

# Clay - Fly Ash Burnt Bricks - An Experimental Study

Jayant L. Patil<sup>1</sup>, Dr. Arun Kumar Dwivedi<sup>2</sup>

Lecturer in Civil Engineering, MET Institute of Technology, Bhujbal Knowledge City, Adgaon, Nashik (MS), India, 422 003<sup>1</sup>

Principal, K.V.N.Naik Institute of Engineering Education & Research, Canda Corner, Nashik (MS), India, 422 002<sup>2</sup>

**ABSTRACT:** The fly ash for the purpose of experimentation was collected from the Thermal Power Station (Eklahre) in Nashik, Maharashtra. The mixtures of clay available at the site and the fly ash with different percentages by weight are prepared. These mixtures are used to make the bricks of clay and fly ash with different proportions. The bricks are marked with specific numbers in their frog to identify them at the time of testing. These bricks are air dried in open atmosphere for 4 - 5 days as per usual practice. The firing of the bricks is done in a traditional way as is done in and around Dhule town. These bricks are fired for fourteen days. At the end of the 14 days, the kiln is allowed to cool as per usual practice. The bricks are taken out from the kiln and stacked in the testing lab of the institute where the sample bricks are tested for water absorption, density and compressive strength as per BIS procedures.

**KEYWORDS:** Burnt Clay Brick, Compressive Strength, Density, Fly Ash, Waste Management, Water Absorption

## I. BACKGROUND

Energy efficiency through improved technologies and the use of fly ash can reduce fuel consumption and pollution levels. Fly ash entails a 30 per cent saving in fuel in firing as compared to traditional clay brick technology as well the improved technological options such as vertical shaft kilns, Habla kilns and tunnel kilns. An Austrian company, "Wienerberger Porotherm", has noted about 60 per cent of energy saving compared to conventional methods [Nirvan (2008)]. At the same time the use of fly-ash in bricks can minimize the problem of

disposal of this waste material to a large extent, in addition, to the saving of the fertile crest of the earth. The fly-ash can also be used in combination with clay or with lime and sand to produce clay-fly-ash bricks and fly-ash-sand-lime bricks respectively. The fly ash can be utilized to make bricks and blocks in one of several ways

- i. To substitute for a portion of the cement and/or aggregates in making concrete bricks and blocks. This is commonly used nowadays in many countries.
- ii. To substitute a portion of the clay used in making clay bricks. This uses the same process for making clay bricks, which requires heating the bricks in kilns to more than 2,000°F, which consumes excessive fossil fuel and generates air pollutants and carbon dioxides due to the combustion of the fossil fuel.
- iii. To substitute for all the clay used in making clay bricks, using the same process which requires burning fossil fuel to heat the kilns at over 2,000 °F. This uses the same process and has the same drawback of (ii) except that 100% fly ash is used in making bricks.
- iv. Use 100% fly ash to make bricks without firing in kilns. It implies "the 100% fly ash brick made without cement or any other binder, and without kiln firing or autoclave curing." The curing method used for fly ash bricks uses much less energy than either kiln firing or autoclave curing. [Henry (2009)]

Utilization of FA can result not only in reducing the magnitude of the environmental problems, but also in exploiting FA as a raw material for value added products while conserving traditional materials and for the

# International Journal of Innovative Research in Science, Engineering and Technology

An ISO 3297: 2007 Certified Organization

Volume 3, Special Issue 4, March 2014

National Conference on Recent Advances in Civil Engineering (NCRACE-2013)

During 15-16 November, 2013

Organized by

Department of Civil Engineering, North Eastern Regional Institute of Science and Technology, Nirjuli, Itanagar, Arunachal Pradesh, India.

extraction of valuable materials. Amongst the many uses of FA, its use as a building material is particularly suitable because it is anticipated, that there would be a considerable shortfall in production of various building materials. According to a study, there is a huge short-fall in the production of bricks—to the tune of 25 billion bricks on an estimated demand of 100 billion bricks per year in India as of today [Mishra & Patel (2004)]. To tackle the problem and encourage the use of FA for making building materials, the Government of India has imposed restriction (Gazette notification of 14th September 1999, issued by the Ministry of Environment and Forests) on brick manufacturers to use at least 25% of FA on weight-to-weight basis if the brick kiln is located within a radius of 50 km from a coal or lignite based thermal power plant. [Goyal (2000)]

## II. ENVIRONMENTAL IMPACT OF BRICK PRODUCTION

The construction sector uses up the earth's resources and contributes to its pollution. This is an increasing concern. Whilst other components of construction, also play a role, it is generally agreed that the production of building materials is the main culprit. Materials production, for instance, requires about 75% of the energy used in construction. In India, it is estimated that the brick industry produces 22% of the CO<sub>2</sub> emissions of the construction sector and requires about 27% of the energy used in building materials production [PA(2007)]. This is because the small and medium scale sectors are predominant and are generally more polluting than modern large-scale industry.

The strategy towards more sustainable construction leaving lesser carbon foot prints, is to promote the use of alternative, low-energy or renewable materials. A combination of factors, including urbanization, attitudes and inappropriate building standards are generating a rise in demand for conventional materials such as steel, bricks and cement, which do have a substantial negative environmental impact. This trend is hard to reverse and it is necessary to aim in mitigating this impact [Pandey and Agrawal (2002)].

The impact of brick-making on the environment is quite significant. "Low efficiency and high coal fuel consumption results in significant air pollution. In

addition to the emissions from the chimney, the work environment is also polluted. During the dry summer months, the wind carries a lot of dust particles from brick kilns. The consumption of coal in brick-making contributes to the greenhouse gases. In addition to air pollution, it also contributes to water pollution and degradation of soil quality due to top soil erosion [FAUP (2005)].

The production of conventional building materials impacts the environment in several ways. Poor quarry management generates lots of waste and leaves behind disused pits. Smoke and dust affects the health of workers and neighboring residents alike. The biggest impact is, however, usually caused by its energy use. Apart from the metal industry, the binders and heavy clay industries are the principal energy users. The production of bricks and lime is carried out by Small and Medium Scale Enterprise (SMEs). The production of bricks by SMEs in some developing nations like Bangladesh and Sri Lanka in South Asia often relies on fuel wood as its main source of energy. Wood consists of nearly 50% carbon; if burnt completely, one kg of wood releases around 1.8 kg CO<sub>2</sub>, the main greenhouse gas. Moreover, each tree cut down for fuel reduces the "CO<sub>2</sub> sink", the environment's capacity to absorb this gas from the air [PA (2007)]. The inefficient use of wood fuel by SMEs, thus contributes to the global environmental crisis. Energy efficiency, therefore, lies at the heart of the commercial viability and sustainability of SMEs. The challenges are therefore to improve the energy efficiency of brick production at the SME level and explore alternatives. [Bhattacharjee and Kandpal (2000)]

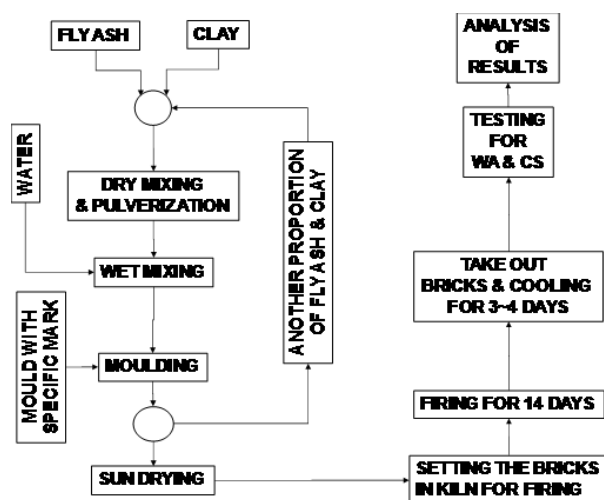
The brick industry which is vital to the housing industry forms a significant amount of the budget that goes into raw material. This apart, the industry employs a large number of people directly and indirectly. It is, therefore, necessary to bring in technology and awareness to harness the potential of this industry further, and decrease its contribution to pollution levels [Tutunlu and Umit (2001)].

## III. MATERIALS & METHODS

In this research, an attempt is done to study the effect of fly ash on the properties of clay – fly ash fire bricks. The

fly ash for this purpose is collected from Thermal Power Station (Eklahre) at Nashik, Maharashtra. The fly ash is mixed with the soil for making the brick, at a local kiln site. The mixtures of clay available at the site and the fly ash with different percentage by weight are prepared. These mixtures are mixed thoroughly by adding the appropriate amount of water and used to make the bricks of clay and fly ash with different proportions. The special wooden mould is prepared for this purpose, with a marking of SSVPS and the brick's batch numbers varying from 0 – 15. The bricks with different % of fly ash are marked with specific numbers in their frog to identify them at the time of testing. These bricks are dried in an open atmosphere for 4 - 5 days and thereafter, fired in a separate open kiln. The firing of bricks is been done in a traditional way as is the manufacturing practice around Dhule. These bricks are fired for a total of fourteen days. At the end of 14 days, the kiln is allowed to cool for four days. The bricks are taken out from kiln and stacked in an open sky for six days and then brought to the testing laboratory of the Institute, where bricks are tested for water absorption and compressive strength as per BIS procedures [BIS-1077 (1982)]. The complete process is explained in Figure 1 in a flow chart.

Figure – 1 : Flowchart Showing Methodology



#### IV. EXPERIMENTATION

##### Water Absorption Test

The water absorption test is carried out on the batches of bricks and the observations are taken. The % water absorption as calculated for different samples of bricks are shown in Table - 1. The dry density of the brick is calculated for the sample of bricks and the results are shown in Table – 2.

**Table – 1 : “WATER ABSORPTION OF THE BRICKS”**

MAR K	% OF FLY ASH ADDE D	WATER ABSORPTION (%)			
		SA- 1	SA- 2	SA- 3	AVERAG E
0	0.00	14.0 4	16.2 1	16.1 4	15.463
1	15.00	14.2 3	15.9 8	15.8 4	15.348
2	20.00	12.9 8	16.5 5	12.7 4	14.090
3	25.00	13.8 5	16.3 6	15.9 7	15.394
4	30.00	19.2 3	17.5 4	16.8 3	17.865
5	35.00	17.6 1	19.7 7	19.6 7	19.015
6	40.00	16.7 9	16.6 8	16.3 6	16.607
7	45.00	17.4 5	17.9 4	17.6 6	17.684
8	50.00	21.0 2	20.5 0	20.5 7	20.696
9	55.00	20.0 7	19.2 6	18.9 4	19.423
10	60.00	18.2 5	18.6 0	18.3 9	18.410
12	65.00	20.7 9	20.8 6	21.6 2	21.093
13	70.00	24.3 9	21.8 1	21.1 3	22.441
14	75.00	25.3 2	25.8 0	23.4 3	24.853

Table – 2 : “DENSITY OF THE BRICKS (DRY)”

MARK	% OF FLY ASH	DENSITY OF BRICK (DRY) (N/m <sup>3</sup> )			
		SAMPLE-1	SAMPLE-2	SAMPLE-3	AVERAGE
0	0.00	17146.49	16913.20	16755.39	16938.36
1	15.00	16673.05	16165.32	16474.08	16437.48
2	20.00	16467.21	15952.61	16398.60	16272.81
3	25.00	16261.37	16137.87	16206.48	16201.91
4	30.00	16192.76	16261.37	16076.12	16176.75
5	35.00	16055.53	16124.15	16055.53	16078.41
6	40.00	15986.92	16041.81	15719.33	15916.02
7	45.00	15774.22	15691.88	15643.85	15703.32
8	50.00	15438.01	15410.57	15369.40	15405.99
9	55.00	15300.79	15273.34	15156.70	15243.61
10	60.00	15156.70	15108.67	15074.36	15113.24
12	65.00	15081.22	15197.87	14998.89	15092.66
13	70.00	14889.11	15081.22	14985.17	14985.17
14	75.00	13859.91	13791.29	14168.67	13939.95

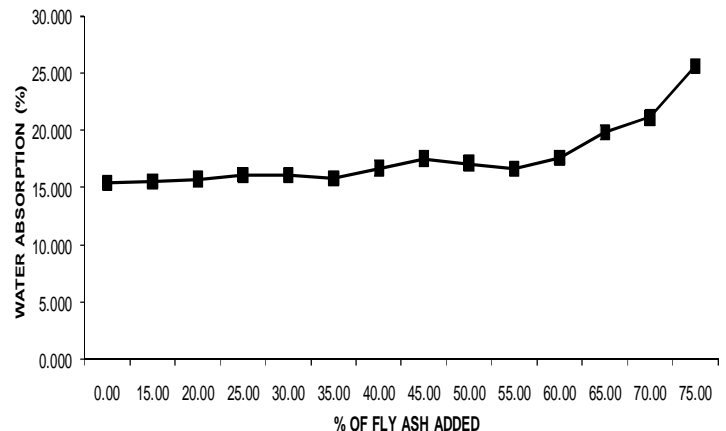
0	0.00	4.32	4.32	4.80	4.56	3.60	4.323
1	15.00	4.80	5.28	5.76	5.52	4.80	5.235
2	20.00	6.24	7.68	6.24	6.72	6.48	6.676
3	25.00	7.20	7.68	7.20	6.96	6.72	7.156
4	30.00	8.16	8.16	8.16	7.92	7.92	8.069
5	35.00	9.13	8.65	8.16	8.65	8.65	8.645
6	40.00	9.13	8.65	9.13	8.65	9.13	8.933
7	45.00	9.61	9.13	8.65	8.89	9.37	9.126
8	50.00	8.65	6.24	6.72	8.89	8.41	7.781
9	55.00	8.16	5.28	6.72	8.16	7.20	7.108
10	60.00	7.68	5.28	6.72	8.16	6.24	6.820
12	65.00	4.32	4.80	6.24	7.68	4.80	5.571
13	70.00	3.84	3.84	5.28	6.24	3.84	4.611
14	75.00	4.08	4.32	4.32	4.80	3.84	4.275

## V. CONCLUSIONS

### Water Absorption

The water absorption % of the bricks increases with every increase in the fly ash % in the bricks. The variation is from 15.463 % at 0% fly ash to 25.545 % at 75% fly ash. The variations in water absorption % with fly ash addition are shown in Figure - 2.

Figure – 2 : “Variation in Water Absorption with Fly Ash”



### Dry Density

The dry densities of the brick samples are decreasing with every increase in % of fly ash. The variations in density (dry) in kN/m<sup>3</sup> versus fly ash addition is shown in Figure - 3. The dry density of the brick samples is

### Compressive Strength Test –

The dimensions of all sample bricks are measured and the average dimension is taken for the calculation of the compressive strength. It is also observed that the dimensions within group itself are also different. However, for the purpose of the calculation of the compressive strength the following dimensions are taken as average dimension.

SIZE OF BRICK	Length	Width	Height	Plan Area (mm <sup>2</sup> )
(mm)	215.00	95.00	70.00	20425.00

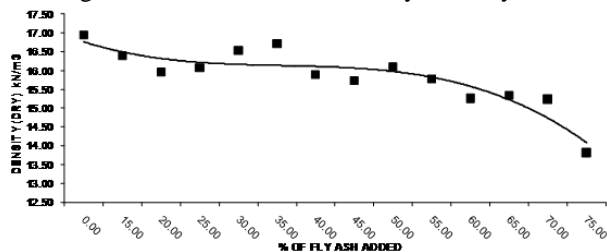
It is obvious from the observations that the clay – fly ash bricks with 45% fly ash content the strength is optimum. The compressive strength as calculated for different samples of bricks are shown in Table - 3.

Table – 3 : “Results of Compressive Strength Test”

MARK	% OF FLY ASH ADDED	COMPRESSIVE STRENGTH (N/mm <sup>2</sup> )					AVERAGE
		SA-1	SA-2	SA-3	SA-4	SA-5	
0	0.00						
1	15.00						
2	20.00						
3	25.00						
4	30.00						
5	35.00						
6	40.00						
7	45.00						
8	50.00						
9	55.00						
10	60.00						
12	65.00						
13	70.00						
14	75.00						

decreasing from 16938.36 N/m<sup>3</sup> for 0% fly ash to 13811.88 N/m<sup>3</sup> for the 75% fly ash.

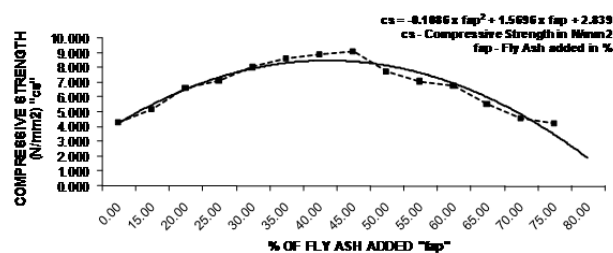
Figure – 3 : “Variation in Density with Fly Ash”



### Compressive Strength

The compressive strengths of the bricks increases with addition in fly ash % up to 40% to 50 % and there after starts decreases. The variation in compressive strength with the % increase of fly ash is shown in Figure – 4. The optimum compressive strength of the brick is 9.126 N/mm<sup>2</sup> at 45% addition of fly ash with clay.

Figure – 3 : “Variation in Compressive Strength with Fly Ash”



### Comments on Quality of Clay - Fly Ash Burnt Bricks

The following are the properties of the fly ash – clay burnt bricks which are experimented –

Optimum % of fly ash addition	:	45%
Water Absorption (at 45% Fly Ash)	:	17.539 %
Compressive Strength (at 45% Fly Ash)	:	9.126 N/mm <sup>2</sup>
Density (Dry) (at 45% Fly Ash)	:	15703.32 N/m <sup>3</sup>

The bricks may be termed as class 7.5 as per BIS 1077 - 1982. As per BIS : 3492 – Part – 2 : 1992, the water absorption up to class 12.5 should be less than 20%. The bricks prepared confirm to this criterion too.

### REFERENCES

- [i] BIS-1077-1982, Indian Standard “Common Burnt Clay Bricks Specifications – Fifth Revision”, Bureau of Indian Standard, Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi, 110002, Second Reprint August 1996
- [ii] Bhattacharjee Ujjwal & Kandpal Tara Chandra (2000), “Potential of Fly Ash Utilization in India”, Energy, 27 (1) ;151-166.
- [iii] Chou Mie-In (2002), “Fired Bricks from Fly Ash”, A Report Published by the Illinois State Geological Survey, a Division of the Illinois, Department of Natural Resources, 615 East Peabody Drive Champaign, IL 61820-6964, USA, 2002
- [iv] Foner H.A., Thomas R.L., Hower J.C. and Graham U.M. (1999), “Characterization of Fly Ash from Israel with Reference to its Possible Utilization”. Fuel, 78 (1) : 215-233.
- [v] FAUP (2005), “Fly Ash Management in India : An Integrated, Approach”, Fly Ash India 2005, International Congress, organized under Fly Ash Utilisation Programme (FAUP), Technology Information, Forecasting & Assessment Council, Department of Science & Technology, Government of India at New Delhi, India, December 2 – 5, 2005
- [vi] Goyal Jagvir (2000), “Promoting Fly-ash Brick”, The Tribune (Online Edition) Science Tribune, Thursday, Chandigarh, India, December 14, 2000.
- [vii] Henry Liu (2009), “Use of Fly-ash to Make Bricks”, Freight Pipeline Company, United State of America, February 2009.
- [viii] Hewat James M. (1996), “Approaches to the Conservation of Salt Deteriorated Brick”, A Thesis for the Post Graduate Program, Degree of Master of Science, University of Pennsylvania, 1996.
- [ix] Mishra P. C. and Patel R. K. (2004), “Management of Fly Ash, in the Context of its Growing Production”, Report of Research Project, Department of Chemistry, National Institute of Technology in Rourkela, India.
- [x] Nirvan G. (2008), “It’s Time to Go in for Green Bricks now”, PrachaR – Integrated Communications Consultant, The Hindu, On-line Edition, September 6<sup>th</sup>, 2008.
- [xi] Okunade Emmanuel Akintunde (2008), “Engineering Properties of Locally Manufactured Burnt Brick Pavers for Agrarian and Rural Earth Roads”, Graduate Thesis, Department of Civil Engineering, University of Ado-Ekiti, Cengage Learning , Science Publications.
- [xii] Pandey Piyush Kant & Agrawal Raj Kumar (2002), “Utilization of Mixed Pond Ash in Integrated Steel Plant for Manufacturing Superior Quality Bricks”, Bulletin - Material Science, Indian Academy of Sciences, 25 (5) ; 443–447.
- [xiii] PA (2007), Practical Action, “Sustainable Small-Scale Brick Production: A Question of Energy”, Technical Brief Note, The Schumacher Centre for Technology and Development Bourton-on-Dunsmore Rugby Warwickshire, CV23 9QZ, United Kingdom.
- [xiv] Tutunlu Faith and Umit Atalay (2001), “Utilization of Fly Ash in Manufacturing of Building Bricks”, International Ash Utilization Symposium, Paper #13, Center for Applied Energy Research, University of Kentucky.