ENGINEERING JOURNAL

Article

Residual Strength Characteristics of Polymer Fibre Concrete Exposed To Elevated Temperature

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Abstract. Mechanical properties of polymer based concrete exposed to high temperature effects are evaluated in the present study. Concrete mixtures were prepared using styrene butadiene rubber (SBR) latex and reinforced with polypropylene (PP) fibres. "Latex polymer modified concrete mixes consisting of different aggregate proportions, polymeric fibre contents (0.1 and 0.3% Vf) and fly ash contents (25 and 50%) were investigated for high temperature performance. Concrete specimens after required curing were subjected to different high temperature effects from 200°C to 800°C and the corresponding weight loss and residual strength was determined. In addition, the residual elastic modulus of polymer concretes was determined from the compressive stress-strain properties. Experimental observations showed that, compared to plain concrete the residual strength characteristics of polymer fibre concretes were affected when exposed to high temperature. Strength degradation occurred with increase in temperature and the test results indicated that the temperature sustainability of polypropylene fibre concretes were observed up to 200°C. A maximum compressive strength loss upto 56.75% for plain concrete and 9.87% for polymer fibre concrete was noticed when exposed to high temperature upto 800°C. Further, microscopic analysis of fibre concretes exposed to high temperature showed possible melting of PP fibres resulting in filling the pore spaces which possibly improved the matrix hardening. Also, the high volume fibre incorporated concrete mixes showed maximum residual strength gain due to favourable matrix strengthening and demonstrated high temperature performance of polymer concretes.

Keywords: SBR latex, high temperature, concrete, polymer fibre, residual strength, elastic modulus

ENGINEERING JOURNAL Volume 19 Issue 4
Received 15 September 2014
Accepted 7 January 2015
Published 31 July 2015
Online at http://www.engj.org/
DOI:10.4186/ej.2015.19.4.117

DOI:10.4186/ej.2015.19.4.117

1. Introduction

Concrete undergoes severe deterioration cycles during its service life starting from different weathering cycles and uncertain fire hazards. The design of concrete needs to consider different sustainability conditions to withstand severe durability cycles due to high performance requirement. However, the high temperature performance of plain concrete is affected due to break down of calcium hydroxide crystals and results in spalling of cover concrete. Polymer based concrete systems are typically used for high performance applications and this necessitates the importance to study its high temperature performance [1, 2]. Concrete system incorporating polymers provide adequate improvement on the compressive strength properties. However, the strength reduction at different temperature cycles has a significant influence when exposed during fire hazards [3]. Many studies have been conducted in plain concrete to evaluate its high temperature performances, whereas the incorporation of different supplementary materials such as metakaolin, silica fume were used along with polypropylene fibres [4]. It was identified that the concrete specimens when exposed to 600°C to 800 °C showed a maximum strength reduction upto 45%. It is noted that concrete exposed to elevated temperature suffered loss in stiffness than compressive strength however the further addition of supplementary material has shown a higher compressive strength even when subjected to high temperature. The incorporation of steel fibres in concrete exposed to high temperature had shown marginal strength degradation. However the polymeric fibres shown loss in stiffness at high temperature and subsequently result in melting [5]. In another investigation the mechanical and micro structural properties of polypropylene fibre concrete were investigated which revealed the formation of small capillary channels formed due to melting of polypropylene fibres. It is also noted that degradation of strength occurred over time when exposed to high temperature in the case of high strength concrete. The micro structural analysis reveals that small pores are formed as a result of melting of polmeric fibres in the respective places where fibres are distributed in the matrix [6]. High temperature effects in concrete also suggests that permeability properties of concrete needs to be investigated. In another study, the permeability measure of HSC incorporating polypropylene subjected to elevated temperature up to 300 °C. The results showed that a sudden increase in permeability due to micro structural pores formed as results of PP melting, which act as continuous channels. It is also observed that melted PP fibres fills in the micro cracks and does not percolate in the cement paste [7–9]. Residual strength degradation in terms of compressive and flexural properties was investigated in the experimental study with targeted high temperature range from 20 – 900°C. No explosive spalling observed during fire test on concrete specimens with fibres and spalling was observed for plain concrete [10–13]. Studies also made to compare the compressive and split tensile strength of high strength concrete with PP subjected to temperature range 300 – 600°C. It was noted that residual compressive strength of PP was higher than those of concrete without pp fibres [14]. The split tensile strength of concrete was sensitive to high temperature than compressive strength with the inclusion of PP fibres when exposed to 200°C. The test results confirmed that addition of PP fibres significantly promote the residual mechanical properties upto certain elevated temperature [15]. Polymer incorporated concrete showed a significant reduction on compressive properties when exposed to temperature around 150°C. It is anticipated that significant loss in strength due to thermo oxidative degradation of epoxy polymer and debonding between polymer-aggregate occurs. Cement based concrete has shown higher mechanical performance than polymer concrete exposed to elevated temperature around 250°C [16]. High temperature performance in the case of self compacted concrete was also investigated for a temp range of 300-600°C. The specimen heated to maximum temperature and cooled suddenly showed spalling tendency in plain concrete specimens and for fibre incorporated specimens the residual mechanical properties were significantly reduced [17]. It can be summarized from the previous studies that significant experimental work has been carried out on high temperature performance of concrete. However, limited studies were conducted on polymer concrete and hence more experimental validation is required to predict the mechanical behaviour of polymer fibre concrete exposed to elevated temperature.

2. Experimental Program

2.1. Materials Used

The production of concrete mixes used in the present study consisted of the following materials – 53 grade ordinary Portland cement [18] as binder; class F fly ash as supplementary cementitious material; river sand as fine aggregate with specific gravity 2.63[19]; crushed granite as coarse aggregate filler in the concrete with specific gravity 2.72. A polymer based latex (SBR) and a hyper plasticizer were used as chemical admixture for improving the workability and matrix strength properties. It appears as a white liquid with PH value of 8.1 at 30°c and solid content of 46%. The properties of various constituents are given in Table 1. Crimped polypropylene fibres of 48mm long with diameter 0.6mm and aspect ratio 80 were used as reinforcement in the polymer matrix and the snapshot of fibre is shown in Fig. 1.

Table 1. Physical properties of various ingredients.

Properties (%)	Fly ash Class F	Cement
SiO_2	59.3	20.81
Al_2O_3	34.6	4.79
Fe_2O_3	5.87	3.2
CaO	1.02	63.9
MgO	0.38	2.61
SO_3	0.1	1.39
Na_2O	1.28	0.18
K_2O	0.01	0.79
Cl^-	0.49	0.002
Loss on ignition	1.9	0.98
Insoluble residue	-	0.12
Moisture content	0.73	-
Specific gravity	2.24	3.17

Fig. 1. Crimped polypropylene fibres used in the study.

2.2. Mixture Proportions for Polymer Fibre Concretes

The experimental study consisted of preparing eight different concrete mixes with different polymeric fibre contents (0.1% and 0.3%V_f) at constant SBR latex (7%). Among the different concrete mixes, 4 plain concrete mixes without latex addition and 4 polymer concrete mixes containing fibre (0.1% to 0.3%) and SBR (7%) were investigated. Based on initial studies conducted, the calculated proportions are given in Table 2. Fresh concrete mixes were prepared in a 40kg capacity concrete mixture and casted in 150mm cube moulds for determination of compressive strength and in 150x300 cylindrical moulds for determination of elastic modulus. After a day, the specimens were remoulded and then cured sufficiently in water and tested at room temperature. The specimens were exposed to different temperature condition (200°C, 400°C, 600°C and 800°C) in an electric muffle furnace (as shown in Fig. 2) and heated at a rate of 4°C/sec. Continuous heating was carried out for 4 hours till it reaches the desired testing temperature and later the sample were cooled to room temperature and tested as per the standard testing condition [17].

DOI:10.4186/ej.2015.19.4.117

Table 2. Various polymer concrete mixes used in the study.

Ingredients	Water+ Polymer composition					Binder + Aggregate composition				
Mix Id	water/binder ratio	F/C ratio	SBR Latex (% by weight of binder)	PP fibres (V_f) % by volume of concrete)	Super plasticizer (% by weight of binder)	Cement (kg/m^3)	Fly ash (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Water (litres/m^3)
S1	0.3	0.6	0	0	1.5	400	100	713	1188	120
S2	0.3	0.6	0	0	1.5	400	200	675	1125	120
S3	0.3	0.8	0	0	1.5	400	200	800	1000	120
S4	0.3	0.8	0	0	1.5	400	100	844	1056	120
MS1	0.3	0.6	7	0.1	1.5	400	100	713	1188	120
MS2	0.3	0.6	7	0.3	1.5	400	200	675	1125	120
MS3	0.3	0.8	7	0.1	1.5	400	200	800	1000	120
MS4	0.3	0.8	7	0.3	1.5	400	100	844	1056	120

Note: F/C – fine to coarse aggregate ratio; w/b – water to binder ratio.

Fig. 2. Muffle furnace.

2.3. Testing Methodology

2.3.1. Compressive strength measurements

Compressive test [20] was carried out in a digital compression testing machine of 2000kN capacity and a loading rate of 2.5kN/sec was maintained during the test and the snapshot is shown in Fig. 3. Elastic modulus of concrete specimens were determined from a casted concrete cylindrical specimens of size 150x300mm and the longitudinal strain was measured using compressometer. A muffle furnace of 1000°C heating capacity was used to study the high temperature performance of various concrete mixes.

Fig. 3. Compression test setup.

The various quantitative measurements from the compressive strength studies are descibed below.

i. Weight loss (%) was measured from the difference of weight of concrete specimen subjected to heating at different temperature range to that of initial weight of concrete before subjected to heating.
ii. Relative weight loss (ratio) calculated from the ratio of weight loss of heated specimen (subjected to different temperature range) after 6 months of alternate wetting and drying cycle to that of intial weight loss of reference concrete specimen (without any wetting and drying) .
iii. Residual compressive strength (MPa) calculated from the specimen exposed to temperature and the strength loss reported in terms of its initial strength without subjecting to high temperature.
iv. Relative compressive strength was calculated from the ratio of residual compressive strength after 6 months of alternate and wetting drying cycles to the initial compressive strength at 28 days of reference concrete tested at different temperature range.
v. Stiffness degradation was calculated from cylindrical specimens of size (150 x 300mm) and was used to calculate the elastic modulus (slope of stress- strain curve) upon loading the specimen after subjecting to different temperature ranges.

3. Experimental Test Results and Discussions

3.1. Effect of Temperature on Weight Loss of Concretes

Experimental results obtained from the temperature studies of different polymer fibre concretes are presented in the Table 3 and 4. The weight loss measurements at 28 days testing of different polymer concretes and the relative weight loss after 6 months of wetting and drying cycles are given in Table 3 and Table 4 respectively. Results showed a progressive increase in weight loss when exposed to high temperature. Similarly, fibre incorporated polymer mixes showed lower weight loss compared to plain concretes. Most importantly, the weight loss was lower with high fibre incorporated concrete specimens which were exposed to high temperature with a maximum weight loss of 4.08%. The test reulsts indicated similar charactersitcs for the weight loss and the relative weight loss (as provided in Table 4) for polymer concrete mixes containing 0.3% V_f of polypropylene fibres. The experimental trends shown in Fig. 4 provides enough justification on the high temperature performance of different polymer concrete tested in this study.

Table 3. Weight loss (%) for different mix proportions (28 days).

Mix id	SBR %	F/C	Fly ash %	PP %	Weight loss (%)			
					200°C	400°C	600°C	800°C
S1	0	0.6	25	0	1.78	2.76	8.26	8.37
S2	0	0.6	50	0	1.10	3.44	9.57	8.06
S3	0	0.8	50	0	1.27	5.58	9.05	7.72
S4	0	0.8	25	0	0.87	4.32	5.98	5.24
MS1	7	0.6	25	0.1	1.06	2.07	3.27	4.40
MS2	7	0.6	50	0.3	1.20	1.81	4.86	5.35
MS3	7	0.8	50	0.1	0.88	2.28	4.10	5.69
MS4	7	0.8	25	0.3	0.88	2.02	3.21	4.08

Note : Average of 5 concrete specimens tested with standard deviation of 0.62%

Table 4. Relative weight loss (180 days) for different mix proportions at elevated temperature.

Mix id	SBR (%)	F/C	PP (%V_f)	Fly ash %	PP (% V_f)	Relative weight loss 200 °C	Relative weight loss 400 °C	Relative weight loss 600 °C	Relative weight loss 800 °C
S1	0	0.6	0	25	0	0.04	0.07	0.20	0.21
S2	0	0.6	0	50	0	0.03	0.08	0.22	0.20
S3	0	0.8	0	50	0	0.03	0.13	0.22	0.19
S4	0	0.8	0	25	0	0.02	0.11	0.15	0.13
MS1	7	0.6	0.1	25	0.1	0.03	0.05	0.08	0.11
MS2	7	0.6	0.3	50	0.3	0.03	0.04	0.12	0.13
MS3	7	0.8	0.1	50	0.1	0.02	0.05	0.10	0.14
MS4	7	0.8	0.3	25	0.3	0.02	0.05	0.08	0.10

Note : Averkage of 5 concrete specimens tested with standard deviation of 0.04.

The assessment on relative weight loss measurement given in Fig. 5 also evidently showed that the plain concrete suffered more weight loss compared to polymer concrete mixes including fibres. The temperature sustainability after repeated wetting and drying cycles of polymer concretes exhibited the material integrity. It can be also noted that, the plain concrete exhibited a maximum weight loss up to 9.57% and a relative weight loss of 0.22. In the case of 25% and 50% fly ash incorporated concrete mixes the increase in temperature had shown a stable weight loss even when subjected to high temperature. The weight loss of PP fibre substituted concrete showed an apparent reduction of weight loss with a maximum value of 5.69% (**MS3**). Similarly, the weight loss was found to be maximum in the case of high aggregate content (F/C 0.8). The relative weight loss in plain concrete mix showed a maximum value of 0.22 for the concrete mix containing 50% fly ash content (S2 and S3). The temperature performance of both plain and polymer concrete specimen were found to be gradually increasing till 600^{o}C and thereafter a rapid increase was anticipated at 800^{o}C. This possibly shown significant decrease in weight loss for all concrete mixes. It can be justified that, weight loss measurements indicate the complete drying of pore water in the concrete as well as undergoes material decomposition internally. However, in PP fibre concrete mixes, the effect of melting of PP fibres inside the matrix occurs at high temperature beyond 400^{o}c with the formation of channels in the matrix and possibly causes filling effect in the micro cracks upon cooling to room temperature. Also, it can be possibly seen in the case of plain concrete specimen that the weight loss occurred due to loss in moisture occuring in the capillary channels and also leads to disintegration of surface mortar, which reduce the total mass of the specimen.

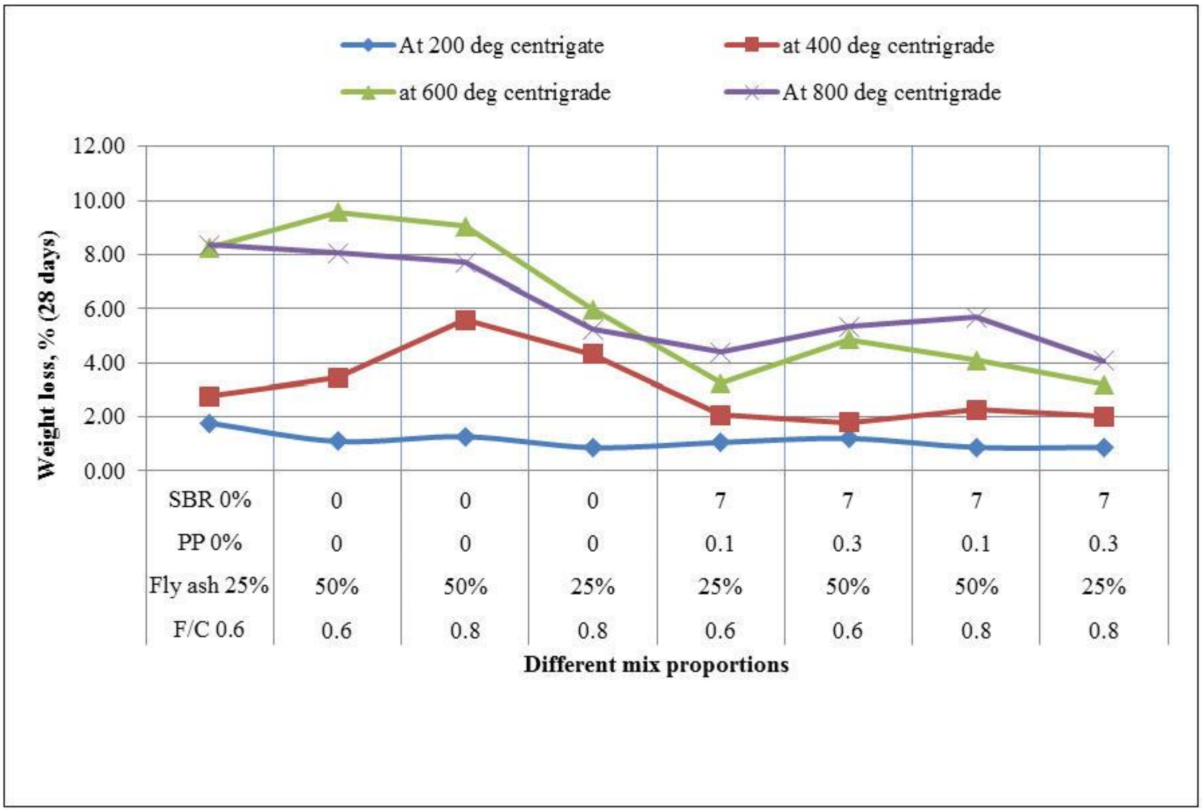


Fig. 4. Weight loss of different concrete mixes at various temperatures.

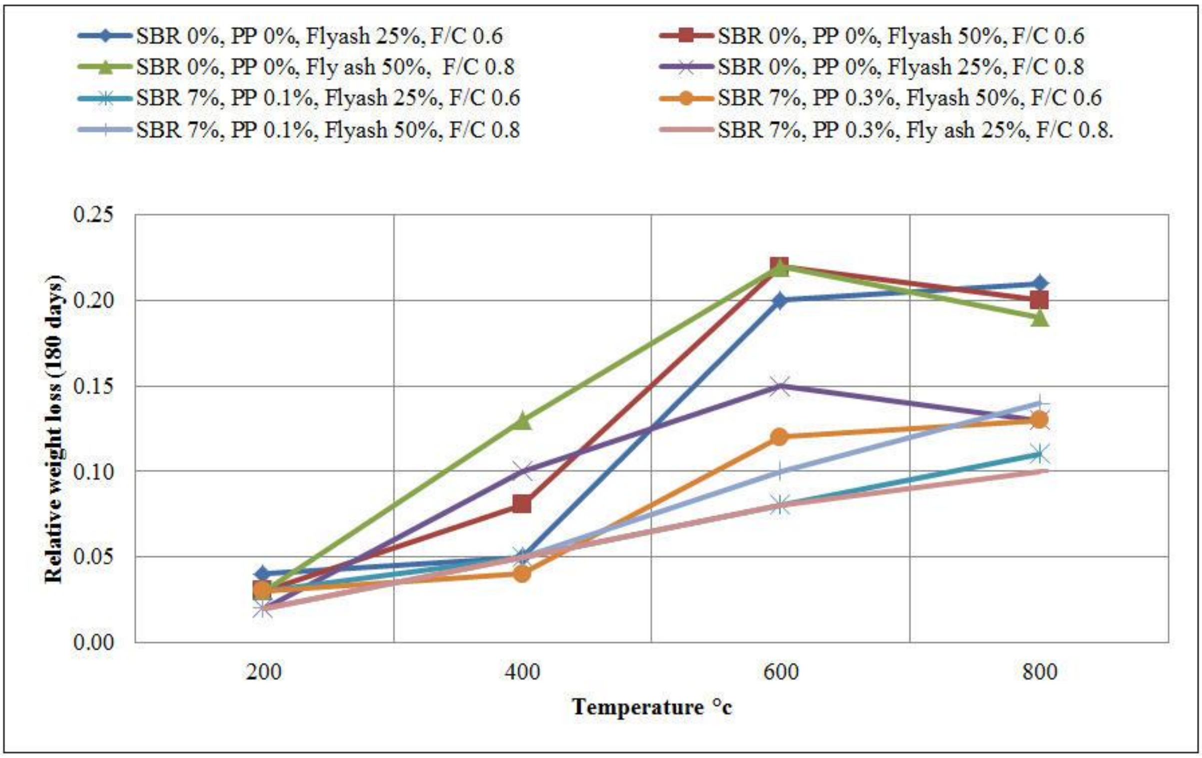


Fig. 5. Relative weight loss of mix proportions at various temperature.

3.2. Effect of High Temperature Exposure on the Compressive Strength

Subsequently after weight loss measurements the relative strength performance of different concrete mixes exposed to high temperature was assessed. Residual strength of all polymer concretes were reportedly higher than plain concretes and this was notably observed in high fibre concretes. As evidently seen from the test results given in Tables 5 and 6 that, the reduction in compressive strength (residual strength) was maximum (56.75%) in the case of plain concrete specimen. As observed from the results, the residual strength of plain concretes showed drastic reduction in strength with increase in temperature beyond 400ºC. However, polymer concretes showed reasonable strength retention and exihibited a maximum residual strength loss upto 3%. The surface of melted PP fibres is shown in Fig. 6(a) and the internal microscopic snapshot shown in Fig. 6(b) provides enough evidence on the relative open channel formed in the matrix due to melting of PP fibres at high temperature (beyond 400ºC). This possibly reveals that the melting of PP fibres had caused a subsequent filling inside the micropores of the matrix and resulted in the matrix strengthening.

Table 5. Residual compressive strength (28 days) for different mix proportions.

Mix id	Initial compressive strength (MPa)	Residual comp strength (MPa) (200 °C)	Residual comp strength (MPa) (400 °C)	Residual comp strength (MPa) (600 °C)	Residual comp strength (MPa) (800 °C)	Percentage of Comp Strength (200°C)	Percentage of Comp Strength (400°C)	Percentage of Comp Strength (600°C)	Percentage of Comp Strength (800°C)
S1	42.7	43.1	37.80	32.50	31.20	+0.93	-11.48	-23.89	-26.93
S2	47.4	46.5	36.80	23.30	20.50	-1.89	-22.36	-50.84	-56.75
S3	43.2	42.1	40.10	35.20	30.20	-2.54	-7.18	-18.52	-30.09
S4	42.8	43.2	40.40	34.60	31.20	+0.93	-5.61	-19.16	-27.10
MS1	46.9	47.9	47.10	54.20	44.30	+2.132	+0.43	+15.57	-5.54
MS2	47.3	48.3	47.90	40.40	44.50	+2.11	+1.27	-14.59	-5.92
MS3	43.4	44.5	47.10	42.30	42.10	+2.53	+8.53	-2.53	-3.00
MS4	55.7	56.5	58.20	59.20	50.20	+1.43	+4.49	+6.28	-9.87

Note : Average of 5 concrete specimens tested with standard deviation of 4.16MPa.

Table 6. Relative compressive strength (180 days) for different mix proportions.

Mix id	SBR	PP	Flyash %	Relative comp strength 200 deg	Relative comp strength 400 deg	Relative comp strength 600 deg	Relative comp strength 800 deg
S1	0	0	25	1.01	0.89	0.76	0.73
S2	0	0	50	0.98	0.79	0.49	0.43
S3	0	0	50	0.97	0.95	0.81	0.70
S4	0	0	25	1.01	0.94	0.81	0.73
MS1	7	0.1	25	1.02	0.98	1.16	0.94
MS2	7	0.3	50	1.02	0.99	0.85	0.94
MS3	7	0.1	50	1.03	1.06	0.97	0.97
MS4	7	0.3	25	1.01	1.03	1.06	0.90

Note : Average of 5 concrete specimens tested with standard deviation of 5.02MPa.

DOI:10.4186/ej.2015.19.4.117

Fig. 6. (a) Surface of fibre concrete showing melted PP fibres at high temperature (800oC).

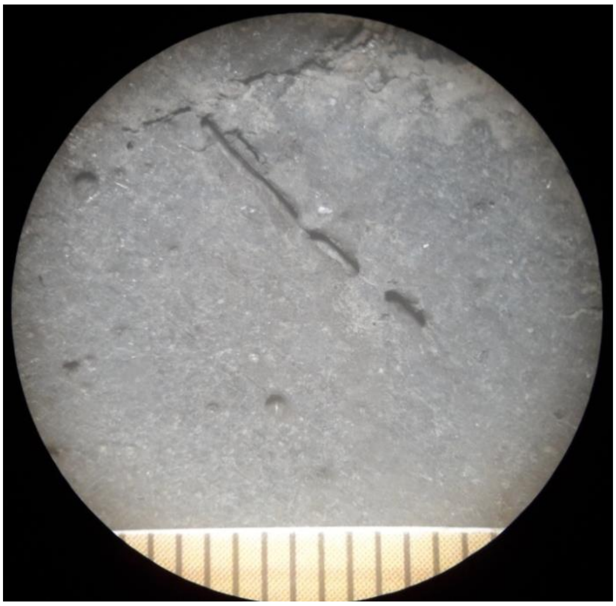


Fig. 6. (b) Melting of PP fibres in polymer fibre concrete at high temperature (400oC).

The relative compressive strength of plain concrete was lower in the case of 50% fly ash substituted concrete mixes (S2) as well as the relative compressive strength was maximum in the case of polymer concrete mix containing higher fibre volume and fly ash substitution (as seen in Fig. 7). This gives an indication that the relative compressive strength was retained even when the concrete specimen being exposed to high temperature after subjected to repeated wetting and drying cycles. The experimental trends clearly indicated a sudden loss in strength with an increase in temperature after 600^{o}C (as seen in Fig. 8). However, the strength reduction was phenomenal at higher temperature up to 800^{o}c. The possible melting of PP fibres and subsequent cooling of thermo plastic polymer reverts back to solid form which can fill the pore structure of the concrete and hence with higher PP fibre content the strength degradation was lower (as seen in Fig. 9). The internal disintegration mechanism occurring in the concrete specimen provided indication of multiple thinner cracks formed on top surface after the specimen exposed to high temperature. The visual examination of concrete specimen showed pale grey colour change on the surface when exposed to high temperature beyond 600^{o}C. This gives an indication that polymer fibre incorporated concrete specimen had shown relative- integrity towards the disintegration of mortar from the aggregate phase as compared to that of plain concrete. The residual compressive strength properties at different temperature ranges provides experimental validation on the performance of polymer concretes. Results demonstrated

DOI:10.4186/ej.2015.19.4.117

the sustainability of polymer based concrete and provides enough reliability of the residual strength properties even when exposed to high temperature accompanied by severe deterioration cycles.

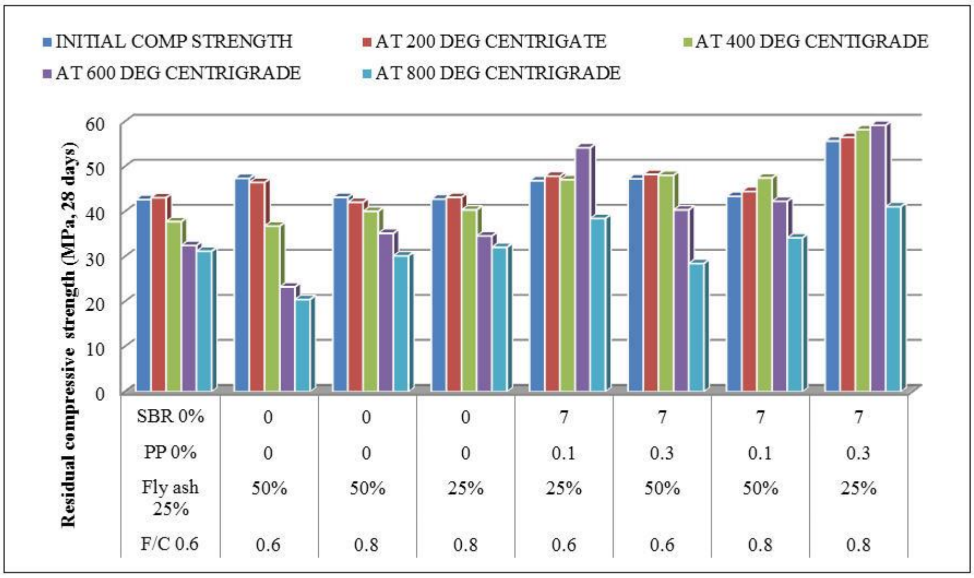


Fig. 7. Residual compressive strength at elevated temperature.

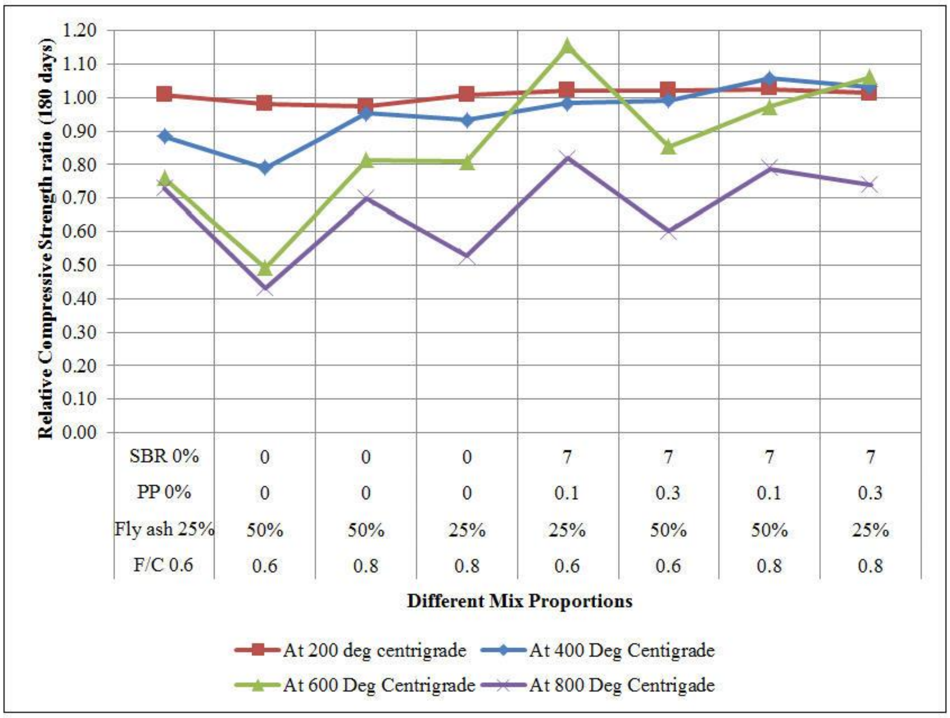


Fig. 8. Relative compressive strength of different concretes at elevated temperature.

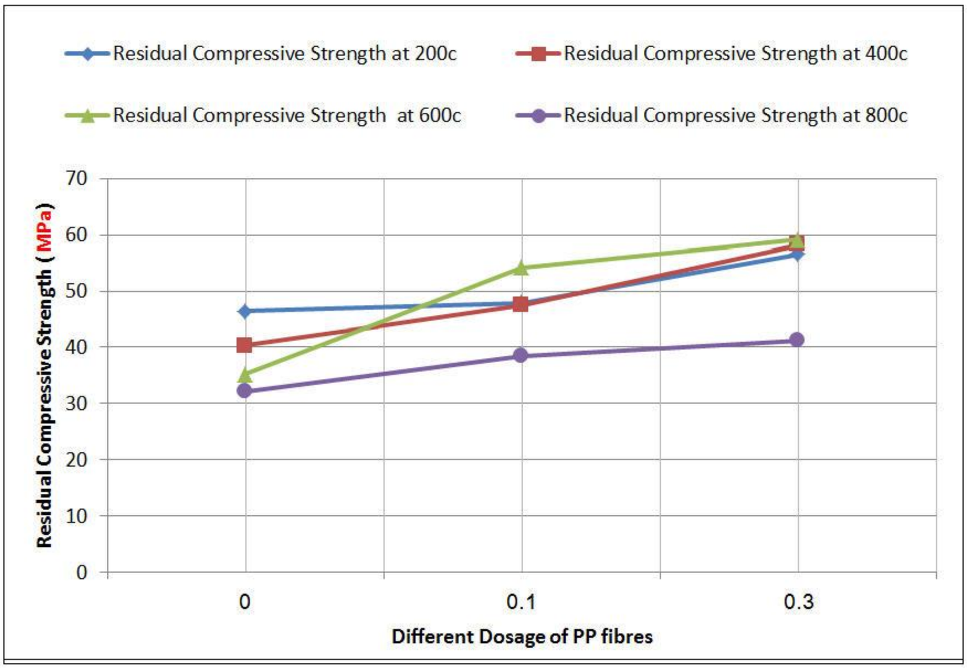


Fig. 9. Residual Compressive Strength of different concretes for different fibres dosage.

3.3. Effect of Temperature on the Residual Elastic Modulus

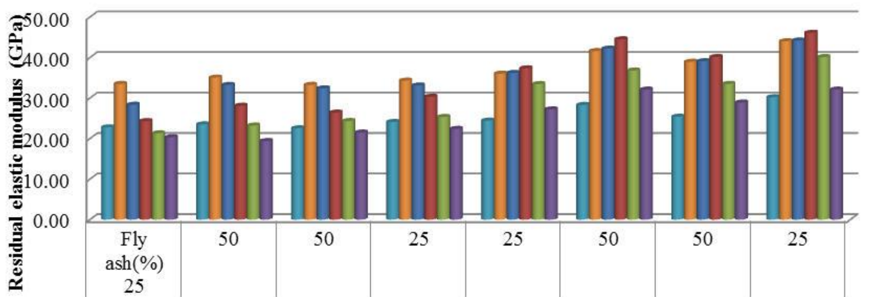
The elastic modulus of various polymer concretes exposed to different temperature was assessed from the compressive stress-strain properties and are presented in Table 7 and represented in Fig. 10. Most notably the loss in elastic modulus was noted in plain concretes at 200°C; whereas the loss was not significant in polymer fibre concretes. With further increase in temperature the loss was phenomenal in plain concretes and a marginal increase upto 3% was noticed in the case of high volume fibre concretes.

Table 7. Residual elastic modulus properties of different polymer concretes.

MIX ID	MIX INGREDIENTS				ELASTIC MODULUS (GPa)		RESIDUAL ELASTIC MODULUS (GPa)			
	PP	F/C	SBR%	Fly ash(%)	7 days	28 days	200° C	400 ° C	600 ° C	800 ° C
S1	0	0.6	0	25	22.77	33.49	28.35	24.32	21.30	20.32
S2	0	0.6	0	50	23.51	35.05	33.24	28.10	23.23	19.4
S3	0	0.8	0	50	22.54	33.26	32.40	26.42	24.34	21.5
S4	0	0.8	0	25	24.10	34.3	33.11	30.34	25.34	22.4
MS1	0.1	0.6	7	25	24.43	36.02	36.21	37.32	33.45	27.21
MS2	0.3	0.6	7	50	28.30	41.6	42.21	44.50	36.80	32.1
MS3	0.1	0.8	7	50	25.40	38.95	39.10	40.12	33.50	28.9
MS4	0.3	0.8	7	25	30.21	44.03	44.21	46.10	40.12	32.1

Note : Average of 5 concrete specimens tested with standard deviation of 3.67GPa.

As anticipated, the stiffness degradation occurred at high temperature (600°C) for PP fibre concretes. This had shown relative reduction in elastic modulus with increase in temperature from 600°C to 800°C. A maximum reduction in stiffness up to 44% was noted in the case of low fly ash substituted plain concrete mixes (**S1**). In the case of polymer concretes (**MS1**), the reduction in elastic modulus was marginally lower and was around 7% for PP fibre concretes. However, with high volume fibre substituted concretes, the elastic modulus (stiffness) degradation was higher at 600°C due to the possible decomposition of calcium hydroxide crystals in the hydrated cement structure. This had subsequently showed a progressive loss in elastic modulus for all concretes; with maximum reduction for plain concretes (without PP fibres). High volume fly ash mixes showed improvement on elastic modulus and exhibited a synergistic performance with fibre addition with SBR latex addition. On the other hand, the polypropylene fibre incorporated concrete mixes showed better elastic modulus compared to plain concrete even though the possible melting of fibres occurred at higher temperature. The possible intrusion of melted PP fibres in the micro crack zone of matrix could possibly improve the stress- strain characteristics. In the case of high volume PP fibre concrete mixes, high temperature resistance inadvertently borne by the fibre reinforced matrix. Results from the studies indicated additional presence of polymeric fibre materials had envisaged high temeprature performance compared to plain concrete. Filler effect of melted polymers inside the pore structure of matrix resisted the matrix disintegration and the effect was pronounced with high volume fibre addition. Stiffness degradation of the composite occurring during progressive high temperature exposure of SBR latex based flyash based concrete mixes is primarily dependent on the matrix integrity.



Fly ash(%)	25	50	50	25	25	50	50	25
SBR%	0	0	0	0	7	7	7	7
F/C	0.6	0.6	0.8	0.8	0.6	0.6	0.8	0.8
PP%	0	0	0	0	0.1	0.3	0.1	0.3
7 days	22.77	23.51	22.54	24.10	24.43	28.30	25.40	30.21
28 days	33.49	35.05	33.26	34.3	36.02	41.6	38.95	44.03
AT 200 C	28.35	33.24	32.40	33.11	36.21	42.21	39.10	44.21
AT 400 C	24.32	28.10	26.42	30.34	37.32	44.50	40.12	46.10
AT 600 C	21.30	23.23	24.34	25.34	33.45	36.80	33.50	40.12
AT 800 C	20.32	19.40	21.50	22.40	27.21	32.10	28.90	32.10

Fig. 10. Residual Elastic Modulus for different concrete mixes.

4. Conclusions

From the experimental studies conducted on the temperature performance of different polymer fibre concretes, the following significant observations are made in this study.

- Polymer incorporated concretes showed a favourable resistance when exposed to elevated temperature upto 400°C and found to be comparatively exhibiting a similar characteristics as that of plain concrete at lower temperature.
- Polymer based fibre inclusion in polymer latex concrete provided adequate matrix strengthening even though when exposed to high temperature upto 400°C.
- The weight loss measurement of polymer concretes substituted with high dosage of polypropylene fibres(0.3% V_f) and fly ash content up to 50% exhibited lower weight loss of 4.08% as well as relative weight loss ratio of 0.1.
- With the increase PP fibre addition, the relative performance of polymer concretes were considerably higher than plain polymer concrete.
- Most importantly the residual compressive strength of polymer fibre concretes exhibited lower strength loss than plain concrete without polymer addition even when exposed to high temperature.
- Residual compressive strength of high volume fibre substituted concretes exhibited better performance than reference concrete without polymer addition.
- The relative compressive strength ratio was also found to be higher in polymer fibre concretes compared to plain concretes.

- Residual elastic modulus of plain concrete was lower compared to PP fibre substituted concrete mixes and the stiffness degradation was noticed after 400^{o}C for all concretes tested in this study.
- Maximum loss in elastic modulus upto 44% was noticed for plain concrete (without polymer fibre) and for polymer fibre concrete the stiffness degradation was around 22%.
- It can be also gneralized that polymer fibre incorporation in concrete resulted in marginal strength reduction even when exposed to high temperature due to pore filling effect of melted PP fibres in the pores (or) cracks. Also the disintegration mechanism was found to be minimal in the case of PP fibre incorporated concrete mixes compared to plain concrete.

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