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Optimization of Compressive Strength for Fly Ash Building Bricks Using Taguchi Method

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ABSTRACT: Now days the Fly ash is used in many areas and it is available at Thermal Power Stations by burning of coal and lignite, it is stored in rooms or stock over fertile land for other uses. It is important for power plant that they should use the fly ash quickly, because fly ash contains sulphur, the place where it will be kept will become barren. In this study investigation was carried out to know the percentage of maximum use mixture of fly ash building brick so that we can use and recycle fly ash with most favorable outcome which is needed for making bricks. The size specimen taken for bricks is as follows, 230mm x 100mm x 90mm. According to Indian standard for different mixture percentage of fly ash (10 to 30%), gypsum (3%), cement (25-35%) and coarse aggregate (45-55%) with three different particles with three different particle size of fly ash 425micron, 600micron, 825micron, compressive strength, Water absorption, Efflorescence test were studied for different mix proportions. The results shows the variations in compressive strength, Water absorption, and Efflorescence test for different mixture proportions of different materials mentioned earlier at different curing time that is 7Days, 14Days, and 21Days. From the previous research based results it was evidently expected that, the maximum optimum compressive strength is obtained for optimum mixture percentage of Flyash-10% Cement-35% Gypsum-3% Coarse Aggregate dust-52%.

Key words: Fly ash, Cement, Gypsum, Coarse Aggregate, Compressive strength, Efflorescence and Water absorption.

I. INTRODUCTION

In the present trend in the construction industry, use of economic and eco friendly material is of a best concern. In present scenario one of the main materials used is cement. It is observed from various research studies that the heat which is emitting from cement shows a bigger percentage in global warming. A Sumathi, k Sarwana raja mohan, In this study they have tried to find the most favorable situation or outcome of mix percely ntage of fly ash brick size of brick specimen - 230mm*110mm*90mm*and brick made up of using flyash- (15to50%)gypsum (2%)lime (5to 30%) &quarry dust (45to55%)brick is made up by Taguchi Method[1]. Dinesh w.gawatre, laxmikant n.vairagade In this study the use of flyash in the most safest and gainful has been one of the hottest topic of research over the last few decades the following are the advantages that has proven to be the additional points in this debate-saving of space for disposal of natural resources-energy efficient and eco friendly[2]. Manas kumar sahoo, As by this we got to know these are about 125 thermal power plants totally identified and structures in India through which a colossal amount of fly ash is produced low grade usage of coal gave 120 million fly ash per year many application are also recognized through this fly ash we also concluded up lay by the addition of lime in excess to fly ash may not result beneficial[3]. Bricks selection in done specification by their characteristics strength tenure of time as the particular requirement are included ASTM that most common international publishers of the bricks are update periodically[4]. Rupendra kumar sinha sharda paratap shrives ashish kumar khandelwal published their research for the purpose of construction in today's world the most important material used is cement but is used to minimized the global warming the maxim um optimized compressive strength required for construction is obtained by optimal mix percent of fly ash[5]. Fly ash is the important of coal construction collected by the mechanical or ESP Indian coal on an average has 30% to 40% ash. Fly ash causes of air pollution, water & soil pollution, disrupt ecological cycle & set off environment hazards the combination of fly ash, lime ,gypsum and sand can used to purpose masonry bricks. Fol-G masonry units can effectively replace conventional masonry units. Because of high strength there will be no brakeage during transportation therefore fol-G bricks are more safe economical & having higher strength these all above contents was presented in Guidelines for manufacturing quality fly ash bricks Prepared By Fly Ash Resource Centre, State Pollution Control Board, Odisha, Bhubaneswar [6]. An industry which deals in cements products account to a bigger emission of CO_2 and they also use high levels of energy resources in the production of cement. In order to reduce these effects, change cement with some pozzolanic materials such as fly ash, which can have an better improve effect against these harmful factors. In this research work, we find the optimum mixture of fly ash (major ingredients) generated at Century Pulp and Paper Thermal Power Plant, sandy, hydrated lime and gypsum and also optimized the best pressure for forming building bricks. Fly ash- 55%, sand- 30% and hydrated lime – 15% with gypsum-14% was found to be the optimum mixture. For the optimum mix studied the compressive strength, tensile strength, Efflorescence, Initial rate of absorption, absorption capacity, Water absorption, shrinkage property, Flexural strength, unit volume weight, apparent porosity, microstructure open pore and impervious pore of the fly ash–sandy/clay–lime-gypsum building bricks manufactured with optimum composition under various building brick forming pressures, radio activity of the bricks made under optimum conditions were also investigated[7]. In this research paper, experimentally investigation is carried out for the fly ash brick mix proportions with different particle size and different material composition for strengthen purpose by Taguchi method (L9 ORTHOGONAL ARRAY MATRIX). Minimum amount of lime and fly ash has been used as binding materials and considered the water binder ratio as control factor. So the effects of fly ash, water/binder ratio, sandy/clay, and gypsum on the performance characteristics are analyzed using mean response data and noise-to-signal ratios. Furthermore, the estimated optimum values of the process parameters are corresponding to binder/ water ratio of 0.4, fly ash of 10%, gypsum of 3%, lime of 35% and sandy/clay of 52% [8]. The addition of fly ash up to 30% at different temperature as 1000ºC and 1200^0C has no significant harmful effects on the brick quality. It was noticed that the fly ash added building bricks show reasonably best properties and may become competitive with the conventional building bricks. Applications of fly ash as a raw material for the building bricks production is not only capable alternative to clay but also a solution to difficult and expensive waste disposal problem[9]. In the present research work the attempt has made to find the optimum mixture percentage of different building brick material like, to obtain maximum compressive strength, tensile strength, Flexural strength, Efflorescence and Water absorption of fly ash brick admixed with lime, fly ash, clay/sandy and gypsum at various proportions. In present scenario composite are most successful materials used in various applications for latest works in the industry. Deepak Singla1, S.R. Mediratta presented research on composite material Al 7075 with fly ash as reinforcement are likely to overcome the cost barrier as well as the different mechanical and physical properties for application in the space craft and automotive industries. Composite material 7075-Fly Ash Composites by using Stir Casting arrangement which was properly distributed the ash particles all over the required specimen and shows significantly improved properties which including toughness, hardness, high tensile strength, low density and good wear resistance as compared to other metals and alloy. On increasing the amount of fly ash strength in all test increases up to a certain level afterwards strength was decreases [10].

II. OBJECTIVE

To find out the optimum mixture composition design for making building brick so as to achieve the maximum Compressive Strength, Efflorescence and Water absorption of fly ash building brick for three different particle size 425, 600, 825micron of fly ash which further cure at different time /days 7, 14 and 21days in solar radiation.

III. NEED FOR THE RESEARCH STUDY

1. To improve the engineering properties such as strength, workability, plasticity, water absorption tightness and Efflorescence of building bricks etc.
2. To improve the compressive strength to estimate the stability and durability of the brick.
3. To maintain the optimum Indian standard uniform size and shape of fly ash bricks and to reduce the plastering thickness.
5. To reduce the overall manufacturing cost of high strengthens building brick.
6. To minimize the consumption of fertile land soil in manufacturing of building bricks and finds the alternative for this problem.
7. To increase the utilization of fly ash in building brick so that we easily recycle the fly ash and protect our fertile land soil from sulphur which is present in fly ash and
8. To find the optimum material ratio composition of fly ash in building brick this satisfied the level of strength properties as well according to market demand and for specific situation like earth quack.

IV. MATERIALS AND METHODOLOGY METHODS

The following are the details regarding methods, methodology and properties of the materials used in this research study.

A. Materials Used

Coarse aggregate dust
Gypsum

Cement
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%. In addition to pozzolanic properties, class C fly ash also possesses cementious properties. Fly ash used is of type class C with a specific gravity of 2.19**.**

Cement: Cement is an important material for binding, now a day's which is used popularly in building construction. It is basically found as mixed form of Calcium oxide (CaO) and magnesium oxide (MgO) in nature. At ordinary temperature Cement reacts with fly ash and forms a compound possessing cementations characteristic or property. When fly ash, cement and calcium silicate hydrates are react with each other, they are responsible for the good strength of the compound.

Gypsum: Gypsum is a soft crystalline rock which is a non- hydraulic binder occurring naturally as or sand. Gypsum have a precious property like incombustibility, small bulk density, good fire resistance, good sound absorbing capacity, hardening and rapid drying with, superior surface finish, and negligible shrinkage etc. In addition it can rise viscosity or improve material strength. It has 2.31 grams per cubic centimeter specific gravity. Gypsum powder has 2.8 to 3 grams per cubic centimeter density.

Coarse Aggregate Dust: Coarse Aggregate Dust is natural send or crushed stone. It is provide dimensional stability and increases volume of concrete it is rest taken from granite quarry. Due to high amount of shipping from nature sources convenient river sand is costly. Also creates nature issue of big-scale depletion of these sources. Use of river sand in construction becomes less attractive, those stone particle that are mostly retained on the 4.75mm riddle. 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. Use of river sand in construction becomes less attractive; a substitute or replacement product for concrete industry needs to be found. Whose continued use has started posing serious problems with respect to its availability, cost and environmental impact. In such a case the coarse aggregate dust can be an economic alternative to the river sand. Usually, Quarry Rock Dust is used in large scale in the highways as a surface finishing material and also used for manufacturing of hollow blocks and lightweight concrete prefabricated Elements. After processing fine particles of size less than 4.75 mm is used in this work. First Arriving mix percentage of fly ash bricks for Fly ash (15 to 50%), Cement (5 to 30%), Gypsum (2%) and Coarse Aggregate dust (45 to 55%). Standard fly ash brick sizes of 230 mm x 110mm x 90 mm are used to cast the bricks. For each proportion 12 number of bricks are casting in that nine bricks are used to determine the compressive strength of brick in N/mm² at 7days,14days, and 21days curing time and three bricks are used to determine the water absorption. Compressive Stress is determined using Compression Testing Machine (CTM) of 3000 KN capacity. The following Flow chart describes the methodology for manufacturing of Fly Ash Bricks with selected Material Composition.

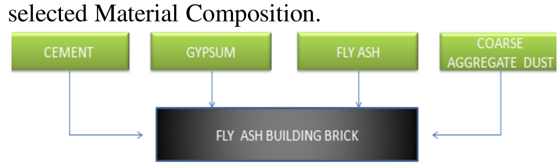

Fig. 1. Manufacturing Flow Chart of Fly Ash Bricks of Selected Material Composition.

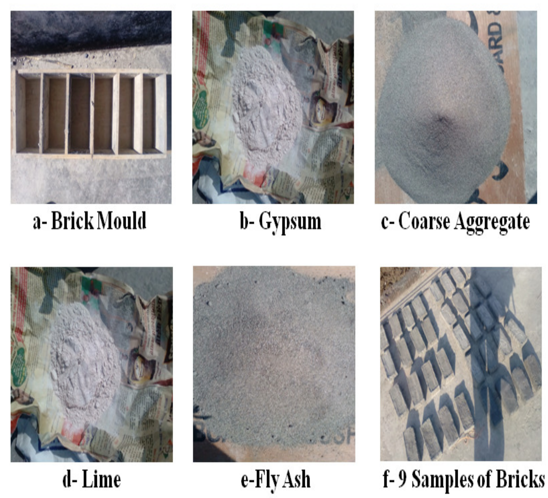

Fig. 2. Different Material Composition used in Manufacturing of Fly Ash Bricks Pictures with Varying Samples and Mould.

B. Methedology Used

In this present research paper as a methodology we are using Taguchi method for finding the optimum mixture percentage with varying materials, material composition ratio and fly ash particle size for analyzing the compression strength, water absorption ratio and Efflorescence test. The material composition ratio percentage of different material with three different particle sizes is shown in table number 2 where gypsum percentage is taken constant throughout the samples. In

Taguchi method we are using L9 orthogonal array where we select 4 factors with three different levels as shown in table number 1. According to this L9 orthogonal array nine experiments were prepared for compression test. Out of which we find the best possible composition ratio with different particle size for the manufacturing of best fly ash building bricks for market concern.

Table 1: L9 Orthogonal Array Chart for Four Factors with Three Levels.

EXPERIMENT NO.	P1	P2	P3	P4	LEVEL
1	1	1	1	1	L1
2	1	2	2	2	L1
3	1	3	3	3	L1
4	2	1	2	3	L2
5	2	2	3	1	L2
6	2	3	1	2	L2
7	3	1	3	2	L3
8	3	2	1	3	L3
9	3	3	2	1	L3

Table 2: Material Ratio Composition in Percentage.

CEMENT	FLY ASH	COARSE AGGREGATE	GYPSUM	PARTICLE SIZE
25%	10%	42%	3%	425
25%	20%	47%	3%	600
25%	30%	52%	3%	825
30%	10%	47%	3%	825
30%	20%	52%	3%	425
30%	30%	42%	3%	600
35%	10%	52%	3%	600
35%	20%	42%	3%	825
35%	30%	47%	3%	425

Table 3: Material Ratio Composition in Grams for 1.175kg.

CEMENT	FLY ASH	COARSE AGGREGATE	GYPSUM
1293.75	517.5	2173.5	155.25
1293.75	1035	2432.25	155.25
1293.75	1552.5	2691	155.25
1552.5	517.5	2432.25	155.25
1552.5	1035	2691	155.25
1552.5	517.5	2173.5	155.25
1811.25	1552.5	2691	155.25
1811.25	1035	2173.5	155.25
1811.25	1552.5	2432.25	155.25

V. RESULT AND DISCUSSION

The experimental based investigation was brought out to find the optimum mixture percentage with varying material composition fly ash building bricks of different particle size admixed with cement, gypsum, and coarse aggregate dust and also to find the water absorption. Arriving set of experiments, Mixture samples are arrived by referring the latest articles and collection of data prepared the local manufacturing companies. For the various varying material compositions, fly ash building bricks are cast and several sets of experimental samples of building bricks according to L9 Orthogonal array was formed so that the following tests were conducted. Tests applied to bricks were as follows: Compressive Strength test, Water Absorption test, Efflorescence test.

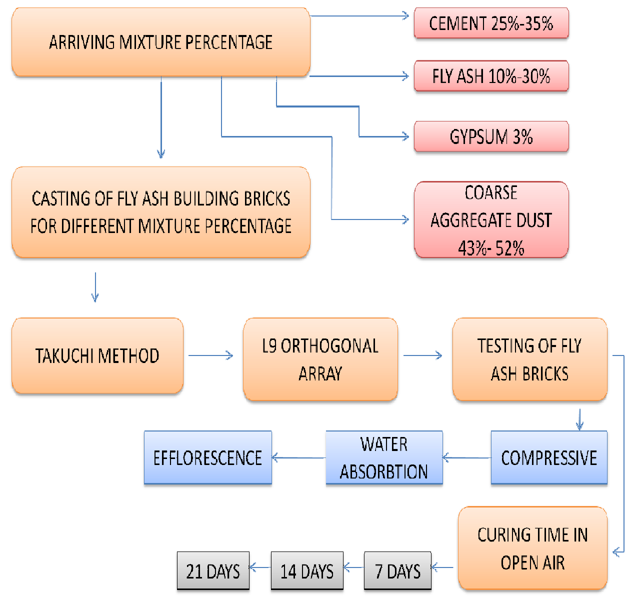

Fig. 3. Methodology Flow Chart.

A. Compressive Strength Test

The compressive strength of fly ash building brick is five times greater than the normal clay brick. The minimum compressive strength of clay brick is 3.5 N/mm². So as the fly ash building brick has the compressive strength of 41.08-158N/mm². Bricks to be used for different works should not have compressive strength less than as mentioned above. In our research paper, we used the digital universal testing machine for testing the compressive strength of bricks. After the wet curing time gets over building bricks are placed for further dry heating under solar radiation for selected three different dry curing times i.e. 7, 14, and 21Days. After completion of solar drying for building bricks under solar radiation, brick samples prepared for testing.

Table 4: Compression Strength of Different Samples.

EX. NO .	CEMEN T	FLY ASH	COARSE AGGREGAT E	PARTICL E SIZE	COMPRESSIO N TEST
1	25%	10%	42%	425	115
2	25%	20%	47%	600	30
3	25%	30%	52%	825	25
4	30%	10%	47%	825	55
5	30%	20%	52%	425	100
6	30%	30%	42%	600	120
7	35%	10%	52%	600	200
8	35%	20%	42%	825	190
9	35%	30%	47%	425	90

For testing the samples the building bricks are placed in the calibrated Compression testing machine of capacity 3000 KN, which applied a uniform load at the rate of 2.9 N/min. The load of failure is the maximum load at which different sample fails which is recorded in the indicator reading on the testing machine, as shown in table number 4 and 5.

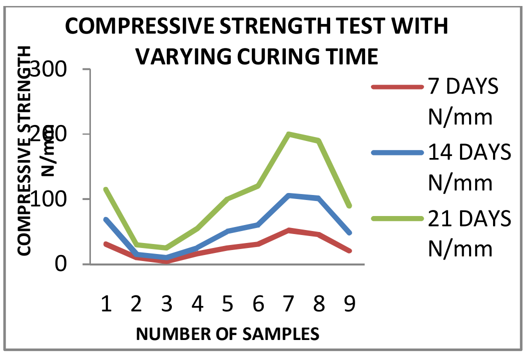

Fig. 4. Graphical Variation between Compressive Strength with different Number of Samples.

Table 5: Compression Strength with Varying Curing Temperature.

EXPERIMENT NUMBER	CURING TIME		
	7 DAYS N/mm	14 DAYS N/mm	21 DAYS N/mm
1	30	68	115
2	10	15	30
3	4	10	25
4	15	25	55
5	25	50	100
6	30	60	120
7	52	105	200
8	45	100	190
9	20	48	90

Taguchi Analysis: Compression Test of Fly Ash Bricks Prepared at Curing Time 7Days versus Cement, Fly Ash, Coarse aggregate, Particle Size.

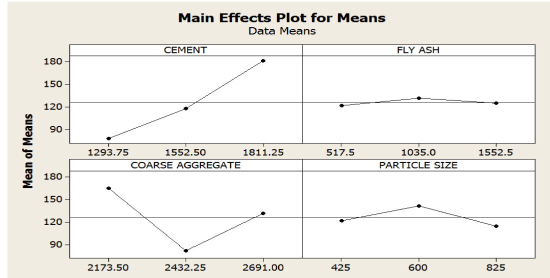

Fig. 5. Main Effects Plot for Mean for Compressive Strength Test of Bricks Prepared at Curing Time 7Days.

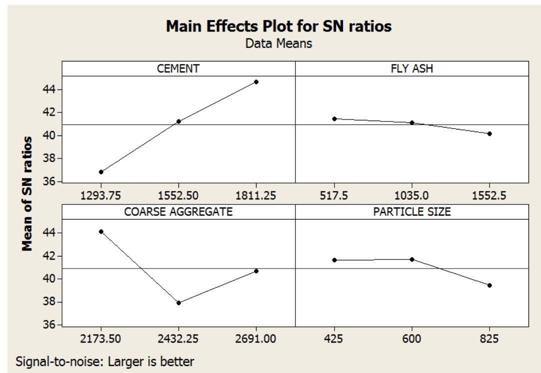

Fig. 6. Main Effects Plot for SN ratios for Compressive Strength Test of Bricks Prepared at Curing Time 7Days.

Table 6: Response Table for Signal to Noise Ratios for Larger is better.

Level	CEMENT	FLY ASH	COARSE AGGREGATE	PARTICLE SIZE
1	36.83	41.47	44.16	41.66
2	41.25	41.13	37.94	41.69
3	44.71	40.18	40.68	39.43
Delta	7.88	1.30	6.22	2.26
Rank	1	4	2	3

Table 7: Response Table for Means.

Level	CEMENT	FLY ASH	COARSE AGGREGATE	PARTICLE SIZE
1	**78.33**	**121.67**	**165.00**	**121.67**
2	**118.33**	**131.67**	**81.67**	**141.67**
3	**181.67**	**125.00**	**131.67**	**115.00**
Delta	**103.33**	**10.00**	**83.33**	**26.67**
Rank	**1**	**4**	**2**	**3**

Taguchi Analysis: Compression Test of Fly Ash Bricks Prepared at Curing Time 14Days versus Cement, Fly Ash, Coarse aggregate, Particle Size.

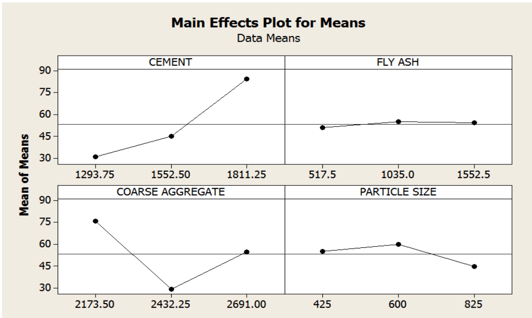

Fig. 7. Main Effects Plot for Mean for Compressive Strength Test of Bricks Prepared at Curing Time 14Days.

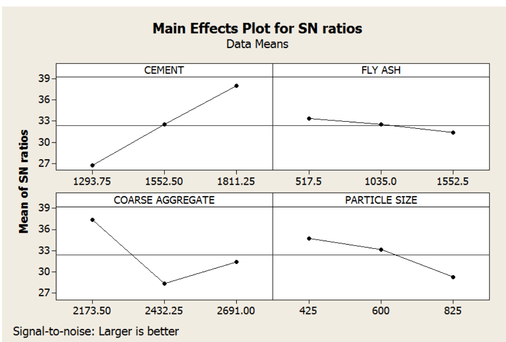

Fig. 8: Main Effects Plot for SN ratios for Compressive Strength Test of Bricks Prepared at Curing Time 14Days.

Table 8: Response Table for Signal to Noise Ratios for Larger is better.

Level	CEMENT	FLY ASH	COARSE AGGREGATE	PARTICLE SIZE
1	26.72	33.39	37.40	34.75
2	32.50	32.50	28.37	33.17
3	38.02	31.35	31.47	29.32
Delta	11.29	2.04	9.04	5.43
Rank	**1**	**4**	**2**	**3**

Table 9: Response Table for Means.

Level	CEMENT	FLY ASH	COARSE AGGREGATE	PARTICLE SIZE
1	31.00	51.00	76.00	55.33
2	45.00	55.00	29.33	60.00
3	84.33	54.33	55.00	45.00
Delta	**53.33**	**4.00**	**46.67**	**15.00**
Rank	**1**	**4**	**2**	**3**

Taguchi Analysis: Compression Test of Fly Ash Bricks Prepared at Curing Time 21Days versus Cement, Fly Ash, Coarse aggregate, Particle Size.

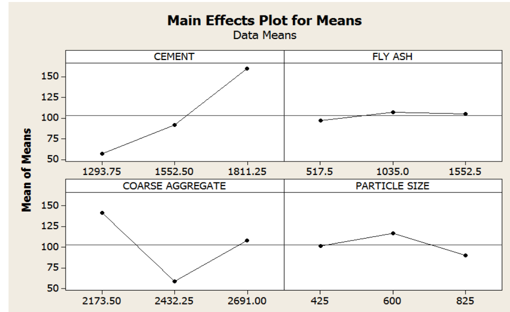

Fig. 8. Main Effects Plot for Mean for Compressive Strength Test of Bricks Prepared at Curing Time 21Days.

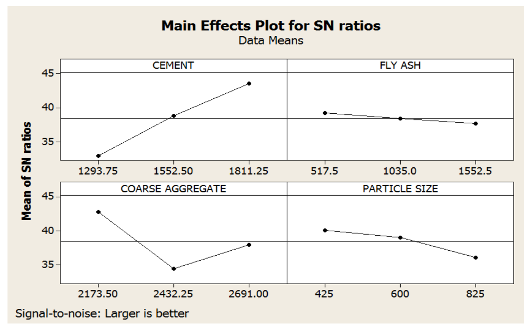

Fig. 10. Main Effects Plot for SN ratios for Compressive Strength Test of Bricks Prepared at Curing Time 21Days.

Table 10: Response Table for Signal to Noise Ratios for Larger is better.

Level	CEMENT	FLY ASH	COARSE AGGREGATE	PARTICLE SIZE
1	**32.91**	**39.20**	**42.79**	**40.10**
2	**38.80**	**38.37**	**34.48**	**39.05**
3	**43.56**	**37.69**	**37.99**	**36.11**
Delta	**10.66**	**1.51**	**8.31**	**3.99**
Rank	**1**	**4**	**2**	**3**

Table 11: Response Table for Means.

Level	CEMENT	FLY ASH	COARSE AGGREGATE	PARTICLE SIZE
1	56.67	96.67	141.67	101.67
2	91.67	106.67	58.33	116.67
3	160.00	105.00	108.33	90.00
Delta	103.33	10.00	83.33	26.67
Rank	1	4	2	3

B. Water Absorption Test:

In water absorption test, firstly we weight all the samples before dipping into the water, after measuring the weight W1.

We dip all the samples into water for 24 hours, after 24 hours we take out all samples one by one and measure the weight as W2.

Table 12: Water Absorption Test Reading Of Different Samples.

EX. NO.	W1 (kg)	W2 (kg)	(W2-W1)	(W2-W1)/W1	(W2-W1)/W1X100 %
1	1.552	1.750	0.198	0.127	12.8
2	1.782	2.040	0.258	0.144	14.5
3	2.336	2.695	0.359	0.153	15.4
4	1.946	2.195	0.249	0.127	12.8
5	2.346	2.660	0.314	0.133	13.4
6	2.012	2.310	0.298	0.148	14.9
7	2.164	2.425	0.261	0.1201	12
8	2.262	2.535	0.273	0.1206	12.1
9	2.258	2.580	0.322	0.147	14.8

After taking all short of reading we placed the entire sample in the oven at temperature of 105 to 115^o C till attains constant weight cool the bricks to room temperature and weight (W1). It is observed that the samples absorbed water not more than 15%. After removing all the bricks from oven, we calculate the Water absorption percentage by weight with formula W% = (W2 – W1/W1) x 100.

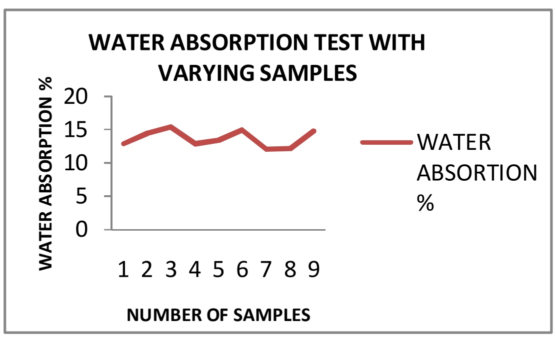

Fig. 11. Graphical Variation between Water Absorption Percentages with Different Number of Samples.

Taguchi Analysis: Water Absorption Test of Fly Ash Bricks Prepared at Curing Time 21Days versus Cement, Fly Ash, Coarse aggregate, Particle Size.

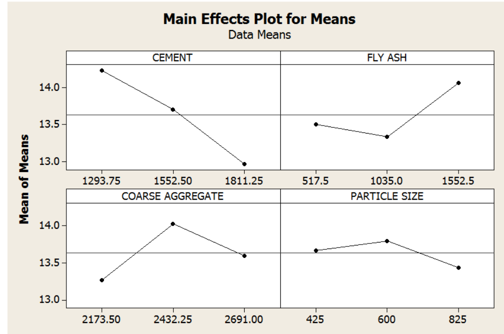

Fig. 12. Main Effects Plot for Mean for Water Absorption Test of Bricks Prepared at Curing Time 21Days.

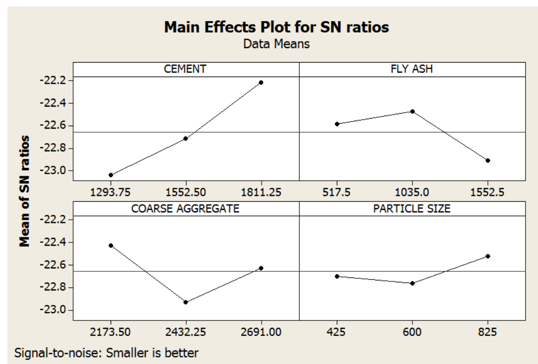

Fig.13. Main Effects Plot for SN ratios for Water Absorption Test of Bricks Prepared at Curing Time 21Days.

C. Efflorescence Test:

For efflorescence test, firstly we placed brick vertically in the water with one end immersed. The water immersion depth of fly ash building brick was 2.5 cm, and then all the arrangements placed in a well warm ventilated room at the temperature of 25-35 ^{0}C until all the water evaporates. The fly ash building brick absorbed and evaporates all the water present in the dish and place the similar quantity of water in the dish and allows it to absorb and evaporate as before. After this process, we examine all the samples of fly ash building bricks and we find the proper percentage of white spot on the surface area of fly ash building bricks. After observation, if any difference produces by the presence of salt deposit, then the report rated as 'effloresced', if there is no difference is occur, then the report rated as 'not effloresced'.

In our present research, it is being observed that the percentage of white spot in the fly ash building bricks= NIL.

Fig. 14. Compressive Strength Testing Machine with 1000N/mm Pressure gauge capacity.

Table 13: Response Table for Signal to Noise Ratios for Larger is better.

COARSE PARTICLE				
Level	**CEMENT**	**FLY ASH**	**AGGREGATE**	**SIZE**
1	**-23.04**	**-22.58**	**-22.42**	**-22.70**
2	**-22.72**	**-22.48**	**-22.93**	**-22.76**
3	**-22.21**	**-22.91**	**-22.63**	**-22.52**
Delta	**0.83**	**0.44**	**0.50**	**0.24**
Rank	**1**	**3**	**2**	**4**

Table 14: Response Table for Mean.

COARSE PARTICLE				
Level	**CEMENT**	**FLY ASH**	**AGGREGATE**	**SIZE**
1	**14.23**	**13.50**	**13.27**	**13.67**
2	**13.70**	**13.33**	**14.03**	**13.80**
3	**12.97**	**14.07**	**13.60**	**13.43**
Delta	**1.27**	**0.73**	**0.77**	**0.37**
Rank	**1**	**3**	**2**	**4**

V. CONCLUSION

In our present research paper we are investigating to determine the optimum mixture percentage of fly ash building bricks for varying material composition with three different particle sizes of fly ash and coarse aggregate dust i.e. 425 micron, 600micron, and 825micron, which prepared at three different curing time under solar radiation i.e. 7 Days, 14 Days, and 21 Days, so that we achieve the optimum mixture percentage for fly ash building bricks of high compressive strength, which we will further use for the different applications also. For the Compressive Strength Test and Water Absorption Test, sample 7 shows best results out of all samples i.e. 400KN/mm2 which is mention in Table Number 4. The best optimum mixture percentage for high compressive strength among all other samples is 10% Fly Ash, 35% Cement, 3% Gypsum and 52% Coarse Aggregate Dust for particle size 600 micron at Curing Time 21 Days. From above results, it is also concluded that for better compression strength lower particle size the large curing time of preparing fly ash building bricks is responsible. It is proof by conducted experiment that by using the above mixture composition percentage we save burning fuel cost because these bricks which we manufacture do not require any baking processes and for preparation or manufacturing normal clay bricks temperature is a basic need as baking process is involved in it. It requires 1773K to 2273K temperature for baking purpose of clay bricks which is maintained five days continuously for manufacturing such bricks and utilizes a large amount of cost for the baking process. After completion of all investigation it is concluded that we save baking cost which makes our product very cost effective and we obtained five times better result as compared different Fly Ash Bricks presently available in market, normal high strength best clay building bricks and the evaluated compressive strength results during experiments for different Fly Ash Bricks was 25 - 35 N/mm^2 for 7 days curing time, for normal best strength clay bricks was 5.85 N/mm^2 which prepared at baking temperature 1773K shows a clear difference and for our selected material composition for fly ash building bricks was 4 - 52 N/mm for 7 days curing time. So it is evident that our research for varying percentage of different material composition for fly ash building bricks is positive.

REFERENCES

[1] Deepak Singla, S.R. Mediratta, "International Journal of Innovative Research in Science, Engineering and Technology", ISSN: 2319-8753 "Evaluation of mechanical properties of al 7075-fly ash composite material", Vol. **2**, Issue 4, April 2013.

[2] Iftekhar Ahmad and Prakash A. Mahanwar "Mechanical Properties of Fly Ash Filled High Density Polyethylene", Journal of Minerals & Materials *Characterization & Engineering,* Vol. **9**, No.3, pp.183-198, 2010.

[3] JaanKersa , PriitKulua , Aare Aruniita , Viktor Laurmaaa , Peter Križanb , LubomirŠoošb and ÜloKaskc "Determination of burning, physical, and mechanical characteristics of polymeric waste material briquettes", *Estonian Journal of Engineering*, 2010.

[4] ROHATGI, P.K (2006) "Fly Ash in Synthesizing Low Cost Metal Matrix Composites for Automotive and Other Engineering Applications", JOM, vol. **58**, issue no.11, pp.71-76, 2006.

[5] Dinesh W.Gawatre1 ,Laxmikant N. Vairagade2 "Strength Characteristics of Different Types of Bricks", *International Journal of Science and Research (IJSR)* ISSN (Online): 2319-7064 Impact Factor (2012): 3.358.

[6] Arati Shetkar, Nagesh Hanche, Shashishankar A "Experimental Studies on Fly Ash Based Lime Bricks", ISSN (Online): 2347 - 2812, Volume-4, Issue -7, 2016.

[7] S. Naganathan * , N. Subramaniam and K. Nasharuddin Bin Mustapha, "*Asian Journal Of Civil Engineering (Building And Housing)*", "Development of brick using thermal power plant bottom ash and fly ash", VOL. **13**, NO. 1, pp. 275-287, 2012.

[8] Naganathan S, Razak HA, Nadzrian AH. "Effect Of Kaolin Addition On The Performance Of Controlled Low-Strength Material Using Industrial Waste Incineration Bottom Ash", "Waste Management And Research", **28**, pp. 848–60 (2010).

[9] Wiebusch B, Seyfried CF. Utilization of sewage sludge ashes in the brick and tile industry, Water Science and Technology, **36**, pp. 251–8 (1997).

[9] Domínguez EA, Ullmann R. Ecological bricks, made with clays and steel dust Pollutant, *Applied Clay Science*, **11**, pp. 237–49 (1996).

[10] Yang J, Liu W, Zhang L, Xiao B. Preparation of load-bearing building materials from autoclaved phosphogypsum, *Construction and Building Materials*, doi:10.1016/j.conbuildmat.2008.02.011.

[11] Lin KL. Feasibility study of using brick made from municipal solid waste incinerator fly ash slag, *Journal of Hazardous Materials*, **B 137**, pp. 1810-1816 (2006).

[12] Singh N, Ramachandran RD, and Sarkar AK. "Quantitative Estimation of Constituents In Fly Ash By Lithium Tetraborate Fusion", "*International Journal Of Environmental Analytical Chemistry*", **83,** pp. 891–896, (2003).

[13] Vassilev SV, and Vassileva VG. Methods for characterization of composition of fly ash from coal fired power stations: a critical overview, Energy Fuels, 19, pp. 1084–1098 (2005).

[14] Landman AA. Aspects of Solid State Chemistry of Fly Ash And Ultramarine Pigments, Phd Thesis, University Of Pretoria, 2002.

[15] Mohapatra R, and Rao JR. Some Aspects of Characterisation, Utilisation And Environmental Effects Of Fly Ash, *Journal Of Chemical Technology And Biotechnology*, **76** pp. 9–26 (2001).

[16] Tahmina Banu, Md. Muktadir Billah, et. al, Experimental Studies on Fly Ash-Sand-Lime Bricks with Gypsum Addition: *American Journal of Materials Engineering and Technology*, Vol. **1**, No. 3, pp 35- 40, 2013.

[17] Prabir Kumar Chaulia and Reeta Das, Process Parameter Optimization for Fly Ash Brick by Taguchi Method: *Material Research,* Vol. **11**, pp 159-164, 2008.

[18] Tutunlu Faith, and Atalay Umit, Utilization of Fly ash in Manufacturing of Building Brick: International Ash utilization Symposium, Center for applied Engineering Research; pp 1-13, 2001.

[19] A. Sumathi, K. Saravana Raja Mohan, "Compressive Strength of Fly Ash Brick with Addition of Lime, Gypsum and Quarry Dust", "International Journal of Chem. Tech Research", ISSN: 0974-4290, Vol.7, No.01, pp 28-36, 2015.

[20] ROHATGI, P.K, "Applications of fly ash in synthesizing low cost Metal Matrix Composites for automotive and other engineering applications", JOM, vol. **58**, issue no.11, pp.71-76, 2006.

[21] SHANMUGHASUNDARAM, P. "Some studies on Aluminum- Fly Ash composites fabricated by two step stir casting method", *European journal of scientific research*, vol. **63**, issue no.2, pp. 204-218, 2011.

[22] RAO, J.BABU, "Development of light weight ALFA composites", *International journal of engineering, science and technology,* Vol.**2,** issue no.11, pp. 50-59, 2010.

[23] MOUTSATSOU, ANGELIKI, "Synthesis of Aluminum-based Metal Matrix Composites (MMCs) with lignite fly ash as reinforcement material", world of coal ash conference in Lexington, USA, 2009.

[24] MAHENDRA, K.V, "Fabrication of Al-4.5% Cu alloy with Fly Ash Metal Matrix Composites and its characterization", materials science-poland, vol 25, issue no.1, 2007.

[25] ITSKOS, GRIGORIOS, "Compaction of high- Ca fly ash-Al- and Al-alloy-composites: evaluation of their micro-structure and tribological performance", *coal combustion and gasification products,* vol. **3**, pp. 75-82, 2011.

[26] CANUL, M.I. PECH, "The use of fly ash and rice-hull-ash in Al/Sicp composites: a comparative study of the corrosion and mechanical behavior", vol. **15**, issue no. 2, pp. 225-232, 2010.

[27] Deepak Singla, S.R. Mediratta, "Evaluation Of Mechanical Properties Of Al 7075-Fly Ash Composite Material", "*International Journal of Innovative Research in Science, Engineering and Technology*", Vol. **2**, Issue 4 April, pp. 951-959, 2013.

[28] ASTM D 6103-00, Standard test method for flow consistency of controlled low-strength material (CLSM), American Society for Testing and Materials, PA, USA, 2000.

[29] ASTM C 140–02. "Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units", "American society for testing and materials, PA, USA, 2003.

[30] ASTM C 67-03, Standard test methods for sampling and testing brick and structural clay tile, American Society for Testing and Materials, PA, USA, 2003.

[31] ASTM C279, 'Standard Specification for Chemical-Resistant Masonry Units, American Society for Testing and Materials, Philadelphia, PA, USA, 2007.

[32] Taylor GD. Materials in Construction, An Introduction, Third edition, Longman, UK, 2000.

[33] Halil MA, Paki T. Cotton and limestone powder waste as brick material, *Construction and Building Materials*, **22**(2008) 1074–80.

[34] S. Naganathan*, N. Subramaniam and K. Nasharuddin Bin Mustapha, "Development Of Brick Using Thermal Power Plant Bottomash And Flyash", "*Asian Journal Of Civil Engineering (Building And Housing)",* VOL. **13**, NO. 1, pp. 275-287, 2012.

[35] Arati Shetkar, Nagesh Hanche, Shashishankar A, "Experimental Studies on Fly Ash Based Lime Bricks", "*International Journal of Recent Advances in Engineering & Technology (IJRAET)* ", Volume-**4**, Issue -7, pp 201-209, 2016.

[36] M Prasanth[1], Rejith Thomas[2], S Sandana Socrates[3], S Sasi Kumar[4], S S Manu[5]," Experimental Investigation on The Compressive Strength Of Pressed Composite Earth Brick", "*International Journal of Research in Engineering and Technology*", Volume: **04** Issue: 08, pp95-98, 2015.

[37] Tarun Gehlot[1], S.S Sankhla[2], "Study Of Compressive Strength Of Fly Ash Concrete Brick With 1:6 And 1:8 Cement Mortar Ratio With Various Percentage Of Recron Fiber", "*IJRET: International Journal of Research in Engineering and Technology*", Volume: **05** Issue: 10, pp.189-194, Oct-2016.

[38] R.V.Shinde[1], S.D.VIkhe[2], S.N.Pawar[3], D.D.Tekale[4], "Study of Engineering Properties of Fly Ash Bricks for Construction", "*International Journal of Innovative Research in Science, Engineering and Technology*", Vol. **5**, Issue 5, pp.8023-8025, May 2016.