(mm)	W(kg)
1.	230	110	75	3.528
2.	230	110	75	3.634
3.	230	110	75	3.740
4.	230	110	75	3.735
5.	230	110	75	3.513

Table 11 Shape and size of FM 5

FM 5				
S.NO	L(mm)	B(mm)	H(mm)	W(kg)
1.	230	110	75	3.251
2.	230	110	75	3.416
3.	230	110	75	3.453
4.	230	110	75	3.315
5.	230	110	75	3.327

Table 12 Shape and size of FM 6

FM 6				
S.NO	**L(mm)**	**B(mm)**	**H(mm)**	**W(kg)**
1.	230	110	75	3.671
2.	230	110	75	3.612
3.	230	110	75	3.594
4.	230	110	75	3.600
5.	230	110	75	3.602

Table 13 Shape and size of FG 1

FG 1				
S.NO	**L(mm)**	**B(mm)**	**H(mm)**	**W(kg)**
1.	230	110	75	3.741
2.	230	110	75	3.369
3.	230	110	75	3.528
4.	230	110	75	3.537
5.	230	110	75	3.473

Table 14 Shape and size of FG 2

FG 2				
S.NO	**L(mm)**	**B(mm)**	**H(mm)**	**W(kg)**
1.	230	110	75	3.734
2.	230	110	75	3.705
3.	230	110	75	3.689
4.	230	110	75	3.677
5.	230	110	75	3.519

Table 15 Shape and size of FG 3

FG 3				
S.NO	**L(mm)**	**B(mm)**	**H(mm)**	**W(kg)**
1.	230	110	75	3.536
2.	230	110	75	3.469
3.	230	110	75	3.575
4.	230	110	75	3.818
5.	230	110	75	3.627

Table 16 Shape and size of FG 4

FG 4				
S.NO	**L(mm)**	**B(mm)**	**H(mm)**	**W(kg)**
1.	230	110	75	3.752
2.	230	110	75	3.528
3.	230	110	75	3.743
4.	230	110	75	3.353
5.	230	110	75	3.537

Table 17 Shape and size of FG 5

FG 5				
S.NO	**L(mm)**	**B(mm)**	**H(mm)**	**W(kg)**
1.	230	110	75	3.467
2.	230	110	75	3.481
3.	230	110	75	3.405
4.	230	110	75	3.566
5.	230	110	75	3.627

Table 18 Shape and size of FG 6

FG 6				
S.NO	**L(mm)**	**B(mm)**	**H(mm)**	**W(kg)**
1.	230	110	75	3.740
2.	230	110	75	3.600
3.	230	110	75	3.843
4.	230	110	75	3.762
5.	230	110	75	3.625

3.2 WATER ABSORPTION TEST

Table 19 Water absorption of FQ 1

FQ 1			
S.NO	**Dry weight W1(kg)**	**Wet weight W2(kg)**	**Water Absorption (%)**
1.	3.350	3.795	13.28
2.	3.540	3.820	7.91
3.	3.630	3.870	6.61
4.	3.623	3.850	6.27
5.	3.320	3.610	8.73
	Average(%)		8.56

Table 20 Water absorption of FQ 2

FQ 2			
S.NO	**Dry weight W1(kg)**	**Wet weight W2(kg)**	**Water absorption(%)**
1.	3.452	3.720	7.77
2.	3.524	3.800	7.83
3.	3.765	3.980	5.71
4.	3.634	3.940	8.42
5.	3.369	3.652	8.40
		Average(%)	7.63

Table 21 Water absorption of FQ 3

FQ 3			
S.NO	**Dry weight W1(kg)**	**Wet weight W2(kg)**	**Water absorption (%)**
1.	3.650	3.92	7.4
2.	3.600	3.940	9.44
3.	3.327	3.673	10.38
4.	3.574	3.945	6.69
5.	3.423	3.667	7.12
		Average(%)	8.95

Table 22 Water absorption of FQ 4

S.NO	**Dry weight W1(kg)**	**Wet weight W2(kg)**	**Water absorption(%)**
1.	3.570	3.824	7.11
2.	3.640	3.905	7.28
3.	3.355	3.84	8.02
4.	3.734	3.965	6.20
5.	3.592	3.827	6.54
		Average(%)	7.03

Table 23 Water absorption of FQ 5

S.NO	**Dry weight W1(kg)**	**Wet weight W2(kg)**	**Water absorption(%)**
1.	3.236	3.546	9.58
2.	3.671	3.924	6.89

3.	3.553	3.950	11.17
4.	3.679	3.925	6.69
5.	3.546	3.797	7.08
		Average(%)	**8.282**

Table 24 Water absorption of FQ 6

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.376	3.792	12.32
2.	3.350	3.758	12.18
3.	3.476	3.837	10.39
4.	3.595	3.915	8.90
5.	3.357	3.763	12.09
		Average(%)	**11.18**

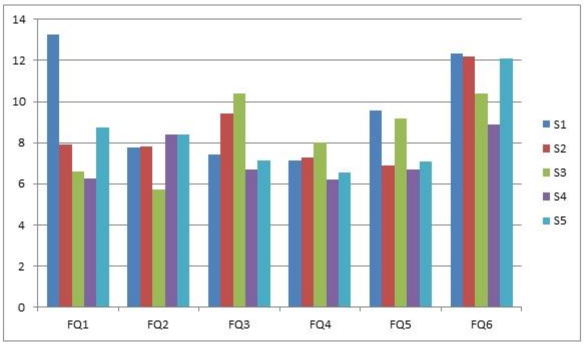


FIG 1 Fly ash + quarry dust bricks water absorption test result comparison for various proportions

Table 25 Water absorption of FM 1

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.249	3.598	10.74
2.	3.273	3.620	10.60
3.	3.624	3.971	9.58
4.	3.271	3.546	8.41
5.	3.463	3.787	9.36
		Average(%)	**9.738**

Table 26 Water absorption of FM 2

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.543	3.874	9.34
2.	3.641	3.898	7.06
3.	3.676	3.916	6.53
4.	3.435	3.765	9.61
5.	3.362	3.672	9.22
		Average(%)	**8.35**

Table 27 Water absorption of FM 3

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.542	3.834	8.24
2.	3.628	3.915	7.91
3.	3.461	3.770	8.93
4.	3.712	3.973	7.03
5.	3.839	4.150	8.10
		Average(%)	**8.04**

Table 28 Water absorption of FM 4

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.528	3.870	9.69
2.	3.634	3.924	7.98
3.	3.740	4.045	8.16

4.	3.735	4.010	7.36
5.	3.513	3.837	9.22
		Average(%)	8.48

Table 29 Water absorption of FM 5

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.251	3.575	9.67
2.	3.416	3.783	10.74
3.	3.453	3.790	9.76
4.	3.315	3.642	9.86
5.	3.327	3.680	10.65
		Average(%)	10.19

Table 30 Water absorption of FM 6

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption (%)
1.	3.671	3.957	7.79
2.	3.612	3.834	6.15
3.	3.594	3.825	6.43
4.	3.600	3.940	9.44
5.	3.602	3.945	9.52
		Average(%)	**7.87**

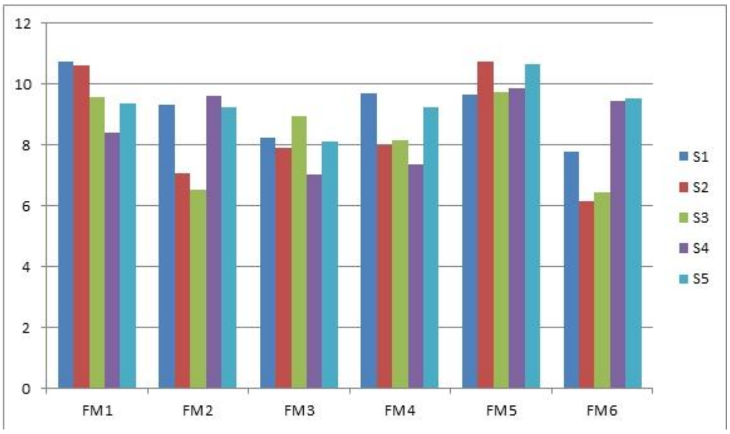


Fig 2 Fly ash + M sand bricks water absorption test result comparison for various proportions

Table 31 Water absorption of FG 1

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.741	4.031	7.75
2.	3.369	3.672	8.99
3.	3.528	3.820	8.28
4.	3.537	3.874	9.53
5.	3.473	3.758	8.21
		Average(%)	**8.55**

Table 32 Water absorption of FG 2

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.734	4.125	10.47
2.	3.705	4.016	8.39
3.	3.689	3.957	7.26
4.	3.677	3.947	7.25
5.	3.519	3.873	11.52
		Average(%)	**8.99**

Table 33 Water absorption of FG 3

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.536	3.872	9.50
2.	3.469	3.750	8.10
3.	3.575	3.894	8.92
4.	3.818	4.025	5.42
5.	3.627	3.964	9.29
		Average(%)	**8.25**

Table 34 Water absorption of FG 4

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.752	4.010	6.87
2.	3.528	3.893	10.35
3.	3.743	3.975	6.20
4.	3.353	3.624	8.08
5.	3.537	3.819	7.97
		Average(%)	**7.89**

Table 35 Water absorption of FG.5

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.467	3.726	7.47
2.	3.481	3.792	8.93
3.	3.405	3.653	7.28
4.	3.566	3.849	7.94
5.	3.627	3.951	8.93
		Average(%)	**8.11**

Table 36 Water absorption of FG.6

S.NO	Dry weight W1(kg)	Wet weight W2(kg)	Water absorption(%)
1.	3.740	4.113	9.97
2.	3.600	3.957	9.92
3.	3.843	4.266	11.01
4.	3.762	4.148	10.26
5.	3.625	3.976	9.68
		Average(%)	10.17

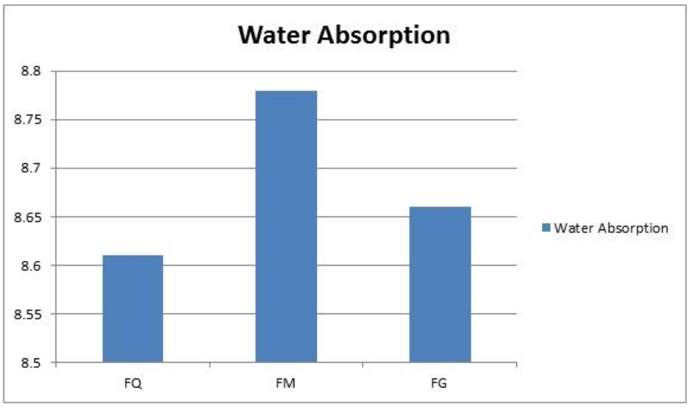


Fig 3 Fly ash + Gypsum bricks water absorption test result comparison for various proportions

The below table represents the average value of the water absorption for different proportions:

S.NO	Brick Mixes	Average (%)	TOTAL AVERAGE (%)
1.	FQ1	8.56	8.61
	FQ2	7.63	
	FQ3	8.95	
	FQ4	7.03	
	FQ5	8.28	
	FQ6	11.18	
2.	FM1	9.74	8.78
	FM2	8.35	

	FM3	8.04	
	FM4	8.48	
	FM5	10.19	
	FM6	7.87	
3.	FG1	8.55	8.66
	FG2	8.99	
	FG3	8.25	
	FG4	7.89	
	FG5	8.11	
	FG6	10.17	

3.3 COMPRESSION TEST

Table 37 Compressive strength of FQ 1

S. NO	L (mm)	B(mm)	H(mm)	Load at failure(kN)	Compressive Strength(N/mm^2)
1.	230	110	75	126	5.0
2.	230	110	75	139	5.49
3.	230	110	75	137	5.45
4.	230	110	75	137	5.42
5.	230	110	75	138	5.45
				Average (%)	5.36

Table 38 Compressive strength of FQ 2

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm^2)
1.	230	110	75	**144**	**5.69**
2.	230	110	75	**147**	**5.81**
3.	230	110	75	**139**	**5.49**
4.	230	110	75	**139**	**5.49**
5.	230	110	75	**147**	**5.81**
				Average (%)	**5.79**

Table 39 Compressive strength of FQ 3

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm^2)
1.	230	110	75	**144**	**5.69**
2.	230	110	75	**146**	**5.77**
3.	230	110	75	**147**	**5.81**
4.	230	110	75	**147**	**5.81**
5.	230	110	75	**148**	**5.85**
				Average (%)	**5.79**

Table 40 Compressive strength of FQ 4

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm^2)
1.	230	110	75	**144**	**5.69**
2.	230	110	75	**149**	**5.89**
3.	230	110	75	**142**	**5.61**
4.	230	110	75	**147**	**5.81**
5.	230	110	75	**146**	**5.77**
				Average (%)	**5.75**

Table 41 Compressive strength of FQ 5

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm²)
1.	230	110	75	**149**	**5.89**
2.	230	110	75	**147**	**5.82**
3.	230	110	75	**142**	**5.61**
4.	230	110	75	**146**	**5.81**
5.	230	110	75	**148**	**5.85**
				Average (%)	5.80

Table 42 Compressive strength of FQ 6

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm²)
1.	230	110	75	**142**	**5.61**
2.	230	110	75	**144**	**5.69**
3.	230	110	75	**141**	**5.57**
4.	230	110	75	**142**	**5.62**
5.	230	110	75	**142**	**5.62**
				Average (%)	5.62

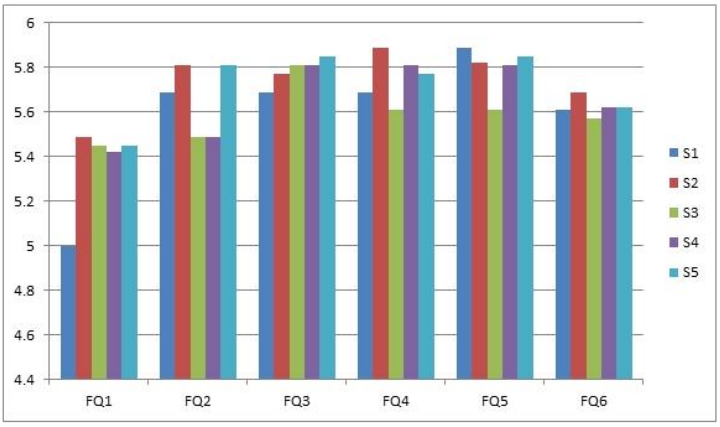


Fig 4 Fly ash + Quarry dust bricks compressive strength test comparison for various proportions

Table 43 Compressive strength of FM 1

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm²)
1.	230	110	75	**134**	**5.30**
2.	230	110	75	**132**	**5.22**
3.	230	110	75	**134**	**5.31**
4.	230	110	75	**134**	**5.30**
5.	230	110	75	**137**	**5.42**
				Average (%)	5.31

Table 44 Compressive strength of FM 2

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm²)
1.	230	110	75	**134**	**5.30**
2.	230	110	75	**139**	**5.49**
3.	230	110	75	**137**	**5.42**
4.	230	110	75	**137**	**5.42**
5.	230	110	75	**139**	**5.50**
				Average (%)	5.43

Table 45 Compressive strength of FM 3

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm²)
1.	230	110	75	**132**	**5.22**
2.	230	110	75	**134**	**5.30**
3.	230	110	75	**133**	**5.26**
4.	230	110	75	**135**	**5.34**
5.	230	110	75	**134**	**5.31**
				Average(%)	**5.29**

Table 46 Compressive strength of FM 4

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm²)
1.	230	110	75	**134**	**5.30**
2.	230	110	75	**134**	**5.30**
3.	230	110	75	**131**	**5.18**
4.	230	110	75	**137**	**5.42**
5.	230	110	75	**135**	**5.34**
				Average (%)	**5.31**

Table 47 Compressive strength of FM 5

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm²)
1.	230	110	75	**137**	**5.42**
2.	230	110	75	**137**	**5.42**
3.	230	110	75	**136**	**5.38**
4.	230	110	75	**134**	**5.30**
5.	230	110	75	**137**	**5.42**
				Average (%)	**5.39**

Table 48 Compressive strength of FM 6

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm²)
1.	230	110	75	**132**	**5.22**
2.	230	110	75	**134**	**5.30**
3.	230	110	75	**132**	**5.22**
4.	230	110	75	**135**	**5.33**
5.	230	110	75	**132**	**5.22**
				Average(%)	**5.26**

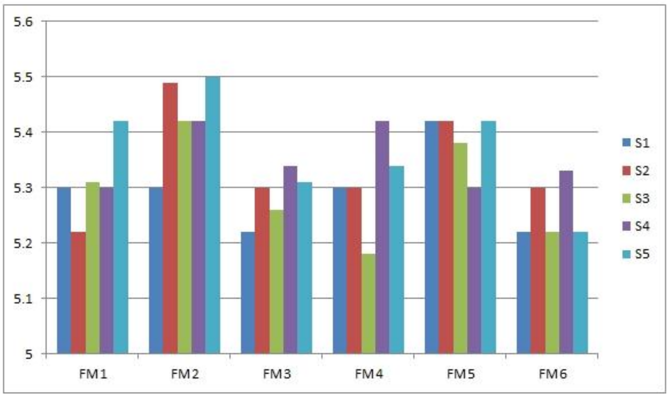


FIG. 5 Fly Ash + M sand bricks compressive strength test values comparison for various proportions

Table 49 Compressive strength of FG 1

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strength(N/mm²)
1.	230	110	75	**137**	**5.42**

2.	230	110	75	137	5.42
3.	230	110	75	139	5.49
4.	230	110	75	137	5.42
5.	230	110	75	139	5.49
				Average (%)	5.45

Table 50 Compressive strength of FG 2

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strenght(N/mm²)
1.	230	110	75	139	5.49
2.	230	110	75	139	5.49
3.	230	110	75	138	5.45
4.	230	110	75	138	5.45
5.	230	110	75	136	5.38
				Average (%)	5.45

Table 51 Compressive strength of FG 3

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strenght(N/mm²)
1.	230	110	75	139	5.49
2.	230	110	75	139	5.49
3.	230	110	75	138	5.48
4.	230	110	75	135	5.33
5.	230	110	75	137	5.42
				Average (%)	5.44

Table 52 Compressive strength of FG 4

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strenght(N/mm²)
1.	230	110	75	137	5.42
2.	230	110	75	136	5.38
3.	230	110	75	139	5.49
4.	230	110	75	134	5.30
5.	230	110	75	137	5.42
				Average (%)	5.40

Table 53 Compressive strength of FG 5

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strenght(N/mm²)
1.	230	110	75	137	5.42
2.	230	110	75	137	5.42
3.	230	110	75	139	5.49
4.	230	110	75	136	5.38
5.	230	110	75	137	5.42
				Average (%)	5.43

Table 54 Compressive strength of FG 6

S. NO	L(mm)	B(mm)	H(mm)	Load at failure(N)	Compressive Strenght(N/mm²)
1.	230	110	75	134	5.30
2.	230	110	75	139	5.49
3.	230	110	75	137	5.42

4.	230	110	75	**137**	**5.42**
5.	230	110	75	**139**	**5.49**
				Average (%)	**5.42**

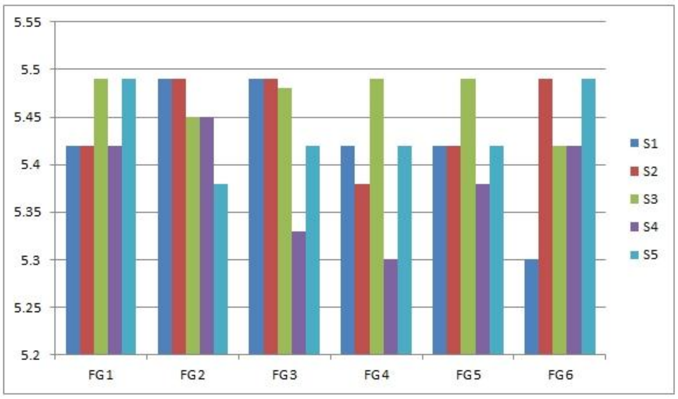


Fig 6 Fly Ash + Gypsum bricks compressive strength values for various proportions

The below table represents the average value of the compressive strength for different proportions:

S.NO	Brick Mixes	Average (%)	TOTAL AVERAGE (%)
1.	FQ1	5.36	5.69
	FQ2	5.79	
	FQ3	5.79	
	FQ4	5.75	
	FQ5	5.80	
	FQ6	5.62	
2.	FM1	5.31	5.33
	FM2	5.43	
	FM3	5.29	
	FM4	5.31	
	FM5	5.39	
	FM6	5.26	
3.	FG1	5.45	5.43
	FG2	5.45	
	FG3	5.44	
	FG4	5.40	
	FG5	5.43	
	FG6	5.42	

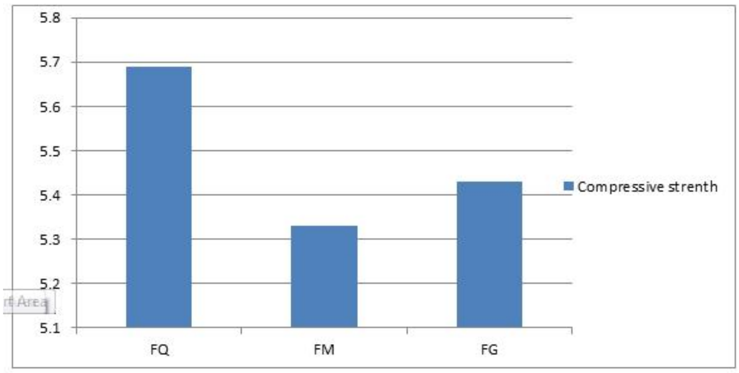


Fig 7 Compressive strength test results

3.4 EFFLORESCENCE TEST

The below table represents the efflorescence for different proportions:

S.NO	Brick Mixes	Efflorescence
1.	FQ1	Slight
	FQ2	Slight
	FQ3	Slight
	FQ4	Slight
	FQ5	Slight
	FQ6	Slight
2.	FM1	Moderate
	FM2	Moderate
	FM3	Moderate
	FM4	Moderate
	FM5	Moderate

	FM6	Moderate
3.	FG1	Nil
	FG2	Nil
	FG3	Nil
	FG4	Nil
	FG5	Nil
	FG6	Nil

CONCLUSIONS

For the various combinations of bricks which are manufactured from the industry and the various tests are made on bricks the following conclusions were arrived.

- It has been noted that the combination of fly ash+ lime+ cement + quarry dust gives the high strength and quality by performing the various tests.
- The addition of fly ash with quarry dust gives the high strength when comparing to other combinations of fly ash with gypsum and M-Sand.
- When comparing to the clay bricks also, fly ash with quarry dust gives the better result.

In terms of cost, the use of quarry dust cost is low when comparing to others like gypsum and M-Sand.

REFERENCES

[1] "Epidemiological Study on Effect of Air Pollution on Human Health in Delhi", Environmental Health Management Series: EHMS/0112012, Central Pollution Control Board, Government of India.
[2] Ramagiri Rushikesh, Chandra Mohan Reddy Sivappagari – Development of IoT based Vehicular Pollution Monitoring System – International Conference on Green Computing and Internet of Things (ICGCIoT) 2015.
[3] Prof.D.D.Mondal, Pooja Bhagat - a system detecting an air pollution and tracking using GPS and GSM - irjet – 2017. Pravendra Singh Dangi, R.S. Pandey (2017) 'Experimental studies of fly ash brick with lime Gypsum & quarry dust',- Concepts Journal of Applied Research.
[4] Safeer Abbas, Muhammad A. Saleem, Syed M.S. Kazmi, and Muhammad J. Munir (2017) 'Production of Sustainable Clay Bricks using Waste Fly Ash:Mechanical and Durability Properties', - Journal of Building Engineering.
[5] Manish Kumar Sahu, Lokesh Singh (2017) 'Critical Review on Fly Ash Bricks',- International Journal of Advance Engineering & Research Development.
[6] R.V.Shinde, S.D.VIkhe, S.N.Pawar, D.D.Tekale (2016) 'Study of Engineering Properties of Fly Ash Bricks for Construction', - International Journal of Innovative Research in Science.
[7] A. Sumathi, K. Saravana Raja Mohan (2015) 'Compressive Strength of Fly Ash Brick with Addition of Lime, Gypsum and Quarry Dust', - International Journal of Chem Tech Research.
[8] Nitin, Tapesh Behl, Rachit, Kapil Dev Patyal (2015) 'Investigation on Fly Ash-Lime-Gypsum Mix Mixed with Stone Dust', - International Journal of Science and Research.
[9] Golden Makaka (2014) ' Influence of Fly Ash on Brick Properties and the Impact of Fly Ash Brick Walls on the Indoor Thermal Comfort for Passive Solar Energy Efficient House', - Computational Water, Energy, and Environmental Engineering.
[10] Nitin S. Naik, B.M.Bahadure, C.L.Jejurkar (2014) 'Strength and Durability of Fly Ash, Cement and Gypsum Bricks', - International Journal of Computational Engineering Research.
[11] Tabin rushad s, Abhishek kumar, Duggal s. K, Mehta p. K (2011) 'Experimental Studies on Lime-Soil-Fly Ash Bricks', - International journal of civil and structural engineering.
[12] S Maitra, S Das, A K Das and A Basumajumdar (2005) 'Effect of heat treatment on properties of steam cured fly ash–lime compacts', - Indian Academy of Sciences.
[13] Tutunlu and U. Atalay (2001) 'Utilization of fly ash in manufacturing of building bricks ', - International Ash Utilization Symposium, Center for Applied Energy Research.
[14] Ashik Kumar Parashar, Rinko Parashar (2012) 'Bricks with Total Replacement of Clay by FlyAsh Mixed with Different Materials', - International Journal of Scientific and Research.
[15] Pimrakar Kedar Matthias Wilhelm, Michael Kochberger and Werner Wruss(2001) 'A new Approach to the production of bricks made of 100% fly ash', - International ash utilization symposium, Centre of Applied energy Research.
[16] Giuseppe Cultrone, Eduardo Sebastián (2009) 'Fly ash addition in clayey materials to improve the quality of solid bricks', - Construction and Building Materials.
[17] Dhadse Sharda, Pramila Kumari, L J Bhagia (2008) 'Fly Ash Characterization, Utilization and Government initiatives in India- A review', - Journal of Scientific and Industrial research.
[18] Xu Lingling, Guo Wei, Wang Tao, Yang Nanru (2005) 'Study on fired bricks with replacing clay by fly ash in high volume ratio', - Elsevier, Construction and Building Materials.
[19] Shakir, Alaa A., Sivakumar Naganathan , Kamal Nasharuddin Mustapha (2013) 'Properties of bricks made using fly ash, quarry dust and billet scale', - Elsevier, Construction and Building Materials.

[20] Tabinrushad S, Abhisek kumar, Duggal S.K, Mehta P.K (2011) 'Experimental Studies on Lime-Soil –Fly Ash Bricks', - International Journal of Civil and Structural Engineering.
[21] Rakesh Kumar (2011) 'Utilisation of Fly Ash for Bricks manufacturing', - Journal of Civil and Structural Engineering.
[22] Tahmina Banu, Md. Muktadir Billah (2013) 'Experimental Studies on Fly Ash-Sand-Lime Bricks with Gypsum Addition', - American Journal of Materials Engineering and Technology.