April 2015

Vol 4, No 4 (2015)

Abhinav-National Monthly Refereed Journal Of Research In Science & Technology (Online ISSN 2277-1174)

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ISSN: 2277-1174

Published by: Abhinav Publication

Abhinav National Monthly Refereed Journal of Research in Science & Technology

A STUDY ON PROPERTIES OF BOTTOM ASH-GGBS GEOPOLYMER CONCRETE FOR PAVER BLOCKS

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ABSTRACT

The production of cement results in emission of many greenhouse gases in atmosphere, which are responsible for global warming. Hence, the researchers are currently focussed on use of waste material having cementing properties, which can be added in concrete as partial replacement of cement, without compromising on its strength and durability. This will result in decrease of cement production thus reduction in emission in greenhouse gases, in addition to sustainable management of the waste. Accordingly, geopolymer concrete is emerged as an innovative concrete which results from the reaction of source materials rich in silica alumina with alkaline liquid. In the present study bottom ash and GGBS based geopolymer was used as the source material to produce geopolymer concrete for paver blocks. The alkaline liquid used in geopolymerisation was the combination of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3). An attempt was made to identify the suitable combination of mix for M30 and M35 grade paver block from BA-GGBS blend geopolymer. In the source material 75% BA and 25% GGBS was selected. The ratio of Na_2SiO_3 to NaOH is chosen as 2.5. From the test result it was observed that compressive strength of M30 and M35 grade was achieved at early ages under ambient curing.

Keywords: Bottom Ash; Ground Granulated Blast Furnace Slag (GGBS); Geopolymer Concrete; Compressive Strength

INTRODUCTION

Portland cement is widely used in concrete industry since many decades ago; however it releases green house gases, i.e. carbon dioxide, into the atmosphere during its manufacture. Geopolymer technology is one of the new technologies attempted to reduce the use of Portland cement in concrete. Silica and alumina rich material reacts with alkaline solutions to form a cementitious materials which is known as geopolymer.

Bottom ash is collected from the bottom of the furnace from the coal fired power plant. Furthermore, the particles of fly ash are very fine whereas bottom ash has much larger particle size, which is about the size of sand but more porous. Bottom ash based geopolymer gives emphasis in reducing carbon dioxide emission and in recycling fly ash and bottom ash. Since both are the waste products of coal fired power plant, it can lead to the awareness of sustainable development to the society. This is very advisable in sustainable developments to reduce carbon dioxide and to recycle the waste materials. At present time, there is limited information on the influence of parameters on geopolymer available, especially geopolymer with bottom ash as the fine aggregate.

GGBS is obtained by quenching molten slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. As a result, study on the effect of different parameters on the bottom ash and GGBS based geopolymer with bottom ash as cement replacement is needed. In addition, research can provide additional information and to further introduce geopolymer to concrete industry. The fly ash (FA), GGBS, rice husk ash (RHA), silica fume (SF) are some of the pozzolanic materials which can be used in concrete as partial replacement of cement. The strength, durability and other characteristic of concrete depends on the properties of its ingredients, proportion of mix, method of compaction and other controls during placing and curing. For concretes, a combination of mineral and chemical admixtures is always essential to ensure achievement of the required strength.

LITERATURE REVIEW

Wang, Li, & Yan (2005) had investigated that the increase of concentration of NaOH increases the compressive strength of geopolymer. This is mainly because of the concentration of NaOH solution is directly affecting the dissolution of the metakaolinite particulates, which affecting the formation of the geopolymer framework. To have strong inter-molecular bonding strength of the geopolymer, more reactive bond for the monomer is needed. This can be achieved by a better dissolving ability to metakaolinite particulates. To obtain a better dissolving ability to metakaolinite particulates, a higher concentration of NaOH solution is required.

Bennet Jose Mathew, et al (2013) conducted an experimental work on use of fly ash, bottom ash and GGBS in geopolymer concrete. Sodium hydroxide, sodium silicate activator were used. The curing was initially used at elevated tempreature of 60ºC for 6 hours and then 100ºC for 3 hours. Then specimens are kept at ambient temperature for 28 days. It was found that fly ash-GGBS based concrete attained comparable strengths. Fly ash based geopolymer concrete attained compressive strength of 68 MPa while bottom ash based concrete attained only 32 MPa. Bottom ash - GGBS based geopolymer concrete gives very low strength probably due to large particle size. Larger particle size reduces the dissolution of bottom ash in activator solution and hence does not take part in the reaction. Concrete cured at ambient temperature attained comparable strength with that of specimens cured at elevated temperatures. Thus at elevated temperature doesn't add much to the final strength of coal ash - GGBS based concrete.

Deependra Kumar Sinha, et al (2013) examined on use of fly ash bottom ash and granulated blast furnace slag (GBFS) as source materials with sodium hydroxide and sodium silicate activator in geopolymer concrete. They attempted elevated temperature 55ºC and ambient temperature is 35ºC. In this experiment fly ash and bottom ash based geopolymer was used as the binder and fillers, in the replacement of Portland cement and natural sand to produce geopolymer concrete. The alkaline liquid that been used in geoploymerisation is the combination of sodium hydroxide (NaOH) and sodium metasilicate (Na_2SiO_3). The result shows that the strength of the geopolymer concrete improved with curing period and temperature. Geopolymerisation behaviour of fly ash and bottom ash were studied with addition of granulated blast furnace slag. It was observed that fly ash has pozzalanic reactivity as well as reactivity with alkaline solution. However bottom ash mostly behaved as inert aggregate especially during early geopolymerisation reaction.

Accordingly, the present study aims to determine the feasibility of using bottom ash and GGBS based geopolymer to produce geopolymer concrete for paver blocks.

MATERIALS

The material used for making bottom ash based geopolymer mortar specimens are bottom ash as the sources as material, river sand, alkaline liquids and water.

The chemical composition of bottom ash and GGBS is shows in table 1.

Table 1. Chemical Composition of Bottom Ash

Oxides	%
SiO_2	51.5
Al_2O_3	32.58
SO_3	5.19

Table 1. Chemical Composition of Bottom Ash (Contd….)

Oxides	%
CaO	0.50
MgO	0.21
Na2O	1.35
K2O	0.58
LOI	1.50

Locally available river sand conforming to grading zone III as per BIS 383-1970 was used as filler for bottom ash geopolymer mortar in this work. Fineness modulus and specific gravity of river sand in the natural state was found to be 2.26 and 2.63 respectively. A combination of sodium silicate solution and sodium hydroxide solution was chosen as the alkaline liquid activators. The sodium silicate solution (Na_2O = 13.7%, SiO_2 = 29.4%, and water = 55.9% by mass) and sodium hydroxide (NaOH) in flakes 97% to 98% purity were purchased from a local supplier in bulk. The NaOH flakes were dissolved in water to make the solution.

EXPERIMENTAL WORK

Mix Design

Based on earlier study by Venkob Rao (2013), 75% BA and 25% GGBS is considered for the properties of paver block. In the mix the liquid / binder 0.5

Na_2SiO_3 / NaOH	= 2.5
Molarity of NaOH	= 6M to 8M
SiO_2/Na_2O	= 1
w/b	= 0.3
Density of concrete	= 2400 kg/m^3

The aggregate quantity was taken as 70% of total volume of ingredient

Properties of paver Blocks

In this investigation compressive strength of bottom ash (BA) and GGBS based geopolymer paver block specimen was determined for two grades. The dimension 230 x 115 x 50 mm was used for M30 grade paver block and 230 x 115 x 60 mm for M35 grade. The casted specimens were kept at room temperature until the day of testing. The compressive strength, split tensile strength, flexural strength and water absorption test of BA and GGBS based geopolymer for paver block concrete was determined at the age of 1 day, 3 days, 7 days and 28 days. The properties were evaluated according to IS 15658:2006.

RESULTS AND DISCUSSIONS

The compressive strength of BA and GGBS based geopolymer paver block concrete at the age of 1 day, 3 days and 7 days are shown in table 2.

From the result, compressive strength of BA and GGBS geopolymer paver block at 8 M was made in the following conclusions.

- BA & GGBS geopolymer paver block for M30 grade was obtained as 25.2 MPa at the age of 1^{st} day, 31.34 MPa at the age of 3^{rd} day, 37.26 MPa at the age of 7^{th} day and 48.81 MPa at the age of 28^{th} day. For M35 grade was obtained as 25.11 MPa at the age of 1^{st} day, 29.45 MPa at the age of 3^{rd} day and 32.15 MPa at the age of 7^{th} day.

- The flexural strength, split tensile strength and water absorption of BA and GGBS geopolymer paver block was given in table 5.2 to 5.4.
- Flexural Strength for BA & GGBS geopolymer paver block for M30 grade for 6 Molarity was obtained as 7.99 MPa at the age of 3rd day, 9.84 MPa at the age of 7th day and 14.11 MPa at the age of 28th days. For M35 grade was obtained as 7.16 MPa at the age of 3rd day, 8.98 MPa at the age of 7th day and 11.94 MPa at the age of 28th day. M30 grade for 8 Molarity was obtained as 9.13 MPa at the age of 3rd day, 10.8 MPa at the age of 7th day and 15.07 MPa at the age of 28th days. For M35 grade was obtained as 9.44 MPa at the age of 3rd day, 11.11 MPa at the age of 7th day and 14.07 MPa at the age of 28th day.
- Split Tensile Strength for BA & GGBS geopolymer paver block for M30 grade for 6 M was obtained as 1.03 MPa at the age of 3rd day, 1.17 MPa at the age of 7th day and 1.58 MPa at the age of 28th days. For M35 grade was obtained as 1.18 MPa at the age of 3rd day, 1.48 MPa at the age of 7th day and 1.80 MPa at the age of 28th day. M30 grade for 8 Molarity was obtained as 1.97 MPa at the age of 3rd day, 2.04 MPa at the age of 7th day and 2.37 MPa at the age of 28th days. For M35 grade was obtained as 1.67 MPa at the age of 3rd day, 1.86 MPa at the age of 7th day and 2.18 MPa at the age of 28th day.

Water Absorption Strength for BA & GGBS geopolymer paver block for M30 grade for 6 Molarity was obtained as 4.64% at the age of 3rd day, 4.72% at the age of 7th day and 4.78% at the age of 28th days. For M35 grade was obtained as 3.9% at the age of 3rd day and 3.97% at the age of 7th day. M30 grade for 8 Molarity was obtained as 5.51% at the age of 3rd day, 5.55% at the age of 7th day and 5.58% at the age of 28th days. For M35 grade was obtained as 4.12% at the age of 3rd day and 4.19% at the age of 7th day.

Table 2. Compressive Strength of BA and GGBS based geopolymer Paver Block Concrete

Grade	Molarity	Combined Aggregate %	Coarse Aggregate %	Fine Aggregate %	Bottom Ash %	GGBS %	Comp Strength in Days (N/mm^2)			
							1	3	7	28
M 30	6M	70	60	40	75	25	25.20	31.34	37.26	**42.28**
M 30	**8M**	**70**	**60**	**40**	**75**	**25**	**33.87**	**35.44**	**39.36**	48.81
M 35	6M	70	60	40	75	25	22.89	25.78	27.22	31.67
M 35	**8M**	**70**	**60**	**40**	**75**	**25**	**25.11**	**29.45**	**32.15**	**37.41**

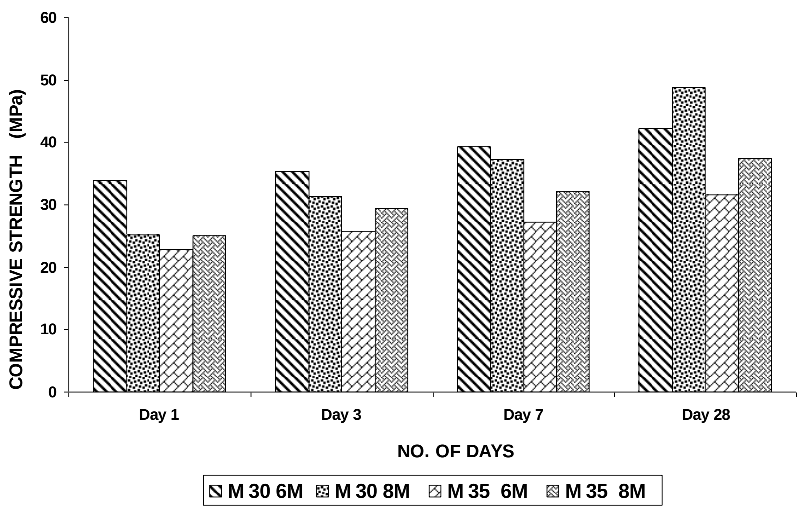

Fig. 1 Graphical Representation for Compressive Strength of BA and GGBS based Geopolymer Paver Block Concrete

Table 3. Flexural Strength of BA and GGBS based Geopolymer Paver Block Concrete

Grade	Molarity	Flexural Strength in Days (N/mm^2)		
		3	7	28
M 30	6M	7.99	9.84	14.11
M 30	8M	9.13	10.80	15.07
M 35	6M	7.16	8.98	11.94
M 35	8M	9.44	11.11	14.07

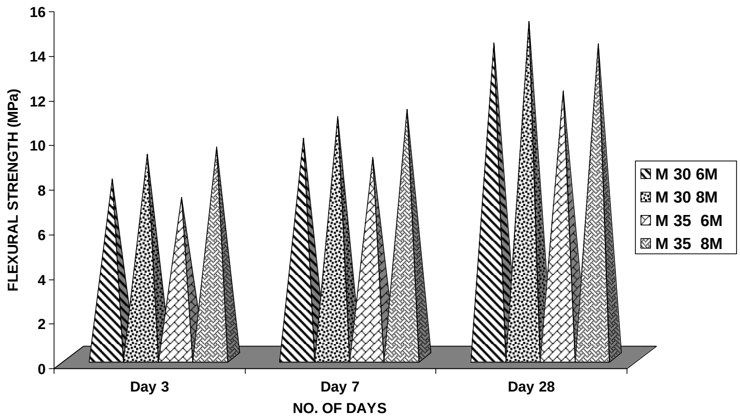

Fig. 2 Graphical Representation for Flexural Strength of BA and GGBS Based Geopolymer Paver Block Concrete

Table 4. Split Tensile Strength of BA and GGBS based geopolymer Paver Block Concrete

Grade	Molarity	Split Tensile Strength in Days (N/mm^2)		
		3	7	28
M 30	6M	1.03	1.17	1.58
M 30	8M	1.97	2.04	2.37
M 35	6M	1.18	1.48	1.80
M 35	8M	1.67	1.86	2.18

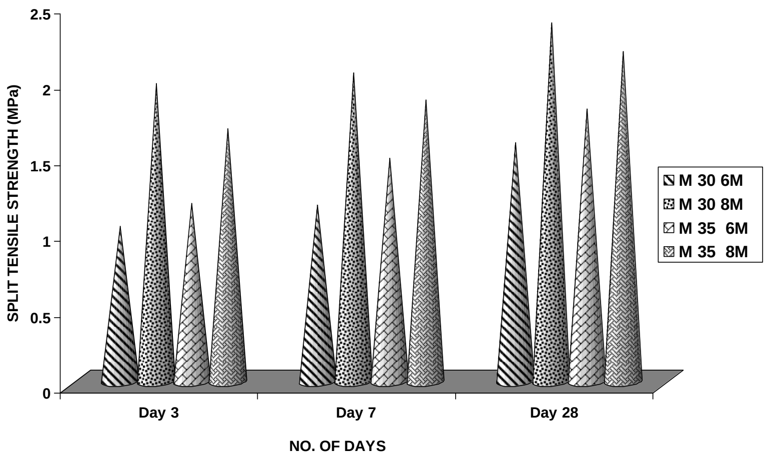

Fig. 3 Graphical Representation for Split Tensile Strength of BA and GGBS based geopolymer Paver Block Concrete

Table 5. Water Absorption Strength of BA and GGBS based Geopolymer Paver Block Concrete

Grade	Molarity	Water Absorption in Days (%)		
		3	7	28
M 30	6M	4.64	4.72	4.78
M 30	8M	5.51	5.55	5.58
M 35	6M	3.90	3.97	4.01
M 35	8M	4.12	4.19	4.22

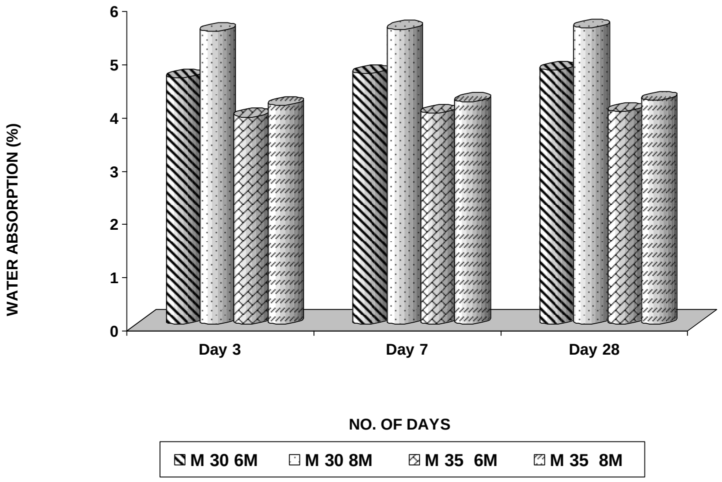

Fig. 4 Graphical Representation for Water Absorption of BA and GGBS Based Geopolymer Paver Block Concrete

CONCLUSION

A study on bottom ash and GGBS in geopolymer paver block was attempted under ambient curing.

In case of M30 grade achieved the desired compressive strength for 6M NaOH concentration at the age of 3 days; whereas for 8M it was attained at 1 day.

In case of M35 grade achieved the desired compressive strength for 6M NaOH concentration at the age of 28 days; whereas for 8M it was attained at 7 day.

The flexural strength of bottom ash and GGBS geopolymer paver blocks reached significant improvement from 3 days onwards. Similar observations were noticed for split tensile strength of bottom ash and GGBS geopolymer paver blocks.

According to IS 1658: 2006, Annexure C, water absorption shall not be more than 6 percent by mass in individual samples, the water absorption should be restricted to 7 percent.

Bottom ash and GGBS in geopolymer paver block attained good results for 8M NaOH concentration than 6 M.

REFERENCES

1. Bennet Jose Mathew, M.Sudhakar, Dr.C.Natarajan, 2013, 'Strength Economic and Sustainability Characteristics of Coal Ash - GGBS based Geopolymer concrete', International Journal of Computational Engineering Research, Vol. 3, Issue 1, pp.32-37.
2. Deependra Kumar Sinha, A. Kumar, S.Kumar, 2013, 'Reduction of Pollution by using Fly Ash, Bottom Ash and Granulated Blast Furnace Slag in geopolymer building materials' Scholars Journal of Engineering and Technology, Vol. 1, pp. 177-182.

3. Venkob Rao, 2013, 'Studies on Bottom Ash, GGBS blend in geopolymer and its use in paver block, Unpublished Thesis, KSR College of Engineering, Tiruchengode, Anna University, Chennai, July 2013.

4. Wamg, Li, and Yan (2005)., Properties of Geopolymer Concrete with Fly Ash as Source Material: Effect of Mixture composition. Paper presented at the Seventh CANMET/ACI International Conference on Recent Advances in Concrete Technology Las Vegas, Nevada, U.S.A., 2004.

5. http://www.ijceronline.com/papers/Vol3_issue1/AH03102070212.pdf

6. http://waset.org/publications/9997832/a-prospective-study-on-alkali-activated-bottom-ash-ggbs-blend-in-paver-blocks

7. http://theglobaljournals.com/ijsr/file.php?val=November_2013_1383311948_d1e39_60.pdf

8. http://saspublisher.com/wp-content/uploads/2013/09/SJET13177-182.pdf