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Effect of Alkaline Activator Solution Ratio and Naoh Molarity on the Synthesis of Ggbs-Based Geopolymer Concrete

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ABSTRACT: Concrete is the second most material used in the world next to water. Ordinary Portland Cement (OPC) is used as primary binder to produce concrete. During manufacturing process of OPC, high emissions of greenhouse gases such as carbon dioxide (CO2) produced which results in polluting the surrounding environment. Geopolymer concrete also referred to as “green” and “environmentally friendly” concrete is carbon free binding material which can be ultimate replacement for traditional Ordinary Portland cement (OPC) concrete. Here, in this paper we studied the behavior of Geopolymer Concrete using (GGBS) under the effectof varying concentration of Alkali Activators. The alkali activators Sodium Hydroxide (NaOH) and Sodium Silicate (Na2SiO3) with Alkali Activator ratio (AAR) of 1:1.5, 1:2 & 1:2.5 were used. Also, the molarity of NaOH was altered for 10Molar, 12Molar and 14Molar. The specimens were casted for Compressive, Split Tensile and were tested after 7 days, 14 days and 28 days of ambient curing. It was observed that Compressive and Split Tensile of the GPC specimen increased with increasing molarity of Sodium Hydroxide (NaOH) and with increase in Alkali ActivatorRatio.

Key words: Alkali activator, GGBS, Compressive Strength, Split Tensile Strength, Molarity, Ambient Curing

I. INTRODUCTION

Cement is the most commonly used binding material used in concrete all over the world. The production and consumption of cement in concrete is directly proportional to environmental pollution leading to hazardous greenhouse gases .This cement usage by the construction industry is accountable for 5-7% of total man-made carbon dioxide emissions globally. Hence there is lot of demand for housing and infrastructure development greater than ever before, the utilization of cementitious materials as a replacement of cement in concrete mixes decreases the amount of CO2 into the atmosphere. The incorporation of mineral admixtures like fly ash, ground granulated blast furnace slag (GGBS), metakaolin, rice husk ash and other waste materials reduce the huge percentage of local landfill space and hence leading to pollution problems. In order to reduce the pollution problems originating from industrial by products, it is the need of the hour to develop profitable building material sout of these wastes this pointled to researchon usage of materials gives greater strength compared with the Portland cement without compromising the durability properties. The advancement of these studies has led to “no cement concrete” which is ecofriendly and hence sustainability can be achieved. Geo-Polymer concrete (GPC) is the greatest advancement of “no cement concrete” and “no water concrete” which is going on, all over the world.

The term „geopolymer‟ was coined in the 1970s by the French scientist and engineer Prof. Joseph Davidovits, and applied to a class of solid materials synthesized by the reaction of an aluminosilicate powder with an alkaline solution (Davidovits 1982a, 1991, 2008).

The primary application for geopolymer binders has since shifted to uses in construction. This is primarily due to the observation, first published by Wastiels et al. (1993), that it is possible to generate reliable, high-performance geopolymers by alkaline activation of fly ash, a by-product of coal combustion. The synthesis of construction materials by alkaline activation of solid, non- Portland cement precursors (usually high-calcium metallurgical slags) was first demonstrated by Purdon (1940). Detailed lists of key historical references and milestones in the development of alkali-activated binders have been presented in various review papers (Malone et al. 1985, Krivenko 1994, Roy 1999, Krivenko 2002); the majorities of these relates to the alkaline activation of blast furnace slags, and so arebeyond the scope of the current discussion. A very extensive review focused predominantly on alkali activation of metallurgical slags has recently been published (Shi et al. 2006. The key distinction to be made here is that the alkaline activation of slags produces a fundamentally calcium silicate hydrate-based gel (Richardson et al. 1994, Wang and Scrivener 1995, Shi et al. 2006), with silicon present mainly in one dimensional chains and some substitution of Al for Si and Mg for Ca, whereas the geopolymer gel is a three- dimensional alkali aluminosilicate framework structure (Duxson et al.2007b).

From the available literature it is noticed that many cementitious materilas like GGBS, rice husk ash, fly ash, silica fume are used as binders in preparation of GPC. In the present study, we studied the behavior of Geopolymer Concrete using (GGBS) under the effect of varying concentration of Alkali Activators. The alkali activators Sodium Hydroxide (NaOH) and Sodium Silicate (Na2SiO3) with Alkali Activator ratio (AAR) of 1:1.5, 1:2 & 1:2.5 were used. Also, the molarity of NaOH was altered for 10Molar, 12Molar and 14Molar. The specimens were casted for Compressive, Split Tensile and were tested after 7 days, 14 days and 28 days of ambient curing. It was observed that Compressive and Split Tensile of the GPC specimen increased with increasing molarity of Sodium Hydroxide (NaOH) and with increase in Alkali Activator Ratio.

Research significance

The continues production and consumption of cement is extremely hazardous. The extensive usage of cement by the construction activities is actually leading huge amount of greenhouse gases. There is a definite need to reduce the amount of cement content in concrete mixes, in order to achieve the sustainability. No cement concrete is the primary agenda of many researchers. Weare using pozzolonic cementitious materiali.e. GGBS instead of cement.The main objectives of present investigation are as listed below.

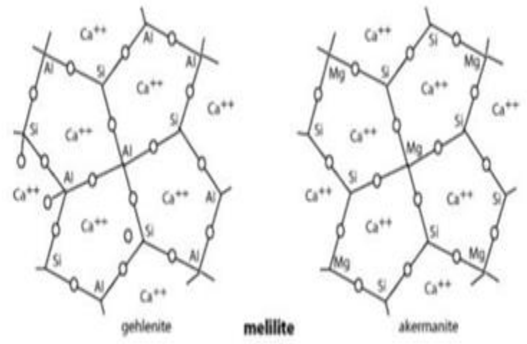
1. Whether fully replacement of cement with GGBS can be utilized in the preparation of GPC mixes or not? How this replacement influences on strengthproperties?

To accept this material along with ground granulated blast furnace slag (GGBS) in preparing GPC mix as structural concrete and its performance in aggressive environments needs to be investigated further.

Materials used

1. Ground Granulated Blast Furnace Slag (GGBS)

Blast furnace slag (abbreviated GGBS, for „ground granulated blast furnace slag") is mainly composed of melilite, a solid solution of gehlenite Ca2Al2SiO7 plus akermanite Ca2Mg (Si2O7) (Figure) and also merwinite Ca3Mg (SiO4)2. Aluminum is only found in gehlenite and magnesium akermanite and merwinite. From a geopolymeric chemistry point of view, gehlenite is the reactive molecule with effective potential as geopolymeric precursor.



Particles above 20 mm in size react only slowly, while particles below 2 mm react completely within approximately 24 hrs in blended cements and in alkaliactivated systems (Wan et al. 2004, Wang et al.2005).
The Specific gravity of GGBS was used are 2.9 and surface fineness of approximately 370 m^2/kg.

2. Alkaline ActivatorSolution

Alkaline activator creates a high pH environment and accelerates the reactions. Mainly two chemicals are used as the alkali activator in their estimated ratio. Sodium hydroxide (NaOH) and sodium silicate (Na2SiO3) are the alkali activator used in this experiment. These alkali liquids are prepared 24hr before the casting of concrete. The mass ratio of Na2SiO3 to NaOH was taken as 1.5, 2, 2.5 based on available literature.

3. Fineaggregate

Fine aggregate conforming to Zone-2 as per to IS: 383- 1970 was used. The fine aggregate are taken from a nearby river source. The specific gravity and Fineness modulus of the aggregate are 2.81 and 2.87 respectively.

4. CoarseAggregate

Well graded are different coarse aggregates sizes 20 mm and 16 mm sizes are taken according to IS: 383- 1970. The specific gravity and Fineness modulus are 2.85 and 6.57 respectively.

Objective and methodology

the main objective of present experiment investigation is to study the mechanical properties of Geopolymer concrete with fully replacement of cement with ground granulated blast furnace slag (GGBS). The ultimate goal is to find the optimum mix proportion which satisfies the strength parameters. In present investigation cement is fully replaced with ground granulated blast furnace slag (GGBS)with varying binder to alkali activator solution ratio and different molarities of alkaline solution i.e. 10M, 12M, and 14M. Using the techniques implemented in the study we can reduce the environmental pollution and reduce landfills due to waste.

AAS/BINDER – 0.4

Mix proportions

AAR	Binder (Kg/m^3)	AAS/Binder ratio	NaOH (Kg/m^3)	Na_2SiO_3 (Kg/m^3)	F.A (Kg/m^3)	C.A (Kg/m^3)
1.5	400	0.4	64	96	933.47	1148.97
2	400	0.4	53.33	106.66	933.47	1148.97
2.5	400	0.4	45.71	114.28	933.47	1148.97

AAR- Alkaline activator ratio Binder – GGBS

OBSERVATION AND TESTRESULT

In this experimental study, compressive strength and split tensile strength for various molarity with varying alkali activator ratio isdone.

The major parameter considered are; -

a) Molarity of sodiumhydroxide
b) Ratio of sodium silicate (Na2SiO3) to sodium hydroxide (NaOH) by mass The test results are tabulatedas;-

Compressive strength for varying molarity with varying ratio at 7, 14 and 28 days

Molarity	7 days(N/mm^2)			14 days(N/mm^2)			28 days(N/mm^2)		
	1.5	2	2.5	1.5	2	2.5	1.5	2	2.5
10M	27.9	30.6	35.4	31.8	34.4	38.2	33.5	36.7	40.6
12M	29.5	33.4	**38.6**	32.8	35.9	**40.4**	35.3	38.4	**43.7**
14M	25.6	27.2	29.8	28.5	30.8	32.6	31.4	33.2	35.7

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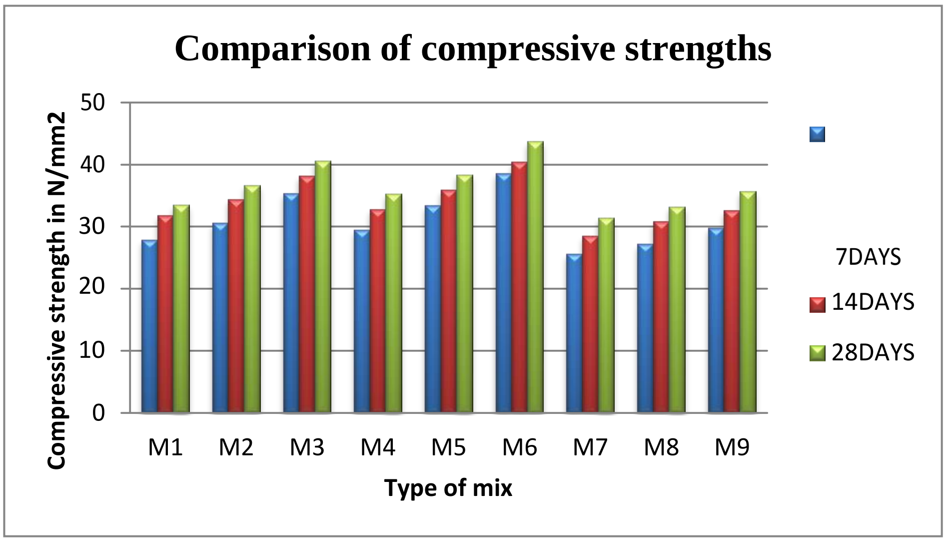
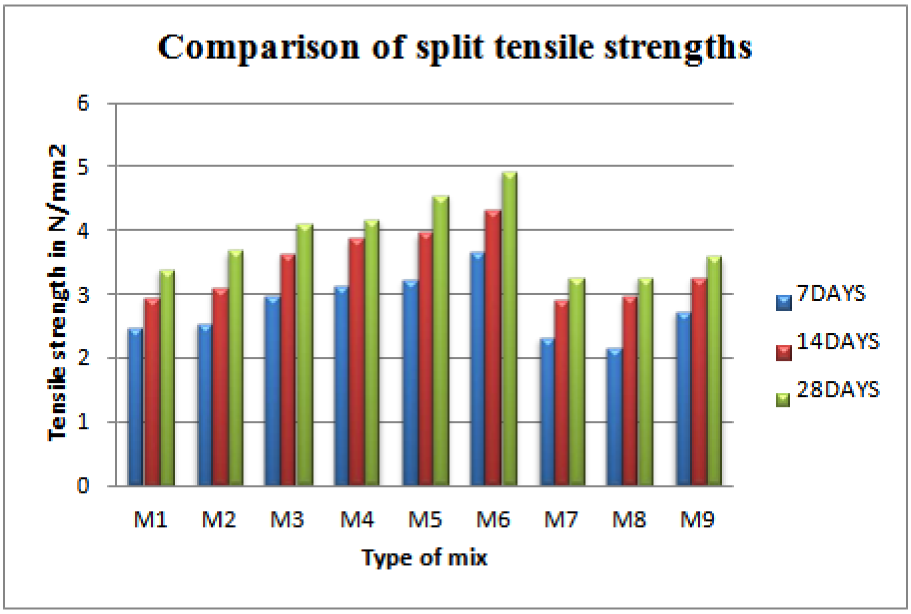


Split tensile strength for varying molarity with varying ratio at 7, 14 and 28 days

Molarity	7 days(N/mm^2)			14 days(N/mm^2)			28 days(N/mm^2)		
	1.5	2	2.5	1.5	2	2.5	1.5	2	2.5
10M	2.47	2.54	2.98	2.95	3.09	3.64	3.39	3.68	4.1
12M	3.14	3.23	**3.67**	3.87	3.97	**4.32**	4.16	4.54	**4.92**
14M	2.31	2.17	2.72	2.91	2.96	3.25	3.25	3.27	3.59



M1- 10M NaOH , 1.5 AAS; **M2**- 10M NaOH , 2 AAS; **M3**- 10M NaOH ,2.5 AAS **M4**- 12M NaOH , 1.5 AAS; **M5**- 12M NaOH , 2 AAS ; **M6**- 12M NaOH , 2.5 AAS **M7**- 14M NaOH , 1.5 AAS; **M6**- 14M NaOH , 2 AAS ;**M9**- 14M NaOH , 2.5 AAS

II. CONCLUSIONS

1. Geopolymer concrete is more economic friendly and has the potential to replace ordinary cement concrete in many applications such as precastunits.
2. It can be observed that for a fixed AAR the Compressive Strength increases with increase in Molarity upto12M.
3. Also, for the fixed value of Molarity, the Compressive Strength increases with the increase inAAR.
4. It can be observed that for a fixed AAR the Split Tensile Strength increases with increase in Molarity upto12M.
5. Also, for the fixed value of Molarity, the Split Tensile Strength increases with the increase inAAR.
6. Geopolymer technology does not only contribute to the reduction of greenhouse gas emissions but also reduces disposal costs of industrialwaste.
7. Geopolymer technology encourages recycling of waste and finally it will be an important step towards sustainability concreteindustry.

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