ARPN Journal of Engineering and Applied Sciences
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EFFECT AND INFLUENCE OF GGBS ON PROPERTIES OF AMBIENT CURED SELF-COMPACTING GEOPOLYMER CONCRETE

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ABSTRACT

The sustainable manufacture of self-compacting geopolymer concrete (SCGC), which has a lower carbon footprint compared with traditional concrete, reflects environmentally friendly concrete. In addition to the physical properties, this article presents an analysis of the fresh and mechanical properties of self-compacting geopolymer concrete. Some parameters such as varied sodium hydroxide molarity from 8 M to 16 M, sodium hydroxide/silicate solution ratio from 1:2.5 alkaline to GGBS, extra water ratio, GGBS content from 400 Kg/m3 to 500 Kg/m3. The current experimental evaluation examines the effectiveness of GGBS in improving SCGC workability and compressive strength due to durability. The sodium hydroxide molarity rises marginally reducing the fresh properties of self-compacting geopolymer concrete. As in the case of self-compacting concrete (SCC) with Portland cement, the durability properties of self-compacting geopolymer concrete are just a fraction of the compressive strength. The durability properties of self-compacting geopolymer concrete are adversely affected by rising test results of physical properties. Out of 5 different SCGC mix series, the optimum mix was achieved when a hundred percent Ground Granulated blast furnace slag (GGBS) and fifty percent river and M-sand were used, which not only showed better compressive strength and durability but also produced adequate workability within the EFNARC Self-Compacting Concrete (SCC) limits.

Keywords: compressive strength, durability, ggbs, geopolymer, ordinary portland, self-compacting.

INTRODUCTION

Concrete is the fundamental item for any form of building work. The manufacture of ordinary Portland cement (OPC) results in the worldwide use of concrete as the primary building material [1Development of OPC raises the risk of becoming a possible and non-environmentally friendly resource for global warming. Certain binding materials will replace OPC use because of rising environmental concerns [2]. In this respect, geopolymer concrete constitutes one of the advanced, low cost and environmentally friendly materials produced as an alternative to the OPC. Geo-polymer self-compacting cement (SCGPC) is a revolutionary type of concrete that does not require vibration and is created by the removal of normal Portland cement [3].

OPC processing involves a high-energy process and non-renewable energy flaming that releases vast amounts of greenhouse gas like carbon dioxide (CO_2) into the atmosphere. Around 2.9 T is required to produce OPC of raw materials, including fuels and catalysts. Lime decarbonisation in the processing of 1 T of OPC is expected to produce around 1 T of greenhouse gas [4]. OPC manufacturing involves a cycle of high energy and flammable materials that emitted vast amounts of greenhouse gases such as CO_2 into the atmosphere [5]. Around 2.9 T of OPC, including fuels and catalysts, is needed to produce raw materials [6]. Calcium decarbonisation is expected to produce approximately 1 T of OPC greenhouse gas in the processing [7].

Intensive work has recently shown that modified concretes obtained through the incorporation of waste materials can contribute to sustainable productivity growth [8]. Such unique frameworks allow further environmental development not only in the construction sector but also prevent the excessive use of natural fines that deplete the innate resource [1]. Fast industrial development has been demonstrated by the growing use of river sands for the construction of river beds. Several problems have arisen including raising the depth of river beds, raising the water table, raising salinity, and damaging water banks [9].

Self-compacting concrete is commonly used as well in precasting and on-scale construction, allowing the filling of concrete with zero compacting helps in highly congested reinforcement. SCC can flow under its weight, which is achieved through the rheology adjustment in a normal concrete phase [12]. Standard SCC consists of a) increasing fines b) adding superplasticizers c) decreasing aggregate size. First produced in Japan, self-compacting concrete improved concrete strength and uniformity in 19881 [13].

Self-compacting geopolymer concrete (SCGC) can be viewed in the concrete industry as an advanced and revolutionary building material. As the name implies, no compacting efforts are required for complete compaction and the use of fly ash with the alkaline solution and superplasticizer as a matrix-forming and strength-binding machine [10]. The heat-cured fly ash concrete was shown to undergo exceptionally low drying shrinkage from standard Portland cement [11].

Preliminary SCC work has suggested a simple blend proportioning method in which coarse aggregates, fine-size aggregates, W / b, and the SP-dose percentage are maintained constantly to achieve self-compatibility. Based on the properties, a water- ratio is generally agreed between 0.9 and 1.0 [13]. Many other researchers have discussed SCC mixing problems and listed various methods such as analytical design methods, compressive strength methods, near aggregate packaging methods,

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based on the statistical factor model and paste rheology [12].

Some concept guidelines, such as EFNARC guidelines 2002 were established using acceptance test methods [27]. The compacting concrete itself is composed of a higher volume of powder, less coarse aggregates, high-quality super-plasticizer (SP) water, and also a viscosity modifier [14]. New technology has been developed which has led to a substantial growth of self-pacing technology by integrating geopolymer into the SCC [26]. Investing in the use of GGBS, sodium hydroxide (NaOH), and silicate mixture (Na_2SiO_3, alkaline activators) as self-compacting geopolymer concrete (SCGC) were performed [15].

While geopolymer delays setting time, flowability is an essential issue that utilizes an enormous quantity of SCGC superplasticizer [16]. The first two days of initial intensity have been considered critical in geopolymerization processes in the SCGC. Using retardants in SCGC to compress themselves harms strength due to long setting time [28]. 8M, 10M, 12M, 14M, and 16M NaOH concentrations in the mix showed major SCGC properties [22].

To achieve ultimate strength, ambient curing methods were adopted which gave importance to concrete laying in precast works [16]. The cures and various other items were often attempted to interrupt the manufacturing of SCGC and the use of raw materials other than GGBS [17].

Geopolymer cement investigations with added OPC also suggested that the use of minimum cement additions in ambient curing conditions could be regarded [24] as an additive to operate geopolymerisation working with the OPC additive on GGBS geopolymer concrete [23], the same proof for improved geopolymerisation in usual climatic conditions is also validated [18]. From the above analysis, by applying additives or mixing by-products, it was able to channel the SCGC study at ambient temperature [19].

A significant thing to understand the probability of using geopolymer is a test of durability on GPC and OPC concrete [20]. A comparison analysis was also performed for normal geopolymer concrete (GPC) and standard concrete and showed superior bonding for GPC specimens [21].

Many experiments have been carried out to achieve high rates of workability and durability, but a maximum composition has not been found to achieve this. Geopolymer concrete research was therefore carried out to ensure maximum workability and durability by contrasting traditional cement and GGBS [29].

State of Art

Sashidhar's current focus of this analysis is on the fresh and compressive strength properties of SCGC by increasing the sodium-hydroxide (NaOH) molarity from 8 M to 12 M. To assess the fresh properties, test methods such as slump flow, T50 cm, and V-funnel and L-box were used. After 7, 28, and 56 days of curing at ambient temperature, the compressive strength of SCGC was calculated. GGBS leads to substantial compressive strength production during the processing times at room temperatures by the SCGC mixes. Studies have shown that the increase in NaOH molarity decreased the fresh characteristics, but the compression strength of SCGC was increased [37].

As the Kasireddy Mallikarjuna Reddy responds, there is no compacting effort to achieve full compaction and additional SCM (Sodium hydroxide and sodium silicate and superplasticizer as the binder for matrix forming and strength), in addition to alkaline solutions. In this analysis, SCGC based on fly ash has been replaced by specific GGBS percentages. Both microwave curing and environmental curing are cured of the concrete specimens. Results have shown that adding GGBS to SCGC based on fly ash decreases the working characteristics and increases binding. The results showed that SCGC is suitable as a supplement to GPC based on fly ash for both the oven and ambient temperature curing with GGBS [33].

Yamini J. to work will investigate the impact on mechanical properties of Self Compacting Geopolymer Concrete (SCGC), combined with Granulated Blast Furnace Slag (GGBFS) and Rice Husk Ash (RHA), of temperature and ambient curing. The study also investigated the effect of the substitution of RHA by percentage (0, 5, 15, and 25 percent) on SCGC's properties. During 3, 7, and 28 days, the stress power, split tensile and flexure power was tested. The microstructure of SCGC specimens was understandable by Scanning Electron Microscopy (SEM) imaging. At ambient curing, the optimal percentage substitute for RHA with GGBFS is 5%, and at 70^0 c is 15%. Around 70 degrees Celsius higher intensity is obtained than at ambient curing. SEM pictures show that a high microstructure and thus higher force of 5% RHA at room temperature and 15% RHA at 70^0C temperature [31].

Purwanto to study the aim to obtain the most workable geopolymer concrete (workable concrete geopolymer/self-compacting cement) and to obtain the basic characteristics of geopolymer concrete in the form of good workability and compressive strength. geopolymer concrete is simple to work with. This analysis consists of coarse aggregates, thin aggregates, F-type fly ash, NaOH, and Na2SiO3 activators. Additional components, including superplasticizers, are used in the manufacturing of geopolymer concrete to increase their workability [30].

GuneetSaini was conducted to develop alkaline activated Self-compacting geopolymers (SCGCs) with a two percent fresh and Harding properties assessment using the Ground Granulated Blast furnace Slag (GGBS), incorporated by weight in nano-silica. Experimental work on 6 mix designs of different 10 M, 12 M, and 16 M alkaline solutions and 450 Kg/m^3, 500 Kg/m^3 binder content was carried out and contrasted with the mix design GPC consisting of 16 M alkaline solution and 500 Kg/m^3 binder content without nano-silica. The Silicate-to-Sodium Hydroxide Ratio, the Liquid-to-Bind ratio, and the Water-to-Bind ratio (W/B) have been set at 2.5 and at 0.45 and 0.27, which have a major effect on the efficiency and mechanical properties of GPC. The oven curing process

VOL. 18, NO. 5, MARCH 2023 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
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held the temperature at 60 μC to catalyze the early geopolymerization. This paper also clarifies the test results for fresh Self-Compacting Betray (SCC) made in compliance with EFNARC guidelines. The mechanical tests performed were 7, 28, 56, and 90 days compression stress checks: split tensile strength checks, and flexure tests after 28, 56, and 90 days. 81.33 MPa, 7.875 MPa, and 6.398 MPa respectively, are maximum compressive, flexural, and split tensile strength at 90 days [35].

MATERIALS AND MIX DESIGN

Materials

Ground granulated blast furnace slag

Ground Granulated blast furnace slag (GGBS) is a by-product of iron manufacturing industries. This GGBS was formed in the form of slag in the blast furnace unit, raw materials like limestone, iron ore, and coke were fed into the blast furnace at 1500^0C at the bottom of the furnace molten iron was formed and above that, a layer of is formed and that slag was removed from the furnace rapidly cooled after that it was ground up to required fineness now GGBS was formed. GGBS that was used in this experimental study formed JSW cement which was available in 50 kg bags. A sample of GGBS was shown in Figure-1. The chemical composition and physical property of GGBS that was used in this study were shown in Tables 1 &2.

Figure-1. Ground granulated blast furnace slag.

Table-1. Physical properties of GGBS.

S. No	Name of the Test		Test Results
1.	Standard Consistency		33
2.	Setting time of cement in minutes Initial Setting time Final Setting time		24 170
3.	Specific Gravity		2.92
4.	Fineness of Cement		1.2
5.	Compressive Strength	3 days	36.67
		7 days	47.87
		28 days	58.05

Table-2. Chemical composition of GGBS.

Parameters	JSW GGBS
CaO	37.34%
SiO_2	37.73%
Al_2O_3	14.42%
Fe_2O_3	1.11%
Glassy Content	99.9%
Loss on Ignition	1.41%

Ordinary portland cement

It is the most common cement used in the world because of the abundance and low cost to produce it. OPC 53 grade is the strength of 53MPa in 28 days of setting. It is used for fast placed construction were initial strength is rapid. The conventional concrete blend was developed in this experimental study with ordinary 53 grade Portland cement (OPC), which is compliant with IS 12269:2013 and has a structural strength of at least 53 M Pa for twenty-eight days.

Figure-2. Ordinary portland cement 53 Grade.

Table-3. Physical properties of OPC.

Name of the Test		Test Results
Standard Consistency		35
Setting time of cement in minutes Initial Setting time Final Setting time		28 244
Specific Gravity		3.14
Fineness of Cement		1.67
C compressive Strength	3 3 days	34.98
	7 7 days	45.27
	2 28 days	56.05

VOL. 18, NO. 5, MARCH 2023 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
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Table-4. Chemical composition of OPC.

Ingredients	Concentration (%)
CaO	66.67
SiO_2	18.91
Fe_2O_3	4.94
Al_2O_3	4.51
SO_3	2.5
MgO	0.87
K_2O	0.43
Na_2O	0.12
Loss of Ignition	1.05

Fine aggregate for river sand

Sand is used as a fine aggregate in mortars and concrete. River Sand for Building Materials. As a finely aggregated material, natural river sand is the favoured option. River Sand is a result of millions of years of natural rock weathering. The river beds are mined. Sand is a granular material that consists of finely divided particles of rock and mineral. The scale is finer than gravel and grosser than silt. Sand may also refer to soil or soil type textural classes, i.e., soil containing by mass more than 85 percent sand particles.

Figure-3. River sand.

Table-5. Physical properties of river sand.

I.S. Sieve (mm)	Percentage passing through I.S. Sieve	
10	100	Fineness modulus = 2.7 Specific Gravity = 2.64 Bulk Density = 1625 kg/m^3 Bulking of sand = 23% Silt content = 0.25%
4.75	98.8	
2.36	95.8	
1.18	63.6	
600 micron	44.8	
300 micron	15.8	
150 micron	5.6	
Zone	II as per IS 383	

Fine aggregate for M-Sand

M- Sand is a replacement for concrete construction for the river sand. Created sand is manufactured by grinding out of hard granite stone. The broken sand is cubic with grounded sides, washed, and marked as a building material. The M-sand formed is under 4.75 mm in thickness. Generated sand is a river sand substitute. The demand for sand has risen drastically due to the rapidly rising construction market, causing a shortage of sufficient river sand mainly.

Figure-4. Manufactured sand.

Table-6. Physical properties of M- sand.

I.S. Sieve (mm)	Percentage passing through I.S. Sieve	
10	99.8	Fineness modulus = 2.8 Specific Gravity = 2.70 Bulk Density = 1633 kg/m^3 Bulking of sand = 19.26% Silt content = 5.5%
4.75	98.6	
2.36	95.6	
1.18	63.4	
600 micron	42.6	
300 micron	15	
150 micron	4.3	
Zone	II as per IS 383	

Coarse aggregate

Aggregates are the world's most polluted content. Aggregates are parts of construction materials such as concrete and asphalt concrete, and the resulting construction material is reinforced by the aggregate. Grow aggregates of more than 0.19 inches are particles with a diameter varying from 0.375 to 1.5 inches. The crushed granite of size 20 mm was locally available for the cement mix used in this experimental work. So IS 383:1970 and IS 2386:1963 work has been done.

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Table-7. Physical properties of coarse aggregate 20mm.

Sieve size (mm)	20mm	
	Requirement as per IS: 383-1970	Percentage Passing
40	100%	100%
20	85-100%	100%
10	0-20%	8.40%
4.75	0-5%	0.80%
Specific gravity		2.65
Water absorption %		0.81%
Aggregate Impact Value		27.3%
Bulk Density (kg/m^3)		44.81
Flakiness		8.89%
Elongation		10.1%

Table-8. Physical properties of coarse aggregate 12.5mm.

Sieve size (mm)	12.5mm	
	Requirement as per IS: 383-1970	Percentage Passing
16	100%	100%
12.5	85-100%	93.4%
10	0-45%	39.23%
4.75	0-10%	6%
Specific gravity		2.8
Water absorption %		0.49%
Aggregate Impact Value		13%
Bulk Density (kg/m^3)		1666
Flakiness		15.3%
Elongation		16.2%

Alkaline activator solution

The Alkaline activator was the second most component in the geopolymer concrete. The main aim of this activator is to react with the GGBS and make it a binder, without this activator solution GGBS cannot behave as binders. The source material like GGBS contains silicon and aluminium in rich quantity and now the alkaline solution will react with silicon and aluminium to form a binder. Generally, the alkaline activator solutions were based mainly on sodium. Sodium Hydroxide and Sodium Silicate are the commonly used alkaline activators in geopolymerisation [34].

Sodium hydroxide

NaOH solution possible in pellets is in the form of 95% to 97% purity in the market. NaOH solution should be made and complicated. The concrete high effects of the Na_2O in Na_2SiO_3 gel on its strength [39].

Sodium silicate

Sodium silicate is known as a water glass. It is possible in the gel form in markets. The ratio of Na_2SiO_3 is 24 hours before casting and mixing its pellets it includes water with 36 hours used [40].

Water

The water will be collected from the nearby tap. The pH value is as perfect for the water as it is used in concrete construction. PH Value Indian Standard 456-2000[6] less than 6.0 water used for mixing and healing shall be clean and free from unhealthy amounts of oils, acids, alkalis, salts, sugar, organic materials, or other substances which may be hazardous to concrete.

Super plasticizer

This reduces the water and the additive to increase concrete strength. To avoid hydration, this absorbs a particle into sheets. The basic gravity of the superplasticizer is optimized for the working ability of 1.06 [41].

Mix design and preparation

It was known that there is no particular code for the design of geopolymer concrete mix. And due to this reason, the mixed design of geopolymer concrete was taken from past literature; it was observed that the overall density of geopolymer concrete made with GGBS was similar to conventional concrete which was around 2400 kg/m^3. The total percentage of combined aggregates was 75% of the total mass of geopolymer concrete and this was similar to normal concrete made with ordinary Portland cement. And the percentage of fine aggregate from the combined aggregate percentage was 37%. The maximum size of coarse aggregate that was used in this experimental investigation was 20mm and 10mm, the quantity of 20mm aggregate was 60% of the total percentage of coarse aggregate and the remaining 40% was 10mm aggregate. The reason for using 10mm aggregates was to fill the voids in the concrete which cannot be filled by 20mm aggregates. As the density of geopolymer concrete was known from this the GGBS and alkaline activator solution combined mass was determined. And also the ratio of alkaline liquid to cementitious material was assumed to be 0.45 and now the quantity of GGBS was determined and also the quantity of alkaline activator solution was determined. After the addition of the alkaline activator solution, geopolymerisation will start. In this experimental study, the concentration of sodium hydroxide for the preparation of the alkaline activator solution was 8 to 16 molarity. The ratio of sodium hydroxide and sodium silicate was taken as 1:2.5 for all molarities.

VOL. 18, NO. 5, MARCH 2023 ISSN 1819-6608
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Tabl-9. Mix proportions of GPC.

Materials		Quantity (kg/m^3)
GGBS		**414**
Fine-Grained	River Sand	330
	M-Sand	330
Gravels	20mm	681.6
	12.5mm	227.2
	10mm	227.2
NaOH		53
Na_2SiO_3		133
Water		10%
Liquid to Cementitious Material Ratio		0.45

Table-10. Mix proportion of NaOH: Na_2SiO_3.

NaOH Molarity (M)	Masses of NaOH Pellets dissolved in 1L of distilled water (g)	Masses of NaOH: Na_2SiO_3 the ratio of 1:2.5 (g)
8M	320 grams	112 grams
10M	400 grams	116 grams
12M	480 grams	120 grams
14M	560 grams	124 grams
16M	640 grams	128 grams

Mix design of cement concrete

Ordinary Portland cement concrete mix was designed as per IS 10262: 2009. The grade of concrete that was taken in this experimental work to compare with geopolymer concrete was M40. The maximum size of coarse aggregate that was used in this experimental investigation was 20mm and 10mm, the quantity of 20mm aggregate was 60% of the total percentage of coarse aggregate and the remaining 40% was 12.5mm and 10mm aggregate. The reason for using 10mm aggregates was to fill the voids in the concrete which cannot be filled by 20mm aggregates. Table-11 shows the mixed design.

Table-11. Mix proportions of OPC.

Materials		Quantity (kg/m^3)	
		M30	**M40**
Cement (OPC 53 Grade)		359	420
Fine aggregate	River Sand	368.5	382.5
	M-Sand	368.5	382.5
Coarse aggregate	20mm	561.5	840.81
	12.5mm	280.75	280.75
	10mm	280.75	280.75
Water		158 lit/m^3	151lit/m^3
Super plasticizer		1.34 kg/m^3	1.89 kg/m^3
Water-Cement Ratio		0.47	0.41
Density of Concrete		2430 kg/m^3	2451 kg/m^3
Mix Proportion		1:2.21:3.09	1:1.83:2.65

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Preparation of geopolymer concrete

Acquire molarity concentration of NaOH solution 1M is equal to 40gms is diffused in dissolved in distilled water & still up to one litre. The NaOH solids mass of 38.5% is measured. The NaOH solution should be diffused after 24 hours of preparation with a temperature of 30^0C the obtained can be used at only room temperature. The prepared solution is to be mixed with the solution of Na_2SiO_3 to acquire get an alkaline solution. GGBS, fine & coarse aggregates, are mixed in a drum mixer for about 3 to 5 minutes to obtain the geopolymer concrete solid constituents mix. Now, the NaOH solution to add the along with extra water added to the dry mix for about 4 minutes mix.

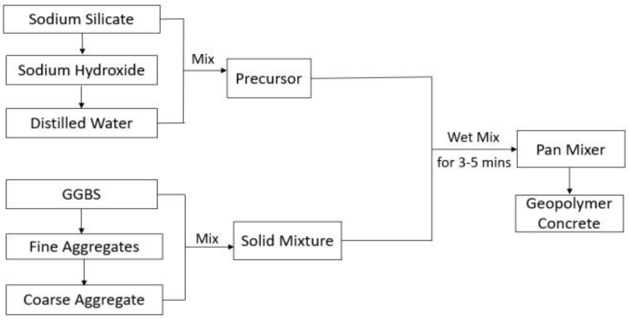

Figure-5. Preparation of geopolymer concrete.

Figure-6. Geopolymer concrete mixing.

Figure-7. Casting of cubes.

EXPERIMENTAL WORK AND ITS RESULTS

Self-Compacting Concrete

Self-compacting concrete (SCC) is liquid concrete that requires no friction and should not vibrate. Superplasticizers and stabilizers are used to significantly improve the ease and flow rate. The self-compact concrete property had the same EFNARC guidelines. The current research in the various fresh concretes provides for the slump flow checks, with some limitations in the European Code for T50, L-Box, U-Box, and V-Funnel. To find green concrete that is waterless, or a concrete spot, it must be interrupted and concrete, contributing to the congested reinforcement of the cross-section in a specific area. And as shown in Table-13 all mixes were described.

Table-12. Test method, property and EFNARC recommended values.

Methods	Workability Property	Acceptance Values as per EFNARC Guide Lines	
		Minimum	Maximum
Slump Flow	FillingAbility	650mm	800mm
T50cm Slump Flow	Filling Ability	2 Sec	5 Sec
V-Funnel	Filling Ability	6 Sec	12 Sec
L-Box	Passing Ability	0.8	1
U-Box	Passing Ability	0	10

Table-13. Mix identification of SCGC and SCC.

Mix	M1	M2	M3	M4	M5	M6	M7
	M30	M40	8M	10M	12M	14M	16M

Slump Flow Test

In slump tests are used to distort the absence of obstacles then it is done in a laboratory according to condition BS EN 12350-8:2010 is provided with a slump flow restriction measuring the flow diameter; it is greater than slump flow to mix under the weight and test slump flow. For the test to be performed, approximately 6000ml

VOL. 18, NO. 5, MARCH 2023 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
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of concrete is needed, sampled normally. Moist the base plate and inside the slump cone, place the base plate on the level stable ground, and hold firmly down the slump cone centred on the base plate. Fill the scoop into the cone. Do not tamp, simply tap the concrete level with the trowel at the top of the cone. Eliminate any leftover concrete from around the cone base. Raise the cone vertically and allow the free-flowing of the concrete.

SF= d_1+d_2 /2

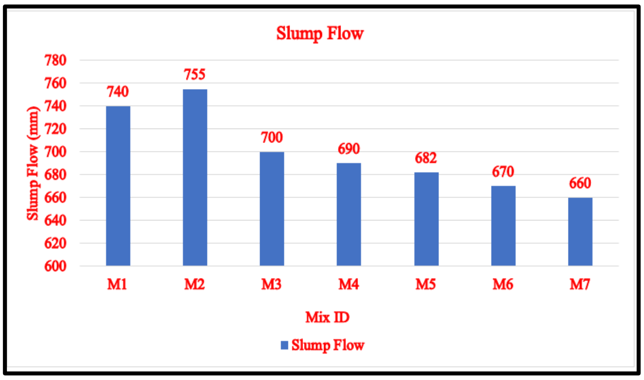

Figure-8. Slump flow test results for GPC and OPC.

T50 Slump Flow Test

By the time the concrete flow is taken, the slump flow test is measured. It is measured in a diameter of 0.50 m to hit the concrete spread into a raise of the cone the top is called T50. This differs between the self-compact, two to ten sec. The time of the T50 is the secondary flow indicator. A lower time suggests a greater ability to flow. Research by BriteEuRam said that a time of three to seven seconds is appropriate for civil engineering applications and housing applications of two to five seconds. The coarsest concentration occurs in the middle of a concrete, mortar, and cement paste tank at the concrete edge in the event of extreme segregation. In the event of small segregation, a mortar boundary without ground aggregation can take place on the edge of the concrete pool. If none of these consequences happens, this is not harmful, as it can happen over a long period.

Figure-9. T_{50} slump test.

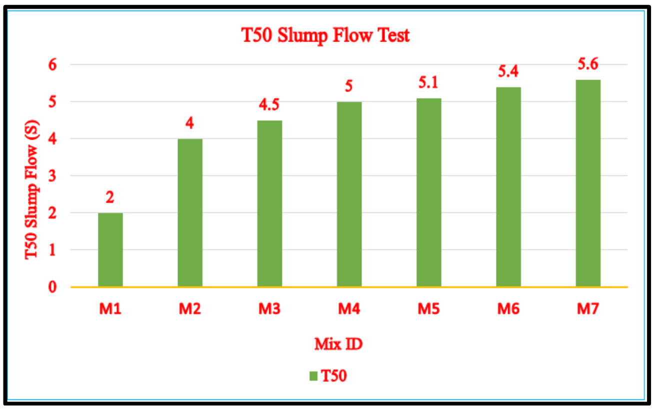

Figure-10. T50 cm slump flow test results for GPC and OPC.

V-Funnel Test

In slump test is used in deforming the absence of obstacle then it is performed in a laboratory as according to condition BS EN 206-9:2010 is provided a limitation of the flow diameter is measured by V-Funnel. The research was developed and implemented by Japanese Ozawa. Around 12,000 ml of concrete is required, usually sampled, for the test to be carried out. On the firm terrain put the V-funnel. Humidify the inside of the funnel floor. Keeping the trapdoor so that excess water can be drained. Open the trap door and place a seat underneath. Simply strip the concrete surface with the trowel head without compacting or tamping the tool with the concrete. After you have filled the door of the pit, open it in about 10 sec. Start the stopwatch when you open the door to the trap and record the total discharge time. This is considered to be the case since light can be seen from above in the funnel. In five minutes the whole analysis must be completed. Do not sweep or humidify the soil from the funnel. Open the trapdoor after calculation and immediately afterward refill the V-funnel. Just underneath, put a bucket. Fill the tool with concrete by compacting or pushing just cut the concrete surface with the above trowel. Start the stopwatch at the same time as the trap door is opened and the time discharge is reported to finish the flow (T5 minute flow time). This should be achieved as light is seen from above in the funnel. The inverted cone shape limits flow. Long flow times may indicate that the mixture is susceptible to blocking. The separation of concrete after five minutes would display a decreased continuous flux with an increase in flow time.

t_{50}< 2

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Figure-11. V-Funnel test [46].

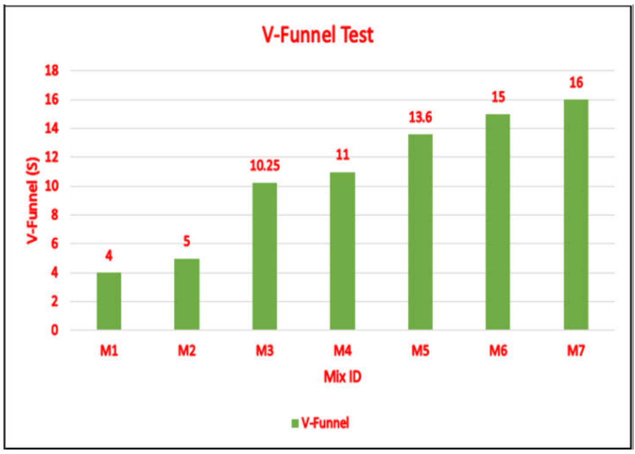

Figure-12. V-Funnel flow test results for GPC and OPC.

L-Box Test

When the slump test deforms the absence of an obstacle, then it will be done in a laboratory where the L-Box constraint is used to determine BS EN 12350-10:2010. The blocking ratio is raised with the L-Box filled with concrete in the vertical segment and 0.8 is determined by the end of the horizontal portion. The time to reach the points of concrete 20 cm (T_{20}) and 40 cm (T_{40}) is recorded across the horizontal portion of the structure. High heights of concrete are determined on the horizontal section edge H_2 and, vertically, H_1 when the concrete rests in the equipment. The blocking ratio, (H_2/H_1), will range from 0.7 to 0.83 for most experiments. If the concrete is calculated, like water autonomously, then the value of the blocking ratio will be unity. Discrimination tolerance can be visually measured. A concrete sample of coarsely aggregated particles that reach the horizontal part of the far end of the case demonstrates good segregation resistance. After the concrete has hardened the L-box can be dissembled. Additional information on concrete segregation resistance can be calculated by cutting off samples of hardened concrete. While the test contains valuable information about the ability to complete and pass and to a lesser extent about the resistance to segregation, the test is less straightforward than the downfall test. Since there are no standardized measurements, the results of different measuring methods cannot be directly compared.

$SF= H_2 /H_1$

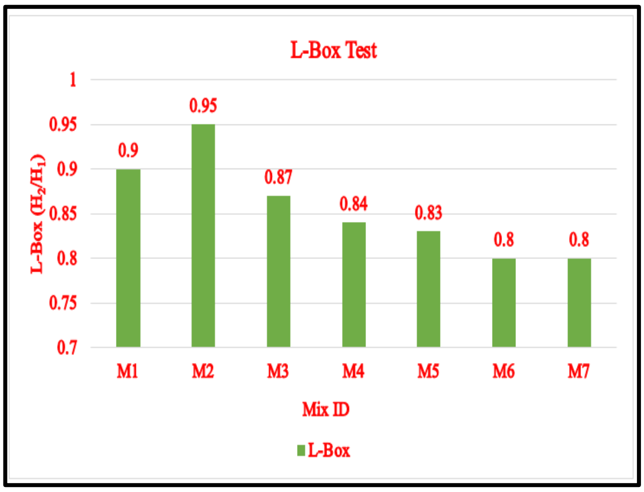

Figure-13. L-Box flow test results for GPC and OPC.

U-Box Test

The Taisei Corporation's Technology Research Center in Japan has developed a U-box test. The device is called a "U-Box shaped" test for some time. Concrete flowing through the self-compact study. It is open with a sliding door with 2 cement parts with a diameter of 0.13 m to 0.50 m centre space, and a clear area of 0.35 m floor. The left side of the chamber is lined with 20000ml of concrete, then the portal is life through the top of the chamber. To do the test, it is important to sample about 20000ml of concrete, to set the level of the equipment on the firm ground, and to ensure that the sliding door can be opened freely, and shut. Moisture the interior surface of the appliance, remove surplus water, and use the concrete sample to fill the vertical section of the appliance. Enable one minute to stand to lift the screen, and spill into another space with concrete. When the rest of the cement is, determine the concrete height in the filled compartment in two positions to determine the average (H_1) of it. In the other devices, measure even the height (H_2). Compute H_1-H_2, the height of charging. Within five minutes, the whole test must be completed. When the concrete is as free as the wind, it's horizontal at rest, so H_1-H_2=0. The lower the value of the ' full height ' is to zero, the greater the flux of concrete and the greater the motion potential.

$SF= H_1 -H_2$

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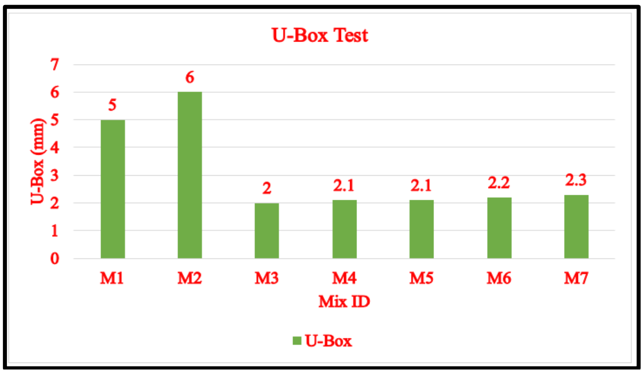

Figure-14. U-Box flow test results for GPC and OPC.

Durability Studies on Geopolymer Concrete and Conventional Concrete

Concrete durability resulting in increased resources utilizes the productivity of concrete materials which are depleting at a very rapid rate.

Durability can resist weather action, chemical attack, and abrasion of concrete as a maximum effect of concrete. In an experimental study on geopolymer concrete and convention, concrete compared to the water absorption; HCl; NaCl; H_2SO_4; $MgSO_4$ is strength due to attack.

Compressive Strength due to Water Absorption Strength

Penetration of moisture is one of the factors that influence the durability of concrete. Beton is a porous material that enables the flow of water, corroding the reinforcement of steel and producing harmful chemicals. So the quality of the concrete must be assessed as a predominant factor. Concrete toughness affects the moisture to penetrate as a porous material to allow water and migration through. For water absorption, a specimen size is 0.15mx0.15mx0.15 m was cast and immersed in ambient curing for 28 days and for 28, 56, and 90 days after water curing and OPC immersed water curing 28, 56, and 90days in water curing. In geopolymer concrete cast cubes with different molarities to compare the normal concrete.

Water absorption=M_1 -M_2 /M_2 X100

M_1 =before curing wt. of sample

M_2 =after curing wt. of sample

Figure-15. Curing of specimens in water absorption.

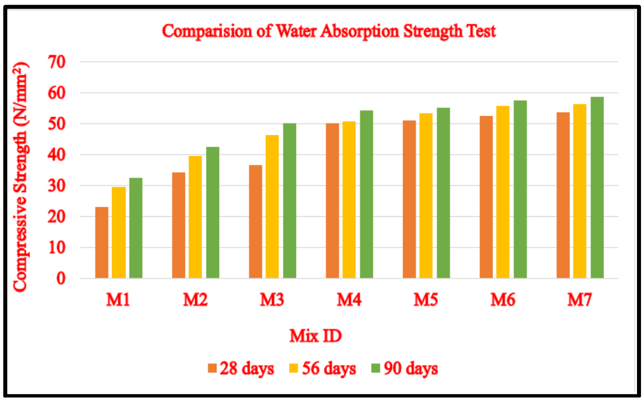

Figure-16. Water absorption test results for GPC and OPC.

Compressive Strength due to Acid Attack

Concrete is in general not completely acid-resistant. All the chemicals will have practical impacts. The speed of action can vary but eventually, the concrete disintegrates. When they contain more calcareous material, almost all the aggregates are vulnerable to acid attack. These materials as Ca and C-S-H are more vulnerable to chemical attacks. The hydrochloric acid (HCl) corrosion rate of concrete is more than sulphuric acid. The present experimental study was conducted on a 0.15x0.15x0.15 m cube concrete model. The specimen is dissolved in a solution of five percent HCl. The degradation of the specimen can be measured by weight reduction of the specimen and also compressive strength reduction is taken water after 28, 56, and 90 days of cure. The water in which the concrete cubes were held was applied hydrochloric acid with a pH of about 2 at a weight of five percent of water. The pH was preserved over 90 days. After 28, 56, and 90 days of immersion, concrete cubes are removed from the acid water. The sample is removed from the curing tube to allow the dry for 24 hours. Comparing strength on GPC and OPC

Resistance of concrete= M_1 -M_2 /M_2 X100

M_1 = per cent loss of wt. of sample

M_2 = per cent loss of compressive strength

Figure-17. Curing of HCl cubes and specimen of HCl cubes.

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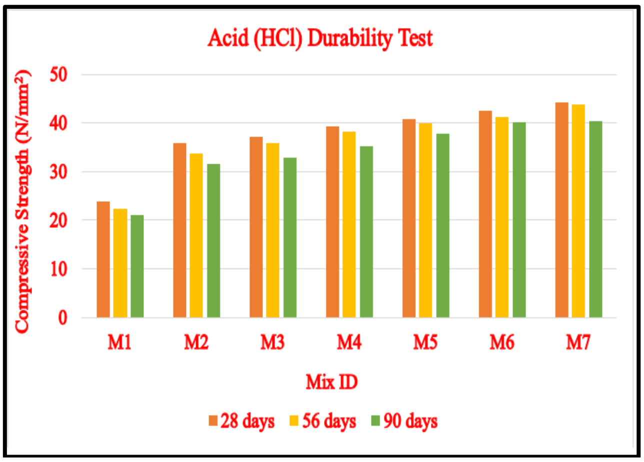

Figure-18. Acid (HCl) test results for GPC and OPC.

Compressive Strength due to Chloride Attack

Concrete resistance to chloride was analyzed by evaluating the loss of compressive strength or difference in the compressive strength of concrete cubes immersed in chloride water weighing five percent by water and those not immersed in chloride water. Casting 0.15x0.15x0.15m of concrete cubes and 28 days of ambient curing and after 28 days of water curing and drying for one day were submerged. NaCl was added to water in five percent for 28, 56, and 90 days. The chloride water concentration was maintained over the whole period. OPC cubes are immersed in normal water curing and after chloride curing for five percent. After an immersion time of 28, 56, and 90 days, the concrete cubes were withdrawn from the chloride water, and the water and girt were extracted from the surface of the measured cubes.

Comparing the strength on GPC and OPC

Resistance of concrete= M_1 -M_2 /M_2 X100

M_1 = per cent loss of wt. of sample

M_2 = per cent loss of strength

Figure-19. Curing of NaCl cubes and specimen of NaCl cubes.

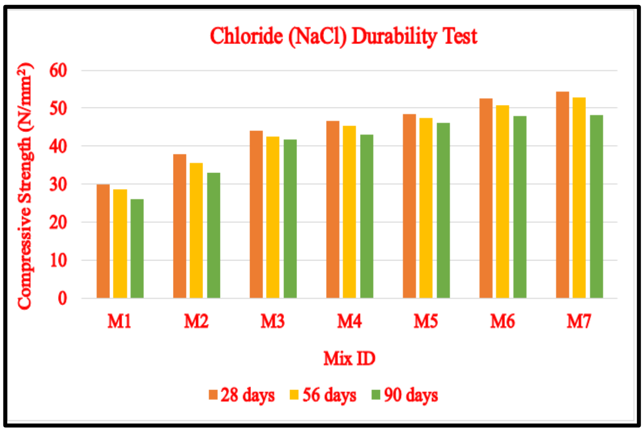

Figure-20. Chloride (NaCl) test results for GPC and OPC.

Compressive Strength due to Sulphuric Acid Attack

Concrete resistance to sulfate was analyzed by evaluating the loss of strength or difference in the strength of concrete cubes immersed in sulphuric water weighing five percent by water and those not immersed in sulphuric water. Casting 0.15x0.15x0.15m of concrete cubes and 28 days ambient cure and next 28 days water cure and drying for one day were submerged. H_2SO_4 was added to water in five percent for 28, 56, and 90 days. The sulphuric water concentration was maintained over the whole period. OPC cubes are immersed in normal water curing and after sulfuric acid curing for five percent. After an immersion time of 28, 56, and 90 days, concrete cubes are withdrawn from the sulphuric water, and the water and girt were extracted from the surface of the measured cubes.

Comparing the strength on GPC and OPC

Resistance of concrete= M_1 -M_2 /M_2 X100

M_1 = per cent loss of wt. of sample

M_2 = per cent loss of strength

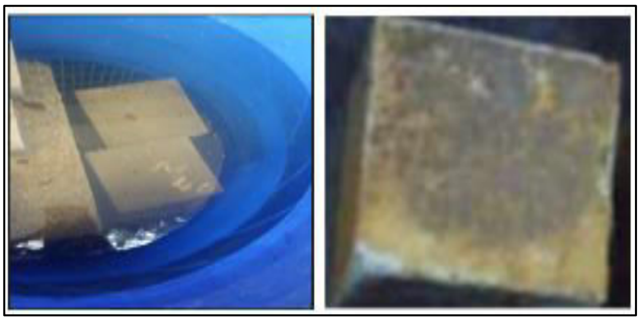

Figure-21. Curing of H_2SO_4 cubes and specimen of H_2SO_4 cubes.

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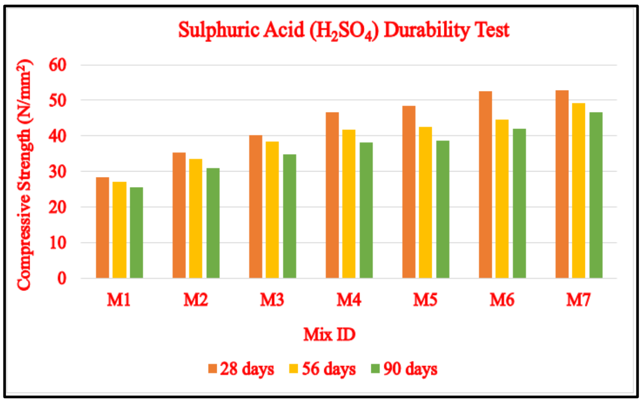

Figure-22. Sulphuric acid (H_2SO_4) test results for GPC and OPC.

Compressive Strength due to Magnesium Sulphate Attack

The sulphate attack monitoring protocol was conducted by immersing the 0.15x0.15x0.15m cube specimen in a five percent $MgSO_4$ solution over a 28, 56, and 90 day's duration. For the curing cube, the specimens are removed to allow the drying for 24 hours. Degradation of the specimen can be measured by determining the weight reduction of the specimen and also the compressive strength reduction of the specimen when submerged in a chemical solution.

Comparing the strength of GPC and OPC

Resistance of concrete= M_1 -M_2 /M_2 X100

M_1 = per cent loss of wt. of sample

M_2 = per cent loss of strength

Figure-23. Curing of $MgSO_4$ cubes and specimen of $MgSO_4$ cubes.

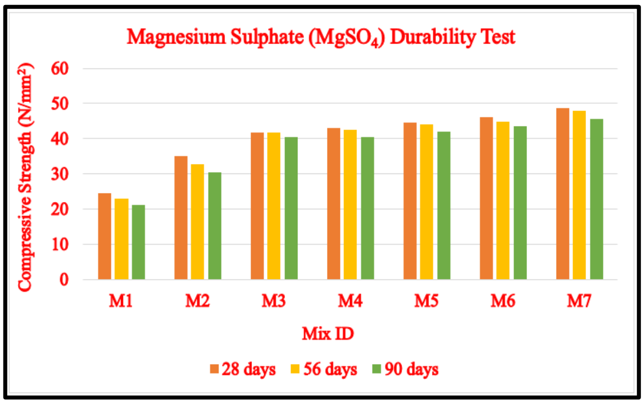

Figure-24. Magnesium sulphate acid ($MgSO_4$) test results for GPC and OPC.

CONCLUSIONS

Experimental study on geopolymer concrete and normal concrete concluded that:

a) The test results show that the flow property increases independent of any molarity, as the GGBS increases. The results indicated an improvement in 0.075% slump flow, 1% T_{50} Slump Flow, 0.001% L-box, 0.75% V-funnel, and 0.02% U-box with increasing molarity.

b) In conventional concrete to compare M30 and M40 results are increasing 0.25% slump flow, 0.02% T_{50} Slump Flow, 0.0005% L-box, 0.01% V-funnel, and 0.1% U-box

c) A durability test is conducted to find the concrete strength of the structure's long life or not it is identified.

d) In this paper, the same various acid test is conducted. In geopolymer concrete specimens immerse in chloride; sulphate; acid; magnesium sulfate acid and water absorption were

e) Observed to compare the normal concrete. The specimen was tested for twenty-eight, Fifty-six, and ninety days. To increase the molarity the strength also increases and day-by-day strength decrease for each molarity.

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