Optimization of particle size of Waste foundry sand in geopolymeric bricks and analysis of carbon sequestration.

Kenneth Peter

Dept. of environmental engineering, KLE Dr. M.S Sheshgiri college of engineering & technology, Belagavi, Karnataka, India

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Abstract – *The investigation concentrates on the ability to put together red mud, waste foundry sand (WFS), clay & fly ash and with the help of sodium hydroxide (NaOH) & sodium silicate (Na_2SiO_3) as binder to produce geo-polymeric bricks with strength of 3.5-4.5kN/m^2. The strength of the bricks was attained after numerous permutations and combinations over the percentage of each component added during the time of brick making and also the curing process and duration for the bricks played a huge role in the following research.*

Key Words: Waste foundry sand, curing temperature, curing duration, compressive strength.

1.INTRODUCTION

The population resumes to grow rapidly in the countries which are still under developing status and great pressure is being placed on land, water, energy, and biological resources to provide an ample supply of food and energy. Population directly possess threat to the environment mainly through changes in land use and industrial operations .The level of economic growth in India is on rise and it has to deal with problems of land interferences on productive agricultural lands. Some estimates indicate that the impact of human activities has come along to such point where the capacity of planet earth and its ecosystems to bear on a sustainable basis has become scarce. Considering all the above reasons it is very important to study the relationship between population pressure, changes in land use and degradation of environment in the country.[2] The indolent and non-standard practices used for disposal has brought down immense challenges in dumping non-ferrous industrial solid waste and municipal solid waste. Such industrial solid waste is currently used for safe waste disposal. A large number of land areas, which influence sustainable use, are dominated by the landfill. Red mud [RM] is an industrial solid waste where the worldwide annual production of red mud is estimated at over 70 million tonnes.[1]

1.1 GEOPOLYMERS AS BINDING MATERIAL

Geopolymer, an inorganic alumino-silicate polymer having potential to form a substantial element of an environmentally sustainable construction. It gets synthesized from materials of geological origin or by-product materials containing both silica and alumina. Alkali activators play a major role in producing geopolymers by dissolving silica and alumina from the raw material and forming alumino-silicate structures. Several waste materials containing silica and alumina sources like red mud, silica fume, GGBS and fly ashes could be used as a source material to produce geopolymer.[5]

2. MATERIALS AND METHODOLOGY

2.1 MATERIALS USED

The materials that were used for the present study are red mud from local refinery plant of Alumina, class F fly ash obtained from a local concrete block manufacturer, clay obtained from the village Desur of Belgaum district via local brick manufacturer, Waste foundry sand obtained from an Industry called Aqua alloys pvt ltd Kolhapur dist. Maharashtra. sodium hydroxide pellets (NaOH) from Nice Chemicals LR grade, 97% assay) sodium silicate gel (Na_2SiO_3) from Sunchem Chemicals with Na_2O =16.25%, SiO_2 =34.25%, wt. ratio =1:2.1, water = 49.50 % and finally demineralized water from Environmental lab KLEMSSCET, Belgaum demineralization unit, <10μS/cm).

2.2 PREPARATION OF ACTIVATOR

The desired amount of NaOH as per the molarity of solution required and dissolve bit by bit into the beaker with water to evade any accident from exothermic reaction. The dissolved solution is then transferred to a 1000ml conical flask to make 1L solution. Then take 350gm of the solution and mix it with 870gm of sodium silicate gel. After mixing well with both the solutions together add 570mL of tap water to get the activator. The activator is then kept under room temperature for 24 hours to let the temperature from exothermic reaction to cool down and also to decrease the gas bubbles present in the activator

2.3 CASTING OF BRICKS

The materials were prepared using ball mill for crushing of WFS to bring sand to desired size during the casting of bricks, the clay and red mud used in this research are sieved using 4.75 mm to get rid of rubbles and unwanted components from red mud and clay respectively. The materials were introduced into container for dry mixing of components before addition of activator for casting of bricks. The mixture was used to cast bricks with the help of mould. The casted bricks were let to cure at room temperature for 24 hours, then the bricks were heat cured in hot air oven at 85^{0}C. Finally, the bricks were wrapped in wet cloth and left for curing for 6 days.

Table -1: Composition of bricks

Set no	Fly ash	WFS	Desur clay	Red mud	Sodium hydroxide(5M)	Sodium silicate (Na_2SiO_3)
A1	28%	21(2.36mm) %	26%	17%	4%	4%
A2	28%	21(2.36mm) %	26%	17%	4%	4%
A3	28%	21(2.36mm) %	26%	17%	4%	4%
B1	28%	21(150µm) %	26%	17%	4%	4%
B2	28%	21(150µm) %	26%	17%	4%	4%
B3	28%	21(150µm) %	26%	17%	4%	4%
C1	28%	21(150µm) %	26%	17%	4%	4%
C2	28%	21(150µm) %	26%	17%	4%	4%
C3	28%	21(150µm) %	26%	17%	4%	4%
D1	28%	21(150µm) %	26%	17%	4%	4%
D2	28%	21(150µm) %	26%	17%	4%	4%
D3	28%	21(150µm) %	26%	17%	4%	4%
E1	28%	21(150µm) %	26%	17%	4%	4%
E2	28%	21(150µm) %	26%	17%	4%	4%
E3	28%	21(150µm) %	26%	17%	4%	4%
E4	28%	21(150µm) %	26%	17%	4%	4%
E5	28%	21(150µm) %	26%	17%	4%	4%

Table 1, shows the quantity of each component used for different set of bricks, the bricks were casted in 5 different series namely "A, B, C, D, E" as shown in the table 1. The quantity of each raw material was calculated for one brick.

Quantity of raw material in weight =Percentage of raw material x 3.5 kg (weight of one brick).

3. RESULTS AND DISCUSSION

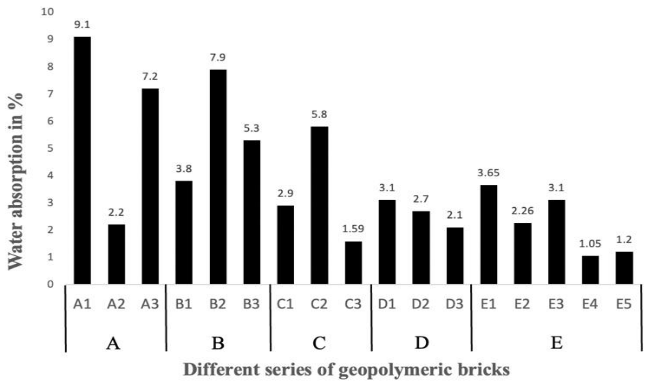
The water absorption and compressive strength are the two important parameters of the clay brick, which were considered as very essential parameters and all the bricks were tested. The bricks were also tested for carbonation test by using traditional method i.e., application of phenolphthalein indicator.

3.1 WATER ABSORPTION TEST

The water absorption test over the bricks was carried out according to the IS 1077:1992. All the series of bricks i.e., "A, B, C, D, E" were subjected to the water absorption test where the bricks were emersed into cold water for 24 hours as per the recommendations of IS 1077:1992 code book. The specifications of the bricks were tabulated through IS 1077:1992 code book in order to lay down certain standard requirements such as classification, general quality and last but not least dimensions of bricks.

The table below portrays the acute values of the absorption test carried out over all the sets of bricks i.e., Series "A, B, C, D, E". It was found that all the set of bricks were well under the maximum standard value of the percentage of brick. Hence, all the set of bricks which underwent the water absorption test have shown positive results in regularity and are safe as per IS 3495(part 2):1992.

Table -2: Water absorption test



3.2 COMPRESSIVE STRENGTH TEST

According to IS 1077:1992, the bricks are generally classified based on their class designation i.e., the bricks are divided into categories over various values of compression strength test attaining a broad spectrum of values from 3.5N/mm^2 to 35N/mm^2.

The compressive strength of any individual brick tested shall not fall below the minimum compressive strength specified for the corresponding class of brick. The lot shall be then checked for next lower class of brick.

Table-3: compressive strength of series "A, B, C, D, E" Geopolymeric bricks

Set no	Compressive strength in N/mm^2	Average compressive strength in N/mm2	Standard deviation
A			
Brick 1	1.11	1.01	0.2
Brick 2	0.78		
Brick 3	1.14		
B			
Brick 1	3.26	2.31	0.9
Brick 2	1.6		
Brick 3	2.06		
C			
Brick 1	2.7	2.5	0.2
Brick 2	2.3		
Brick 3	2.5		
D			
Brick 1	6.4	5.47	1.2
Brick 2	4.06		
Brick 3	5.94		
E			
Brick 1	2.39	2.11	1.1
Brick 2	1.82		
Brick 3	3.98	4.13	
Brick 4	4.4		
Brick 5	4.02		

As seen in the Table-3, the set A bricks had no significant strength in them, this was due to the particle size of WFS being 2.39 mm resulting in lower surface area for the binder to react and adhere to the surface of the dry mixed components. The set D bricks gave the highest strength in the lot due to the particle size of WFS being 0.150 mm which immediately increased the surface area of the dry mix and helping the binders to bind properly resulting in higher strength of bricks, the bricks were also kept for heat curing for more than 48 hours at 85^0C. Hence, the bricks were a success with average of 5.47 N/mm^2. The same composition of bricks was tested by dividing the set E bricks for comparisons the brick 1 and 2 was provided heat curing for 24 hours at 85^0C and brick 3,4,5 was provided heat curing for 48 hours at 85^0C due to which the increase in strength can be seen in brick 3,4,5 with an average of 4.13 N/mm^2 and bricks 1,2 providing the average strength of 2.11 N/mm^2.

3.3 CARBON SEQUESTRATION

Carbon sequestration/adsorption test was done for the geopolymeric bricks, there was no artificial addition of carbon dioxide done to the bricks and the bricks were subjected to natural atmospheric carbon dioxide for adsorption.

The traditional way of determining the depth of carbonation is to spray phenolphthalein indicator onto the surface of a freshly split brick. In the following research, the geopolymeric bricks were split into two different geometry, one brick being split parallel to the length of the brick and the other brick being split perpendicular to the length of the brick for enhanced results over the depth of carbonation. Another set of red clay bricks were used and split in the same geometry like the geopolymeric bricks and the tests were carried upon on the bricks similar to geopolymeric bricks for a comparative study on the carbonation of bricks. The indicator is a colourless base indicator, which turns purple-red when the pH is above 9 and remains colourless in the acidic range.

Table-4 Physical dimensions of bricks

Specimen no	Dimensions of experimental area in bricks(cm)			Total surface Area (cm^2)
	L	B	D	
A1	19		6	114
A2	20		6.2	124
B1		10	7	70
B2		9.5	7	66.5
C1	16		6	96
C2	17		7	119
D1		10	7	70
D2		10	6.5	65

In the above table 4.3.1, the specimen no A1, A2 represents the bricks which were split parallel to the length of the Geopolymeric brick. B1, B2 represents the bricks which were split perpendicular to the geopolymeric bricks. The specimen no B1, B2 represents the red clay bricks split parallel to the length of the bricks and D1, D2 represents the red clay bricks perpendicular to the length of the bricks.

Table-5 Area of bricks undergoing coloration

Specimen no	Total surface area (cm^2)	Surface area with coloration (cm^2)	Percentage area of coloration
A1	114	60	52.6
A2	124	55.8	45
B1	70	36	51.42
B2	66.5	24.75	37.2
C1	96	0	0
C2	119	0	0
D1	70	0	0
D2	65	0	0

The specimen A1, A2, B1, B2 are extracted by splitting of geo-polymeric bricks. The coloration of specimen to purple-red color proves the carbonation process in the specimens, the specimen C1, C2, D1, D2 are extracted from conventional clay fired bricks and as the table 5 shows there was no coloration seen during the experimenting of specimens. This is due to no external chemicals being used for binding (geopolymeric binders) of the bricks.

Fig 4.4 A1, A2 Specimens

Fig 4.5 C1, C2 Specimens

Fig 4.4 B1, B2 Specimens

Fig 4.5 D1, D2 Specimens

4. CONCLUSION

The waste foundry sand with particle size of 150 μm or 0.150 mm used in casting of bricks provided the highest strength. On checking for carbonation in brick E3, E5 using phenolphthalein indicator, the bricks showed the signs of carbonation. Conventional Clay burnt bricks didn't show any sign of carbonation during indicator application. Hence, providing evidence of the carbon sequestration on geopolymeric bricks.

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