ISSN 2228-9860 eISSN 1906-9642 CODEN: ITJEA8

TuEngr Group

International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://TuEngr.com

Effect of Polypropylene Fibres on the Ductility performance of Ternary Blended Concrete Beams

Sala Gayathri[1*], K.Suguna[1], P.N.Raghunath[1]

Dept. of Civil and Structural Engineering, Annamalai University, Annamalainagar, INDIA.
**Corresponding Author(Email: sala.gayathri @gmail.com).*

Paper ID: 13A7H

Volume 13 Issue 7

Received 12 January 2022
Received in revised form 12 May 2022
Accepted 19 May 2022
Available online 26 May 2022

Keywords:
Cracking; Deflection; Ductility; Energy Capacity; Energy Ductility; Fibre Reinforced Concrete; Nano-Alumina; Polypropylene Fibre; Strength; Static Loading; Zeolite.

Abstract

The results of an experimental study conducted to evaluate the material characteristics of ternary blended concrete containing Nano-alumina and Zeolite along with polypropylene fibres to act as micro-reinforcement has been presented in this paper. The optimum combination of nano-alumina and zeolite has been obtained through preliminary studies. The beams were cast with concrete containing 1% Nano-Alumina and 10% Zeolite having PPF fibres in three-volume fractions (0.1, 0.2 and 0.3%). Six beam specimens of overall dimensions 150mm x 250mm x 3000mm were tested for their flexural capacity in a standard loading frame. One beam was made out of control concrete. The remaining five beams were made with ternary blended concrete with and without micro-reinforcement. The beam specimens were examined for their behaviour under static loading conditions. The performance of the beam specimens was assessed in terms of first crack load, deflection at first crack load, yield load, deflection at yield load, ultimate load, deflection at ultimate load, deflection ductility, and deflection ductility ratio, energy ductility and energy ductility ratio. The inclusion of polypropylene fibres increased ultimate crack load by 40%, decreased deflection by 84.17%, decreased crack width by 45.45%, decreased crack spacing by 55%, increased deflection ductility by 34.31%, increased energy ductility by 84.38% and increased energy capacity by 151% compared to the control concrete beam.

Disciplinary: Civil & Structural Engineering.

Cite This Article:

Gayathri, S., Suguna, K. , Raghunath, P. N. (2022). Effect of Polypropylene Fibres on the Ductility performance of Ternary Blended Concrete Beams. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 13*(7), 13A7H, 1-13. http://TUENGR.COM/V13/13A7H.pdf DOI: 10.14456/ITJEMAST.2022.134

1 Introduction

In recent years, ultra-fine materials are introduced into concrete to achieve particle packing thereby resulting in improved performance for use under varying environmental conditions. Some ultrafine materials include nano silica, nano alumina, nano clay, Zeolite, Alccofine. The inclusion of a 0.3% volume fraction of PP fibres increased compressive strength by 18.93%, reduced crack area by 53.1% and reduced crack width by 51.51% (Banthia et al. 2006). The beams increased bending resistance by 5.17% and increased tensile strength by 50% with the inclusion of 0.8 kg/m^3 PP fibres in concrete (Hiep et al. 2020). The addition of a 0.35% volume fraction of polypropylene fibres increased deflection by 14.28% at ultimate load, decreased crack width by 43.90%, increased energy absorption capacity by 157.14%, and increased ductility factor by 97.36% and increased ultimate flexural strength by 19% (Arivalagan 2012). The addition of 0.6 kg/m^3 PP fibres increased the cracking load by 33.98% (Yang, 2021). The addition of a 0.4% volume fraction of PP fibres increased compressive strength by 5%, increased tensile strength by 65%, increased flexural strength by 80% and reduced shrinkage cracking by 83% (Ahmed, 2016). The addition of 0.5% polypropylene fibres increased compressive strength by 15% and increased initial crack load by 10% (Sundar -2017). The addition of a 0.2% volume fraction of PP fibres increased flexural toughness by 95% and increased impact resistance by 90% (Alhozaimy-1996). The addition of PP fibres increased compressive strength by 16%, increased split tensile strength by 23%, and increased flexural strength by 36% (Patel-2011)

2 Experimental Program

2.1 Materials

The concrete mixtures were made using OPC 53 grade (IS 12269-2013) cement. The specific gravity of cement used was 3.15 and the w/c ratio 0.48. Natural river sand conforming to the requirements of IS 383:2016 was used as fine aggregate. 20mm and 12mm size crushed granite coarse aggregate was used. HYSD bars of characteristic strength 500MPa were used for the main reinforcement. The concrete specimens were made with different cement replacement materials (zeolite-10% and 1% NA) and varying volume fractions (0.1%, 0.2% and 0.3%) of polypropylene fibres. Additionally, Conplast 430 superplasticizer was used to meet the workability and strength requirements. The characteristics of the materials used are presented in Table 1.

Table 1: Properties of Material

Material	Specific Gravity	Specific Surface area (m^2/g)
Cement	3.14	300
Zeolite	2.6	20
Nano Alumina	1.2	30
Polypropylene Fibre	0.910	-
Fine Aggregate	2.61	-
Coarse Aggregate	2.80	-

2.2 Mix Proportion

Mix design has been done according to IS 10262:2019. The concrete consisted of 387 kg/m3 of cement, 654 kg/m3 of FA and 1219 kg/m3 of CA. A water binder ratio of 0.48 was adopted for the control concrete and ternary blended concrete with and without fibres. The desired slump in each case has been achieved through the use of SP in appropriate dosages. The mix details are presented in Table 2.

Table 2: Mix Details

Details	CC	Z	ZA	ZAP-1	ZAP-2	ZAP-3
Cement (Kg/m^3)	387	348.3	344.43	344.43	344.43	344.43
FA (Kg/m^3)	654	654	654	654	654	654
CA (Kg/m^3)	1219	1219	1219	1219	1219	1219
Zeolite (Kg/m^3)	-	38.70	38.70	38.70	38.70	38.70
Nano-Alumina (Kg/m^3)	-	-	3.87	3.87	3.87	3.87
PPF (%)	-	-	-	0.1%	0.2%	0.3%
Water (l/m^3)	187	187	187	187	187	187

2.3 Preparation of Control Specimens

The absolute volume method recommended by ACI 318-18 was used to compute the quantities of materials. Cubes of size 150X150X150mm have been used for estimating the compressive strength, Prism's specimens of size 100X100X500 mm were cast and tested for determining the modulus of rupture and Cylinder specimens of size 150X300mm were cast and tested for finding the modulus of elasticity. The nomenclature of beam specimens and test results of control specimens are is presented in Tables 3 and 4.

Figure 1: Casting and Curing of Control Specimens

Table 3: Nomenclature of Test Beams

Designation of Beams	Description
CC	Conventional Concrete
Z	Specimen with 10% Zeolite
ZA	Specimen with 10% Zeolite and 1% Nano- alumina
ZAPS-1	Specimen with 10% Zeolite , 1% Nano- alumina and 0.1% Polypropylene Fibre
ZAPS-2	Specimen with 10% Zeolite , 1% Nano- alumina and 0.2% Polypropylene Fibre
ZAPS-3	Specimen with 10% Zeolite , 1% Nano- alumina and 0.3% Polypropylene Fibre

Table 4: Experimental Results of Control Specimens

S.No.	Mix Designation	Compressive Strength (N/mm^2)		Modulus of Elasticity (GPa)	Split Tensile Strength (N/mm^2)	Modulus of Rapture (N/mm^2)
		Cube	Cylinder			
1	CC	39.04	30.45	31.18	3.32	6.5
2	Z	40.93	31.51	32.53	3.78	7.1
3	ZA	42.06	33.22	34.42	4.26	7.5
4	ZAPS-1	44.98	35.08	34.99	4.89	7.7
5	ZAPS-2	46.59	35.97	35.41	5.18	7.9
6	ZAPS-3	42.12	33.69	36.21	5.53	8.9

2.4 Details of Beam Specimens

A total of six beams were cast in this study. One beam was made with control concrete. One beam was made with Zeolite-based concrete. One beam was made with ternary blended concrete containing nano-alumina and Zeolite. Three beams were fabricated with ternary blended concrete containing polypropylene fibres in varying volume fractions. The beam specimens were of size 150X250X3000mm. The longitudinal steel consisted of 8 mm-dia. 2-legged links at 125 mm c/c. A reinforced index of 0.603% was adopted for the beam specimens. The details of the beam specimen are presented in Figure 2.

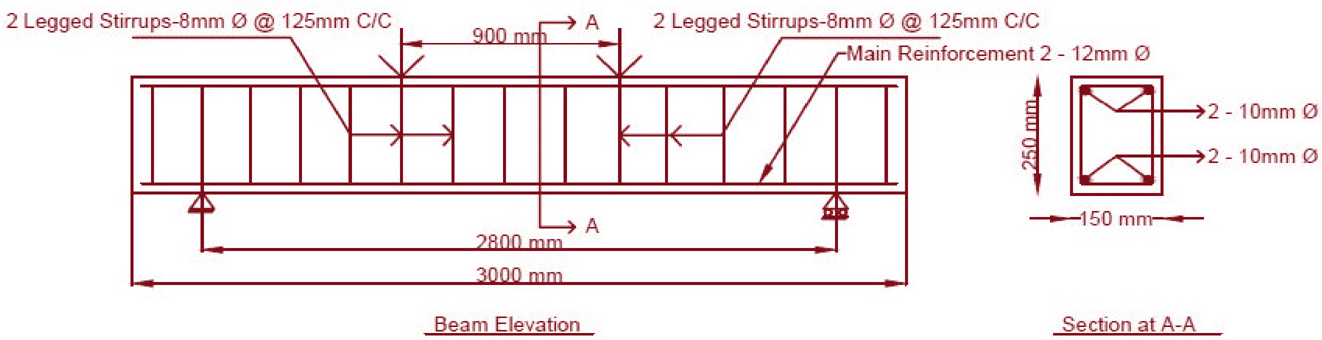

Figure 2: Reinforcement details of Beam Specimens

Table 5: Details of Beam Specimens

Sl. No.	Beam Designation	Steel Ratio	PPF Volume Fraction (%)
1	CC	0.603	0
2	Z	0.603	0
3	ZA	0.603	0
4	ZAPS-1	0.603	0.1
5	ZAPS-2	0.603	0.2
6	ZAPS-3	0.603	0.3

2.5 Test Setup

The RC beam specimens were subjected to static loading in a loading frame of capacity 1000 kN until failure. Four-point bending test was conducted over a span of 2800 mm. The deflections were measured at the desired positions using displacement gauges with an accuracy of 0.01 mm. The crack width was measured using a crack detection microscope with an accuracy of 0.02 mm. The crack growth and propagation were monitored throughout the loading process. The static loading test setup is shown in Figure 3.

Figure 3: Static Loading Arrangement and Instrumentation

3 Test Results and Discussion

3.1 Effect of PPF on Strength

A maximum increase of 45.71% in the first crack load was shown by the ternary blended concrete beam having a 0.3% volume fraction of polypropylene fibres (ZAPS-3) over the control beam CC. The beam specimens ZS, ZAS, ZAPS-1, ZAPS-2 & ZAPS-3 exhibited an increase of 8.57%, 17.14%, 28.57%, 42.85% and 45.71% with respect to the CC beam. The beam specimens ZAS, ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase of 7.89%, 18.42%, 26.31% and 34.21% with respect to the ZS beam. The beam specimens ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase of 9.75%, 17.07% and 24.39% with respect to the ZAS beam. The effect of PPF on the first crack load is presented in Figure 4. The test results of beam specimens are presented in Table 6.

Table 6: Test Results of Beam Specimens

Beam Designation	First Crack Load (kN)	Deflection at First Crack Load (mm)	Yield Load (kN)	Deflection at Yield Load (mm)	Ultimate Load (kN)	Deflection at Ultimate Load(mm)
CCS	17.50	2.00	34.50	7.09	52.50	14.47
ZS	19.00	2.51	35.71	7.17	55.00	16.54
ZAS	20.50	2.92	37.50	7.22	58.50	18.08
ZAPS-1	22.50	3.55	39.00	8.82	62.50	20.90
ZAPS-2	24.00	3.86	42.00	9.38	68.00	23.56
ZAPS-3	25.50	3.94	45.00	9.71	73.50	26.65

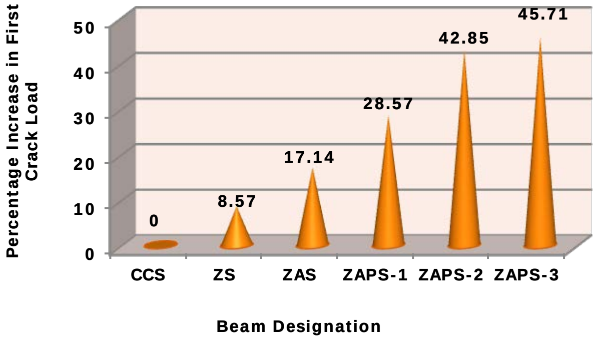

Figure 4: Effect of PPF on First Crack Load

The yield load was obtained from the load-deflection curve. The beams ZS, ZAS, ZAPS-1, ZAPS-2 and ZAPS-3 exhibited an increase of 3.51%, 8.69%, 13.04%, 21.74% and 30.43% compared to the CCS beam specimen. The beam specimens ZAS, ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase of 5.01%, 9.21%, 17.61% and 26.01% with respect to the ZS beam. The beam specimens ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase of 4%, 12% and 20% with respect to the ZAS beam. The effect of PPF on yield load is presented in Figure 5

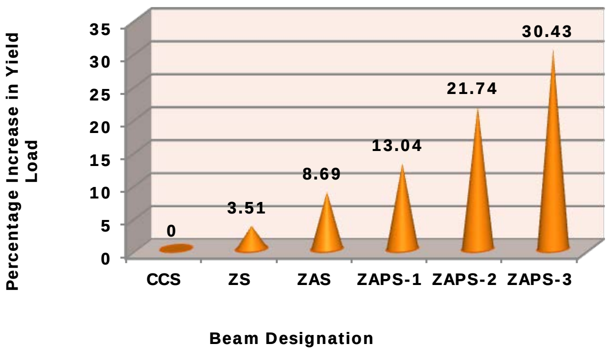

Figure 5: Effect of PPF on Yield Load

The Ultimate load was obtained corresponding to the stage of loading beyond which the beam cannot resist any additional deformation at the same load intensity. The beams ZS, ZAS, ZAPS-1, ZAPS-2 and ZAPS-3exhibited an increase of 4.76%, 11.42%, 19.04%, 29.52% and 40.0% compared to CCS beam. The beam specimens ZAS, ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase of 6.36%, 13.63%, 23.63% and 33.63% with respect to the ZS beam. The beam specimens ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase of 6.87%, 16.23% and 25.64% with respect to the ZAS beam. The effect of PPF on Ultimate load is presented in Figure 6

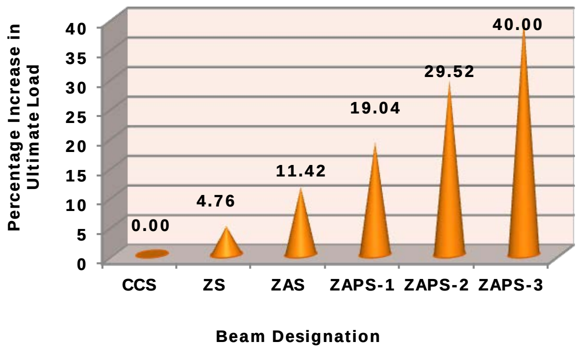

Figure 6: Effect of PPF on Ultimate Load

3.2 Effect of PPF on Deflection

Beams with PP fibres exhibited an increase in deflection at the first crack load of 77.5%, 93% and 97% compared to the CCS beam. The beam specimensZAPS-1, ZAPS-2and ZAPS-3exhibited a decrease of 21.57%, 32.19% and 34.93% compared to the ZAS beam. The beam specimensZAPS-1, ZAPS-2and ZAPS-3 exhibited a decrease of 41.43%, 53.78% and 56.97% compared to the beam ZS. ZAS beam exhibited a decrease of 16.33% over the ZS beam. Figure 7 shows the effect of PPF on a deflection at first crack load.

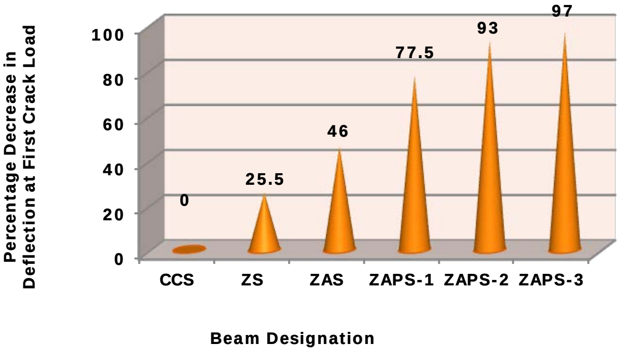

Figure 7: Effect of PPF on Deflection at First Crack Load

The deflection at yield load was obtained from load-deflection plots. The specimens ZS, ZAS, ZAPS-1, ZAPS-2 and ZAPS-3 exhibited a decrease up to 1.13%, 1.84%, 15.94%, 32.29% and 36.95% with respect to the CCS beam specimen. The beam ZAPS-1, ZAPS-2 and ZAPS-3 showed a decrease of 20.01%, 30.82% and 34.42% in deflection over the ZS beam specimen. The beams ZAPS-1, ZAPS-2 and ZAPS-3showed a decrease in deflection of 22.16%, 29.91% and 34.48% with respect to beam ZAS. Figure 8 shows the effect of PPF at yield load deflection.

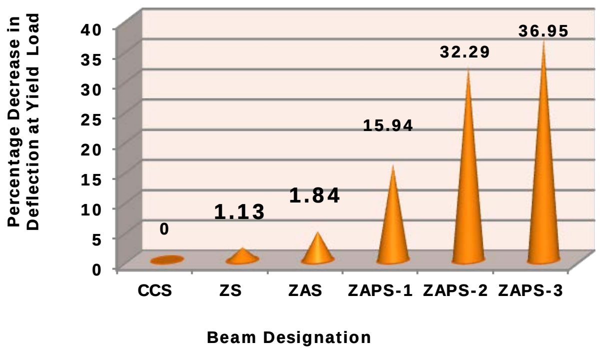

Figure 8: Effect of PPF on Deflection at Yield Load

The beam specimens ZS, ZAS, ZAPS-1, ZAPS-2 and ZAPS-3 showed a decrease up to 14.30%, 24.94%, 44.43%, 62.81% and 84.17% with respect to the CCS specimen at Ultimate load. The beamsZAPS-1, ZAPS-2 and ZAPS-3 exhibited a decrease of 26.36%, 42.44% and 61.12% with respect to the ZS beam. The beams ZAPS-1, ZAPS-2 and ZAPS-3 showed a decrease in deflection of 15.59%, 30.30% and 47.40% compared to the beam specimen ZAS. The decrease of 9.31% was exhibited by the beam specimen ZAS over the ZS beam. Figure 9 shows the effect of PPF on ultimate load deflection.

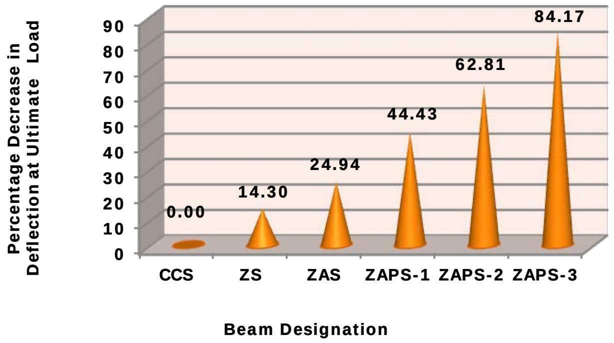

Figure 9: Effect of PPF on Deflection at Ultimate Load

3.3 Load-Deflection Relationship

The curves were linear up to the first crack stage. The slope of the curves started decreasing with an increase in loading. The beam also showed an increase in the number of cracks. With a further increase in load, the reinforcing steel started yielding and the slope of the curves started decreasing largely. The beam showed higher deflections and the number, as well as the size of cracks, increased furthermore. The cracks also propagated towards the compression face of the beam. This trend continued up to the ultimate stage. The relationship between load-deflection is shown in Figure 10.

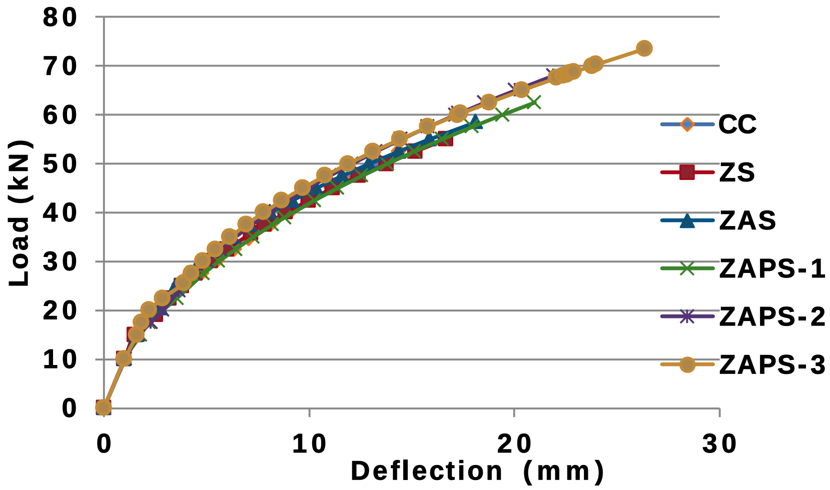

Figure 10: Load-Deflection Response of Beams

3.4 Cracking History and Failure Modes

The test beams experienced considerable flexural cracking and vertical deflection near to failure. Well distributed closely spaced cracking was observed. None of the beams exhibited sudden catastrophic failure. The crack width, number of cracks and the average spacing of cracks at the ultimate stage are furnished in Table 7. The Polypropylene fibre reinforced ternary blended concrete beams exhibit a decrease in crack width and a decrease in spacing of cracks compared to the CC beam specimens.

Table 7: Crack Width and Mode of Failure

Beam Designation	Crack Width (mm)	No. of Cracks	Crack Spacing (mm)	Failure Mode
CCS	0.44	13	160	Flexure
ZS	0.4	15	135	Flexure
ZAS	0.37	17	115	Flexure
ZAPS-1	0.32	20	94	Flexure
ZAPS-2	0.28	23	85	Flexure
ZAPS-3	0.24	27	72	Flexure

Beams ZS, ZAS, ZAPS-1, ZASP-2 and ZAPS-3 exhibited a decrease in spacing of cracks of 15.62%, 28.12%, 41.25%, 46.87% and 55% with respect to CC beam. The inclusion of PP fibres exhibited a decrease in spacing of cracks by 30.37%, 37.03% and 46.66% compared to the ZS beam. ZAS beam showed a 14.81% decrease in spacing of cracks compared to the ZS beam. The beams with PP fibres (ZAPS-1, ZASP-2 and ZAPS-3) exhibited a decrease in crack spacing by18.26%, 26.08% and 37.39% compared to the beam ZAS. Figure 11 shows the effect of PPF on the spacing of cracks.

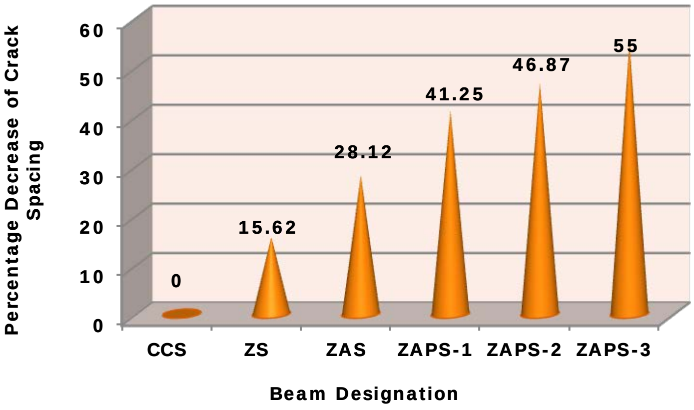

Figure 11: Effect of PPF on Crack Spacing

Beams ZS, ZAS, ZAPS-1, ZASP-2 and ZAPS-3 exhibited a decrease in width of crack of 9.09%, 15.9%, 27.27%, 36.36% and 45.45% with respect to the beam CC beam. The PP fibre beams (ZAPS-1, ZASP-2 and ZAPS-3) exhibited a decrease in width of cracks by 20%, 30%and 40.0% found compared to the ZS beam. The ZAS beam showed a 7.5% decrease in crack width compared to the ZS beam. The PPF beams (ZAPS-1, ZASP-2 and ZAPS-3) exhibited a 13.51%, 24.32% and 35.13% decrease in crack width compared to the ZAS beam. Figure 12 shows the effect of PPF on the width of cracks.

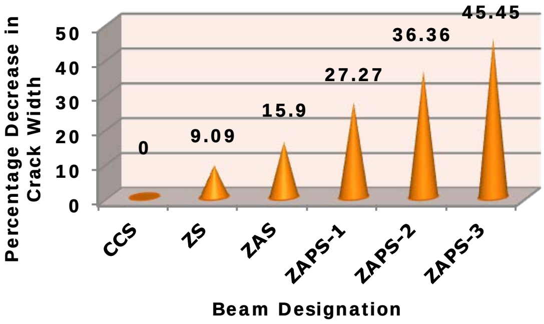

Figure 12: Effect of PPF on Crack Width

Beams ZS, ZAS, ZAPS-1, ZASP-2 and ZAPS-3 exhibited an increase in the number of cracks of 15.38%, 30.76%, 53.84%, 76.92% and 107.69% respectively compared to the conventional concrete beam. Beams with PP fibres (ZAPS-1, ZASP-2 and ZAPS-3) exhibited a 33.33%, 53.33% and 80% increase in the number of cracks compared to the ZS beam. ZAPS-1, ZASP-2 and ZAPS-3 exhibited17.64%, 35.29% and 58.82% increase in the number of cracks compared to the beam ZAS. Figure 13 shows the effect of PPF on the number of cracks.

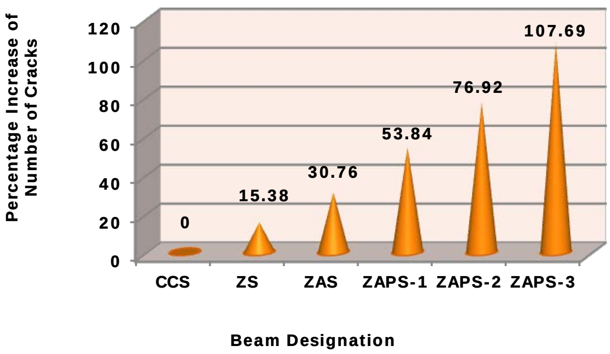

Figure 13: Effect of PPF on Number of Cracks

The mode of failure and crack pattern of the six beams is shown in Figure 14. In the early stages of loading, hairline cracks were observed in the constant moment zone. With the increase in loading, new cracks formed and the existing cracks propagated further with an increase in size along the loaded span.

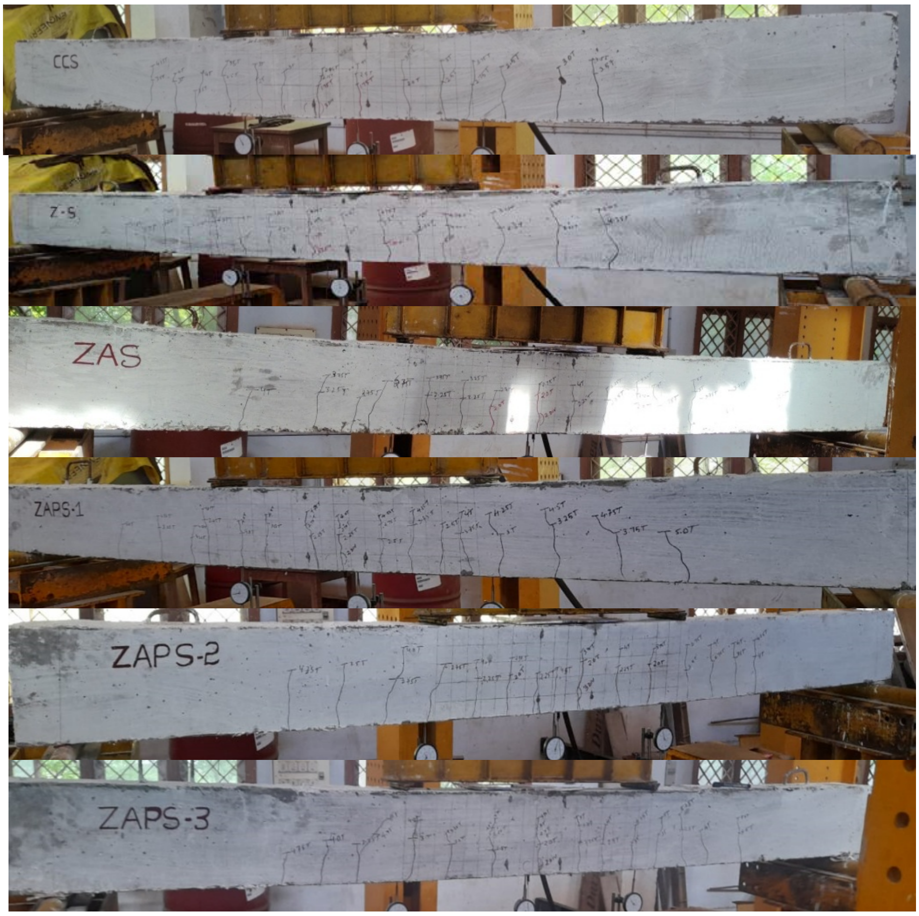

Figure 14: Crack Pattern of Beam Specimens

3.5 Moment-Curvature Relationship

The moment-curvature relationship of the beam specimens is shown in Figure 15. It has been noticed that up o the first crack, M – Phi curves were linear having high slopes. With increased loading, the slope of the curves started decreasing gradually up to the yield stage. The same trend continued up to the ultimate stage.

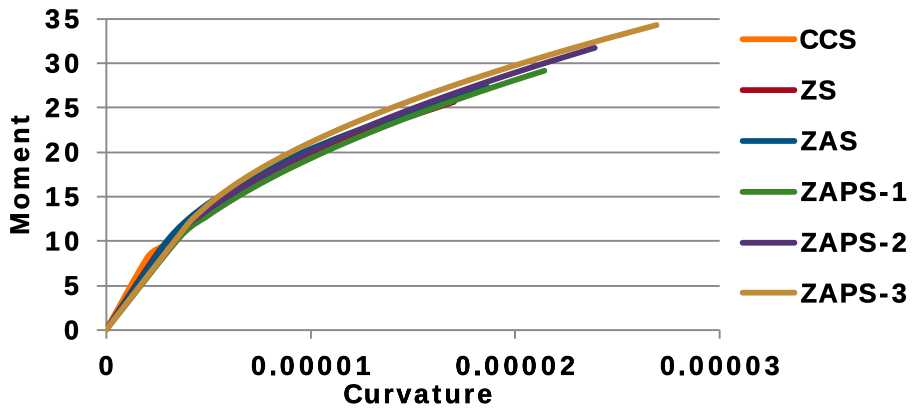

Figure 15: Moment-Curvature Relationship of Beams

3.6 Ductility Index

The ductility of a beam is essentially its ability to sustain inelastic deformation without any loss in its load-carrying capacity, prior to failure. The ductility indices of all the beam specimens tested in this investigation are presented in Table 8. The effect of PPF on Deflection ductility and Energy ductility is presented in Figures 16 and Figure 17. It can be observed from the results that fibre inclusion has a noticeable effect on the beam ductilities. The ductility increased with an increase in fibre volume fraction. The beam ZAPS-3 beam showed a maximum increase of 34.31 % in deflection ductility and 84.38 % in energy ductility over the beam without fibres. The beam specimens ZS, ZAS, ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase in deflection ductility up to 13.23%, 15.19%, 16.17%, 23.03% and 34.31% respect to CC beam. The beam specimens ZAS, ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase up to 1.29%, 3.89%, 5.19% and 5.84% with respect to ZS beam. The specimens ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase up to 2.5%, 3.75% and4.37% with respect to ZAS beam.

Table 8: Ductility Indices of Beam Specimens

Beam Designation	Deflection Ductility	Deflection Ductility Ratio	Energy Ductility	Energy Ductility Ratio
CCS	1.52	1	3.01	1
ZS	1.54	1.01	3.12	1.04
ZAS	1.56	1.03	3.32	1.06
ZAPS-1	1.6	1.05	3.75	1.13
ZAPS-2	1.62	1.06	4.52	1.21
ZAPS-3	1.63	1.07	5.55	1.23

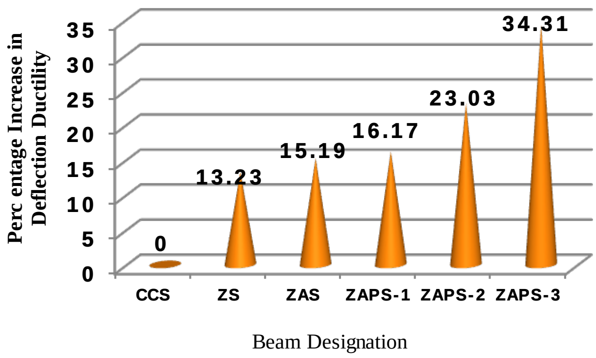

Figure 16: Effect of PPF on Deflection Ductility of Beams

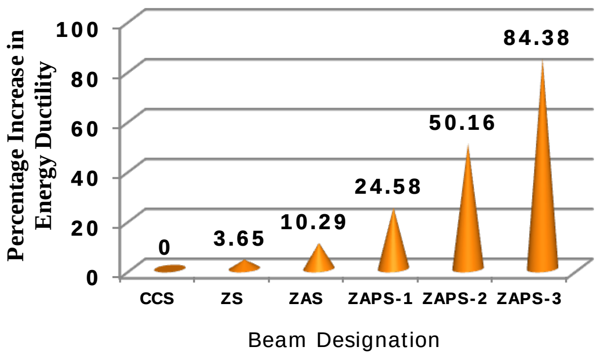

Figure 17: Effect of PPF on Energy Ductility of Beams

3.7 Energy Capacity

The energy capacity of all the beam specimens tested in this investigation is presented in Figure 18 and Table 9. It is a known fact that, for any structural member, larger ductility would lead to larger energy capacity. An assessment of energy capacity has been made based on the area available under the load-deflection response plots. The beam ZAPS-3 exhibited a maximum increase of 151 % in energy capacity over the control beam. The beam specimens ZS, ZAS, ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase up to 23%, 40%, 74%, 103% and 151% with respect to CC beam. The beam specimens ZAS, ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase up to 14.10%, 41.84%, 65.80% and 104.84% with respect to the ZS beam. The specimens ZAPS-1, ZAPS-2 and ZAPS-3 showed an increase up to 24.14%, 45.14% and 79.31% with respect to the ZAS beam.

Table 9: Energy Capacity Results

Beam Designation	Energy Capacity (kN-mm)
CCS	551.10
ZS	675.70
ZAS	771.90
ZAPS-1	958.24
ZAPS-2	1120.35
ZAPS-3	1384.11

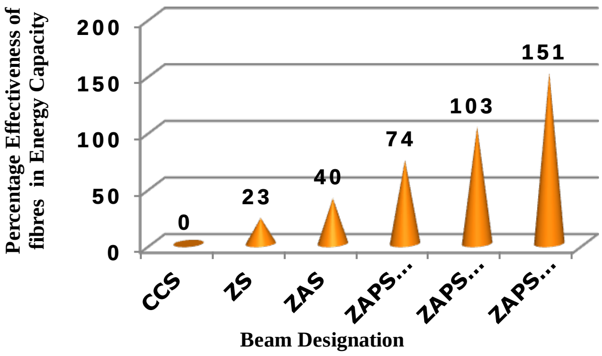

Figure 18: Effect of PPF on Energy Capacity.

4 Conclusion

Ternary Blended Concrete Beams with the inclusion of 1% nano-alumina, 10% Zeolite and 0.3% volume fraction of PPF exhibited an increase of 40% in flexural strength compared to CC beams

At all load levels, the ternary blended concrete beams containing 1% NA, 10% zeolite and PP fibres with 0.3% volume fraction showed a maximum decrease of 84.17% in deflection compared to the CC beam.

The maximum increase of 34.31%, 84.38% and 151% in deflection ductility, energy ductility and energy capacity has been exhibited by concrete beams with PP fibres at 0.3% volume fraction and zeolite 10% with NA 1%.

The maximum reduction of 45.45% in crack width has been observed with ternary blended concrete beam containing1% N.A, 10% Zeolite and 0.3% volume fraction of PP fibres

5 Availability of Data and Material

Data can be made available by contacting the corresponding author.

6 References

Ahmed S, Bukhari IA, Siddiqui JI, Qureshi SA. A study on properties of polypropylene fiber reinforced concrete. In31st conference on our world in concrete and structures 2006 (pp. 63-72).

Alhozaimy AM, Soroushian P, Mirza F. Mechanical properties of polypropylene fiber reinforced concrete and the effects of pozzolanic materials. Cement and Concrete Composites. 1996;18(2):85-92.

Arivalagan S. Cyclic behaviour of reinforced cement concrete composite beam made with polypropylene fiber. J. Civil Eng. 2012;40(2):105-14.

Arslan G, Keskin RS, Ozturk M. Shear behaviour of polypropylene fibre-reinforced-concrete beams without stirrups. Proceedings of the Institution of Civil Engineers-Structures and Buildings. 2017;170(3):190-8.

Banthia N, Gupta R. Influence of polypropylene fiber geometry on plastic shrinkage cracking in concrete. Cement and concrete Research. 2006;36(7):1263-7.

Patel PA, Desai AK, Desai JA. Evaluation of Engineering Properties for Polypropylene and steel fibre Reinforced Concrete. IJAET, 2012; 3(1):42-45. https://www.ijert.org/evaluation-of-mechanical-properties-for-polypropylene-and-steel-fibre-reinforced-concrete

Vu HH, Do TG, Nguyen TT. The application of polypropylene fiber for reinforced concrete beams and slabs. InIOP Conference Series: Materials Science and Engineering 2020 (Vol. 869, No. 7, p. 072042). IOP Publishing.

Yang X, Liang N, Hu Y, Feng R. An Experimental Study of Shear Resistance for Multisize Polypropylene Fiber Concrete Beams. International Journal of Concrete Structures and Materials. 2022;16(1):69-79.

Sala Gayathri is a student in the Department of Civil and Structural Engineering, Annamalai University, Chidambaram. She got her Master's from JNTUH, Hyderabad, Telangana. Her research is based on the use of Micro and Nano filler in Combination as Partial Replacement of Cement in Polypropylene fiber Reinforced Concrete.

Dr. K. Suguna is a Professor in the Department of Civil and Structural Engineering, Annamalai University, Chidambaram. She got her Master's and PhD degrees in Structural Engineering, from Annamalai University, Chidambaram. Her research interest includes Alternative Materials for the Construction and Rehabilitation of Structures.

Dr. P. N. Raghunath is a Professor in the Department of Civil and Structural Engineering, Annamalai University, Chidambaram. he got his Master's and PhD degrees in Structural Engineering, Annamalai University, Chidambaram. His research interest includes Polymer and Fiber Composites.