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Investigative Learning on Behavioral of Ternary Blended Self-Compacting Geopolymer Concrete

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ABSTRACT

Basic concept of choosing self-compacting concrete is to reach the three parameters that is followability character, passing character and minimizing the segregation without any external forces. The production of cement in large quantities leads to so many disorders in the environment and nature balance. In this view the concept of mineral admixture with same pozzolonic properties like fly ash (FA), silica fume (SF), ground granulated blast furnace slag (GGBS), Metakaolin (MK), and rice husk ash (RHA) are using as a binder material in the concrete as a partial replacement of cement. The preparation of concrete total replacement of OPC with combination mineral admixtures in the presence of alkaline activator solution is the new technique, and this shows good mechanical properties at oven curing. Due to the high viscosity in nature the geopolymer concrete fails in the lack of compaction. To compensate this issue the self compacting geopolymer concrete has been introduced. SGPC doesn't require any additional arrangement for the compaction, by its own weight it can be done mechanically. To achieve the optimum strengths and serviceability in concrete with these mineral admixtures the NaOH and Na2So3 solution to add and they get geopolymer concrete, but this required compaction. The new concept in concrete is Self-compacting geopolymer concrete was designed with different proportions of the mineral admixtures. To achieve the workability and passing abilities of the SGPC the chemical admixture is taken in to the consideration. In this investigative study replacement of cement in concrete by GGBS, Fly ash and Silica Fume are taken. The replacement of GGBS with cement in all mixes is kept constant as 60% and the Fly Ash and silica Fume were taking in the 40:0; 30:10; 20:20; 10:30; 0:40 ratios. Fresh concrete properties of the SGPC were tested slump cone, T50 value, L-box and verified with these values with the EFNARC guidelines. For this test procedure M25 grade ternary blended SGPC is taken with GGBS, Fly ash and Silica fume are taken as complete replacement instead of binder as cement. Compressive strength values of SGPC mix at optimum were determined at different curing periods. From the test results, it is observed that the optimum replacement of Fly ash and Silica fume is 30% and 10% with 12M Alkaline Activator Solution.

Keywords:-*Ground granulated blast furnace slag, silica fume, mineral admixtures, self-compacting geopolymer concrete, l-box, t50 value, alkaline activator solution.*

INTRODUCTION

In the construction world ordinary Portland cement plays vital role all over the universe. OPC is the main binder in the concrete from the beginning .where the urbanization accelerates the using of OPC also same in the lines. Manufacturing of one ton of cement exerts nearly 0.85 ton carbon dioxide [6].The production of OPC results remarkable changes in the environmental and nature imbalance. At present everyone has to think to minimize the CO_2 emissions [7]. This to overcome the supplementary cementitious mineral admixture blended concrete is designed and it is named as the Geoplymer concrete. Supplementary cementitious admixture are mainly by products of Industrial waste like GGBS, Fly ash. Geopolymer concrete is a outcome via the mixing of Industrial by product material such as fly ash, blast furnace slag (GGBS), rice husk ash, etc. to the CA and FA in the presence of potassium or sodium based alkaline activator solution[3].Comparative with all this binder materials the OPC is the main binder in the concrete from the decades[16].Every year a large amount of unmanaged Industrial by products are thrown out all over the world and its occupies the large amount of open lands and pollute the environment[5].To proper utilization of these industrial wastes researchers are done so many investigations on this materials and they introduced new concept in concrete by partial replacement of cement with SCMs and termed as geopolymer concrete by Davidovits in 1978 [7]. Due to character of high viscosity of geopolymer concrete is fail in the compaction [12].The experiments were performed on the concrete properties like workability and it is the high significance consideration towards the excessive viscosity. The inclusion of superplasticizers and activators to the geopolymer concrete influences lot in improving the workability of the geopolymer concrete [2].The less percentage of slag and alkaline activator solution in the concrete increases the setting time and workability of the SGPC[8].The study included complete replacement of binder as a cement in concrete with supplementary cementitious materials like fly ash, Ground granulated blast furnace slag (GGBS) and silica fume and noticed that the remarkable improvement in mechanical properties of the SGPC. To improve the setting and curing conditions of the SGPC a small quantity of OPC has to add [11].Geopolymerisation is rapidly activated in presence of oven curing and the nominal strength is reached only in 3 days after casting of specimens [4].The fly ash consists of low percentage of Ca is best suited for compactable geopolymer paste. The fly ash mainly consists of SiO_2, Al_2O_3 , part of Fe_2O_3 and other oxides[5]. Study on GGBS as supplementary material in cement is continued from 1939 and reported major changes in the concrete with the above. GGBS is the by-product of Iron manufacturing blast furnace and it is combination of Ca, $MgSiO_3$ and Al_2SiO_5 [9]. The production of GGBS releases only 7% of CO_2 compare to the equal amount of cement produced. SGPC is has a main disadvantage that high strengths reaches at oven curing, but in situ conditions it is not possible. To avoid this, improve fineness of the fly ash in the concrete can accelerate the strengths. Fly ash reaction in alkaline solution addition of calcium can improve drastically. This leads to produce the C-S-H gel par with alumina silicate geopolymer gel [14]. This results in decrease in setting time and increase in mechanical properties of the SGPC with increment of Cao portion [10]. Where the samples are cured at ambient temperatures results in mechanical properties are raised in addition of calcium oxide and calcium hydroxide as a replacement of fly ash. It is observed that where these samples are curing at high temperatures the hardened properties are decreased [15]. Hydrated lime addition to the fly ash and GGBS blended SGPC influences the early age strength [13].Lot of experimental studies are carried out on the freshen properties of the SGPC; workability is the most considerable aspect due its high viscosity. To minimize this, influence of mixing of superplasticizers in the concrete are studied [1].To improve the workability the addition of extra water leads to decrease the other properties up to 27% and enhance the workability up to 200%.Chemical admixtures enhances the workability to 115% and the minimizes the

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other properties to 25% .To overcome all this problems the SS and SH activated self-compacting geopolymer is introduced. This is one of the innovative concrete in construction industry and it is determined on the basis of filling ability, passing ability and segregation resistance.A per the EFNARC guidelines the coarse aggregate size shall not cross the 20mm.The freshened properties of the SGPC are reported by performed test like T50 value ,U-Box,J-Ring,L-Box,V-Funnel and slump cone.

EXPERIMENTAL INVESTIGATION

The present investigative study is carried out by taking GGBS at constant proportion of all mixes and the FA and SF were taking 0-40% by increment and depletion of 10% in SF and FA alternatively for mixes SGPC1, SGPC2, SGPC3, SGPC4, and SGPC5(Table 1).For all the mixes the w/b ratio kept at 0.3 and extra water content is taken as 23% and 7% chemical admixture by mass of the powder were used to get the required workability as per EFNARC guidelines. Total Five sets of SGPC mixes were prepared and tested for the determination of optimum molarity concentration from 8M to 14M.SS to SH ratio is taken for all mixes 2.5.

To prepare the test mixes ,Initially , the binder materials GGBS ,Fly ash And Silica fume are taken in to the mixer and mix all three till no lumps in the binder.14mm fine grained and angular shaped coarse aggregate are add to the ternary binder in the mixer and mix well with help of external force. To add 8M alkaline activator solution this was prepared 24 hours before to the mix and mixed properly till to get required paste condition. Repeat the above procedure for 10M,12M,14M AAS and tested for satisfy the fresh properties of SGPC like filling ability, passing ability and high segregation resistance at acceptable limits and find the optimum mix at considerable molarity solution and cast the specimens with the mix to determine the mechanical properties of the SGPC. Filling ability is the ability to flow under its self-weight into all spaces within the formwork. Passing ability of SCC is the ability to pass through congested openings such as gap between steel and reinforcing bars under its self-weight. Segregation resistance is the ability to maintain uniform paste throughout the process of transporting and placing, without separation and migration.

SGPC MIX PROPORTIONS

Table 1: *Mix propertions of the SGPC*

S NO	MIX DESIGNATION	BINDER PROPORTIONS %			SS/SH RATIO	SUPERPLASTICIZER RATIO %	WATER /BINDER RATIO %
		GGBS	FA	SF			
1	SGPC1	60	40	0	2.5	7	0.3
2	SGPC2	60	30	10	2.5	7	0.3
3	SGPC3	60	20	20	2.5	7	0.3
4	SGPC4	60	10	30	2.5	7	0.3
5	SGPC5	60	40	0	2.5	7	0.3

RESULTS

Workability and Mechanical Properties

To determine the workability properties of the SGPC at different molarities were tested by slump cone, T50 value and L-Box apparatus. From this as per EFNARC guidelines the recommended values at different molarities was compared and reported(Table 2). Optimum concentration of alkaline activator solution for all the mixes is 12M and values related to the corresponding tests were satisfies the EFNARC guidelines.

To evaluate the mechanical properties of the SGPC was carried out by casting

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100X100X100mm cubes were casted for compressive strength test at 7,28,56 days ambient and oven curing with 1000KN compressive testing machine . For oven curing the specimens were put in to the oven at 60°c for 24 hours and after remove from the oven and leave for remaining days curing in the ambient conditions.

Table 2: *Test value of workability of SGPC at 8,10,12,14 M*

S NO	MIX DESIGNATION	MOLARITY CONCENTRATION [M]	WORKABILITY TESTS [LIMITING VALUES]		
			SLUMP CONE [650-800 MM]	T50 VALUE [2-5 SEC]	L-BOX [0.8-1.0]
1	SGPC1	8	655	7	0.88
		10	725	5	0.96
		12	725	5	0.93
		14	780	7	0.94
2	SGPC2	8	640	5	0.86
		10	735	6	0.84
		12	715	4	0.91
		14	775	9	0.95
3	SGPC3	8	665	6	0.92
		10	730	5	1.01
		12	720	3	0.94
		14	780	7	0.99
4	SGPC4	8	655	7	0.88
		10	725	5	0.85
		12	715	5	0.94
		14	785	8	0.86
5	SGPC5	8	675	6	0.94
		10	745	5	0.93
		12	715	5	0.89
		14	760	7	0.94

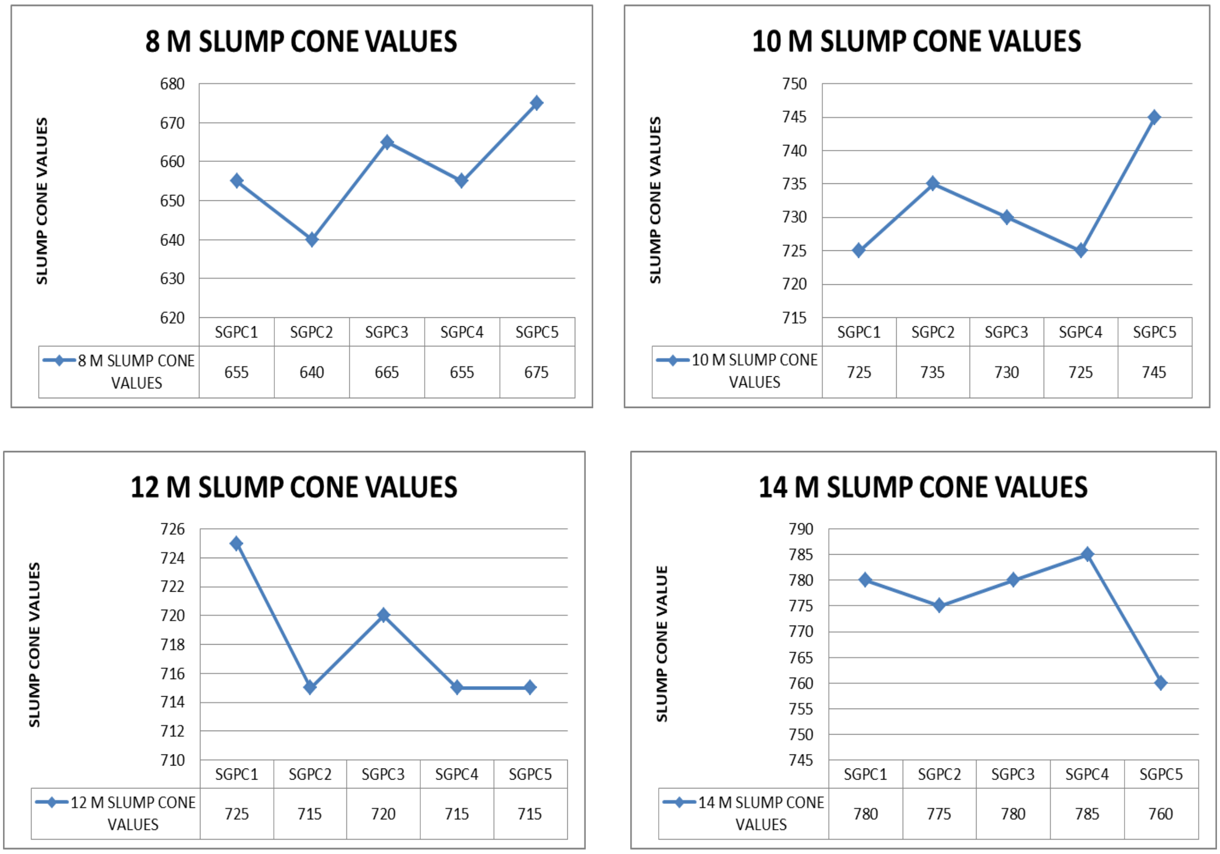

Fig.1: *Slump cone values for SGPC at 8,10,12,14M*

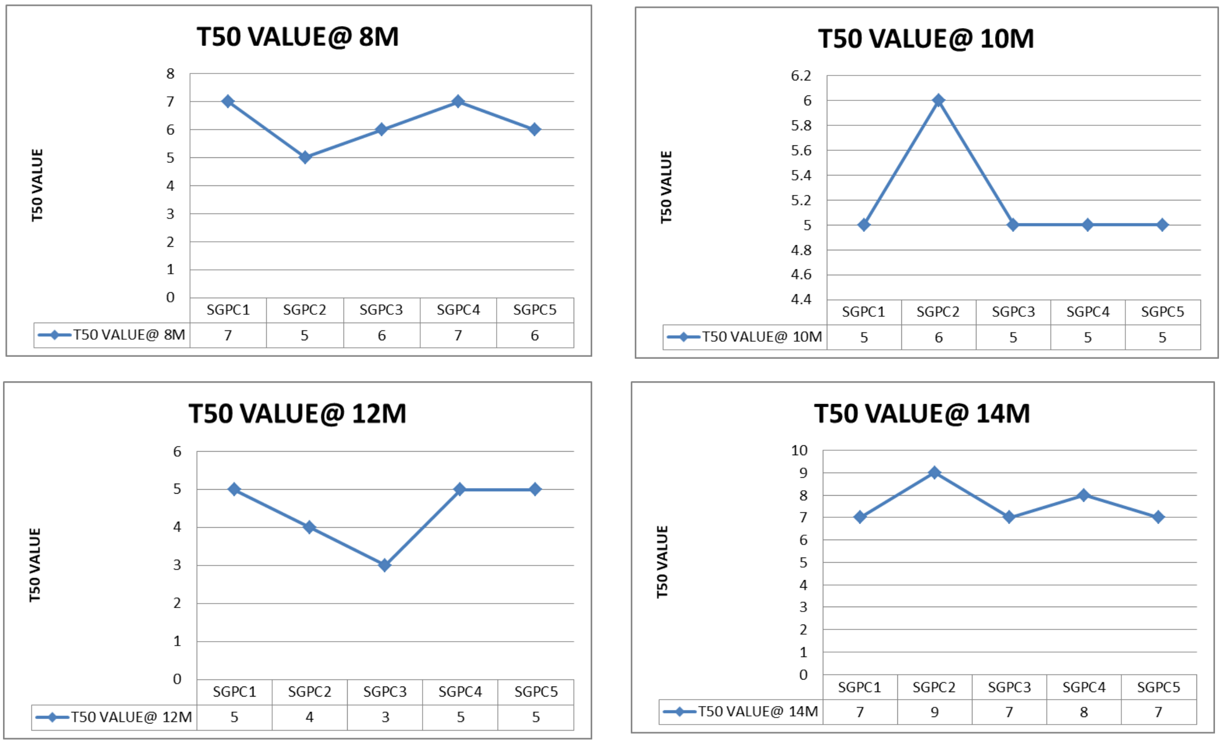

Fig.2: *T50 values for SGPC at 8,10,12,14M*

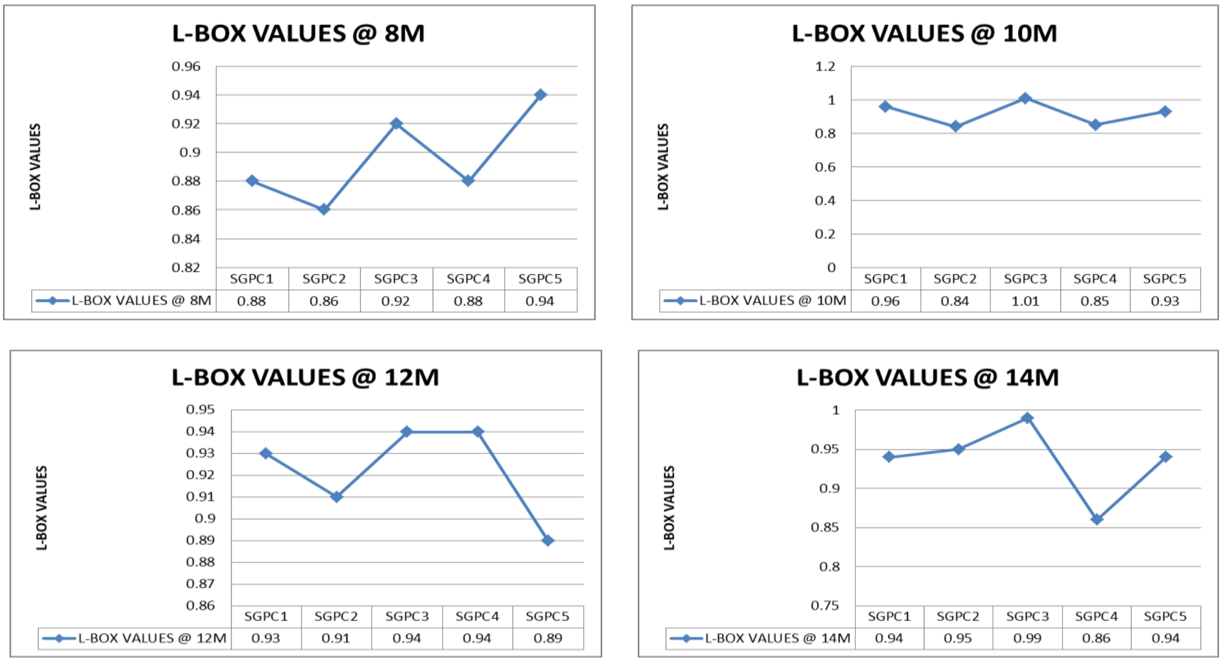

Fig.3: *L-Box values for SGPC at 8,10,12,14M*

Table 3: *Compressive test values for SGPC at ambient and ovencuring*

S NO	MIX DESIGNATION	SS/SH RATIO	S P RATIO	COMPRESSIVE STRENGTH [KN/MM^2]					
				AMBIENTCURING[DAYS]			OVENCURING[60^{O}C]		
				7	28	56	7	28	56
1	SGPC1	2.5	7	25.89	30.88	34.02	31.12	33.24	34.68
2	SGPC2	2.5	7	26.36	31.52	33.48	30.82	32.76	35.24
3	SGPC3	2.5	7	25.87	30.98	33.81	30.79	33.45	33.92
4	SGPC4	2.5	7	26.14	31.02	34.62	31.29	34.52	34.83
5	SGPC5	2.5	7	26.65	31.34	33.58	31.68	33.94	34.24

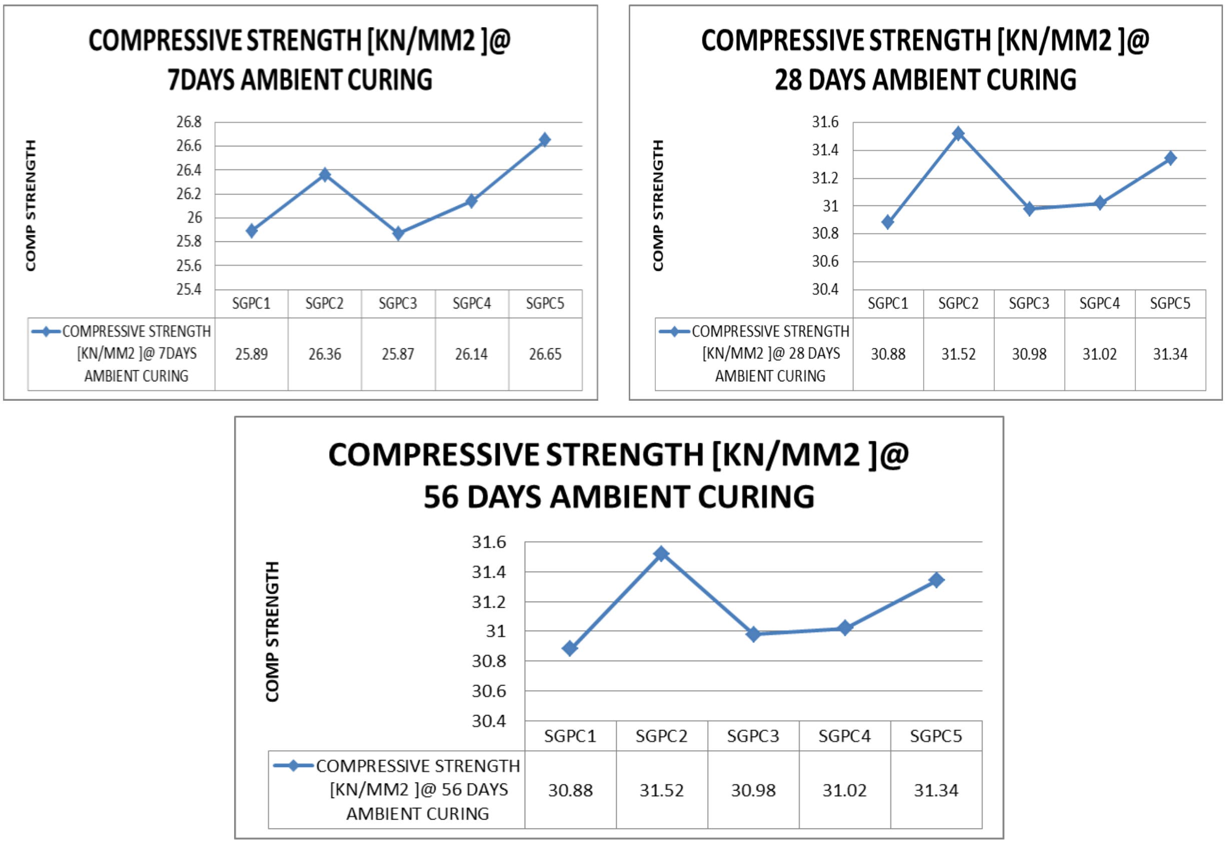

Fig.4: *7,28,56 Days compressive strength values for SGPC at ambient curing.*

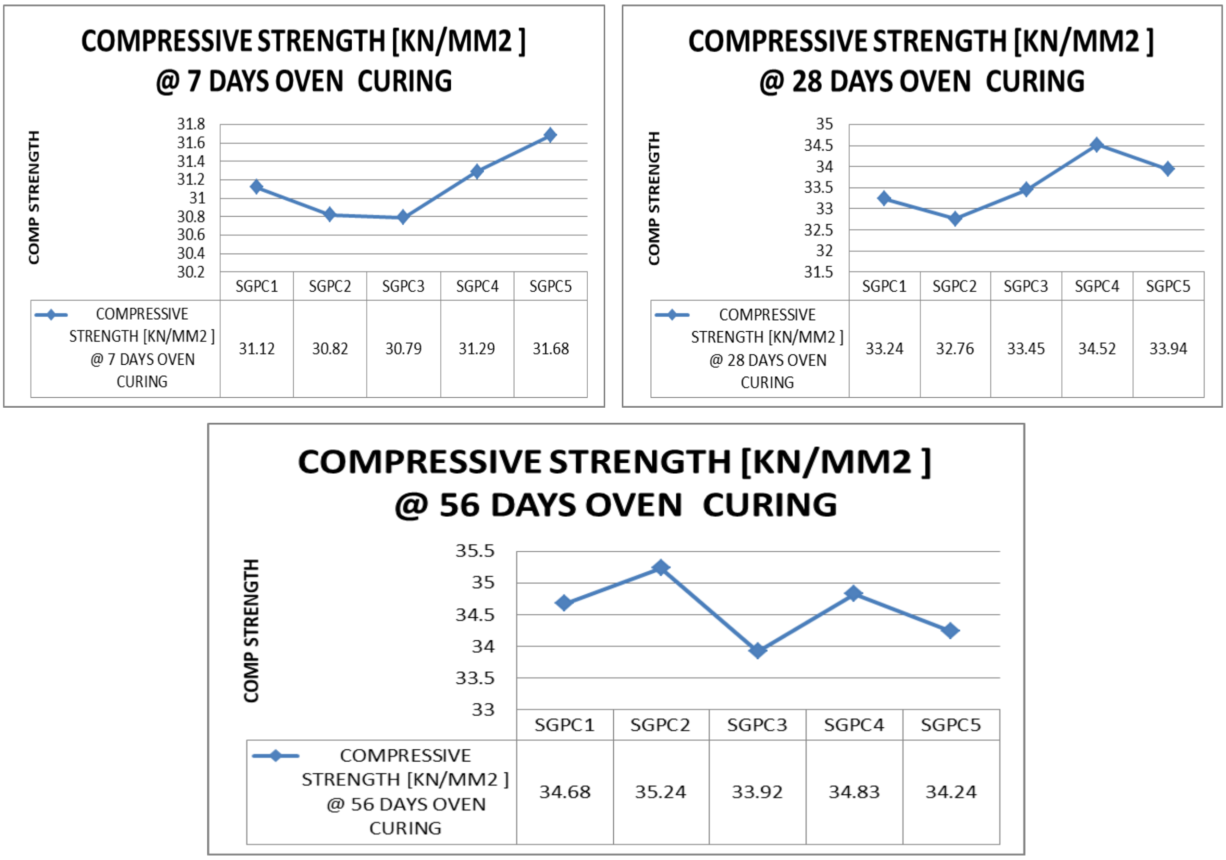

Fig.5: *7,28,56 Days compressive strength values for SGPC at Oven curing*

CONCLUSIONS

1. The ternary geopolymer concrete mix with Fly ash and silica fume at 30%and 10% at 12M was considered as optimum mix.
2. The water to binder ratio 0.3 is fixed at for all mixes is not showing any change in workability only the Alkaline activator solution concentration influences the fresh and hardened properties of the SGPC.
3. The superplasticizer Hi-FORZA 245 is mixed to the SGPC at 7% constant to improve workability properties.
4. Compressive strengths of the SGPC specimens shows better results in oven curing than ambient curing.
5. SGPC5 with GGBS 60%,FA0% SF 40% reports the good compressive test values than other mixes.

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Bibliography

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