Journal of Green Engineering (JGE)

Volume-10, Issue-2, February 2020

Sustainable Effects of Crimped White Polypropylene Fibre with Fly Ash and SBR Latex to Act as Green Building Materials in Modified Concrete

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Abstract

This paper deals with the sustainable effect of styrene-butadiene rubber (SBR) latex with crimped PP (polypropylene) fibre 0.1% and 0.3% (aspect ratio-80) used for high-performance concrete (HPC) on mechanical behaviour. However, the constant dosage percentage of SBR latex (7%) of polymer mixes proportion with w/c-0.3. The laboratory test has performed the crushing and flexural rigidity of polymer-modified (PM) concrete exhibit HS (higher strength) than compared to control concrete (CC). Also, SBR latex without fibre concrete exhibits an improved crushing strength of 16.31% than that of CC. SBR latex concrete with 0.3% of fibre shows 23.4%

Journal of Green Engineering, Vol. 10_2, 327–341. Alpha Publishers

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increased. Also, 15.23% increased in the flexural rigidity of SBR latex without fibre than that of CC. However, PM concrete with 0.3% of fibre exhibited higher bending stress around of 51.44 % than compared to CC. Subsequently, the best curing regime was observed the higher strength attainment in SBR latex fibre concrete is 6-day wet curing followed by 22-days of dry curing. Though, SBR latex with 0.3% of fibre concrete showed higher strength than that of 0.1% of fibre SBR latex concrete.

Keywords: Bending stress, Crushing strength, Polypropylene, SBR latex, Ultrasonic pulse velocity

1 Introduction

PM concrete has gained sustainable attention to covering the past 25 years and well known in 1970 for repair works like an overlay for flooring, bridge decks and precast components in Eco-friendly conditions. PMC has produced the excellent tensile strength, good adhesion, waterproof and high resistance in chemical effects. Polymer due to its mobility improves the cohesiveness, prevents bleeding of concrete owing to its high entrapped air and increasing the crushing strength of PMC concrete. Polymer form a film around the cement particle and stitches voids present in the concrete making and stronger to be used in structures like blast resistance structures, vibration and shock resistance. Currently, PP fibres have enlarged in modern building construction industries used for crack resistance materials to arrest the initial and final cracks, drying shrinkage crack and increased Re3 toughness index in CC.

2 Related works

Alhozaimy et al. [1] observed the PP addition significantly does not affect on the crushing but toughness index was improved. However, the presence of silica fume, the crushing strength was increased around 17% for PCC and 23% for fibre cement concrete. The bending stress has considerably increased when the inclusion of the fibre 0%, 0.1% & 0.3% by 44%, 271% & 387% respectively.

Adnan Colak [2] investigated the research work by the addition of SP in CC showed a higher rate of crushing strength at 7-days. However, the addition of latex decreases the crushing strength of each mix. Generally, Latex high concentration increases the resistant to chemical attack and also there was affect the crushing strength when the lower dosage of latex.

Jianzhuang Xiao et al. [3] suggested the reduction in residual crushing strength (RCS) without PP fibre at 400 degrees, whereas RCS has increased when the PP fibre addition in CC. Further, the residual bending stress was noted at higher temperature for different HPC addition and control samples without explosive spalling than that of CC without PP fibres.

Consolazio [4] observed that PP fibre at higher elevated temperature melts and create a path when water vapour pressure built up and overcomes the spalling of concrete.

Ali Behnood et al. [5] investigated the higher residual crushing value of fibre concrete than that of CC. Also, indirect measurement of split tensile of PP fibre showed less strength in concrete at 100°C.

Ahmad et al. [6] observed in his study that reinforced concrete beam after flexural and shear crack strengthened by PM mortar shows 36% increased in load-carrying capacity.

Saeid Kakooei et al. [7] investigated that increase in fibres with a volume of 1.5 & 2 kg/m3 exhibit higher compressive strength. However, fibre addition in concrete by decreasing permeability owing to degradation method, volumetric drying shrinkage and enlargement of concrete which is considerably improved the structures. The opposition to electrical conductivity by the addition of fibres to act as reinforced beams decreases the corrosion of rebars indirectly.

Banthia et al. [8] studied that area where vibrational load resistance is the necessary use of fibres. However, it plays a role by limitation of cracks and provides high crushing strength, bending stress with increasing fibre volume.

Shaker et al. [9] investigated that latex addition in PM concrete exhibits better bonding between the cement and aggregate phase, denser in microstructure, smaller capillary pores compare to the nominal concrete. However, improved penetration resistivity in water saturation also helps to retain the water for cement hydration.

Kiachehr Behfarnia and Omid Farshadfarl [10] concluded the best suitable material effects on least volume in Zeolite and positive approach materials is Metakaoline than compared to silica fume in self-consolidating concrete. Also, PP fibres produced less gain in crushing strength.

Mahmoud Nili and Afroughsabet V [11] examined the impact and strength attainment in 0.36 & 0.46 (w/c) with presence of PP (0, 0.2, 0.3 & 0.4%) and 8 percent of silica fume (SF) for each mix. From, 0.5% of PP with 8% of SF was drawn the excellent performance in hardened characteristics.

Gao et al. [12] observed polymer and the hydrating product showed less water-absorption due to less porosity as a result of increased density. However, SF shows higher strength attainment with less chloride ion diffusion-coefficient.

Peng Zhang and Qing-fu Li [13] examined the composite matrix in PP (0.06, 0.08, 0.1 & 0.12%) with binary materials (fly ash with SF) produced the more reliable in long term performance on the volumetric shrinkage and water permeability. However, gradually decreased the carbonation when the PP addition up to 0.1%. Further, this work concluded there was slight resistance has improved in freeze-thaw.

3 Objectives

- To improve the workability in fresh concrete mode by using fly ash, PP, SBR Latex as used for sustainable binding materials.
- To alter the curing process and mode developed by crushing strength, bending stress for each mix.
- To predict the UPV values for each mix and associated with quality control process as per guidelines.

4 Material Used

4.1 OPC-53 Grade- IS 12262 1969 [14]

Table 1 represents the basic test values were performed in laboratory.

Table 1 OPC-53 grade test results

Consistency	setting time (minutes)		Specific gravity	Fineness	Mortar crushing strength (MPa) [CM 1:3]		
	Initial	Final			3-d	7-d	28-d
32%	120	255	3.18	4%	23.95	29.30	45.35

4.2 Fine Aggregate (FA)

Locally available nearby natural source material used for FA having specific gravity is 2.54 under Zone-III, fineness is 2.90 and confirms [15].

4.3 Coarse aggregate (CA)

Passing -20 mm and retained-10 mm of crushed stone (CA) used and having fineness is 6.85 with specific gravity is 2.57.

4.4 Crimped Polypropylene Fibres (PP)

Figure 1 and Table 2 represents the image and results respectively.

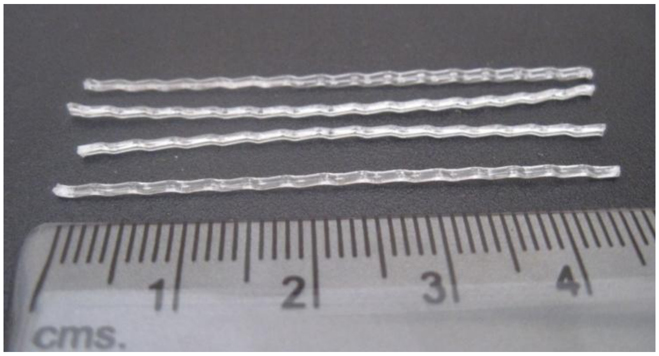

Fig 1 Image of fibres (PP)

Table 2 Polypropylene fibres

Appearance	Fibre (Vf) %	Relative Density (g/cc)	Length (mm)	l/d ratio	Diameter (mm)	Tensile strength	Failure strain
Crimped PP – white colour	0.1, 0.2 & 0.3	0.9	48	80	0.6	450	15%

4.5 Poly Carboxylic Ether based Superplasticizer (PCE)

PCE was used for various mixes owing to achieving the desirable slump within the range of 85 mm in fresh concrete.

4.6 Water

All samples have fully immersed in normal water without any harmful impurities.

4.7 Mix proportions

Table 3 represents the experimental investigation so far engaged for conceptual mix design of nine different mixture proportion of concrete mix with 0.4 w/b-ratio, different F/C-ratio 0.6 and FLA 25% and 50% (by weight) with one type of crimped polypropylene fibres from 0.1% to 0.3% and also with and without SBR 7% added for throughout experimental works with further improvement of workability for add (by weight of binder content) containing PCE was used.

Table 3 Mix constituents details

Mix	OPC	Fly ash (FLA)	Aggregate Fine	Aggregate Coarse	Water	F/C	w/b	SBR Latex %	PP(%) Vf
			Kg/m^3						
KL-0	400	100	844	1056	120	0.8	0.3	0	0
KL-1	400	200	800	1000	120	0.8	0.3	0	0
KL-2	400	100	844	1056	120	0.8	0.3	7	0.1
KL-3	400	200	800	1000	120	0.8	0.3	7	0.1
KL-4	400	100	844	1056	120	0.8	0.3	7	0.3
KL-5	400	200	800	1000	120	0.8	0.3	7	0.3
KL-6	400	100	844	1056	120	0.8	0.3	7	0
KL-7	400	200	800	1000	120	0.8	0.3	7	0

4.8 Specimen Details

Table 4 represents the different sample size details were casted as per standard specification.

Table 4 Specimen details

Shape	Size of the concrete specimens (m)	Tested
Cube (compression)	0.15 x 0.15 x 0.15	Crushing & UPV [17]
Prism (Flexural rigidity)	0.1 x 0.1 x 0.5	Flexural rigidity – 3rd point loading method

4.9 Samples, Method of Curing & Testing Methods

All the ingredients initially dry mixed after that required amount of water with superplasticizer was added. Further, 30 seconds were used for a horizontal type of table vibrator in fresh concrete and finished top surface with the help of a trowel. After reached 24-hours, all the samples were demoulded and kept curing for protecting the temperature occurred inside the concrete when hydration takes place at different age of curing.

Figure 2 shows the concrete samples have tested for strength in CTM as prescribed in IS) 516-1959 [16] and Figure 3 represents the flexural testing machine for assessing the bending behaviour of fibre concrete.

Fig, 2 Test setup for CTM

Fig. 3 Test setup for flexural rigidity

5 Results and Summary

5.1 Crushing failure of Concrete

Figure 4 denotes the experimental results for altered curing process adopted for each mix. From the test results, it has proved the SBR latex modified concrete was maximum crushing strength by using for 6-days wet followed by 22-days for dry curing than that of all mixes.

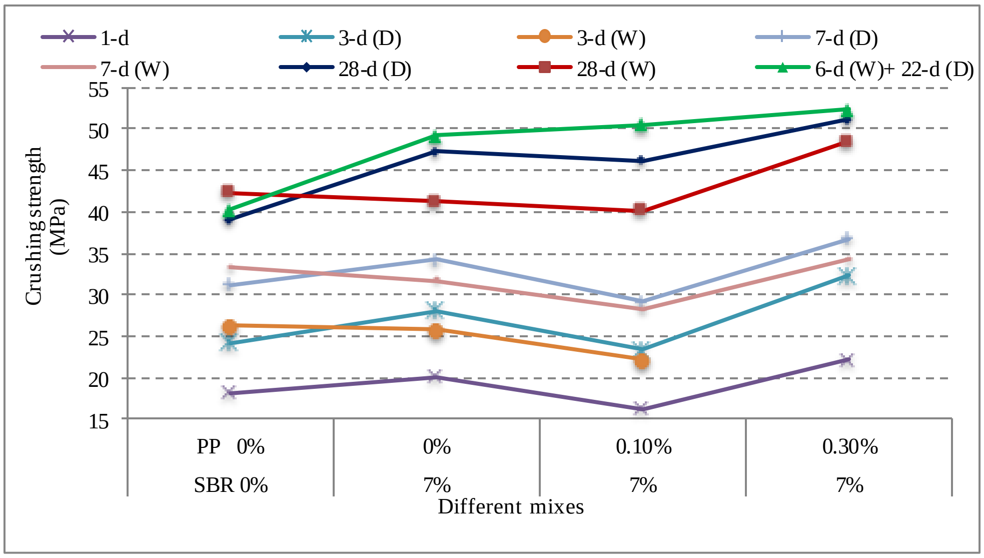

Fig. 4 Crushing strength without fly ash mixes

Figure 5 graphically represents the alternate curing in crushing strength of fly ash substituted in OPC. For 7% of SBR Latex with 0.3% of PP reached the excellent improvement in crushing strength 52.30 MPa at 6-days for wet followed by 22-days of dry-cured samples than that of other cycling processes of curing.

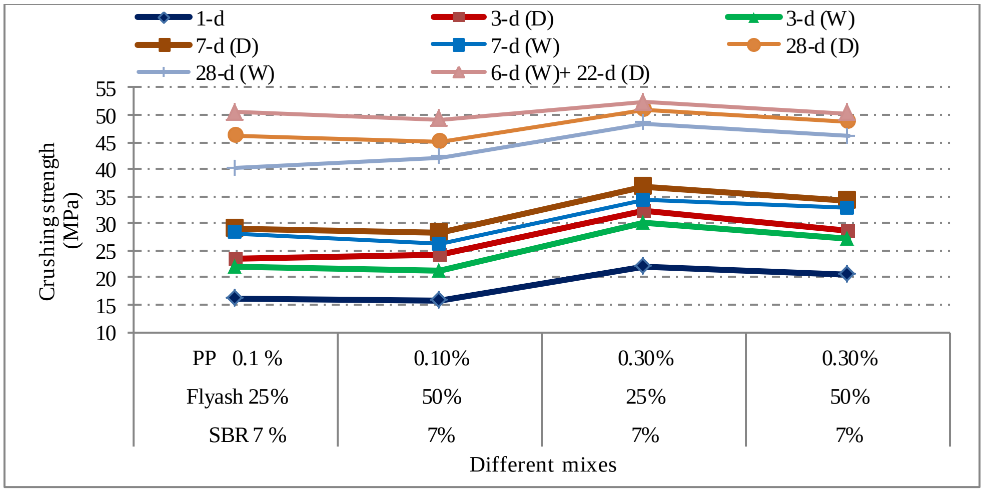

Fig. 5 Crushing strength with fly ash mixes

5.2 Flexural rigidity

Figure 6 graphically represents the alternate curing in bending stress (flexural) with 25 and 50% of fly ash substituted in OPC for each mix. However, SBR Latex (7%), 0.3% of PP and 25% of fly ash have reached maximum bending stress 6.10 MPa for 6-days wet followed by 22-days of dry-cured samples than that of another curing methods.

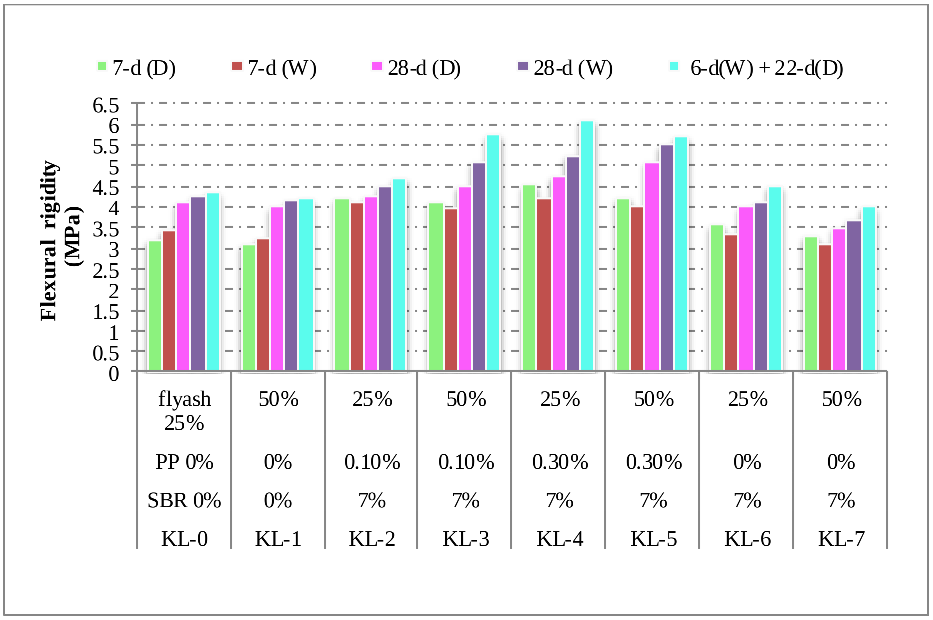

Fig. 6 Flexural rigidity for different curing regime

5.3 UPV (Ultrasonic pulse velocity)

The digital UPV machine used to measure the UPV as prescribed in IS 13311 part 1 [17] when the pulse velocity is induced into the concrete from the transducer to the receiver at a known distance (0.15 m). The time taken divided by path length is known as UPV and measured continuously for each sample. Figure 7 represents the recorded UPV from 3120 m/sec to 4420 m/sec for dry and wet curing at 28-days and also prescribed the conclusion Southararajan and Sivakumar [18].

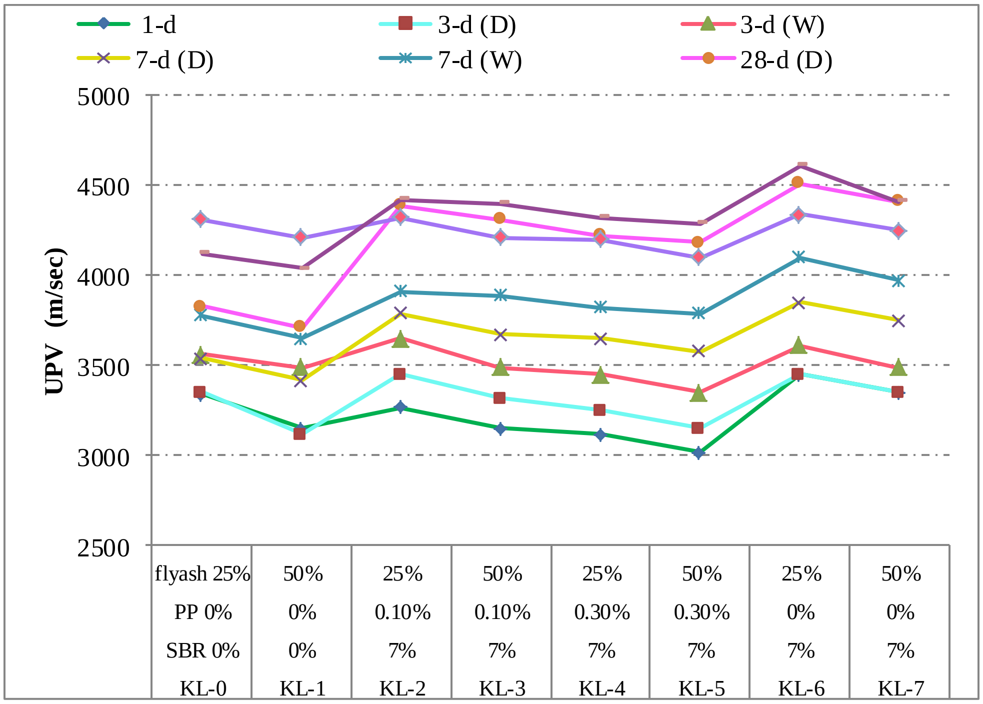

Fig. 7 UPV for different mixes

6 Conclusion

From the laboratory investigations, it has invented higher bending stress by addition of 0.3% of PP fibres and bring to knowledge related to sustainable binding materials with Eco-friendly.Usage of SBR latex at different mixes, it is the working mechanism of strength attainment in concrete for different curing regime.Crushing strength of concrete specimens exhibited an excellent improvement than compared to CC. Flexural rigidity has drastically gained than compared to the crushing strength of concrete for every mix.It's performed the reinforcing index of PP fibre concrete has developed in micro levels, density, and strength attainment. UVP to predict the structural quality of concrete for all mixes lies within the Good rating as per code. It's transparent from this research work when the usage of composite materials and provided better sustainable characteristics than CC and also initiated up a diversity of innovative and exciting production materials.

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Biographies

Dr V.M. Sounthararajan working as a Professor in the Department of Civil Engineering at CMR Technical Campus, Hyderabad, Telangana. He has 9.5 years teaching as well as research experience. Also, eight years of Industrial experience. He is a reviewer for more than four reputed journals. He is a Member of Indian Society for Technical Education. He has received the best research awards at VIT University in the year of 2012 and 2013. He has published more than 58 research papers in various National and International journals, conferences and recently filed one patent.

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Dr L Ponraj Sankar working as a Professor in the Department of Civil Engineering at CMR Institute of Technology, Hyderabad, India. He completed his Diploma in Civil Engineering Govt. Polytechnic, Tuticorin, Tamil Nadu, Bachelor's degree in Civil Engineering in ACCET, Karaikudi, Master's and PhD degree in Structural Engineering from Anna University, Chennai, India. His areas of research interest are High Performance Concrete, Reinforced Concrete Structures, Structural Design of Multistory Building, Retrofitting and Rehabilitation of Structures and Materials, Optimization technique and soft computing. He has been published several papers in national and international Journals and Conferences and also he presented one International conference paper presentation at Mahsa University, Malaysia. He is having academic experience of 14 years and Six months including two years of service at Haramaya University, Ethiopia and 18 years of industrial experience in Structural Design and Construction of Multistory Buildings and Residential Buildings. In January 2020, he has applied one Patent.