International Journal of Emerging Trends in Engineering and Basic Sciences (IJEEBS)
ISSN (Online) 2349-6967
Volume 7, Special Issue 4 (July-August 2020), PP. 195-203

"FEASIBILITY OF COFIRED BLENDED ASH AS AN ALTERNATIVE RAW MATERIAL IN THE DEVELOPMENT OF SUSTAINABLE CONSTRUCTION MATERIAL"

Shreyashkumar Dalal, Saurabh Dubbalwar, Rameshwar Atkari, Omkar Wanjari , Sudhanshu Tembhurnikar, Prof. Laxmikant Vairagade

Civil Engineering Department, G.H.R.A.E.T Nagpur, Maharashtra, India

Abstract:- Since the large demand has been placed on building material industry especially in the last decade owing to the increasing population which causes a chronic shortage of building materials, the civil engineers have been challenged to convert waste to useful building and construction material. Recycling of such waste as raw material alternatives may contribute in the exhaustion of the natural resources; the conservation of not renewable resources; improvement of the population health and security preoccupation with environmental matters. In the review of utilization of those waste from industry, this paper reviewed recycling waste material i.e. co-fired blended ash in paver blocks & bricks production. The effects of this CFBA on the bricks properties as physical, mechanical properties will be reviewed and recommendations for future research as out comings of this review will be given. This reviewed approach on paver blocks & bricks making from CFBA is useful to provide potential and sustainable solution.

Keywords:- Bricks, Co-fired blended ash, compressive strength, material testing, paver block

1. Introduction

1.1. Bricks

Bricks formed from concrete are usually termed as blocks or concrete masonry unit, and are typically pale grey. They are made from a dry, small aggregate concrete which is formed in steel molds by vibration and compaction in static machine. The finished blocks or bricks are cured, rather than fired, using low-pressure steam. Concrete bricks are manufactured in a wide range of shapes, sizes and face treatments – a number of which simulate the appearance of clay bricks.

Concrete bricks are available in many colors and as an engineering brick made with sulphate-resisting Portland cement or equivalent. When made with adequate amount of cement they are suitable for harsh environments such as wet conditions and retaining walls. Concrete bricks contract or shrink so they need movement joints every 5 to 6 meters, but are similar to other bricks of similar density in thermal and sound resistance and fire resistance.

1.2. Co-fired Blended Ash

Co-firing biomass has limitations because combustion systems are designed to provide optimum performance with a specific fuel. When optimized to burn coal, the combustion systems do not perform as well when solid fuels with different combustion characteristics are used. In addition, unique chemical components of raw biomass may enhance corrosion and fouling within the boiler. Different ash and fly ash properties, fuel handling properties, and dust properties can also hamper the effectiveness of supporting systems including pollution control systems. For these reasons, raw biomass portions in co-fired systems are typically less than 25%, but can vary significantly depending on the specific systems utilized. In many countries biomass co-firing, sometimes referred to as co-combustion, is one of the most economic ways to reduce CO_2.

Co-firing is a near term, low-cost option (when compared to other capture technologies) for efficiently and cleanly converting biomass to electricity by feeding biomass as a partial substitute fuel in coal-fired boilers. This concept has been demonstrated successfully in over 150 installations worldwide and has resulted in some commercially operating units, using a variety of feed-stocks in all boiler types commonly used by electric utilities including pulverized coal, cyclone, stoker, and FBC boilers. Common feed-stocks include woody and herbaceous materials, energy crops (Rice husk), and agricultural and construction residues. Extensive demonstrations and tests have confirmed that biomass energy can provide as much as 15–20% of the total energy input with only fuel feed system and burner modifications.

When the coal and rice husk blended and heated together at around 800°C - 1000°C, if forms co-fired blended ash. According to studies, if the ash contain less than 20% of rice husk content then, there will be cementitious property in that ash. So, it can be used as replacement to the cement.

1.3. Compressive Strength

Compressive strength is the maximum compressive stress that, under a gradually applied load, a given solid material can sustain without fracture. The formula for calculating compressive strength is:

$$CS = F / A$$

Where in compressive strength (CS) is equal to the force (F) at the point of failure divided by the cross sectional area. Compressive strength tests must be performed with equal opposing forces on the test material. Test materials are normally in cylinders, cubes or spheres.

Some materials fracture at their compressive strength limit; others deform irreversibly. Compressive strength is a key value for designing structures. The compressive strength of concrete is the most common performance measurement used by engineers when designing buildings and other structures.

Compressive strength is a limit state of compressive stress that leads to failure in a material in the manner of ductile failure (infinite theoretical yield) or brittle failure (rupture as the result of crack propagation, or sliding along a weak plane). Compressive strength is measured on materials, components and structures. By definition, the ultimate compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely.

Measurements of compressive strength are affected by the specific test methods and conditions of measurement. Compressive strengths are usually reported in relationship to a specific technical standard.

Concrete and ceramics typically have much higher compressive strengths than those with high tensile strengths. Compressive strength is a widely used for specification requirements and quality control of concrete. Engineers know their target tensile (flexural) requirements, and express these in terms of compressive strength.

1.4. Material testing

1.4.1. Sieve analysis test

A sieve analysis (or gradation test) is a practice or procedure used (commonly used in civil engineering) to assess the particle size distribution (also called gradation) of materials by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the amount of material that is stopped by each sieve as a fraction of the whole mass.

The size distribution is often of critical importance to the way the material performs in use. A sieve analysis can be performed on any type of non-organic or organic granular materials including sands, crushed rock, clays, granite, feldspars, coal, soil, a wide range of manufactured powders, grain and seeds, down to a minimum size depending on the exact method. Being such a simple technique of particle sizing, it is probably the most common.

Sieve analysis helps to determine the particle size distribution of the material. In this we use different sieves as standardized by the IS code and then pass materials through them and thus collect different sized particles left over different sieves. The IS sieve set is generally used is: 80mm, 63mm, 50mm, 40mm,31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm, 6.3mm,4.75mm, 3.35mm, 2.36mm, 1.18mm, 600μm, 300μm, 150μm and 75μm.

1.4.2. Soundness test:

Soundness of cement is the ability of a hardened paste to retain its volume after setting. A cement is said to be unsound (i.e., having lack of soundness) if it is subjected to delayed destructive expansion.

Unsoundness of cement is due to presence of excessive amount of hard-burned free lime or magnesia.

Soundness of cement indicates quality to expand on the setting. Unsound cement expands too much on setting and develops cracks in the structure.

The test used for determining soundness of cement is known as “Le chatelier apparatus test.”

By soundness of cement, it is understood that, its capacity to form a non-disintegrating, hard uniformly strong mass on the setting.

This depends on its original composition, proper burning, and grinding. Presence of lime in the free state, an excess of sulphate or magnesia and a very fine size may be the cause of soundness in cement.

The Indian Bureau of Standards has specified the le chatelier apparatus test – the same as adopted by British and American Standards for soundness test of cement.

Fig.1 Sieve Analysis

Fig. 2 Soundness Test (Le Chatleir’s Apparatus)

2. Experimental Program

2.1. Size of mold

The rectangular mold shall be confirm to IS 45658:2006. They may be in the form of PVC or rubber. The concrete of desirable grade is directly put into it and allow for setting for 24 hours before de-molding it. The mold of different sizes and shapes are available in the market.

Paver block size of (240×120×80) mm.

For fly ash bricks there is arrangement made in the plant only to cast the brick according to the demand of owner of plant.

Brick size- 9”×4”×3”

Fig. 3 Paver Block Mold

Fig. 4 Brick Mold

2.2. Weighing of materials

According to the grade of concrete & mix design, the materials are to be weighed before the mixing.

Table 1 Material Specifications

Materials required	Paver block (M25 grade)	Bricks (1:1)
Cement	OPC 53 grade conforming to IS 269	
Aggregates	6mm & 10 mm aggregates (Crushed aggregates) conforming to IS 383	
CFBA	Fine particles(% of cement)	
Water	Potable water	

Fig. 5 Weighing of Materials

2.3. Mixing of materials

Concrete mixing is very important for good strength of structure. Machine mixing is faster and cheaper than hand mixing and done for large quantity. It generally produces more strength and better workability. Hand mixing procedure has to be carried out only for small concrete work. Mixing of all the materials should be done until uniform color and consistency appear.

Fig. 6 Mixing of Materials

2.4. Casting

Concrete is placed in the mold and allowed to get compact on vibrator machine to remove the void. The vibrator machine vibrate at 2600 rpm.

The mortar for bricks is place on compaction machine and allowed mortar to compact in the size of bricks with well compaction.

Fig. 7 Casting of Paver Blocks

Fig. 8 Casting of Bricks

2.5. Stacking

After the casting of paver block, they are allowed to set by placing on wooden plank in 7 to 8 layer for 24 hours.

Fig. 9 Stacking

2.6. De-molding of paver blocks and drying of bricks

After 24 hours of casting of paver block, it will allow to get de-molded. Whereas, bricks after casting are allowed to get dry in atmospheric temperature for 24 hours.

International Journal of Emerging Trends in Engineering and Basic Sciences (IJEEBS)
ISSN (Online) 2349-6967
Volume 7, Special Issue 4 (July-August 2020), PP. 195-203

Fig. 10 De-molding of Paver Blocks

Fig. 11 Drying of Bricks

2.7. Testing

Compressive strength of paver blocks as well as bricks was tested on the Compression Testing Machine (CTM). The compressive strength is calculated by formula,

$$\text{Compressive strength (N/mm2)} = \frac{(\textit{\textbf{Total load applied}})}{(\textit{\textbf{Cross sectional area}})}$$

Fig. 12 Testing of Paver Blocks

Fig. 13 Testing of Bricks

3. Results

Table 2 Compressive Strength of Paver Blocks & Bricks

Replacement of Cement with CFBA (in %) (M25)	Compressive Strength of Paver Blocks			Compressive Strength of Bricks		
	7 Days (N/mm^2)	14 Days (N/mm^2)	28 Days (N/mm^2)	7 Days (N/mm^2)	14 Days (N/mm^2)	28 Days (N/mm^2)
0	34.78	41.73	47.89	20.66	21.95	23.21
5	39.13	45.91	50.24	22.38	25.83	29.68
10	42.08	49.04	53.06	26.26	28.41	33.58
15	46.82	51.04	55.65	19.80	20.66	21.54
20	33.04	36.52	40.87	18.08	19.80	20.98

25	31.47	34.78	38.23	-	-	-

4. Conclusion

From experimental results, we conclude that the compressive strength of paver block for 15% replacement of cement with CFBA gives quite good result than that of conventional paver blocks. Whereas, in case of bricks, the compressive strength of the conventional brick is less than that of the 10% replacement of cement with CFBA. Hence, the conventional paver blocks & bricks can be replace by the partially replaced paver block & bricks. The co-fired blended ash is feasible in the development of sustainable construction materials.

5. Future scope

Co-fired Blended ash is cheaply and readily available. Co-fired blended ash as produced on large scale in industries, it leads to attain economy. It will ultimately reduce the cost of the construction and helps to reduce the pollution. Hence, the partially replacement of cement by CFBA may lead to achieve economy in construction as well as it is environmentally sustainable as the waste material (CFBA) is used as a partial replacement of the cement.

6. Acknowledgement

We are extremely thankful to our guide Prof. Laxmikant Vairagade under whom our project took the shape of reality from mere idea. We are thankful to our guide for enlightening us with his precious guidance and constant encouragement. We thank our guide for providing us with ample support and valuable time. We are indebted to our guide who constantly provided a stimulus to reach our goals.

We are grateful to Dr. Tushar Shende, HOD Civil EngineeringDepartment, GHRAET, for his kind co-operation and timely help.

We express our gratitude towards Dr. Sanjay L. Haridas, Dean Academics, GHRAET, for his never ending support, planning and motivation.

We express our gratitude towards Dr. Vivek R. Kapur, Principal GHRAET, for his never ending support and motivation.

Lastly, we would like to thank all those who were directly or indirectly related to our project and extended their support to make the project successful.

Also, we would like to Mr. Rahul Nemade, Director **of** Naman Industry who imparted us their valuable guidance timely.

References

1. Bhimaji Dashrath Kanawade, Sonali Ratnakar Nawale; "Strength and Durability of Concrete Paver Block", Advances in Civil & Structural Engineering Volume 2 Issue 3.

2. Vikas Kumar Patel, V. V. Singh, "A Review on Precast Cement Concrete Paver Blocks Using Fly Ash", International Journal of Advance Research, Ideas and Innovations in Technology. ISSN: 2454-132X. Impact factor: 4.295.

3. Tarun R. Naik, R. N. Kraus, Rafat Siddique, "Controlled low-strength materials containing mixtures of coal ash and new pozzolanic material", ACI Materials Journal 100(3):208-215 · May 2003.

4. Dinesh W. Gawatre, Akshay S. Ghaytadhkar, Nikhil N. Gage, Sumit D. Bhar, Shubham.S..Deare., "To improve Mechanical properties of concrete paver block", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).

5. P. Vila, M. N. Pereyra, Á. Gutiérrez, "Compressive strength in concrete paving blocks. Results leading to validate the test in half-unit specimens", Instituto de Estructuras y Transporte, Facultad de Ingeniería, Universidad de la República, Montevideo, Uruguay.

6. G.Pragna, P.M.S.S.Kumar, “An Experimental Study on Strength Improvement of Concrete Paver Blocks by Using Flyash, Glass Fiber and GGBS”, International Journal of Innovative Research in Science, Engineering and Technology. ISSN (Online): 2319-8753. ISSN (Print): 2347-6710.
7. Nor Baizura Hamid, Siti Noraiza Ab Razak, Mardiha Mokhtar, Mohd Erwan Sanik, Masiri Kaamin, Ahmad Hakimi Mat Nor, Mohd Zakwan Ramli, “Development of Paving Blocks using Waste Materials”, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8, Issue-9S3, July 2019.
8. Alaa. A. Shakir, Sivakumar Naganathan, Kamal Nasharuddin Bin Mustapha, “Development of Bricks from Waste Material: A Review Paper”, Australian Journal of Basic and Applied Sciences, 7(8): 812-818, 2013 ISSN 1991-8178.
9. Obada Kayali, “High Performance Bricks From Fly Ash”, 2015 World of Coal Ash (WOCA), April 11-15, 2005, Lexington, Kentucky, USA.
10. Pravin P. Gadling, M.B. Varma, “A Review of Ecofriendly Bricks by Using Fly Ash”, Journal of Construction Engineering, Technology and Management. Volume 7 Issue 4.
11. R.V.Shinde, S.D.VIkhe, S.N.Pawar, D.D.Tekale, “Study of Engineering Properties of Fly Ash Bricks for Construction”, International Journal of Innovative Research in Science, Engineering and Technology. Vol. 5, Issue 5, May 2016. ISSN (Online): 2319-8753 ISSN (Print): 2347-6710.
12. Shri Krishna Gurlhosur, Abdul Samad M Kamdod, Dr.V.M.Patil and Dr. Sreekanth B, “An Experimental Study on Fly Ash Bricks and Cost Estimation Analysis”, IJRSI. Volume II, Issue X, October 2015. ISSN 2321 – 2705.
13. P.P. Gadling, Dr. M.B. Varma, “Comparative Study on Fly Ash Bricks and Normal Clay Bricks”, IJSRD International Journal for Scientific Research and Development. Vol. 4, Issue 09, 2016. ISSN (online): 2321-0613.
14. Christopher R. Shearer, Nortey Yeboah, Kimberly E. Kurtis and Susan E. Burns, “The Early Age Behavior of Biomass Fired and Co-fired Fly Ash in Concrete”, 2011 World of Coal Ash (WOCA) Conference- May 9-12, 2011in Denver, CO, USA.
15.Christopher R. Shearer and Kimberly E. Kurtis, “Use of Biomass andCo-Fired Fly Ash in Concrete”, ACI MATERIALS JOURNAL, DOI: 10.14359/51686827.