Impact Factor (SJIF): 4.542

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444
Volume 4, Issue 3, March-2017

DEVLOPMENT OF GEOPOLYMER CONCRETE WITH VARIOUS TEMPERATURE AND DIFFERENT WATER CONTENTS

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Abstract - *The demand of concrete is increasing day by and Cement is used for satisfying the need day of development of infrastructure facilities, 1 tone cement production generates 1 tone CO_2 which adversely affect the environment. In order to reduce the use of OPC and CO_2 generation, the new generation concrete has been developed such as GEOPOLYMER CONCRETE. It uses GGBFS and Alkaline Solution as their Binding Materials. Geopolymer requires Oven Curing of Ambient Temperature and 60^0C for a period of 24hr concrete and to study the Effect of Oven Curing and Ambient room temperature curing on them. The alkaline solution used for present study is sodium silicate and sodium hydroxide solution and examine the effect of sodium hydroxide at different molarity. The casted cube and cylinder will be cured at normal room temperature and Oven heat provision for 24 hours and to ascertain the behavior of concrete mixed with GGBFS, thereby examining the changes of properties.*
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I. INTRODUCTION

Concrete usage around the world is second only to water. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. The environmental issues associated with the production of OPC are well known. The amount of the carbon dioxide released during the manufacture of OPC due to the calcination of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the extent of energy required to produce OPC is only next to steel and aluminium.On the other hand, the abundant availability of fly ash worldwide creates opportunity to utilize this by-product of burning coal, as a substitute for OPC to manufacture concrete. When used as a partial replacement of OPC, in the presence of water and in ambient temperature, fly ash reacts with the calcium hydroxide during the hydration process of OPC to form the calcium silicate hydrate (C-S-H) gel. The development and application of high volume fly ash concrete, which enabled the replacement of OPC up to 60% by mass is a significant development. Finally, many cement concrete structure have exhibited early distress and problems, which has an adverse effect on the resource productivity of the industry.

'Geopolymer Concrete' (GPC) is a type of inorganic polymer composite, which has recently emerged as a prospective binding material based on novel utilization of engineering materials. It has the potential to form a substantial element of an environmentally sustainable construction industry by replacing/supplementing the conventional concretes. GPC can be designed as high strength concrete with good resistance to chloride penetration, acid attack. Sulphate attack etc. The geo-polymeric concretes are commonly formed by alkali activation of industrial alumino silicate waste materials such as fly ash (FA) and ground granulated blast furnace slag (GGBS), and have very small footprints of greenhouse gases when compared to traditional concretes. Because of possible realization of even superior chemical and mechanical properties compared to Ordinary Portland cement (OPC) based concrete mixes, and higher cost effectiveness, GPC mixes based on FA and GGBS are being discussed for their potential application in concrete industry including structural concreting, precast panels and ready-mixes. In the present investigation, the strength properties of GPC after exposure to elevated temperatures are studied and are compared with the published results pertaining to OPC mixes.

II. MATERIALS AND METHODS

A. Ground-granulated blast-furnace slag (GGBS or GGBFS)

Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron 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. GGBS was obtained from JSW cements limited. Bellari, Karnataka. It was given to Laboratory for testing. Two major uses of GGBS are in the production of quality-improved slag cement, namely Portland

Blastfurnace cement (PBFC) and high-slag blast-furnace cement (HSBFC), with GGBS content ranging typically from 30 to 70%; and in the production of ready-mixed or site-batched durable concrete. GGBS cement can be added to concrete in the concrete manufacturer's batching plant, along with Portland cement, aggregates and water.GGBFS is used as a direct replacement for Portland cement, on a one-to-one basis by weight. Replacement levels for GGBFS vary from 30% to up to 85%. Typically 40 to 50% is used in most instances.

Figure 1:GGBFS

B. Alkali Activator Solution

A combination of sodium hydroxide solution (NaOH) and sodium silicate and sodium hydroxide were used as alkaline activator solution.The sodium hydroxide solution was prepared by dissolving the sodium hydroxide solids, in the form of pellets in distilled water. In order to avoid the effect of unknown contaminants in the mixing water, the sodium hydroxide pellets were dissolved in distilled water In this study, the molar concentration of NaOH used is 12M.There are various molar concentration of NaOH but many of research paper shows that the maximum strength of concrete achieve in 12M, after 12M the strength is decreases, So in this investigation it is selected 12M.Since the molecular weight of Sodium Hydroxide is 40g, and in order to prepare 12M solution 12 x 40= 480 gms of Sodium Hydroxide was dissolved in 1000 ml of distilled water. The sodium silicate solution contained Na_2O =14.7%, SiO_2 = 29.4%, and 55.6% of water, by mass. The activator solution was prepared at least 2 hour prior to its use. Same procedure was done for 8M And 12M.

C. Fine Aggregate

Natural river sand conforming to Zone II as per IS 383 (1987)[2], with a fineness modulus of 3.45 and a specific gravity of 2.6, was used.

D. Coarse aggregate

The crushed coarse aggregate of 20 mm maximum size rounded obtained from the local Site study. In My study, I have used two types of aggregate10 mm and 16 mm . The physical properties of coarse aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS ; 2386

E. Super Plasticizer

Master Glenium Sky 8784 made by BASF super plasticizer made by BASF was added to the mixture to improve the workability of fresh concrete.

F. Water

Extra water is added to increase the workability of the concrete.

G. TEST CONDUCTED

1. Compressive Test

The compressive strength of the geopolymer concrete was tested as per IS 516:1959 [8]. Cube specimens 150 mm in size were cast for each proportion and tested for their compressive strength at the ages of 3, 7 and 28 days. All the specimens were tested using the Compression Testing Machine (CTM) 2000 kN in capacity under a uniform rate of loading of 140 kg/cm2/min until failure, and the ultimate load at failure was registered to enable calculation of compressive strength.

2.Split Tensile Test

The split tensile strength test was carried out as per IS 5816:1999 [12]. Cylindrical concrete specimens 150 mm in Diameter and 300 mm in height were cast. The specimens were then tested to determine the splitting tensile strength using a Universal Testing Machine (UTM) at the ages of 3, 7 and 28 days.

III. MIX PROPORTION AND RESULTS

Since no code provisions are available for the mix design of geo-polymer concrete, the density of geo-polymer concrete was assumed to be 2400 kg/m3, and other calculations were made based on the density of concrete as per the design proposed by Lloyd and Rangan (2010) [14]. The combined total volume occupied by the coarse and fine aggregates was assumed to be77 %. The alkaline liquid to binder ratio was taken to be 0.35. The target strength of 30 MPa was fixed as for a regular strength concrete. The mix proportions are given in table 1. In table 1 shows that the replacement of 100% GGBFS.Master glenium sky 8784 has been used to improve the workability of the mix. An admixture dosage of 1.5% by mass of GGBFS, has been found suitable in the present study.Extra water in the quantity of about 17% by weight of GGBFS was added to improve the workability. The mixing was continued for about 7-9 minutes. After casting, the moulds were placed in the oven where they were dried at Ambient Temperature 60°C and 70°C for 24 hours and ambient room temperature. Then the specimens were taken out and removed from their moulds. Then the specimens were taken out and allowed to cure at room temperature until the day of testing.

Table 1-Mix Proportion of Geo-polymer concrete

Mix	Temperature	GGBFS (kg/m3)	Coarse aggregate (kg/m3)		Fine aggregate (kg/m3)	Sodium silicate (kg/m3)	Sodium Hydroxide (kg/m3)	Sp (%)	Water (%)
			20mm	10mm					
GP 1 8M	Ambient	406.58	774.23	519.61	551.2	101.4	41.02	1.5%	17%
	60°C	310.56	774.23	519.61	551.2	101.4	41.02	1.5%	17%
GP 2 10M	Ambient	406.58	774.23	519.61	551.2	101.4	41.02	1.5%	17%
	60°C	310.56	774.23	519.61	551.2	101.4	41.02	1.5%	17%
GP 3 12M	Ambient	406.58	774.23	519.61	551.2	101.4	41.02	1.5%	17%
	60°C	310.56	774.23	519.61	551.2	101.4	41.02	1.5%	17%

1.COMPRESSIVE STRENGTH(MPa) TEST

Table 2- ***Compressive strength at ambient Temperature***

Molarity	Material	Compressive strength (N/mm^2)		
		3 Days	7 Days	28 Days
8 M	GGBFS	23.14	31.26	34.40
10 M	GGBFS	27.20	32.94	39.01
12 M	GGBFS	32.55	35.53	44.43

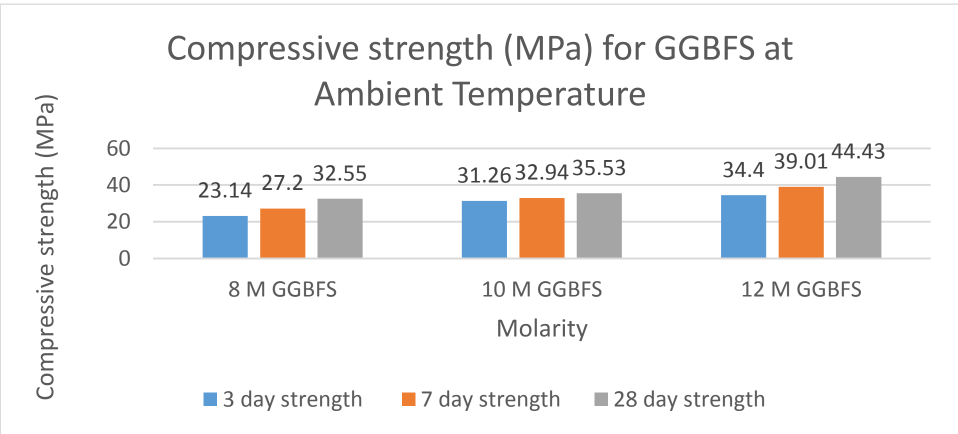

Figure 2-Compressive strength at Ambient Temperature

As shown in figure 2 that 100% of GGBFS at ambient temperature. It is observed that when increase in molarity. The compressive strength of Geopolymer concrete increase.

Table 3- compressive strength result for GGBFS at 60^{0}C

Molarity	Material	Temperature	Compressive strength (N/mm$^{2)}$		
			3 Days	7 Days	28 Days
8 M	GGBFS	60^{0}C	31.32	37.07	41.01
10 M	GGBFS	60^{0}C	36.52	39.14	43.25
12 M	GGBFS	60^{0}C	39.89	43.96	50.33

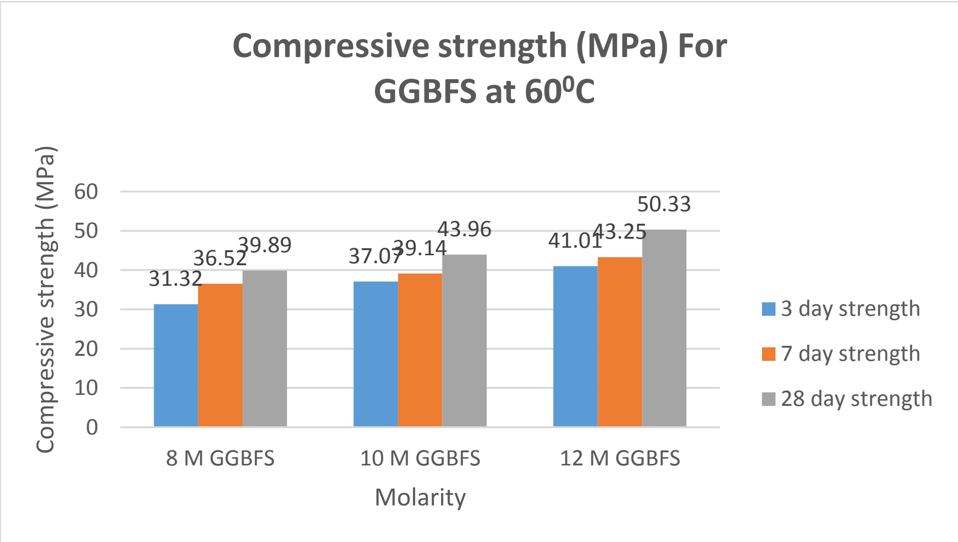

Figure 3- Compressive strength (MPa) For GGBFS at 60^{0}C

As shown in figure 3 that 100% of GGBFS at 60^{0}C temperature. It is observed that when increase in molarity. The compressive strength of Geopolymer concrete increase.

2.TENSILE STRENGTH(MPa)TEST

Table 4-Split Tensile Strength

Molarity	Material	Split Tensile strength (N/mm$^{2)}$		
		3 Days	7 Days	28 Days
8 M	GGBFS	1.37	2.12	3.03
10 M	GGBFS	1.58	2.23	3.42
12 M	GGBFS	1.95	2.90	3.59

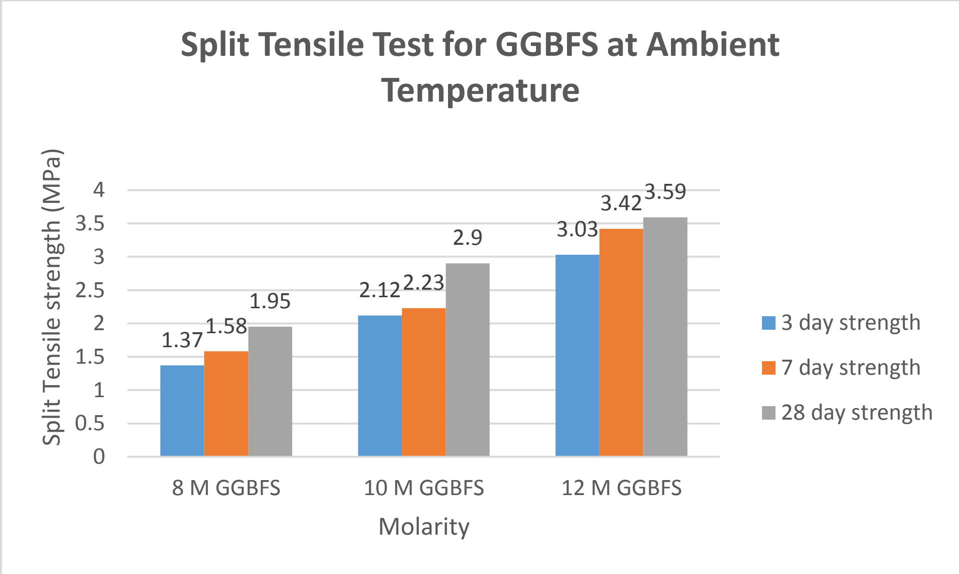

Figure 4-Split Tensile at Ambient Temperature

As shown in figure 4 that 100% of GGBFS at ambient temperature. It is observed that when increase in molarity. The split tensile strength of Geopolymer concrete increase.

Table 5- Split Tensile Test for GGBFS at 60^{0}C

Molarity	Material	Temperature	Split Tensile strength (N/mm$^{2)}$		
			3 Days	7 Days	28 Days
8 M	GGBFS	60 ^{0}C	2.01	3.17	4.74
10 M	GGBFS	60 ^{0}C	2.35	3.69	5.36
12 M	GGBFS	60 ^{0}C	2.64	4.05	6.11

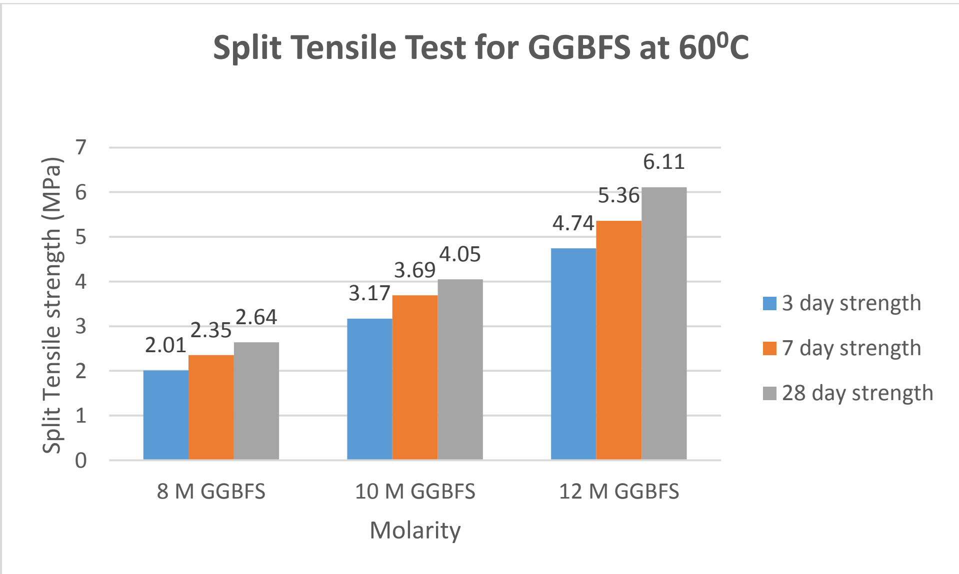

Figure 5- Split Tensile Test for GGBFS at 60^{0}C

As shown in figure 5 that 100% of GGBFS at 60^0C temperature. It is observed that when increase in molarity. The split tensile strength of Geopolymer concrete increase.

3. Compressive strength for GGBFS using 15%,20%,25% water content at Ambient Temperature

Compression strength test result using 15%,20%,25% water content at ambient temperature for 12 M.

Table 6- Compressive Strength Results For GGBFS

Molarity	Material	Temperature	Water content	Compressive strength (N/mm2)		
				3 Days	7 Days	28 Days
12M	GGBFS	Ambient	15%	31.07	34.64	45.16
12M	GGBFS	Ambient	20%	34.14	39.67	49.75
12M	GGBFS	Ambient	25%	30.56	34.78	45.07

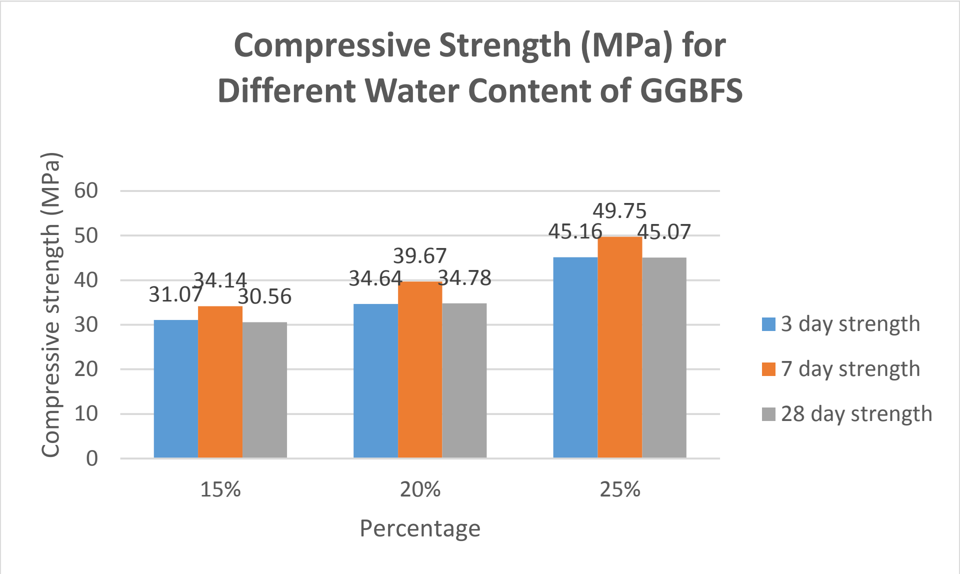

Figure 6- Compressive Strength (MPa) for Different Water Content of GGBFS

4.Tensile strength for GGBFS using 15%,20%,25% water content at Ambient Temperature

Tensile strength test 15%,20%,25% water content at ambient temperature for 12 M.

Table 7- Split Tensile Strength results for GGBFS

Molarity	Material	Temperature	Water content	Split Tensile strength (N/mm2)		
				3 Days	7 Days	28 Days
12M	GGBFS	Ambient	15%	1.90	2.25	3.52
12M	GGBFS	Ambient	20%	2.31	3.14	4.37
12M	GGBFS	Ambient	25%	2.03	3.03	4.24

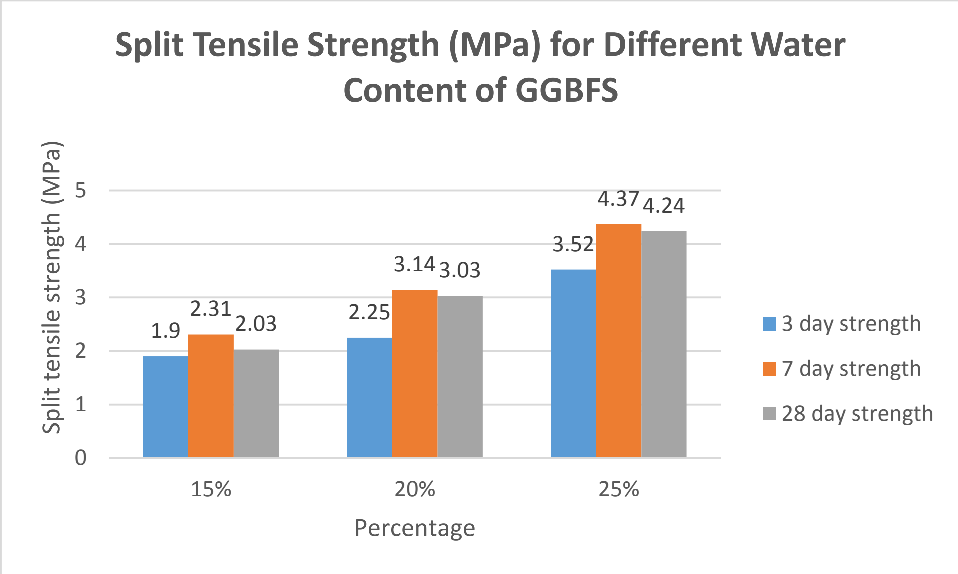

Figure 7- Split Tensile Strength (MPa) for Different Water Content of GGBFS

IV. CONCLUSIONS

The experimental results show that it is possible to produce geo-polymer concrete of substantial strength using GGBFS The following conclusions can also be derived from the present study:

In comparison to the ordinary portland cement the setting time of the geopolymer cement is very less.

The compressive strength and split tensile strength of geopolymer concrete increased with increase in molar concentration of NaOH because leaching action of silicon and aluminium from the source materials get increased with higher concentration of NaOH results in higher compressive and Split Tensile strength of geopolymer concrete.

Compressive Strength and Split Tensile Strength as the Molarity of NaoH increase, there is increase in the strength for 3, 7 and 28 days of concrete.

It is possible to achieve required Compressive and Split tensile Strength strength of Geo-polymer concrete at ambient temperature using GGBFS.

It is also concluded that the compressive and tensile strength is increasing with increasing the temperature.

It is observed that when increasing water content to 15%, 20% and 25% into the mix, the workability of Geopolymer concrete increase and it is also observed that when increasing water content to 15%, 20% and 25% into the mix there are decrease in strength.

It is concluded that 25% of water content taken using GGBFS because GGBFS based Geopolymer for 25 % water content achieve target strength. If we going beyond 25 % water content, the Strength are decrease and not achieve target strength.

The Geo-polymer concrete was a good workable mix. High early strength was obtained in the Geo-polymer concrete mix.

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