Experimental investigation on partial replacement of clay using boiler ash to make eco black brick.

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Abstract

This research incorporates waste boiler ash into masonry construction materials using alkali-activation. The boiler ash, derived from three different Indian pulp and paper mills, has many undesirable characteristics for alkali-activation, when combined with supplementary materials in the form of clay and lime, high compressive strengths are observed in the bricks. A brick formulation with a solids phase weight ratio of ash (70): clay (20): lime (10), liquid to solid ratio of 0.45, and 2 M NaOH produces bricks with compressive strengths between 11 and 15 MPa after 28 days curing at 30°C. An economic and environmental analysis indicates that these bricks can be produced for similar costs as the clay fired brick with reduced environmental impact, making them a viable alternative in the market.

1. Introduction

Boiler ash is a generic term applied to many types of ash produced by the burning of various materials. They are 4 general types of boiler ash commonly available, each with its own chemical and environmental characteristics.

Wood Ash –From boilers where wood (or bark) is used as a heating source.

Coal Ash –From coal powered electrical generating power plants, actually two forms, bottom ash and fly ash.

Tire Ash – Produced from burning shredded tires for fuel in generating plants.

Incinerator Ash–Produced from burning MSW (Municipal Solid Waste, i.e. Garbage) as a waste disposal method.

2. Highlights

- Waste boiler ash from Indian paper industry incorporated into bricks using alkali-activation.
- Compressive strengths up to 15 MPa using 70% ash after 28 days curing at 30 °C
- Economic performance comparable to clay-fired brick, with reduced environmental impact
- An economic and environmental analysis indicates that these bricks can be produced for similar costs as the clay fired brick with reduced environmental impact, making them a viable alternative in the market.

3. Materials

Various Alkali-activated bricks were made out of boiler ash, clay, hydrated lime, sodium hydroxide pellets, and municipal water. The percentages by weight of raw materials combusted to produce the boiler ash was 63% bagasse pit, 27% rice husk, and 10% petroleum coke. Both the boiler ash and clay were placed in an oven at 105°C to remove any moisture from the specimens. The clay was then ground and sieved to pass the sieve (150-300mm) to break up any large agglomerates. The lime was also sieved to pass the 150mm sieve to remove any large agglomerates. Laboratory grade >97% sodium hydroxide pellets. Municipal water was used throughout to attempt to represent field conditions.

3.1. Raw material for boiler

3.2. Boiler ash

4. Mixed proportion

- Boiler ash = 70%
- Clay soil = 20%
- Lime powder = 10%
- Sodium hydroxide = 2M
- Liquid to solid weight = 0.45

Design	Proportion
Mix 1	70% ASH+20%CLAY+10%LIME+2M NAOH
Mix 2	60% ASH+30%CLAY+10%LIME+2M NAOH
Mix 3	50% ASH+40%CLAY+10%LIME+2M NAOH

5. Manufacturing process

- Tests were performed to determine the mechanical characteristics of the bricks made using alkali-activation.
- To prepare the samples, first the sodium hydroxide pellets were dissolved in water by stirring until a homogenous solution was formed.
- Due to the exothermic reaction, this was done a day in advance to allow the solution to cool down to room temperature.
- Next, the dry materials (boiler ash, clay, and hydrated lime) were weighed, added to a bowl, and mixed using a planetary mixer for 3 minutes to attain a homogenous composition of the solids phase.
- The NaOH solution was then weighed and added to the bowl. This was mixed with the solids phase at

maximum speed until a homogenous wet consistency was formed.

- This typically took between 20 and 30 minutes to achieve. The mixture was then transferred into 2 cubic molds where the samples were cast using tamping and vibration.
- Samples were cast in two layers which were each hand tamped and vibrated for 1 minute to compact the mixture and remove any air bubbles.
- Samples were then sealed using two layers of plastic wrap and placed in the oven to cure at 30°C.

5.1 Brick mould

5.2 Black brick

6. Testing of specimen

6.1. Brick compressive strength

For the compression testing of brick, 190 mm x 90 mm x 90 mm size cubes were used. All the bricks were tested in saturated condition, after wiping out the surface moisture. The cubes were tested in at the age of 7,14 and 28 days of curing using compression testing machine of 3000 KN capacity. Loading was continued till the readings were reserved from the incremented values. The reversal in the reading values indicates that the specimen has failed. The Machine was stopped and the reading at that instant was noted which was the ultimate load. The ultimate load divided by the cross sectional area of the specimen is equal to the ultimate cube compressive strength.

Compressive strength = Load / Area of brick

6.2. TEST RESULT

TABLE 6.2.1

SN.NO	BOILER ASH In %	CLAY In %	LIMESTONE In %	250 ml of 2M NAOH Solution	COMPRESSIVE STRENGTH IN MPa		AVERAGE MPa
					SAMPLE 1	SAMPLE 2	
1	70%	20%	10%	2M NAOH	2.0	2.3	2.15
2	60%	30%	10%	2M NAOH	2.7	3.0	2.85
3	50%	40%	10%	2M NAOH	3.4	3.5	3.45

14 DAYS TEST

TABLE 6.2.2

PROPOTION	TESTING DAY	COMPRESSIVE STRENGTH IN MPa		AVERAGE MPa
		Sample 1	Sample 2	
1	14	4.26	4.32	4.29
2	14	4.72	4.58	4.65
3	14	5.2	5.81	5.50

28 DAYS TEST

TABLE 6.2.3

PROPOTION	TESTING DAY	COMPRESSIVE STRENGTH IN MPa		AVERAGE MPa
		Sample 1	Sample 2	
1	28	6.5	6.65	6.57
2	28	7.61	7.8	7.705
3	28	7.82	7.76	

6.3 Calculating of water absorption value (%)

Table 6.3.1

PROPOTION	W1 (Kg)	W2(Kg)	W2-W1	(W2-W1)/W1	(W2-W1)/W1×100 (%)
1	2.75	3.16	0.41	0.149	14.9
2	2.69	3.15	0.46	0.171	17.1
3	2.71	3.18	0.47	0.173	17.3

Water absorption = (W2-W1)/W1×100

= [(2.75-3.16)/2.75]X100

= 14.9%

6.4 Hardness Test on Bricks

A good brick should resist scratches against sharp things. So, for this test a sharp tool or finger nail is used to make scratch on brick. If there is no scratch impression on brick then it is said to be hard brick.

6.5 Shape and Size Test on Bricks

Shape and size of bricks are very important consideration. All bricks used for construction should be of same size. The shape of bricks should be purely rectangular with sharp edges. Standard brick size consists length x breadth x height as 19cm x 9cm x 9cm.

To perform this test, select 20 bricks randomly from brick group and stack them along its length, breadth and height and compare. So, if all bricks similar size then they are qualified for construction work.

6.6 Color Test of Bricks

A good brick should possess bright and uniform color throughout its body.

6.7 Soundness Test of Bricks

Soundness test of bricks shows the nature of bricks against sudden impact. In this test, 2 bricks are chosen randomly and struck with one another. Then sound produced should be clear bell ringing sound and brick should not break. Then it is said to be good brick.

7. Conclusion

This alkali activation as a way to beneficially reuse boiler ash waste. The boiler ash are differ from the use of raw material and we take ash form the paper

mills. We testing the boiler ash brick, the compressive strength is achieve. Average strength of the ash brick is 7.5mpa.To achieve these strengths, supplementary materials in the form of clay and lime were used, but through cost and environmental analysis this was shown to perform well relative to the comparator, fired clay bricks.

8. References

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