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Geopolymer Self Compacting Concrete Performance Incorporating Polyethylene Terephthalate

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ABSTRACT

For the facilitation of construction industry Ordinary Portland Cement use is escalating, ultimately contributing to rise in the global temperature. Infrastructure concerns with green concrete as well as cost and service life. Thus, to counter these problems, Self-Compacting Geopolymer Concrete (SCGC) is gaining much attention. This research's aim is to analyse Poly-Ethylene Terephthalate fiber effect on SCGC. Ground Granulated Blast Furnace Slag (GGBFS) along with Fly Ash were utilized class F in three different proportions (40:60, 50:50 and 60:40) as binders along with alkali activators. For elasticity to hardened properties slump flow of T500 mm test, V-funnel test and L-box, as well as the mechanical properties tests were done accordingly. Results showed hardened properties enhanced with the increase of the slag quantity, The reinforced with PET fibers in different percentages (0, 0.05%, 0.1%, 0.15%, 0.2%, 0.25%, 0.3%, 0.35%, 0.4%, 0.45%, 0.5%, 1% and 1.5%) by volume of the mix respectively. Fiber's addition till 1% increased the compressive strength by 13% approximately, but at 1.5% addition the strength started to reduce. Hence up to 0.5% addition of PET fibers fresh properties satisfies the requirements for Self-Compacting Concrete (SCC), but 1% and 1.5% didn't. This research sought to assess SCGC properties after PET inclusion.

1. INTRODUCTION

The viscous self-compacting properties are enough to be taken care of without bleeding/segregation, which is also unlike Conventional Concrete (CC). (Olatokunbo M. Ofuyatan, 2020). For strength and durability compaction is required for CC where decreased strength and properties are observed when compaction is not enough which prompts voids. Cement is the most utilized binding material in construction. One of the ozone depleting substances (CO_2, and so forth) are delivered to the climate when the Ordinary Portland Cement (OPC). Thus, the new eco-friendly underlying materials ought to be used rather than conventional cement to adapt to ecological issues (Mehmet Eren Gülsan, 2019).

Geopolymer Concrete (GC) is acquiring attention to eliminate the OPC as binder & utilize modern byproducts like fly ash, slag, adding to ecological advantages (Sherin Khadeeja Rahman, 2021). While Self-Compacting Concrete (SCC) is being used in structures that are highly reinforced, because of its high flowability. The Self-Compacting Geopolymer Concrete (SCGC) is a clever thought, which incorporates the properties of both GC and SCC while research is still needed to enhance utilizing the SCGC in construction (Mehmet Eren Gülsan, 2019). However, reuse of plastic waste gained

much attention in previous years in construction industry, for both ecological and economic reasons (Foti, 2019).
Because of the low tensile strength of SCC many types of fibers are being used one of them is steel, as it works on the post-breaking, durability, and malleability of the concrete (Mehmet Eren Gülsan, 2019; Farhad Aslani, 2019). As use of steel fibers effects fresh properties badly, thus many researchers have used recycled plastic in different forms to increase the strength of SCC, including Poly-Ethylene Terephthalate (PET) fiber to enhance concrete properties (U.Balamurugan, 2017; Abdulkader Ismail Al-Hadithi A. T., 2019; Vijaya, 2018; Pierre Matar, 2019; Rabar H. Faraj, 2021; Rabar H.Faraj, 2020; Sadaqat Ullah Khana, 2020; Tamil Selvi.M, 2014; Waseem Khairi Mosleh Frhaan, 2021). Therefore, this research uses PET to reinforce SCGC and evaluate its properties.

2 MATERIALS AND METHODS

2.1 MATERIALS

As binders Grade 80 GGBFS as per ASTM C-989 and BS 6699 was used along with F class FA as per standard ASTM C618 and EN 450. Both were added in three proportions 40% GGBFS with 60% FA (Sherin Khadeeja Rahman, 2021), 50% GGBFS with 50% FA (Mehmet Eren Gülsan, 2019), 60% GGBFS with 40% FA (Md Adil Ahmed, 2021). Adding, 12 molarity (M) Sodium Hydro oxide along with Sodium Silicate (Na_2SiO_3) as alkali activators were used as shown with 2.5 as silicate to hydro oxide ratio, and 0.5 was taken as alkali to binder ratio (Mehmet Eren Gülsan, 2019).
For coarse aggregate size 10-20mm as per ASTM-C33/C33M and EN 12620. The fine aggregate sand, by passed through sieve #4 as per ASTM- C33/C33M and EN 12620. Ratio of water to binder plays a wider role mix design.). ASTM C1602 and EN 1008 binder ratio of 0.44. Naphthalene based Superplasticizer/ viscosity modifying agent Ultra Super Plast 470 product of Ultra Chemicals, LLC. USA which was added for high flowability as per standard EN 934-2: 2000.

Figure 1 Appearance of Material (a. Bottle Cutter, b. PET Fiber)

PET fibers were cut form soft drink/ water bottles of 2-4mm width and 25-35 mm length (U.Balamurugan, 2017; Abdulkader Ismail Al-Hadithi N. N., 2016). They were added in different proportions 0.05%, 0.1%, 0.15%, 0.2%, 0.25%, 0.3%, 0.35%, 0.4%, 0.45%, 0.5%, 1%, 1.5% in the three mixed proportions of FA and GGBFS ratio of 50:50 (Mehmet Eren Gülsan, 2019), 40:60 (Md Adil Ahmed, 2021) and 60:40 (Sherin Khadeeja Rahman, 2021) respectively. Fig. 1 (a) and Fig. 1 (b) show the bottle cutter and PET fibers respectively.

2.2 MIX PROPORTION AND BATCHING

A total of 234 Samples (3 cylinders and 3 beams for each mix) were prepared for this project as per table 1. Table 1 shows the hardened properties test, fresh properties tests were also done accordingly. The samples were prepared with FA and GGBFS different ratios. These mix proportions were reinforced with PET fibers. The SCGC volume batching quantity of all ingredients is shown in table 2.

TABLE 1
TABLE 2

2.3 MIXING AND CASTING

In this study, mixes were prepared via hand as per mixing procedure explained by (Mehmet Eren Gülsan, 2019) as shown in Fig. 2(a). Then mixture was put into the cylinder and beam molds after all the constituents were mixed together. Total 234 samples were prepared in which 117 were cylinders of 6in diameter and 12in height, and 117 were beams of 18"x 6"x 6". Three is the number of samples which were casted for every mix proportion after that average value was taken as shown in Fig. 2(b).

Figure 2 Mixing & Casting of SCGC (a. Mixing of SCGC, b. Casting of SCGC)

2.4 CURING REGIME

Sample were casting and cure for a period of 4 days under ambient conditions... The samples were left for 4 days before curing. After the rest period, sample were cured. In this research, 28 days curing was done of all the cylinders and beams for maximum strength. Samples were left to dry at ambient conditions for one week after curing (S Oyebisi, 2019).

2.5 TESTS FOR FRESH PROPERTIES

There is a rundown of fresh properties that are critical to comprehend to choose the appropriateness of SCGC. For better quality control, workability, flowability, capacity to pass. The voids fresh properties tests are significant by following tests were performed for fresh properties:

2.5.1 SLUMP FLOW AND T500 MM TEST

Standard that was used to perform this test is B. 12350-8 EN. Firstly, slump cone was filled with mix, after that it was upwardly raised and left the concrete to flow. Then circle's diameter was noted as shown in Fig. 3. Simultaneously with the help of stopwatch noted the time to reach the 500mm circle.

650–800mm for slump flow and 2–5 s for T500mm is set as a standard for SCC (EFNARC, 2002). Fig. 3(a) and Fig. 3(b) shows the apparatus used for this test which was performed at BUITEMS concrete lab.

Figure 3 Slump Flow and T500mm Test (a. Slump Flow Apparatus, b. Slump Flow test)

2.5.2 V-FUNNEL TEST

Segregation of material were performed via V-funnel test according to B. 12350-9 EN. Concrete was poured in the apparatus. After filling, opened the gate within 10 sec and recorded the time with stopwatch in which the apparatus is emptied. 6–12 sec standard is set for SCC (EFNARC, 2002). The samples were prepared and performed at BUITEMS concrete lab.

2.5.3 L-BOX TEST

Passing ability was patterned with the help of L-box test. Sample were performed via L-box test is B. 12350–10 EN, T. Three #4 reinforcement's bars were fitted in front of Horizontal portion (HP). The sections were separated by a movable gate. Filled the Vertical Portion (VP), after that opened the gate and concrete started flowing into the HP. After that the height sample were noted. The blocking ratio was calculated by dividing horizontal sample portion height with vertical portion. 0.8–1 blocking ratio standard for SCC (EFNARC, 2002).

2.6 HARDENED PROPERTIES

2.6.1 COMPRESSIVE STRENGTH

Determined the strength by casting cylinders (6" diameter and 12" height) and testing them on UTM as per ASTM standard C39/C39M-12a.

2.6.2 FLEXURAL STRENGTH

PET fibers were used to counter to crack initiation. Flexural strength was determined by casting beams (6"x6"x18") and testing them on UTM as per ASTM standard C293M.

3 RESULTS AND DISCUSSIONS

3.1 SLUMPS FLOW AND T500 MM TEST

Results showed no major change in the results of the three main mixes SAM1, SAM2 and SAM3. Whereas, by increasing slag quantity observed small depletion in the slump flow. Thus, this is because of the GGBFS's angular shape as if we compare it to the spherical shape of class F FA (Partha Sarathi Deb, 2014). Moreover, the PET fibers quantity mix enhances the diameter of the slump while reduced with each increment. While T500 mm time increased. Indicated that till 0.5% of PET fibers addition the mixes were according to the EFNARC requirements. Adding 1 and 1.5 percent the slump flow values were not satisfactory as per EFNARC. Moreover, T500 mm for all the mixes satisfies the EFNARC requirements i.e., 2 to 5 seconds. Table 3, Fig. 4 and Fig. 6 indicate slump flow and T500 mm results. Whereas Fig. 5 and Fig. 7 indicate trend lines of slump flow and T500mm test which gives an assumption of the fiber quantities.

TABLE 3

FIGURE 4

FIGURE 5

FIGURE 6

FIGURE 7

3.2 V-FUNNEL TEST

The outcome of V-funnel showed no major change in the results of the three main mixes SAM1, SAM2 and SAM3. Whereas, observed small increase in the discharge time with the increase of slag quantity. Thus, because of the GGBFS's angular shape if we compare it to the spherical shape of class F FA (Partha Sarathi Deb, 2014). Moreover, increment of PET fibers in the mix the discharge time also increased. Additionally, the results indicated that upto 0.5% of PET fibers mixes were according to the EFNARC requirements. However, at 1 and 1.5 percent addition the time taken for full discharge didn't satisfy EFNARC requirements. Table 4 and Fig. 8 shows V-funnel test results. Trend line is shown in the

Fig. 9 which gives an approximation of the results for PET fibers percentages.

TABLE 4

FIGURE 8

FIGURE 9

3.3 L-BOX TEST

No major changes were observed in the results of the three main mixes SAM1, SAM2 and SAM3 in L-box test. It was observed, with each increment of PET fibers in the mix the blocking ratio decreased. Moreover, up to 0.5% addition of PET mixes were as per EFNARC requirements. However, at 1 and 1.5 percent addition the passing ability didn’t satisfy EFNARC requirements. Table 5 and Fig. 10 convey L-box test results. Thus, the trend line shown in the Fig. 11 which gives an approximation of the results for fibers quantities that are not included in this research.

TABLE 5

FIGURE 10

FIGURE 11

3.4 COMPRESSIVE STRENGTH TEST

UTM tests indicated the compressive strength results. Therefore, Table 6 and Fig. 12 describes compressive strength of mix proportions. These results indicated that the increment of the slag quantity in binder enhanced the compressive strength (Partha Sarathi Deb, 2014). Moreover, in samples having 0% PET, observed 12% increase when the slag quantity increased from 40% to 50%, also achieved 23% more strength when the slag quantity increased from 50% to 60%. Thus, from the results it was obvious that at ambient conditions the strength increased with the increment of Slag quantity (Partha Sarathi Deb, 2014).

With the increase of PET percentage, the strength also enhanced till 1% reinforcement (U.Balamurugan, 2017; Abdulkader Ismail Al-Hadithi A. T., 2019), approximately 13% more than the normal samples. It was observed at 1.5% inclusion of PET the strength started to diminish. Moreover, the trend line is also shown in the Fig. 13 gives approximate results for PET quantities that are not included in this research.

TABLE 6

FIGURE 12

FIGURE 13

3.4 FLEXURE STRENGTH TEST

Table 7 and Fig. 14 presents flexural strength of sample proportions. The results depicting the flexural strength to be enhanced by increasing slag quantity in the binder. Moreover, samples indicating having 0% PET, observed 37% increase when the slag quantity increased from 40% to 50%, also achieved 9% more strength when the slag quantity increased from 50% to 60%. However, from the results it was obvious that at ambient conditions the strength increased with the increment of slag quantity (Partha Sarathi Deb, 2014).

Samples when reinforced with PET the results were approximately same till 0.15% PET quantity. Whereas, with each increment of PET percentage the strength also increased till 1% reinforcement (U.Balamurugan, 2017; Abdulkader Ismail Al-Hadithi A. T., 2019), approximately 42% more than the normal samples. Additionally, at 1.5% inclusion of PET the strength started to diminish. Moreover, trend line is also shown in the Fig. 15 which shows that the PET inclusion more than 1% reduces the flexural strength.

TABLE 7

FIGURE 14

FIGURE 15

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

This research was executed to know about the properties of SCGC with PET fibers. From the results obtained through experimental phase, it is apparent that.

- GGBFS in the binder affects fresh properties negatively, this may be due to shape of the particles which are angular in shape which causes more cohesiveness in the mix than FA.
- Addition of PET fibers increase the hardened properties till 1% by total volume of the mixture. Whereas after 1% addition the strength starts to decrease, this may be due to the empty spaces left in between the samples due to excess of fibers.
- Fresh properties of SCGC reinforced with PET fiber till 0.5% were according to the EFNARC requirements but at 1% and 1.5% addition the fresh properties requirements were not satisfied, this may be due to the hindering caused by the excess quantity of the fibers.
- The key findings of this research were that the PET fibers inclusion in SCGC had a positive effect on hardened properties but also showed negative effect on fresh properties, thus this finding is significant for further research in this area.

4.2 RECOMMENDATIONS

It is advised that further research can be carried out by;

- Oven drying, which could increase the strength.
- Reinforcing the samples with smaller width of PET fibers.
- Using alkali activator that is economical.
- Machine mixing.

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Table 1Sample preparation for self-compacting geopolymer concrete

Mix (M)	Fly ash (in place of binder)	Slag (in place of binder)	PET (by volume of total mix)
SCGC (SAM1)	50%	50%	0
SCGC (SAM2)	60%	40%	0
SCGC (SAM3)	40%	60%	0
SCGC (SAM4)	50%	50%	0.05%
SCGC (SAM5)			0.1%
SCGC (SAM6)			0.15%
SCGC (SAM7)			0.2%
SCGC (SAM8)			0.25%
SCGC (SAM9)			0.3%
SCGC (SAM10)			0.35%
SCGC (SAM11)			0.4%
SCGC (SAM12)			0.45%
SCGC (SAM13)			0.5%
SCGC (SAM14)			1%
SCGC (SAM15)			1.5%
SCGC (SAM16)	60%	40%	0.05%
SCGC (SAM17)			0.1%
SCGC (SAM18)			0.15%
SCGC (SAM19)			0.2%
SCGC (SAM20)			0.25%
SCGC (SAM21)			0.3%
SCGC (SAM22)			0.35%
SCGC (SAM23)			0.4%
SCGC (SAM24)			0.45%
SCGC (SAM25)			0.5%
SCGC (SAM26)			1%
SCGC (SAM27)			1.5%
SCGC (SAM28)	40%	60%	0.05%
SCGC (SAM29)			0.1%
SCGC (SAM30)			0.15%
SCGC (SAM31)			0.2%
SCGC (SAM32)			0.25%
SCGC (SAM33)			0.3%
SCGC (SAM34)			0.35%
SCGC (SAM35)			0.4%
SCGC (SAM36)			0.45%
SCGC (SAM37)			0.5%
SCGC (SAM38)			1%
SCGC (SAM39)			1.5%

Table 2 Mix proportion of SCGC.

Mix	**Binder Kg/m^3**	**Slag Kg/m^3**	**Fly ash (Kg/m^3)**	**Alkali activators ratio to binder**	**Na_2SiO_3/NaOH**	**Coarse Aggregate (Kg/m^3)**	**Fine Aggregate (Kg/m^3)**	**Water- (kg/m^3)**	**Superplasticizer (Liters in 100kg of binder)**	**PET fibers (%)**
SAM1	450	225	225	0.5	2.5	742.88	865.61	200	2	0
SAM2	450	180	270	0.5	2.5	742.88	865.61	200	2	0
SAM3	450	270	180	0.5	2.5	742.88	865.61	200	2	0
SAM4-SAM15	450	225	225	0.5	2.5	742.88	865.61	200	2	0.05,0.1,0.15,0.2,0.25, 0.3,0.35,0.4,0.45,0.5,1, 1.5
SAM16-SAM27	450	180	270	0.5	2.5	742.88	865.61	200	2	0.05,0.1,0.15,0.2,0.25, 0.3,0.35,0.4,0.45,0.51, 1.5
SAM28-SAM39	450	270	180	0.5	2.5	742.88	865.61	200	2	0.05,0.1,0.15,0.2,0.25, 0.3,0.35,0.4,0.45,0.51, 1.5

Table 3Slump Flow and T500 mm Test Results

Mix (M)	**Slump (mm)**	**Slump Average (mm)**	**T500mm (sec)**	**According to the EFNARC**	**Remarks**
SAM1	690-700	695	2	Pass	As per EFNARC
SAM2	700-715	707	2	Pass	As per EFNARC
SAM3	675-677	676	2	Pass	As per EFNARC
SAM4	693-696	694	2	Pass	As per EFNARC
SAM5	685-703	694	2	Pass	As per EFNARC
SAM6	690-693	691	2	Pass	As per EFNARC
SAM7	684-695	689	2	Pass	As per EFNARC
SAM8	685-694	689	2.5	Pass	As per EFNARC
SAM9	677-685	681	2.5	Pass	As per EFNARC
SAM10	675-685	680	2.5	Pass	As per EFNARC
SAM11	676-680	678	2.67	Pass	As per EFNARC
SAM12	671-682	676	3	Pass	As per EFNARC
SAM13	670-680	675	3	Pass	As per EFNARC
SAM14	600-600	600	4	Fail	Slump flow is not according to the EFNARC requirements, but time taken to reach 50cm circle is ok
SAM15	550-570	560	5	Fail	Slump flow is not according to the EFNARC requirements,

					but time taken to reach 50cm circle is ok
SAM16	695-720	707	2	Pass	As per EFNARC
SAM17	696-715	705	2	Pass	As per EFNARC
SAM18	694-715	704	2	Pass	As per EFNARC
SAM19	690-710	700	2	Pass	As per EFNARC
SAM20	691-708	699	2	Pass	As per EFNARC
SAM21	687-700	693	2	Pass	As per EFNARC
SAM22	688-697	692	2	Pass	As per EFNARC
SAM23	683-697	690	2	Pass	As per EFNARC
SAM24	686-695	690	2	Pass	As per EFNARC
SAM25	683-692	687	2	Pass	As per EFNARC
SAM26	610-613	611	3	Fail	Slump flow is not according to the EFNARC requirements, but time taken to reach 50cm circle is ok
SAM27	572-572	572	5	Fail	Slump flow is not according to the EFNARC requirements, but time taken to reach 50cm circle is ok
SAM28	676-676	676	2	Pass	As per EFNARC
SAM29	672-678	675	2	Pass	As per EFNARC
SAM30	670-672	671	2	Pass	As per EFNARC
SAM31	660-673	666	2	Pass	As per EFNARC
SAM32	662-667	664	2	Pass	As per EFNARC
SAM33	660-663	661	2	Pass	As per EFNARC
SAM34	661-661	661	2.5	Pass	As per EFNARC
SAM35	659-660	659	2.5	Pass	As per EFNARC
SAM36	657-659	658	3	Pass	As per EFNARC
SAM37	656-656	656	3	Pass	As per EFNARC
SAM38	590-593	591	4	Fail	Slump flow is not according to the EFNARC requirements, but time taken to reach 50cm circle is ok
SAM39	540-547	543	5	Fail	Slump flow is not according to the EFNARC requirements, but time taken to reach 50cm circle is ok

Table 4 V-Funnel Test Results

Mix (M)	**Time for full discharge of V-funnel (sec)**	**According to the EFNARC**
SAM1	6.25	Pass
SAM2	6	Pass
SAM3	6.37	Pass
SAM4	6.3	Pass
SAM5	6.3	Pass
SAM6	6.31	Pass
SAM7	6.31	Pass
SAM8	6.5	Pass
SAM9	7	Pass

SAM10	8	Pass
SAM11	9	Pass
SAM12	9.25	Pass
SAM13	10	Pass
SAM14	14	Fail
SAM15	17	Fail
SAM16	6	Pass
SAM17	6	Pass
SAM18	6.25	Pass
SAM19	6.25	Pass
SAM20	6.3	Pass
SAM21	6.75	Pass
SAM22	7	Pass
SAM23	7.5	Pass
SAM24	8.5	Pass
SAM25	9.67	Pass
SAM26	14	Fail
SAM27	16	Fail
SAM28	6.4	Pass
SAM29	6.45	Pass
SAM30	6.45	Pass
SAM31	6.94	Pass
SAM32	7.2	Pass
SAM33	7.25	Pass
SAM34	9	Pass
SAM35	10	Pass
SAM36	10.5	Pass
SAM37	11.75	Pass
SAM38	15	Fail
SAM39	17	Fail

Table 5 L-box Test Results

Mix (M)	Vertical Portion concrete depth (H1) (mm)	Horizontal portion concrete depth (H2) (mm)	Blocking ratio (H2/H1)	According to the EFNARC
SAM1	87	82	0.94	Pass
SAM2	87	82	0.94	Pass
SAM3	87	82	0.94	Pass
SAM4	87	82	0.94	Pass
SAM5	89	82	0.92	Pass
SAM6	89	82	0.92	Pass
SAM7	91	82	0.9	Pass
SAM8	91	81	0.89	Pass
SAM9	93	80	0.86	Pass
SAM10	94	77	0.82	Pass
SAM11	95	77	0.81	Pass
SAM12	95.5	77	0.8	Pass
SAM13	95	76	0.8	Pass
SAM14	127	52	0.4	Fail
SAM15	127	25	0.19	Fail
SAM16	88	81	0.92	Pass
SAM17	89	81	0.91	Pass
SAM18	89	80	0.89	Pass
SAM19	89	79	0.88	Pass
SAM20	93	80	0.86	Pass
SAM21	91	77	0.84	Pass

SAM22	93	78	0.83	Pass
SAM23	94	77	0.82	Pass
SAM24	94	77	0.82	Pass
SAM25	95	77	0.81	Pass
SAM26	135	60	0.44	Fail
SAM27	130	20	0.15	Fail
SAM28	88	80	0.9	Pass
SAM29	90	81	0.9	Pass
SAM30	90	80	0.88	Pass
SAM31	92	81	0.88	Pass
SAM32	93	77	0.82	Pass
SAM33	93	76	0.81	Pass
SAM34	94	76	0.8	Pass
SAM35	94	76	0.8	Pass
SAM36	92	74	0.8	Pass
SAM37	92	73	0.79 (Approx 0.8)	Pass
SAM38	140	40	0.3	Fail
SAM39	130	30	0.23	Fail

Table 6 Compressive strength of SCGC samples

Specimen	**Compressive Strength (Psi)**				
	S1	**S2**	**S3**	**MEAN**	**Standard Deviation of the Samples**
SAM1	440	455	431	442	12.12
SAM2	389	395	410	389	10.82
SAM3	564	581	580	575	9.54
SAM4	450	438	432	440	9.17
SAM5	455	459	421	445	20.88
SAM6	430	480	440	450	26.46
SAM7	497	478	510	495	16.09
SAM8	486	499	515	500	14.53
SAM9	492	500	514	502	11.14
SAM10	530	501	499	510	17.35
SAM11	529	511	505	515	12.49
SAM12	515	504	535	518	15.72
SAM13	514	536	510	520	14.00
SAM14	527	533	560	540	17.58
SAM15	462	468	480	470	9.17
SAM16	387	400	395	394	6.56
SAM17	398	385	402	395	8.89
SAM18	389	395	410	398	10.82
SAM19	409	416	420	415	5.57
SAM20	420	419	427	422	4.36
SAM21	410	426	430	422	10.58
SAM22	440	420	409	423	15.72
SAM23	440	425	437	434	7.94
SAM24	450	418	440	436	16.37
SAM25	424	439	460	441	18.08
SAM26	460	455	465	460	5.00
SAM27	416	399	400	405	9.54
SAM28	579	570	585	578	7.55
SAM29	576	580	584	580	4.00

SAM30	595	610	595	600	8.66
SAM31	612	601	611	608	6.08
SAM32	598	607	625	610	13.75
SAM33	606	610	629	615	12.29
SAM34	624	615	627	622	6.24
SAM35	634	631	637	634	3.00
SAM36	634	630	650	638	10.58
SAM37	648	647	655	650	4.36
SAM38	702	695	700	699	3.61
SAM39	572	611	620	601	25.51

Table 7 Flexural Strength of SCGC

Specimen	Flexural strength (Psi)				
	S1	**S2**	**S3**	**MEAN**	**Standard Deviation of the Samples**
SAM1	71	95	80	82	12.12
SAM2	47	50	59	52	6.24
SAM3	93	79	98	90	9.85
SAM4	68	79	93	80	12.53
SAM5	78	81	93	84	7.94
SAM6	106	88	97	97	9.00
SAM7	98	101	115	105	9.07
SAM8	95	100	120	105	13.23
SAM9	105	105	120	110	8.66
SAM10	138	118	110	122	14.42
SAM11	145	116	111	124	18.36
SAM12	120	111	141	124	15.39
SAM13	120	125	130	125	5.00
SAM14	116	135	160	137	22.07
SAM15	102	89	94	95	6.56
SAM16	48	59	61	56	7.00
SAM17	60	52	65	59	6.56
SAM18	69	61	74	68	6.56
SAM19	68	66	76	70	5.29
SAM20	65	71	80	72	7.55
SAM21	78	77	73	76	2.65
SAM22	80	75	82	79	3.61
SAM23	80	69	85	78	8.19
SAM24	75	77	85	79	5.29
SAM25	77	80	86	81	4.58
SAM26	88	90	101	93	7.00
SAM27	65	66	70	67	2.65
SAM28	100	90	95	95	5.00
SAM29	102	94	98	98	4.00
SAM30	124	101	105	110	12.29
SAM31	120	110	115	115	5.00
SAM32	120	116	121	119	2.65
SAM33	114	123	135	124	10.54
SAM34	137	119	138	128	10.69
SAM35	121	126	140	129	9.85
SAM36	127	129	134	130	3.61
SAM37	125	140	128	131	7.94

SAM38	141	151	170	154	14.73
SAM39	103	118	109	110	7.55

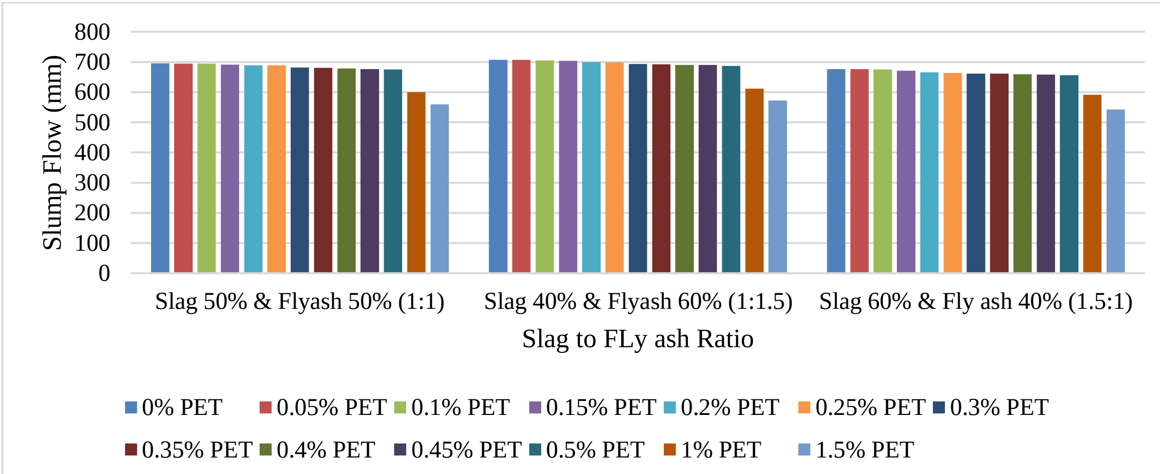

Figure 4Slump Flow test results comparison

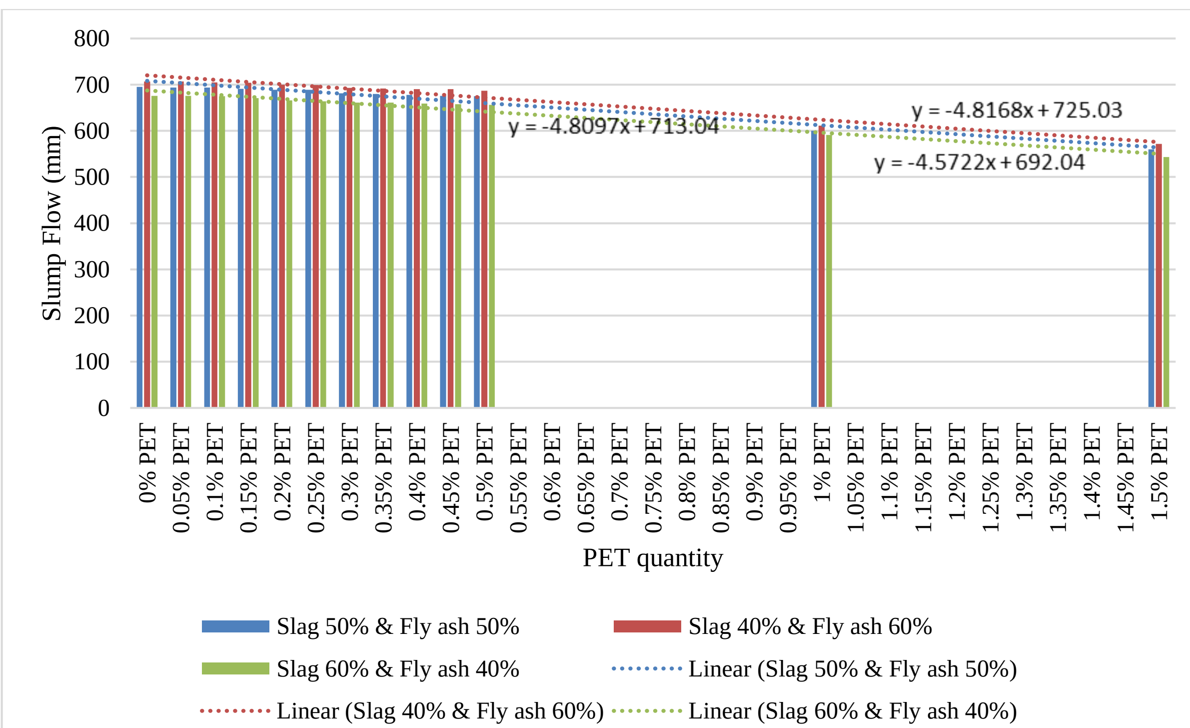

Figure 5 Trend line of Slump Flow Test

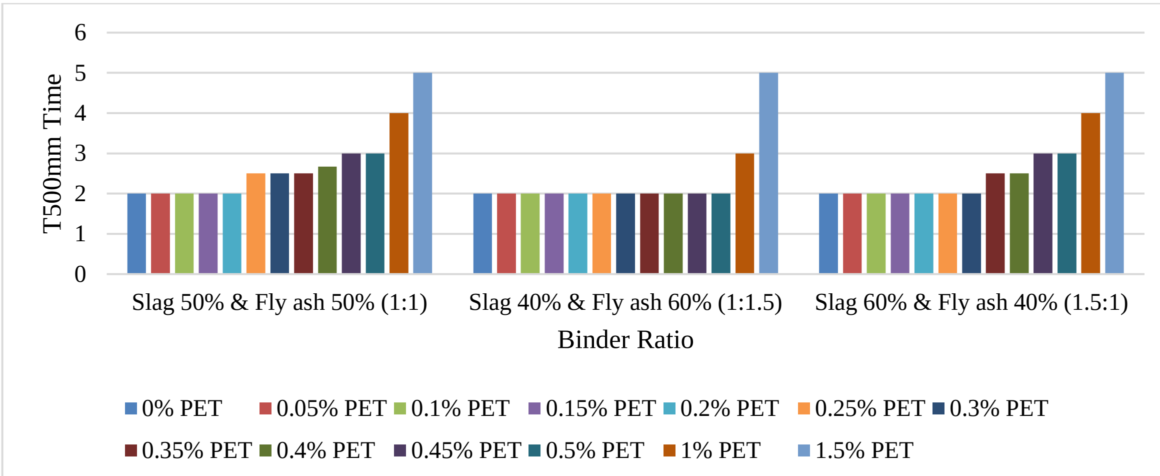

Figure 6 T500mm test results comparison

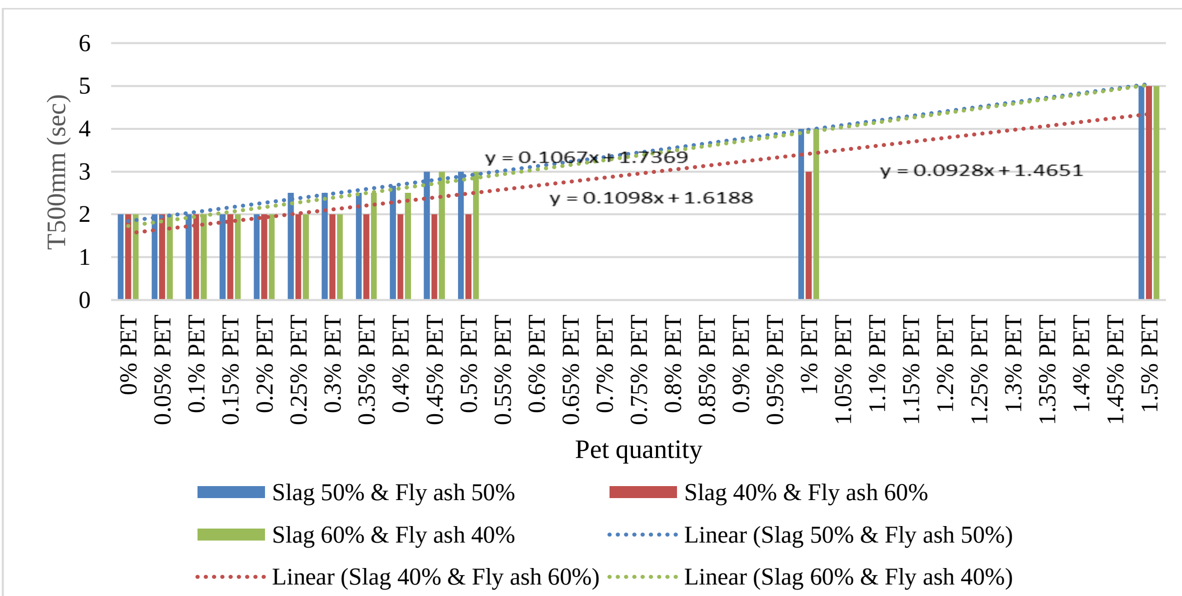

Figure 7 Trend line of T500mm Test

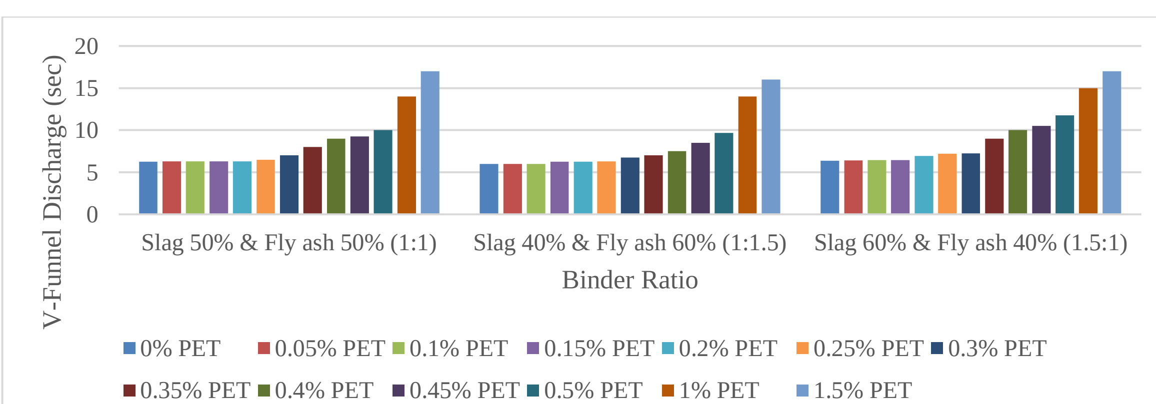

Figure 8 V-Funnel Test results comparison

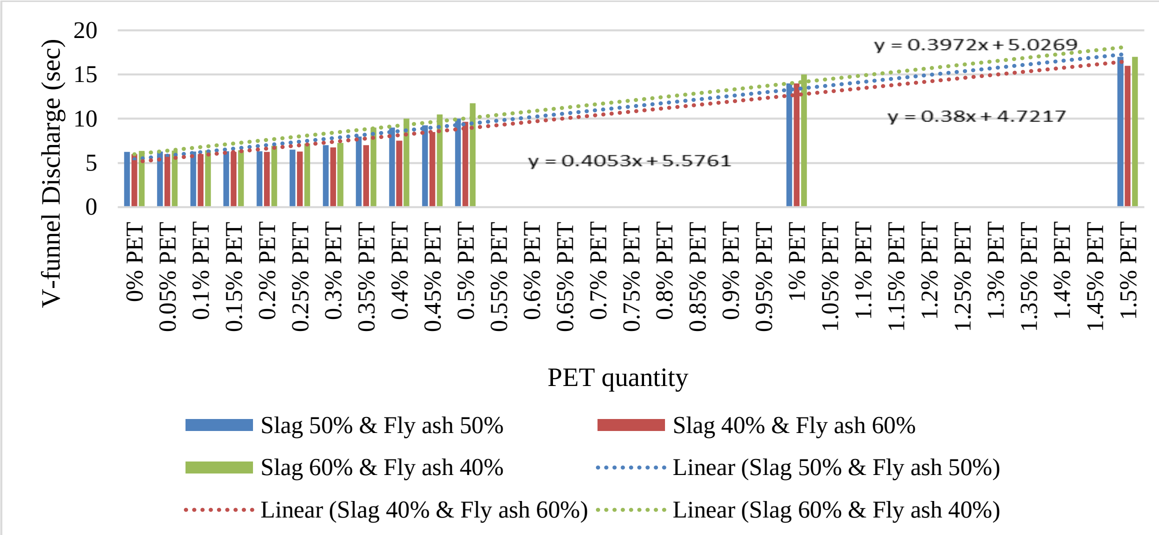

Figure 9 Trend line of V-funnel Test

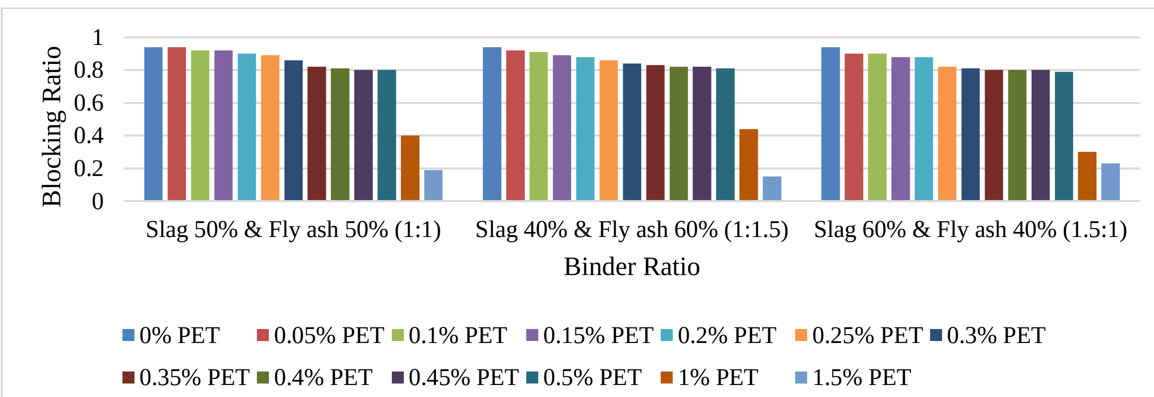

Figure 10 L-box Test results comparison

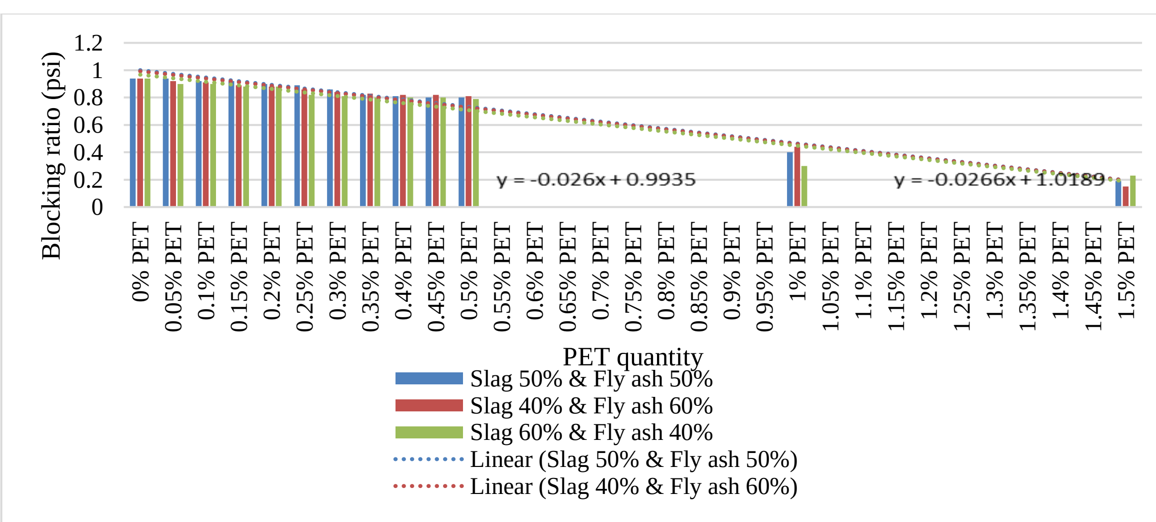

Figure 11 Trend line of L-box test

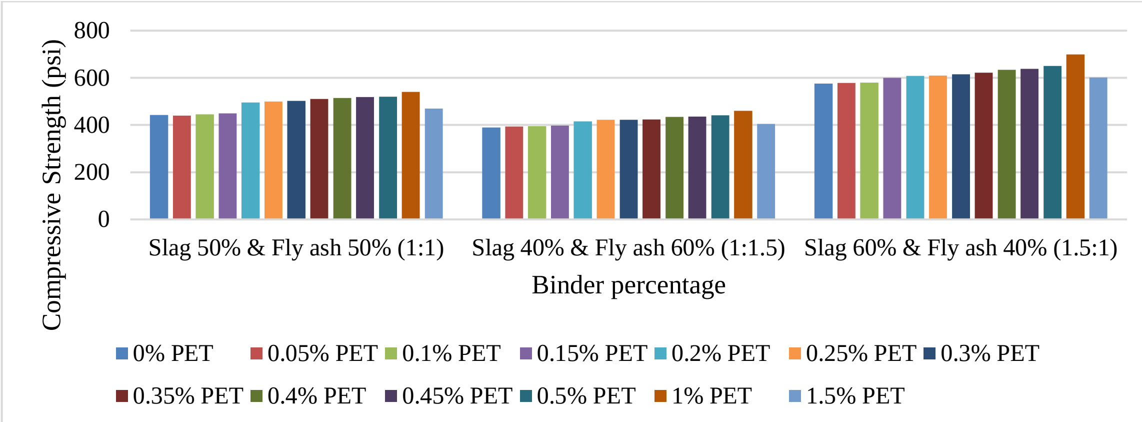

Figure 12 Comparison of compressive strength of SCGC Samples

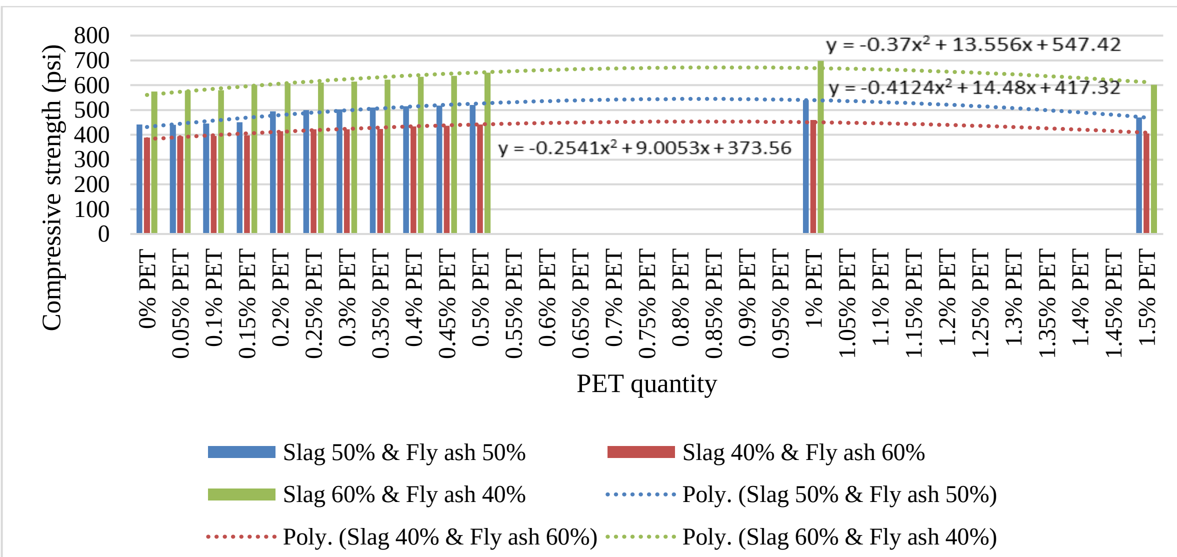

Figure 13 Trend line of compressive strength of SCGC samples

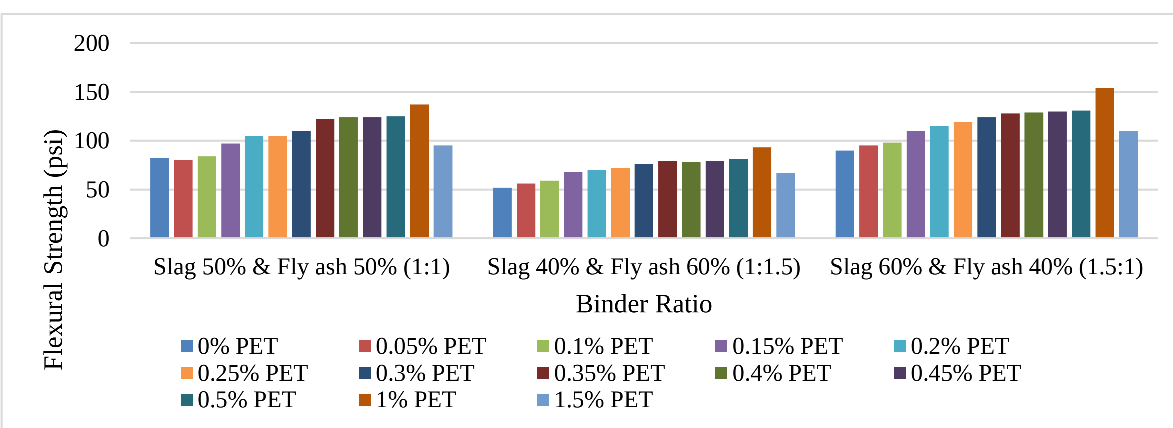

Figure 14 Comparison of Flexural Strength Test of SCGC Samples

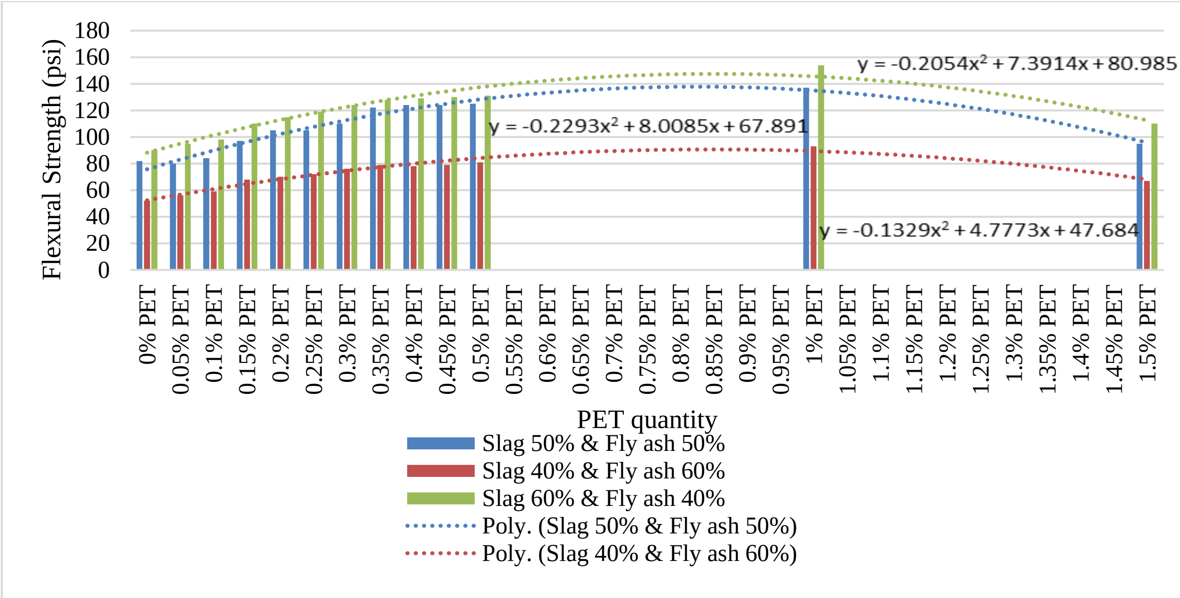

Figure 15 Trend line of Flexural Strength Test of SCGC Sample