Stone Sludge: Economical Solution for Manufacturing of Bricks

Mamta Rajgor, Jayeshkumar Pitroda

Abstract*—A new approach to the production of brick was carried out by using Class F fly ash. Marble and granite industry has grown significantly in the last decades with the privatization trend in the early 1990s.Accordingly, the amount of mining and processing waste has increased .Stone waste is generally a highly polluting waste due to both of its highly alkaline nature,and its manufacturing and processing techniques ,which impose a health threat to the surroundings. Brick is one of the most common masonry units as a building material due to its properties. Many attempts have been made to incorporate wastes into the production of bricks, for examples, limestone dust, wood sawdust, processed waste tea, fly ash, polystyrene and sludge. Recycling such wastes by incorporating them into building materials is a practical solution for pollution problems. This paper represents the utilization of stone sludge waste in manufacturing fly ash bricks. In this paper, an attempt is made to study the properties of stone waste fly ash bricks.

***Keywords*—Class F Fly ash, Stone sludge, Natural resources,Eco-construction bricks,Sustainability, Environment, Waste re-use, cost feasibility**

I. INTRODUCTION

India possesses over 85,600 million tonnes of reserves of calcareous stones. Estimated production of calcareous stones expected to cross over 188.6 million tonnes in view of the industrial development in the India. Calcareous stone waste is generated during mining and processing of the calcareous stone. The Indian calcareous stone industry currently produces around 17.8 million tonnes of solid calcareous waste per annum. The accumulated waste is of the order of 250 million tonnes. The waste is a serious environmental hazard. It adversely affects the fertility of the soil, contaminates the water resources and increases the drainage problem, besides causing serious air pollution.Natural and artificial stone industry generate large volume of stone waste.It is classified into various forms such as powder or fines , aggregates, larger stone pieces and cobbles, damaged blocks or slabs and stone slurry. These generated wastes cause environmental, health and economical drawbacks. Marble cutting industry produces large amounts of solid wastes on large areas, which are expected to increase as construction is continuously increased, owing to the fact that the world production of marble industry has been increasing annually in the recent years.

This paper represents the use of sludge generated from natural marble manufacturing processes as raw material or as a by – product instead of being a waste material. All natural stones including marble, granite and slate, which can be cut to size, polished and used for construction purposes.

II. EXPERIMENTAL MATERIALS

A. Materials

a) Flyash (Class F):The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds.

Figure 1 : Production of Class F Fly ash

Table 1
Chemical Composition Of Class F Fly Ash

SR.NO	CHEMICAL COMPOUND	CLASS F
1	**SiO_2**	**54.90**
2	$A1_2O_3$	25.80
3	Fe_2O_3	6.90
4	**CaO**	**8.70**
5	MgO	1.80
6	SO_3	0.60
7	Na_2O & K_2O	0.60

Source:http://www.flyash.com

Figure2: Class F fly ash

Source: Site Image- "Gaytri Brick Works "Jay Maharaj Construction, GIDC, Vallabh Vidyanagar.

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B. Sand

Sand is a naturally occurring granular material composed of finely divided rockand mineral particles.The composition of sand is highly variable ,depending on the local rock resources and conditions, but the most common constituent of sand is silica(Silicon dioxide, or SiO_2), usually in the form of quartz.

Figure: 3Sand

Source:Site Image- "Gaytri Brick Works" Jay Maharaj Construction GIDC, Vallabh Vidyanagar

Table-2 Classification Of Sand

SR. NO.	TYPES OF SAND	PARTICLE SIZE
1	Fine	0.06 mm to 0.2 mm
2	Medium	0.2 mm to 0.63 mm
3	Coarse	0.63 mm to 2.0 mm

C. Acetylene Carbide Lime

Pure calcium oxide is fused with coke in order to render the highest yield in the manufacture of acetylene. The quality of the resultant carbide lime is a direct result of the excellent quality raw materials.Carbide lime is finer in particle size, and physically, having a very finely divided particle size makes carbide lime better. A finer particle size means faster and more reactivity.

Figure 4: Acetylene Carbide Lime

Source: Site Image- "Gaytri Brick Works", Jay Maharaj Construction, GIDC, Vallabh Vidhyanagar

D. Kheda Dust

Kheda dust is used for finishing purposes. The size of particles is less than 0.06mm.

Figure 5 : Kheda dust

Source: Site Image- "Gaytri Brick Works", Jay Maharaj construction , GIDC, Vallabh Vidhyanagar

E. Stone Waste

Stone waste/Granite has been commonly used as a building material. Today industry's disposal of the stone waste/Granite powder material is one of the environmental problems around the world. Stone waste/Granite blocks are cut into smaller blocks in order to give them the desired shape and size. During the process of cutting, in that original stone waste/Granite mass is lost by 30% in the form of dust. Every year 250-400 tons of stone waste/Granite waste are generatedon site.

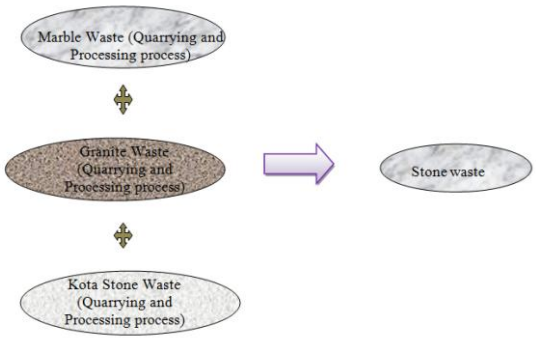

Figure: 6Stone waste

Table-3
Chemical Compositions Of Marble, Granite, Kota Stone

CHEMICAL COMPOSITION	MARBLE	GRANITE	KOTA STONE
Lime (CaO)	**28-32%**	**1-4%**	**38-42%**
Silica (SiO_2)	3-30% (varies with variety)	72-75%	24-26%
MgO	20 to 25%	0.5-1%	4-6%
FeO + Fe_2O_3	1-3%	-	-

Source:Mamta B Rajgor, Jayeshkumar R Pitroda "A Study of Utilization Aspect of Stone Waste In Indian Context", January 2013 (GRA)

F. Water

Water is an important ingredient of brick as it actually used for manufacturing of brick.Since it helpsto bind all the raw materials for giving proper mix. Water used for making brick should be free from impurities.

III. DESIGN MIX

The design mix proportion is done in Table 4.

Table-4
Sample Information Of Stone Waste With Replacement Of Fly Ash In Fly Ash Bricks

S.	F.A. Class F	S.A.	K.D.	S.L.	S.W.	T.P.
S0	**60%**	15%	15%	10%	**0%**	100%
S1	**50%**	15%	15%	10%	**10%**	100%
S2	**40%**	15%	15%	10%	**20%**	100%
S3	**30%**	15%	15%	10%	**30%**	100%
S4	**20%**	15%	15%	10%	**40%**	100%

S5	**10%**	**15%**	**15%**	**10%**	**50%**	**100%**
S6	**0%**	15%	15%	10%	**60%**	100%

S= Sample, F.A.= Fly Ash, SA= Sand,SL= Sludge Lime,KD= Kheda Dust,SW=Stone waste,TP= Total Percentage

IV. EXPERIMENTAL SET UP

Table-5
Design Mix Proportion For Various Brick

SR.NO.	SAMPLE	CLASS F FLY ASH REPLACEMENT WITH STONE WASTE
1	S0	Standard Fly ash brick
2	S1	10% replacement
3	S2	20% replacement
4	S3	30% replacement
5	S4	40% replacement
6	S5	50% replacement
7	S6	60% replacement

V. EXPERIMENTAL METHODOLOGY

The evaluation of Stone waste for use as a replacement of fly ash material begins with the brick testing. Brick contains fly ash, Lime, Gypsum, sand, water, and stone waste. With the control brick, i.e. 10%, 20%,30%,40%,50% and 60% of the fly ash is replaced with stone waste ,the data from the stone waste fly ash brick iscompared with data from a standard fly ash brick without stone waste. Five bricks samples were cast having size of230x115x75mm.The manufacturing process of bricks broadly consists of three operations viz. mixing the ingredients, pressing the mix in the machine and curing the bricks for a stipulated period.

Selection of machinery depends on the bricks mix contents. For manufacturing stone waste fly ash bricks, the best suited machinery is a Vibro - press machine, which is an indigenous low cost machine and can be run by ordinary semiskilled worker. Its production capacity is 1000 bricks per shift and can be operated in two shifts without any operation/maintenance load. The maintenance cost is so low that it can be ignored. 15 lakh bricks can be produced for each machine in its life cycle.

A. Compressive strength

The brick specimens are immersed in water for 24 hours. The frog of the brick is filled flush with 1:3 cement mortars and the specimen are stored in damp jute bag for 24 hours and then immersed in clean water for 24 hours. The specimen is placed in compression testing machine with 6 mm plywood on top and bottom of it to get uniform load on the specimen. Then load is applied axially at a uniform rate of 14 N/mm^2. The crushing load is noted. Then the crushing strength is the ratio of crushing load to the area of brick loaded. Average of five specimens is taken as the crushing strength.

Figure: 7Setup of Compression strengthtest machine

Table -6 Compressive Strength Of Bricks (230x115x75) At 7, 14, 21days For Stone Waste Fly Ash Bricks

SAMPLES	AVERAGE ULTIMATE COMPRESSIVE STRENGTH AT [N/mm^2]		
	7 DAYS	14 DAYS	21DAYS
S0	2.13	2.33	3.38
S1	2.84	3.27	3.30
S2	3.03	3.16	3.40
S3	3.79	3.95	4.20
S4	2.91	3.00	3.40
S5	2.83	2.95	3.20
S6	2.11	2.27	2.92

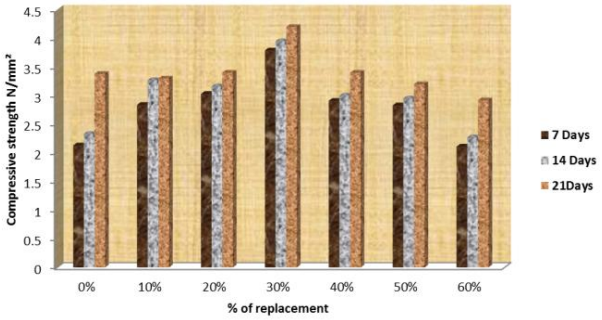

FIGURE: 8% Replacement v/s Compressive Strength of Bricks at 7, 14 & 21 days

VI. ECONOMIC FEASABILITY

Table- 7 Costs Of Materials

SR. NO.	MATERIALS	RATE (Rs/Kg)
1	Fly ash (Class F)	0.55
2	Sand	0.55
3	Stone waste	0.20
4	Kheda dust	0.25
5	Lime	1.50

Table - 8
Total Cost Of Materials For Stone Waste Fly Ash Brick

TYPES OF BRICKS	MATERIALS					Cost of brick [Rs/Nos]
	Fly ash Class F	Sand	Kheda dust	Lime	Stone sludge	
S0	60.00	15.00	15.00	10.00	0.00	**3.08**
S1	50.00	15.00	15.00	10.00	10.00	2.97
S2	40.00	15.00	15.00	10.00	20.00	2.86
S3	30.00	15.00	15.00	10.00	30.00	2.75
S4	20.00	15.00	15.00	10.00	40.00	2.64
S5	10.00	15.00	15.00	10.00	50.00	2.53
S6	0.00	15.00	15.00	10.00	60.00	**2.42**

Table -9
Comparison Of Stone Wastebricks With Ordinary Commonly Used Clay Bricks

SR NO	DESCRIPTION	CLAY BRICKS	STONE WASTE FLY ASH BRICKS
1	Size, mm	215*100*70	230*115*75
2	Volume, cm^3	1505	1983.75
3	Bricks in 1 Cum Masonry	664	500
4	Density, Kg /m^3	1600	1668
5	Cost ,Rs	4000/1000	2420/1000
6	Compressive Strength, Kg/cm^2	30-50	30-50
7	Water Absorption,%	20-25	8-12

VII. CONCLUSION

Based on limited experimental investigations concerning compressive strength of Brick, the following observations are made regarding the resistance of partially replaced Stone waste:

(a) As the percentage of stone waste increases, compressive strength increases up to a certain point and then after the decreases. The optimum point at which we get maximum strength is replaced **30%** stone waste by class F fly ash.

(b) Use of Stone waste inbrick cansolve the disposalproblem; reducecost and produce a 'greener' Eco-friendly bricks for construction.

(d) Environmental effects of wastes and disposal problems of waste can be reduced through this research.

(e) A better measure by an innovative Construction Material is formed through this research.

(f) It provides innovative use of class F fly ash which contains less than 20% lime.

(g) This study helps in converting the non valuable stone waste into bricks and make it valuable.

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