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STUDY ON COMPRESSIVE STRENGTH OF GEOPOLYMER CONCRETE PASTE BY REPLACEMENT OF GGBFS %

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ABSTRACT

This study focuses on how to arrive at the mix proportion of fly ash to alkaline activator ratio based on the void content of low calcium fly ash. Experimental Compressive strength result of Geopolymer paste for the Molarity M6, M8, M10, M12, M14, M16 for the GGBFS replacement of Fly ash at 25%, 30% and Alkali Activity ratio 1, 1.5, 2, 2.5, 3. The fly ash is replaced with Ground granulated blast furnace slag (GGBFS) at 25% and 30% for room temperature curing for the particle size of 90 microns in size of fly ash and GGBFS, tested at the end of seven days. From the detailed earlier study, the maximum compressive strength mix proportion is taken up in respect of the alkaline activator ratio. The GGBFS percentage is taken up and tested at the end of 7 days at room temperature, and the results are reported. The maximum compressive strength at the end of 7 days are 18.84 N/mm2, 19.44 N/mm2, 20.00 N/mm^2, 20.32 N/mm^2, 17.76 N/mm^2 and 14.30 N/mm^2 respectively.

KEYWORDS: GGBFS, Fly Ash, Compressive strength of 7 days.

1 INTRODUCTION

Geopolymer concrete is a newer alternative to traditional Portland cement-based concrete, in which the cement is entirely replaced by pozzolanic materials rich in silica and alumina, such as fly ash. Alkaline liquids are then used to activate the mixture to form a binder. The water-to-geopolymer binder ratio has been studied in experimental investigations to optimize the workability and compressive strength of geopolymer concrete, and heat curing in an oven at 900C for eight hours has been used to test its strength. In past research, the activated liquid to fly ash ratio of 0.35 by mass was found to be optimal.

Concrete is one of the most widely used materials in the world, and Ordinary Portland cement (OPC) is typically used as the primary binder. However, the production of OPC is known to release large amounts of carbon dioxide due to the calcination of limestone and combustion of fossil fuels. As a result, there is a need to reduce carbon dioxide emissions by using more environmentally friendly construction materials. Geopolymer concrete offers a solution by reducing the usage of Portland cement and utilizing by-product materials, such as fly ash, which reduces the amount of carbon dioxide released during the manufacturing process.

1.1 OBJECTIVE OF STUDY

- To investigate the development of compressive strength of alkaline activated alumina silicate paste.
- To determine Experimental Compressive strength result of Geopolymer paste for the Molarity M6, M8, M10, M12, M14, M16 for the GGBFS replacement of Fly ash at 25%, 30% and Alkali Activity ratio 1,1.5, 2, 2.5, 3.

2 LITERATURE REVIEW

According to a study by Hardjito et al (2004), geopolymer concrete has significant potential as a material for the future due to its environmentally friendly nature and excellent mechanical properties, both in the short and long term, as well as its durability. Geopolymer concrete technology has already been used in practical applications such as precast concrete products and waste encapsulation. However, further research is necessary to fully understand the science behind geopolymer technology. This includes studying the reactivity and reaction mechanism of the geopolymer material, as well as the rheology of fresh geopolymer concrete or paste. In addition, a large database of various characteristics of geopolymer concrete should be collected to prepare design tools and codes/standards for this new material.

The research conducted by Subhash V. Patankar et al. (2013) aimed to investigate the effect of water-to-geopolymer binder ratio on the production of fly ash based geopolymer concrete. The study concluded that the flow of geopolymer concrete increased with an increase in the water-to-geopolymer binder ratio, as more water was added to the mix. Conversely, geopolymer concrete became more viscous with a decrease in the water-to-geopolymer binder ratios due to a reduction in the amount of water in the mixture. The compressive strength of geopolymer concrete was found to be inversely proportional to the water-to-geopolymer binder ratio, similar to the effect of water-to-cement ratio in cement concrete. The suitable range of water-to-geopolymer binder ratio was determined to be between 0.25 to 0.35, as higher ratios led to segregated mixes while lower ratios resulted in viscous and dry mixes.

In the study by P. Eswaramoorthi et al. (2014) titled "Fibers Study On Properties Of Geopolymer Concrete With Polypropylene," the authors found that Geopolymer concrete exhibited compressive and split tensile strength higher than conventional concrete. The compressive strength of Geopolymer concrete without fibers was 10.63% higher than conventional concrete, and the split tensile strength was 11.58% higher. The addition of polypropylene fibers resulted in a 10.70% increase in compressive strength and a 13.62% increase in split tensile strength compared to conventional concrete. The study also found that Geopolymer concrete had properties comparable to or better than traditional cements, and low-calcium fly ash-based Geopolymer concrete was suitable for structural applications. The load deflection test revealed that the strain energy absorbed, ductility factor, and toughness index were significantly increased in GPC with the addition of polypropylene fibers. Furthermore, Geopolymer concrete reduces the consumption of cement, emissions of carbon dioxide, and greenhouse effect.

In the paper titled "Geopolymer concrete for environmental protection" by B. Vijaya Rangan (2014), the author discusses the benefits of using geopolymer concrete in terms of environmental protection. Geopolymer concrete is made by upcycling low-calcium fly ash and blast furnace slag, which are waste or by-products from industries, into a high-value construction material for infrastructure development. The paper mainly focuses on fly ash-based geopolymer concrete, which uses low-calcium fly ash (ASTM Class F) instead of Portland cement to make concrete. Geopolymer concrete has excellent compressive strength and is suitable for structural applications. The paper identifies the key factors that influence the properties of both fresh and hardened concrete and provides simple guidelines for designing mixture proportions.

In the paper by Janani R et al (2015), the authors conducted an experimental study on the use of manufactured sand in geopolymer concrete. The following conclusions were drawn based on the results obtained:

- When fully replacing river sand with manufactured sand, there was a 9% increase in compressive strength.
- When fully replacing river sand with manufactured sand, there was a 12% increase in tensile strength.
- When fully replacing river sand with manufactured sand, there was a 10% increase in flexural strength.

The study suggests that geopolymer concrete using manufactured sand can be a viable alternative to ordinary Portland cement concrete. The absence of cement in geopolymer concrete results in significant energy savings and reduces the production of ordinary Portland cement. Additionally, the use of waste materials like fly ash can help reduce pollution and promote a cleaner environment.

The study conducted by S Ganesh Kumar et al (2015) focused on the application of geopolymer concrete and highlighted the importance of various parameters such as $Na_2SiO_3/NaOH$ ratio, molarity of NaOH, curing temperature, and curing time in determining the strength of geopolymer concrete. It was observed that replacing fly ash with GGBS gradually increased the strength without requiring oven curing. However, there are still some gaps in the knowledge and research community should focus on filling those gaps. Despite the wide acceptance of Portland cement, geopolymer technology offers desirable properties and environmental benefits. Therefore, it is believed that geopolymer technology will make significant progress in the near future.

P.Vignesh et al (2015)," An experimental investigation on strength parameters of fly ash-based geopolymer concrete with GGBS." The study found that the optimal replacement level of fly ash with GGBS in GPC can be determined. The water absorption properties of GPC are lower than those of traditional concrete. GPC can achieve 70% of its compressive strength within the first 4 hours of setting. The study also investigated the various strength properties of GPC with different levels of GGBS replacement.

Chamila Madusanka Gunasekara (2016) conducted a study on the influence of fly ash properties on the mix design and performance of geopolymer concrete. The study focused on low calcium, class F precursor fly ash obtained from five different coal power stations in Australia. Geopolymer mixes were prepared using the fly ash and examined for compressive strength over a range of activator modulus at a fixed Na_2O dosage, in order to optimize the mix design for each specific fly ash. The first phase of the research involved conducting tests on geopolymer mortar, which helped assess micro structural and pore-structural changes with the degree of geopolymerization and correlate it with the compressive strength of final geopolymer systems. Based on the data analysis, the study concluded that the chemical, physical, and mineralogical properties of precursor fly ash have a significant effect on the compressive strength of geopolymer mortars.

Sandeep Hake et al (2016)," Effect of temperature and curing methods on geopolymer concrete." The study examined the impact of temperature and various curing methods on the compressive strength of geopolymer concrete. Results showed that in oven curing, the rate of strength gain is slow at 600^{O}C and increases at 900^{O}C, but decreases at 1500^{O}C, where cracks appear on cubes. Optimum results with respect to electricity usage were obtained at 900^{O}C. In accelerated curing, the best results were achieved at 800^{O}C. For membrane curing, the compressive strength was highest at 900^{O}C, which was also the optimum temperature with respect to electricity usage. In steam curing, the highest compressive strength was achieved at 1000^{O}C. The study highlights the importance of heat in the polymerization process of geopolymer concrete.

3 MATERIALS AND METHODS

3.1GENERAL

The alumina silicate material such as Fly Ash , Ground Granulated Blast Furnace Slag (GGBFS) activated in alkaline medium such as sodium hydroxide and sodium silicate with different proportion. The physical properties are obtained by the respective test carried out in the laboratory. The physical and chemical properties are listed in this chapter.

3.2 MATERIAL USED

3.2.1 Alumina Silicate Materials

Low calcium class C Fly Ash is to be used in the entire experimental work. The Fly Ash was procured from Ennore thermal power plant. Ground Granulated Blast Furnace Slag (GGBFS) a by-product of iron melting industry is used in the present study. This is grouped under Alumina Silicate material the physical and chemical properties are listed in table 3.1 & 3.2.

Table 3.1 Physical Property of ASMs

Material	Physical state	Odour	Appearance	Bulk density (g/cc)	Particle size distribution(µm)			Specific gravity	Blaine specific surface (m^2/kg)
					d_{10}	d_{50}	d_{90}		
LCFA	Micronized power	Odourless	Grey colour powder	0.526	2.32	12.95	29.19	2.25	487
GGBFS	Micronized power	Odourless	White colour powder	0.95	1.69	12.85	46.85	2.90	358

Note: (i) LCFA- Low Calcium Fly Ash

(ii)GGBFS- Ground Granulated Blast Furnace Slag

Table 3.2 Chemical Composition of ASMs (in percentage by weight)

Materials	SiO_2	Al_2O_3	Fe_2O_3	$SiO_2+Al_2O_3+Fe_2O_3$	CaO	MgO	Na_2O	K_2O	SO_3	TiO_2	LOI	Other	SiO_2/Al_2O_3	Na_2O/SiO_2	Na_2O/Al_2O_3	CaO/SiO_2	CaO/Al
LCFA	58.96	28.92	5.72	93.60	0.87	1.88	0.16	0.66	0.08	1.75	0.58	0.30	2.04	0.002	0.005	0.01	0.03
GGBFS	32.47	18.00	1.16	51.63	35.69	8.08	0.20	0.22	1.63	0.59	0.72	1.86	1.80	0.006	0.011	1.10	1.98

Note: (i) LOI – Loss of Ignition (ii) The total percentage of (SiO_2 + Al_2O_3 + Fe_2 o_3) is less than 70% in the above LCFA Sample. Further, CaO content is less than 10%. Hence, it is classified as class according to ASTM C 6128 - 03 or pozzolanic in nature of FA according to IS3812 (2003).

The molar ratio of LCFA and GGBFS shows that SiO_2/Al_2O_3= 0.81, 1.80, Na_2O/SiO_2= 0.008, 0.006, Na_2O/Al_2O_3= 0.006, 0.011, CaO/SiO_2= 0.80, 1.10, CaO/Al_2O_3 0.65, 1.98 respectively.

The molar composition of LCFA is 1.10 Na_2O, 180.75 Al_2O_3, and 368.50 SiO_2 and the molar composition of GGBFS is 1.00 Na_2O, 90.00AL_2O_3& 162.03 SiO_2.

3.2.2 Sodium Hydroxide (NaOH)

Generally the sodium hydroxide are available in solid state by means of pellets and flakes. The cost of sodium hydroxide is mainly varied according to the purity of substance. Geopolymer paste is homogeneous material and its main process to activate the sodium silicate. So it is recommended to use up to 94-96% purity. The chemical and physical properties of sodium hydroxide are listed in table 3.3.

Table 3.3 Chemical and Physical Properties of Sodium Hydroxide (NaOH)

Appearance /Colour	Boiling Point	Molecular Weight	Specific Gravity	Assay	Carbonate (Na_2CO_3)	Chloride (Cl)	Sulphate (SO_4)	Lead (Pb)	Iron (Fe)	Potassium (K)	Zinc (Zn)
Light yellow liquid (gel)	102ºC for 40% Aqueous Solution	184.04	1.6	97%	2%	0.01%	0.05%	0.001 %	0.00 1%	0.1%	0.02 %

3.2.3 Sodium Silicate (Na_2SiO_3)

Generally, the sodium silicate is also known as water glass or liquid glass available in liquid (gel) form, in the present investigation sodium silicate (ratio between Na_2O to SiO_3) is used. As per the manufacture, silicates were supplied to the detergent company and textile industry as bonding agent. Same sodium silicate is used for making of geopolymer paste. The chemical and physical properties of sodium silicate are listed table 3.4.

Table 3.4 Chemical and Physical Properties of Sodium Silicate (Na_2SiO_3)

Chemical formula	Na_2O (%)	SiO_2 (%)	H_2O (%)	Appearance	Colour	Boiling point	Molecular weight	Specific gravity
Na_2SiO_3 colourless	8.00	27.00	65.00	Liquid(gel)	Light yellow	102ºC for 40% Aqueous Solution	184.04	1.53

3.3 GEOPOLYMER SYNTHEIS

The mix proportion is arrived so that FA/void by volume and weight proportion as FA and AA is worked out. The End mix proportion by weight is listed in table.

The consistency of fly ash is also studied in correlation with void content for LCFA. In respect of GGBFS consistency is also with void content but it differs due to calcium content of GGBFS.

3.4 METHODOLOGY

The geopolymer paste is prepared based on the physical properties of Low calcium fly ash obtained from Ennore thermal power station. The mix proportion for the geo polymer paste using Low calcium fly ash is calculated based on the properties of the fly ash. The calculation of mix proportion is listed in Annexure- I. The fly ash to alkaline activator ratio is 1.4 (FA/AA) based on the void content. In this research the fly ash as 150,90,63and 45 microns is taken up and analyzed the compressive strength for FA^{+}/AA =1.40.The proportion for this study is through analysis of the alkaline activator ratio (AAR) is the ratio of sodium silicate and sodium hydroxide and the ratio is 1.0, 1.5, 2.0, 2.5 and 3.0. The solution of sodium hydroxide for the molarity 6, 8, 10, 12, 14, 16, 18 is prepared. For the room temperature curing the fly ash is replaced with Ground Granulated Glass Furnace Slag (GGBS) at 25%, 30% the max strength is obtained in all the combinations of 90 microns.

3.5 SPECIMEN AND TEST

Various paste specimen of size 50x50x50mm are cast for the molarity 6, 8, 10, 12, 14, 16 in respect of Na_2SiO_3/NaOH ratio. The mix proportion obtained by minimum void approach is based on water. The fly ash to alkaline activator ratio is also arrived based on water solid ratio The tables 4.1- 4.6 show the mix proportion and compressive strength of Geopolymer paste. The mix proportion for casting cubes of 50mm x 50mm x 50mm in size for the 90 micron passing FA and GGBFS.

MIX POURED INTO THE MOULD

CUBES CASTED

COMPRESSION TESTING MACHINE

COMPRESSED CUBES

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4 RESULTS

Table 4.1: Mix Proportion of Geopolymer Paste using 'LCFA' for various AARs and Their Characteristics (M=6; FN=90µm; $FA^+/AA=1.4$)

Specimen ID	Na_2SiO_3/ NaOH (AAR)	FA^+	GGBS (%)	FA^+		AA	Total Water	Total Solids	Water /Solid (W/S)	Density (gm/cc)	Compressive Strength (N/mm^2)
				Fly Ash	GGBS						
6.1	1.0	145.83	25	109.38	36.46	104.17	72.92	177.08	0.4118	1.62	18.84
6.2	1.0	145.83	30	102.08	43.75	104.17	72.92	177.08	0.4118	1.58	13.24
6.3	1.5	145.83	25	109.38	36.46	104.17	70.83	179.17	0.3953	1.28	18.20
6.4	1.5	145.83	30	102.08	43.75	104.17	70.83	179.17	0.3953	1.64	14.52
6.5	2.0	145.83	25	109.38	36.46	104.17	69.44	180.56	0.3846	1.58	17.16
6.6	2.0	145.83	30	102.08	43.75	104.17	69.44	180.56	0.3846	1.67	11.68
6.7	2.5	145.83	25	109.38	36.46	104.17	68.45	181.55	0.3770	1.63	14.56
6.8	2.5	145.83	30	102.08	43.75	104.17	68.45	181.55	0.3770	1.58	8.80
6.9	3.0	145.83	25	109.38	36.46	104.17	67.71	182.29	0.3714	1.58	10.88
6.10	3.0	145.83	30	109.38	36.46	104.17	67.71	182.29	0.3714	1.59	8.52

Note:(i) 'M' refers to the molarity; (ii)'FN' refers to the fineness of both Fly ash and GGBFS; (iii) FA^+ = (FA+ GGBF); (iv) In the specimen ID, the first digit refers to the 'molarity' and the second digit refers to the serial no. allotted to the specimen at the time of casting and the same is the used in the tables for easy identification of the specimen and the corresponding results; (V)sum of all precursors and AA_s=250g, which is constant for all molarities

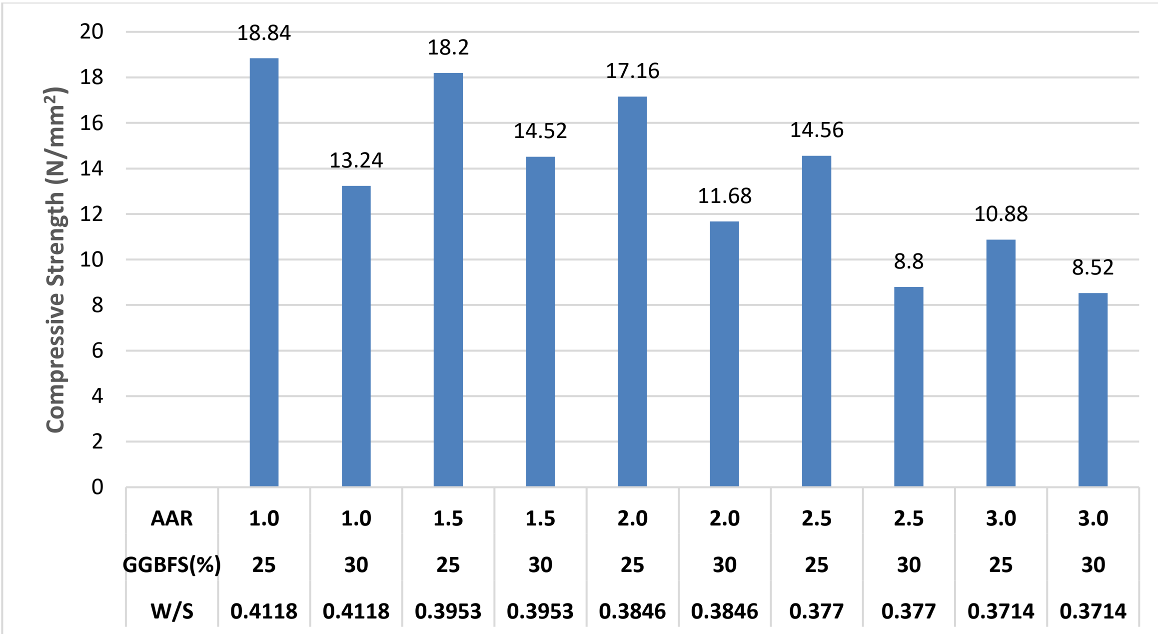

Figure 4.1: Compressive Strength of Geopolymer Paste using 'LCFA' for various AARs (M=6; FN=90µm; $FA^+/AA=1.4$)

Table 4.2: Mix Proportion of Geopolymer Paste using 'LCFA' for various AARs their Characteristics (M=8; FN=90µm; $FA^+/AA=1.4$)

Specimen ID	Na_2SiO_3 /NaOH (AAR)	FA^+	GGBS (%)	FA^+		AA	Total Water	Total Solids	Water /Solid (W/S)	Density (gm/cc)	Compressive Strength (N/mm^2)
				Fly Ash	GGBS						
8.1	1.0	145.83	25	109.38	36.46	104.17	70.05	179.95	0.3893	1.65	19.44
8.2	1.0	145.83	30	102.08	43.75	104.17	70.05	179.95	0.3893	1.62	13.82
8.3	1.5	145.83	25	109.38	36.46	104.17	68.54	181.46	0.3777	1.50	18.48
8.4	1.5	145.83	30	102.08	43.75	104.17	68.54	181.46	0.3777	1.68	16.68
8.5	2.0	145.83	25	109.38	36.46	104.17	67.53	182.47	0.3701	1.65	17.68
8.6	2.0	145.83	30	102.08	43.75	104.17	67.53	182.47	0.3701	1.64	12.04
8.7	2.5	145.83	25	109.38	36.46	104.17	66.82	183.18	0.3647	1.56	15.68
8.8	2.5	145.83	30	102.08	43.75	104.17	66.82	183.18	0.3647	1.58	9.76
8.9	3.0	145.83	25	109.38	36.46	104.17	66.28	183.72	0.3607	1.58	10.50
8.10	3.0	145.83	30	109.38	36.46	104.17	66.28	183.72	0.3607	1.63	11.08

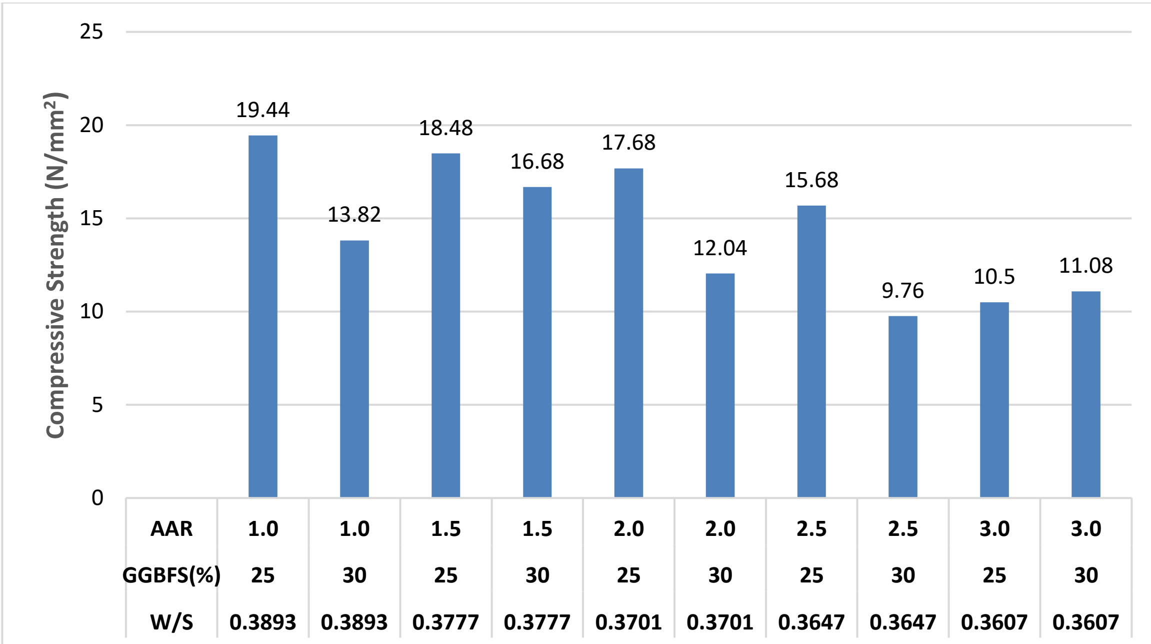

Figure 4.2: Compressive Strength of Geopolymer Paste using 'LCFA' for various AARs (M=8; FN=90µm; $FA^+/AA=1.4$)

Table 4.3: Mix Proportion of Geopolymer Paste using 'LCFA' for various AARs their Characteristics (M=10; FN=90µm; $FA^+/AA=1.4$)

Specimen ID	Na_2SiO_3/ NaOH (AAR)	FA^+	GGBS (%)	FA^+		AA	Total Water	Total Solids	Water /Solid (W/S)	Density (gm/cc)	Compressive Strength (N/mm^2)
				Fly Ash	GGBS						
10.1	1.0	145.83	25	109.38	36.46	104.17	67.40	182.60	0.3691	0.57	20.00
10.2	1.0	145.83	30	102.08	43.75	104.17	67.40	182.60	0.3691	0.55	14.60
10.3	1.5	145.83	25	109.38	36.46	104.17	66.42	183.58	0.3618	0.57	19.48
10.4	1.5	145.83	30	102.08	43.75	104.17	66.42	183.58	0.3618	0.55	16.80
10.5	2.0	145.83	25	109.38	36.46	104.17	65.76	184.24	0.3570	0.68	18.84
10.6	2.0	145.83	30	102.08	43.75	104.17	65.76	184.24	0.3570	0.62	13.08
10.7	2.5	145.83	25	109.38	36.46	104.17	65.30	184.70	0.3535	0.60	16.52
10.8	2.5	145.83	30	102.08	43.75	104.17	65.30	184.70	0.3535	0.62	12.48
10.9	3.0	145.83	25	109.38	36.46	104.17	64.95	185.05	0.3510	0.59	14.30
10.10	3.0	145.83	30	109.38	36.46	104.17	64.95	185.05	0.3510	0.62	12.48

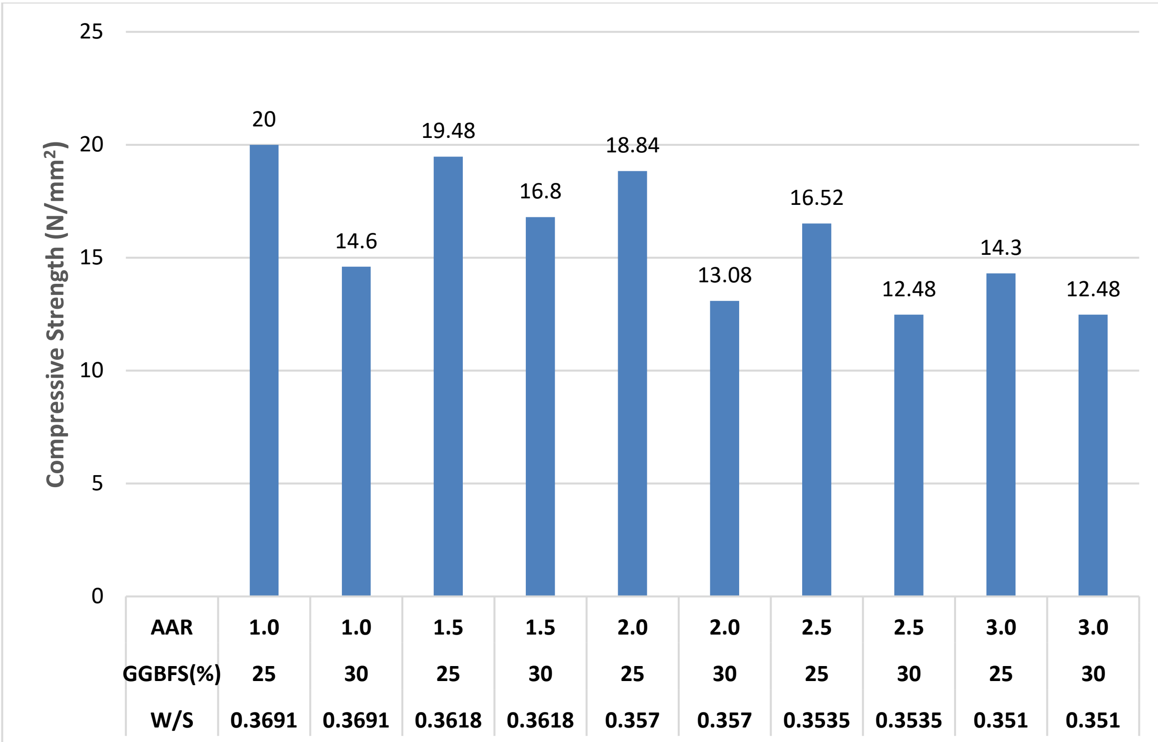

Figure 4.3: Compressive Strength of Geopolymer Paste using 'LCFA' for various AARs (M=10; FN=90µm; $FA^+/AA=1.4$)

Table 4.4: Mix Proportion of Geopolymer Paste using 'LCFA' for various AARs their Characteristics (M=12; FN=90µm; $FA^+/AA=1.4$)

Specimen ID	Na_2SiO_3 /NaOH (AAR)	FA^+	GGBS (%)	FA^+		AA	Total Water	Total Solids	Water /Solid (W/S)	Density (gm/cc)	Compressive Strength (N/mm^2)
				Fly Ash	GGBS						
12.1	1.0	145.83	25	109.38	36.46	104.17	64.90	185.10	0.3506	0.60	20.32
12.2	1.0	145.83	30	102.08	43.75	104.17	64.90	185.10	0.3506	0.62	15.42
12.3	1.5	145.83	25	109.38	36.46	104.17	64.42	185.58	0.3471	0.61	20.12
12.4	1.5	145.83	30	102.08	43.75	104.17	64.42	185.58	0.3471	0.62	17.76
12.5	2.0	145.83	25	109.38	36.46	104.17	64.10	185.90	0.3448	0.64	20.04
12.6	2.0	145.83	30	102.08	43.75	104.17	64.10	185.90	0.3448	0.59	15.88
12.7	2.5	145.83	25	109.38	36.46	104.17	63.87	186.13	0.3431	0.63	19.80
12.8	2.5	145.83	30	102.08	43.75	104.17	63.87	186.13	0.3431	0.62	15.64
12.9	3.0	145.83	25	109.38	36.46	104.17	63.70	186.30	0.3419	0.62	19.48
12.10	3.0	145.83	30	109.38	36.46	104.17	63.70	186.30	0.3419	0.61	13.48

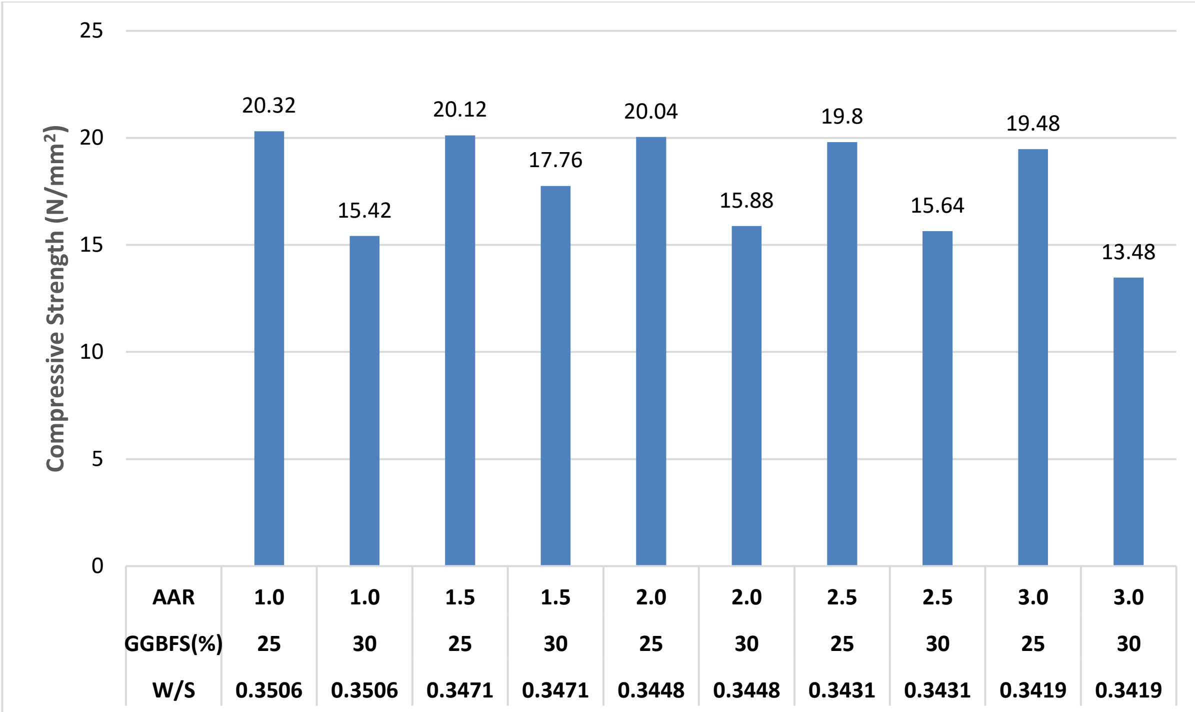

Figure 4.4: Compressive Strength of Geopolymer Paste using 'LCFA' for various AARs (M=12; FN=90µm; FA^+/AA=1.4)

Table 4.5: Mix Proportion of Geopolymer Paste using 'LCFA' for various AARs their Characteristics (M=14; FN=90µm; FA^+/AA=1.4)

Specimen ID	Na_2SiO_3 /NaOH (AAR)	FA^+	GGBS (%)	FA^+		AA	Total Water	Total Solids	Water /Solid (W/S)	Density (gm/cc)	Compressive Strength (N/mm^2)
				Fly Ash	GGBS						
14.1	1.0	145.83	25	109.38	36.46	104.17	62.50	187.50	0.3333	0.60	16.44
14.2	1.0	145.83	30	102.08	43.75	104.17	62.50	187.50	0.3333	0.61	16.36
14.3	1.5	145.83	25	109.38	36.46	104.17	62.50	187.50	0.3333	0.59	15.28
14.4	1.5	145.83	30	102.08	43.75	104.17	62.50	187.50	0.3333	1.78	11.36
14.5	2.0	145.83	25	109.38	36.46	104.17	62.50	187.50	0.3333	1.71	15.16
14.6	2.0	145.83	30	102.08	43.75	104.17	62.50	187.50	0.3333	1.78	15.12
14.7	2.5	145.83	25	109.38	36.46	104.17	62.50	187.50	0.3333	1.75	14.84
14.8	2.5	145.83	30	102.08	43.75	104.17	62.50	187.50	0.3333	1.69	14.56
14.9	3.0	145.83	25	109.38	36.46	104.17	62.50	187.50	0.3333	1.65	10.12
14.10	3.0	145.83	30	109.38	36.46	104.17	62.50	187.50	0.3333	1.67	17.76

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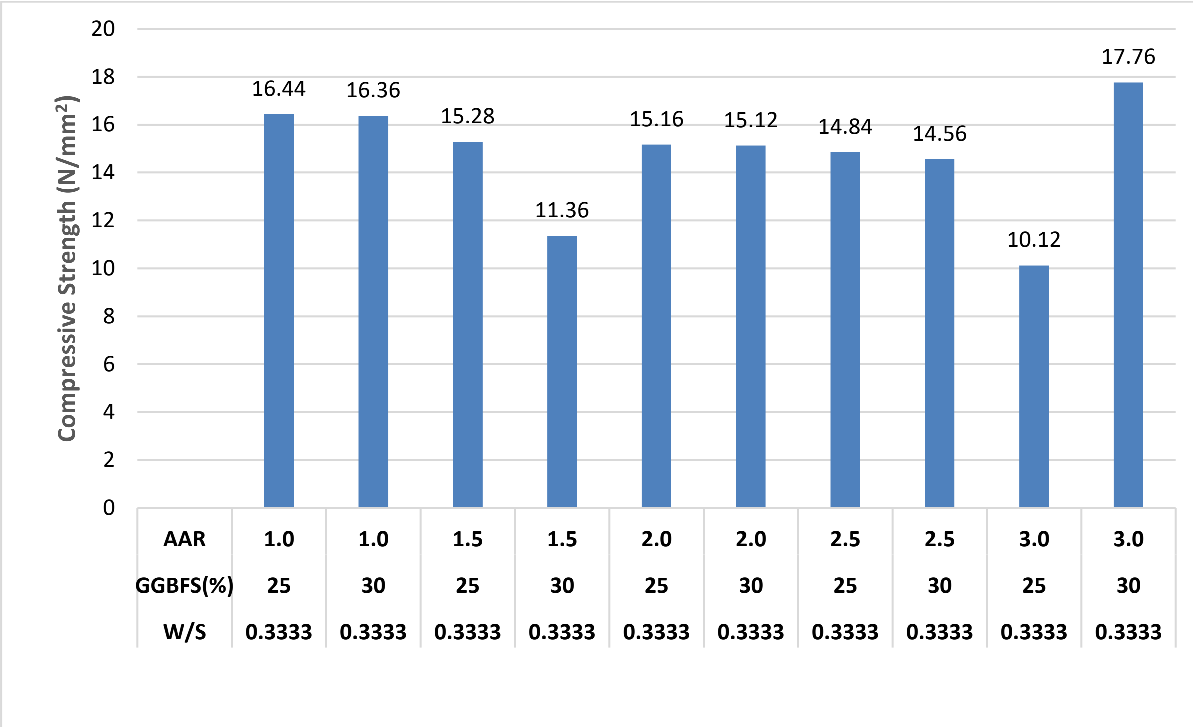


Figure 4.5: Compressive Strength of Geopolymer Paste using 'LCFA' for various AARs (M=14; FN=90µm; FA⁺/AA=1.4)

Table 4.6: Mix Proportion of Geopolymer Paste using 'LCFA' for various AARs their Characteristics (M=16; FN=90µm; FA⁺/AA=1.4)

Specimen ID	Na_2SiO_3 /NaOH (AAR)	FA^+	GGBS (%)	FA^+		AA	Total Water	Total Solids	Water /Solid (W/S)	Density (gm/cc)	Compressive Strength (N/mm^2)
				Fly Ash	GGBS						
16.1	1.0	145.83	25	109.38	36.46	104.17	60.26	189.74	0.3176	0.64	12.60
16.2	1.0	145.83	30	102.08	43.75	104.17	60.26	189.74	0.3176	1.78	14.30
16.3	1.5	145.83	25	109.38	36.46	104.17	60.71	189.29	0.3207	1.76	12.40
16.4	1.5	145.83	30	102.08	43.75	104.17	60.71	189.29	0.3207	1.77	13.48
16.5	2.0	145.83	25	109.38	36.46	104.17	61.01	188.99	0.3228	1.74	11.44
16.6	2.0	145.83	30	102.08	43.75	104.17	61.01	188.99	0.3228	1.73	12.50
16.7	2.5	145.83	25	109.38	36.46	104.17	61.22	188.78	0.3243	1.72	10.50
16.8	2.5	145.83	30	102.08	43.75	104.17	61.22	188.78	0.3243	1.73	11.8
16.9	3.0	145.83	25	109.38	36.46	104.17	61.38	188.62	0.3254	1.72	10.08
16.10	3.0	145.83	30	109.38	36.46	104.17	61.38	188.62	0.3254	1.70	11.20

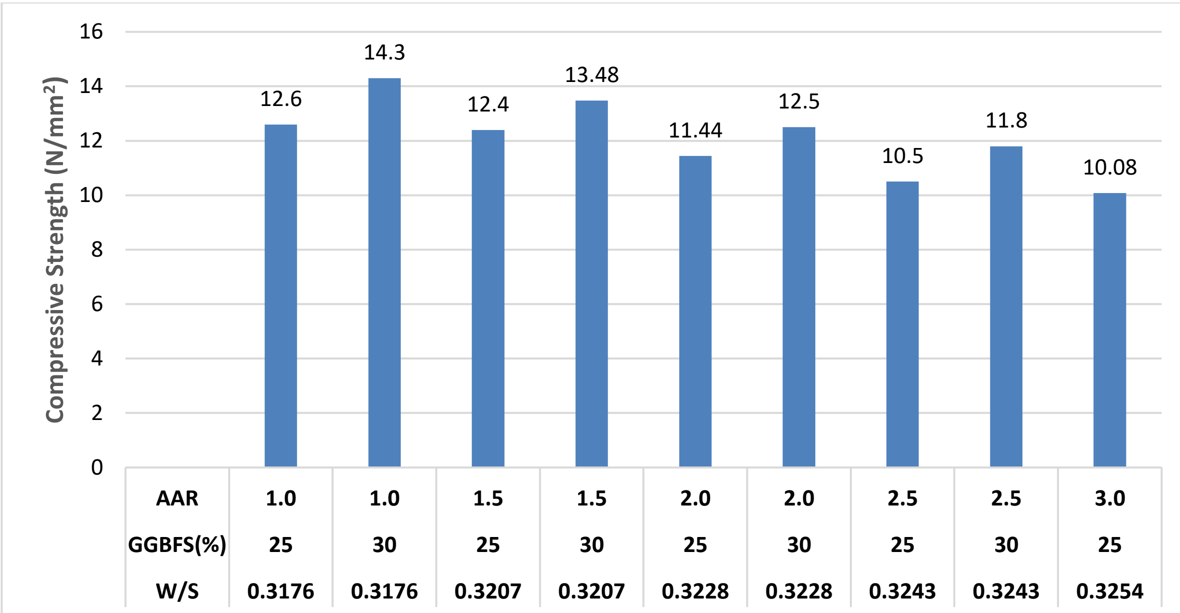
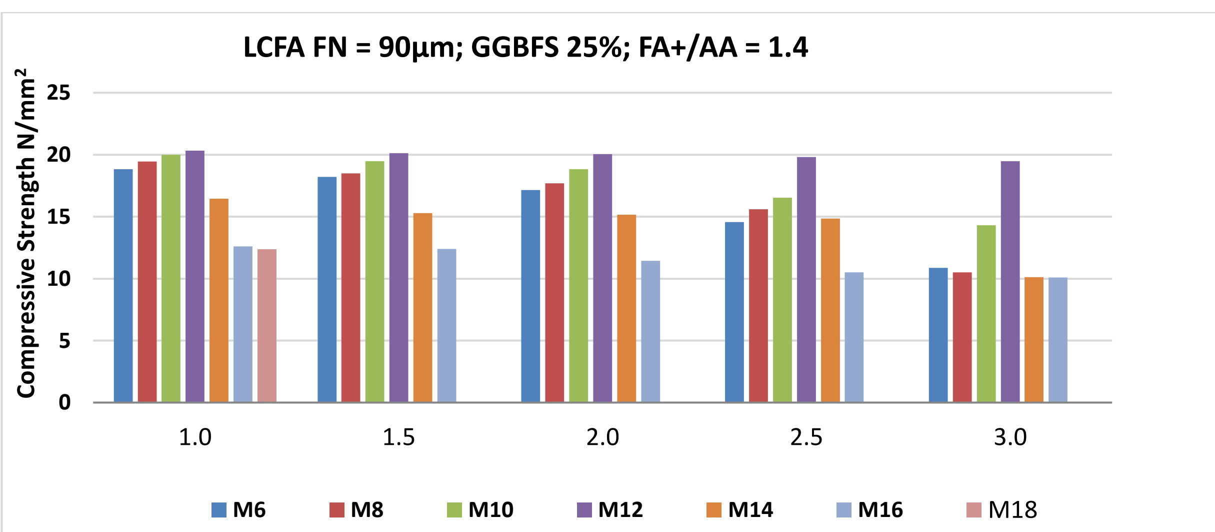
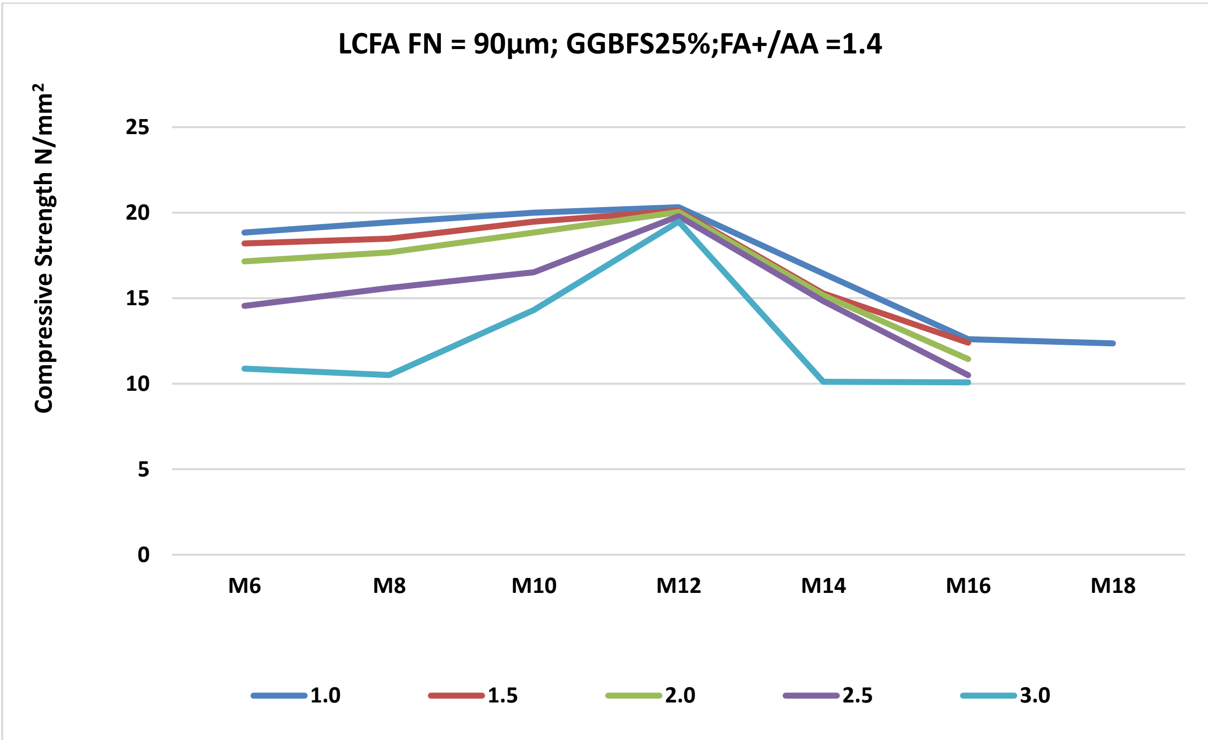


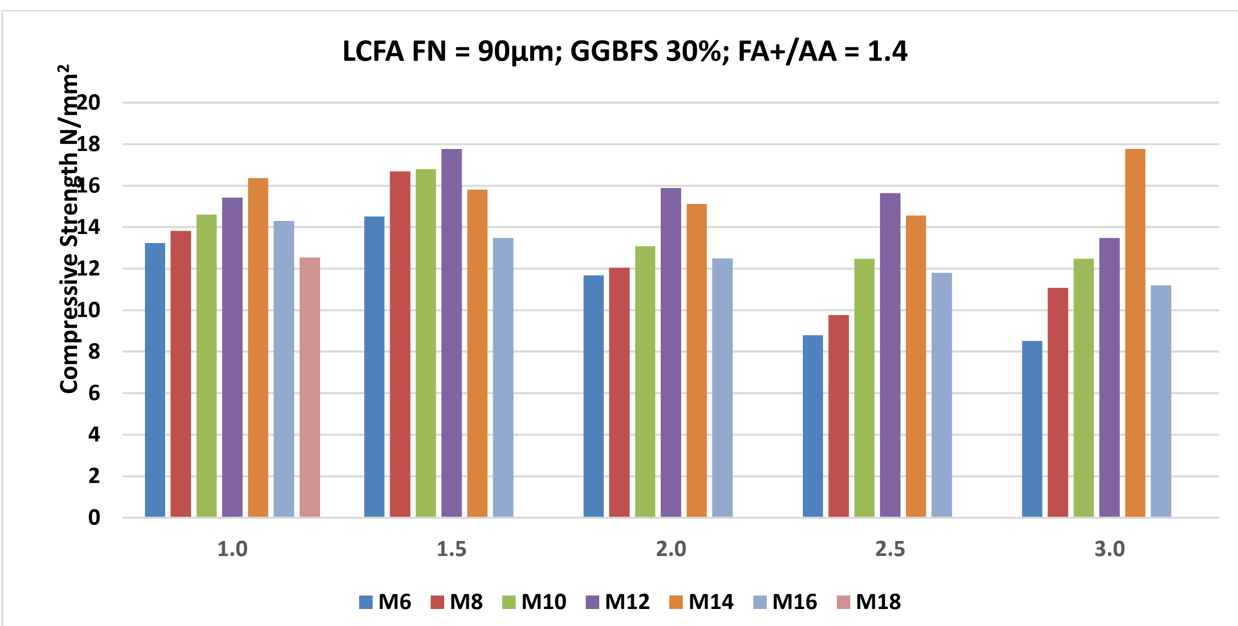
Figure 4.6: Compressive Strength of Geopolymer Paste using 'LCFA' for various AARs (M=16; FN=90µm; FA^{+}/AA=1.4)

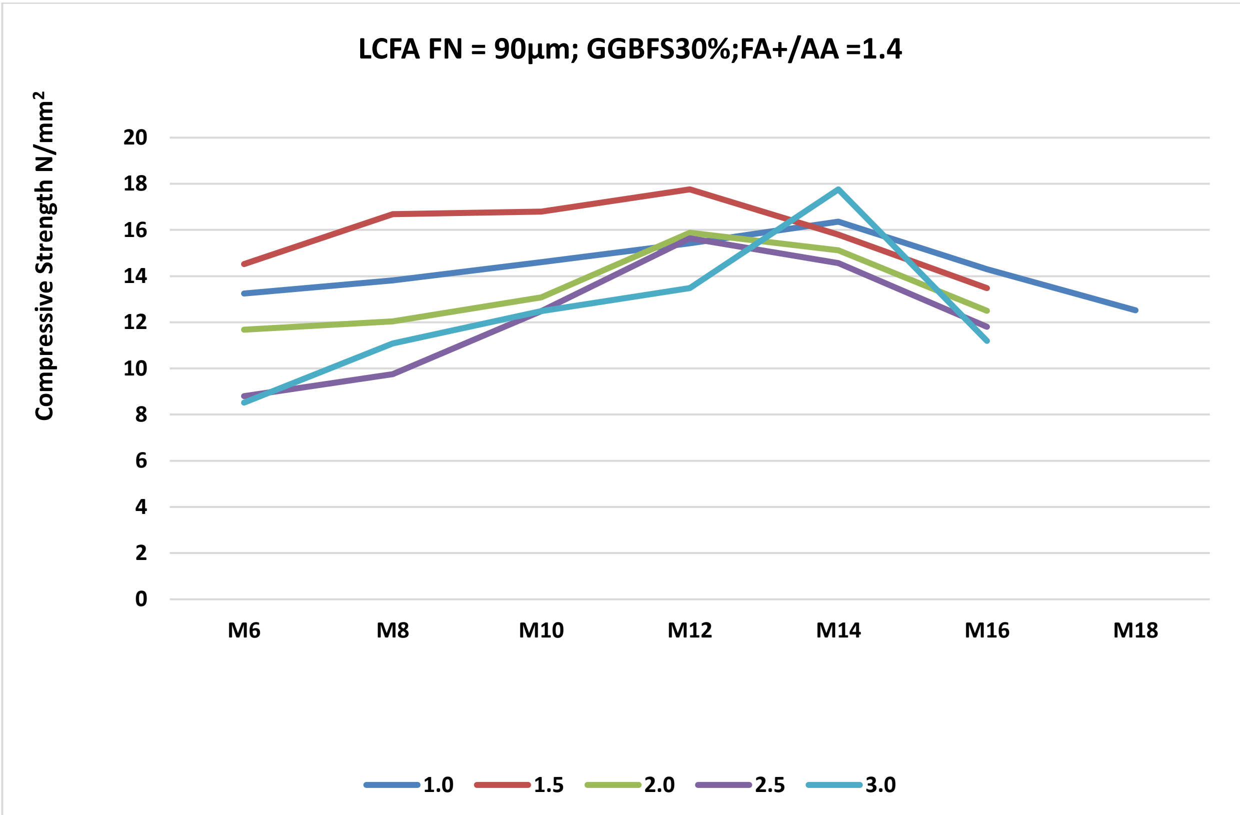
COMPARISON GRAPH OF GGBFS 25%





COMPARISON GRAPH OF GGBFS 30%





5 CONCLUSIONS

OBSERVATIONS AND CRITICAL REMARKS

Based on the extensive observation, following are the salient conclusions.

- The maximum compressive strength of 90 micron LCFA is 20.32 N/mm^2 for FA$^+$/AA= 1.4, M12, AAR is 1.0, GGBFS is 25% and the water solid ratio is 0.3506.
- The minimum compressive strength of 90 micron LCFA is 8.52 N/mm^2 for FA$^+$/AA= 1.4, M6, AAR is 3.0, GGBFS is 30% and the water solid ratio is 0.3714.
- On observing the maximum compressive strength of respective 7 days around 70-80% of the strength attained at the end of seven days

- These strengths are all above 8.00 N/mm^2 but lot of surface cracks are noticed during the room temperature curing. Hence, it is not advisable to use above 30% GGBFS replacement of fly ash.

REFERENCE

1. D. Hardjito, S.E. Wallah, D.M.J. Sumajouw, and B.V. Rangan. *brief review of development of geopolymer concrete*George Hoff Symposium, American Concrete Institute, Los Vegas, USA,2004.
2. Sanjay S. Jamkar, Subhash V. Patankar, Yuwaraj M. *GhugalEffect of Water-to-Geopolymer Binder Ratio on the Production of Fly ash Based Geopolymer Concrete*. (ICRTET'2013).
3. G.E.Arunkumar,P.Eswaramoorthi. *Fibers Study On Properties Of Geopolymerconcrete With Polypropylene.*International Refereed Journal of Engineering and Science. Volume 3, Issue 2. PP.60-75 2014.
4. B. Vijaya Rangan. *Geopolymer concrete for environmental protection.* The Indian Concrete Journal2014.
5. Dr M I Abdul Aleem, S Dinesh, and S Ganesh Kumar, "*application of geopolymer concrete*," Volume: 02 Issue: 09 2015.
6. Janani R, Revathi A. "*Experimental Study of Geopolymer Concrete with Manufactured Sand"*. International Journal of Science, Engineering and Technology Research ;Volume 4, Issue 4, 2015
7. P.Vignesh, K.Vivek, , "*an experimental investigation on strength parameters of flyash based geopolymer concrete with ggbs,"* International Research Journal of Engineering and Technology,Volume: 02 Issue: 02, 2015.
8. ChamilaMadusankaGunasekara, *"influence of properties of fly ash from different sources on the mix design and performance of geopolymer concrete"* 2016
9. Dr. Rajaram Damgir, Sandeep Hake, , Dr. S. V. Patankar, "*effect of temperature and curing type on geopolymer concrete"*, vol. No.5, Special Issue No.(01),2016.