Synergetic Effect of Sugarcane Bagasse Ash with Low Modulus of Fiber Reinforced Concrete

V.M. Southararajan, Y Stalin Jose, S. Sivasankar

Abstract: ***This research work has experimentally investigated on the effects of low modulus fibers (PP) used in concrete for the various percentages like 0. 0.5% and 1.0% (by volume fraction) along with different percentage of sugar cane bagasse ash from 0 to 15% replaced in Portland cement (by weight of binding material) for different mixes and tested for the various properties of high-performance concrete (HPC). This experimental test results indicated that the usage of SCBA is restricted up to 10% with 0.5% of PP (Polypropylene) along with 1.5% of superplasticizers produces the higher flexural strength was increased up to 78.30% and compressive strength of concrete was increased up to 25.80% when compared to control (plain) concrete at 28 days. Finally, the usage of low modulus fibre reinforced concrete to act as a corrosion inhibitor agent during the chloride attack than compared to high modulus fibers and reduce the plastic shrinkage due to excellent flexibility in concrete and also increases the life span.***

Keywords: Compressive, Flexural, Polypropylene, Split tensile, Sugarcane bagasse ash, Quarry dust,

I. INTRODUCTION

The concrete is a wide range of constructing building material that has ultimate strength and adaptability. It consists of Portland cement, river sand and aggregate (e.g., stone or rock) mixed with water. Normally the Portland cement blended with water, to form a cement paste that coats act as binding material to cover the surface of aggregates.

Initially hydrating reaction will takes place within a few hours. However, it may take much longer for final setting time while hardening the concrete to reach its target strength by further extending the hardening process to attain the later age gain in concrete over period of years.

SCBA is a binding material that is obtained from sugar cane industries and these materials to act as a by-product of binding materials which is consisting of higher amount of silica oxide and reacts as a very fine solid glassy sphere of silicon dioxide. However, the main drawback of these raw materials having more grains particle size thereby it's required for pre heating in hot air oven or furnace. Finally, to improve the fineness of the particle size, which in turn contributes to the effects of pozzolanic binding materials and it decreases the particle pore sizes in the Portland cement paste and also improves the quality of concrete.

The major crises shortage of river sand therefore so many alternate materials has introduced the quarry stone dust which is one of the alternate by-product materials that is obtained from the crushing process of stones and these materials are in ample which is obtained from rock quarry industries being an economic alternate filling materials to natural river sand with low cost. Quarry dust, being a volatile material, its inhaling property which causes respiratory problems while disposing the quarry dust without any precautionary measurement. By replacing the normal river sand with stone dust will reduce the requirement of land fill area and resolve the problems due to scarcity of river sand. Quarry dust offers economy alternate materials and produces the higher strength when compared to natural river sand with or without supplementary cementitious alternating binding materials in the concrete. The effects of two binary admixtures in concrete have progressively performed the test thermogravimetric, isothermal calorimetry, pozzolanic index tests and shrinkage for various mixes. The usage of sugar cane bagasse ash in Portland cement a clear change was observed the kinetics of hydration and portlandite content. Furthermore, the different particle size of SCBA and rice husk ash showed the transitional behaviour of drying shrinkage and also increased the specific surface area [1]. The usage of Bagasse ash blended concrete was observed the low heat of hydration, additional strength gain due to pozzolanic reaction, significant reduction in permeability of concrete due to improvement of pore refinement microstructures and also less drying shrinkage when compared to conventional concrete [2]. The preheated content of SCBA up to 1100°C for different hours in furnace was progressively carried out on various parameters such as scanning electron microscopy (SEM) and X-Ray diffraction (XRD) due to grain size and percentage difference in chemical composition and also weight gains due to effect of temperature variation in different hours [3]. The effect of sugarcane bagasse ash along with reactive aggregates in Portland cement was controlling the alkali-silica reaction during the hydration process. The pozzolanic activity index test was performed and observed for 10% replacement up to 23% similarly in the case of 40% was 46% reduction the mortar bar expansion [4].

Manuscript published on 30 September 2019
* Correspondence Author
Dr VM. Southararajan*, Professor, Department of Civil Engineering, CMR Technical Campus, Kandlakoya, Medchal Road, Hyderabad – 501401, Telangana, India.
Email: southararajan.civil@cmrtc.ac.in
Dr Y. Stalin Jose, Associate Professor, Department of Civil Engineering, Malla Reddy Institute of Technology and Science, Maisammaguda, Secunderabad, Hyderabad - 500 100, Telangana, India.
Email: stalinjosecivil@gmail.com
Dr S. Sivasankar, Associate Professor, Department of Civil Engineering, CMR Technical Campus, Kandlakoya, Medchal Road, Hyderabad – 501401, Telangana, India.
Email: sivasankar.civil@cmrtc.ac.in

Retrieval Number: C6139098319/2019©BEIESP
DOI:10.35940/ijrte.C6139.098319
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

The various production and usage of concrete are unavoidable than any other material available in this world, for approximately 15 billion tons of aggregates can produce the 25 billion tons of concrete, so there is an increased demand required for natural materials in concrete thereby more shortage of natural materials like river sand and crushing stone aggregates. Therefore to minimize the scarcity of natural materials while using the waste by-product materials was introduced into the construction industries. A synergistic interaction effect on the SBCA combinations with 2% of polypropylene fiber for various mixes was noted in the higher bending stress on the flexural rigidity and also exhibited the multiple splitting and bridging the crack formation was observed when the fibers are added [5-7]. Due to the consumption of a large amount of carbon-di-oxide produced in cement manufacturing industries therefore to minimize the pollution while using the mineral admixtures in concrete thereby the fibrous matter that remains after sugarcane is crushed to extract their juice is termed as bagasse and optimum amount of waste is suitable in concrete and other purposes of landfilling. Furthermore, a higher amount of addition of bagasse ash causes a reduction in the strength of concrete thereby how to compensate these issues by addition of fibers in concrete. Also, the synergistic effect of bagasse ash content as a replacement of Portland cement along with influences of natural and artificial fibers added in concrete thus resulting to increases the compressive strength, split tensile strength, the flexural strength of high-performance concrete [8-14]. Although a various literature review of research works focused on the fiber content in the hardened properties, limited information is available about the effects of fiber shape on reinforcing and toughening characteristics of RFC for various mixes of concrete.

II. RESEARCH SIGNIFICANCE

The main accountability of this research work has focused on the waste by-product materials used in concrete for various mixes thereby this work has strongly recommended in the construction industries used for building materials in concrete based on the experimental test results.

III. EXPERIMENTAL DETAILS

A. Cement

The ordinary Portland cement 53 Grade (OPC) was used. The physical properties of OPC has been tested in accordance with IS 12262 1969 [15] and the obtained values are given in Table I.

Table- I: Test observation values for OPC

Test name	Values
Standard-consistency	34 %
Initial setting	145 minutes
Final setting	261 minutes
7 days of crushing strength of cement mortar	28 MPa
28 days of crushing strength of cement mortar	54 MPa
Specific-gravity	3.15

B. SCBA

From Table II represents the various chemical oxides available in sugarcane bagasse ash and usage of this materials to act as a mineral admixture and more suitable in binding materials in Portland cement for different percentage replaced and also reduce the cost of the project work.

Table II: Different percentage of oxides in SCBA

Oxides Name	Values (%)
Silica	67.44
Aluminium	5.83
Ferric	0.22
Calcium	2.45
Phosphorous	1.15
Magnesium	0.61
Sulphide	4.25
Loss on Ignition	18.05

Fig. 1. Image of preheated at 600^0C for SCBA

C. Quarry Dust (QD)

In the manufacturing granite industries during the cutting and grinding the natural stone at the stage huge quantity amount of waste materials are stored and these materials to act as waste materials that are more suitable for fill materials for various aspects and also compromising the best alternative materials (maximum replacing up to 50% by weight of fine aggregate) in building construction in concrete therefore before using this material has to do same initial studies in laboratory after tested the aggregate values are represented in Table III.

Table-III: Lab test value for quarry dust (Physical properties)

Material Name	Specific gravity	Bulk density (kg/m^3)	Water absorption (%)	Moisture content (%)	Fine particles less than 75 microns (%)	Fineness modulus (Sieve analysis)
	IS 2386 -1963 (Part 3) [16]					Zone II as prescribed in IS 383-1970 [17]
Quarry dust	2.57	1750	1.35	0.75	10 to 15	

D. Coarse Aggregate (CA)

Crushed granite blue metal stone used as coarse aggregates used for material is passing through 20 mm sieve and obtained on 12.5 mm.

Retrieval Number: C6139098319/2019©BEIESP
DOI:10.35940/ijrte.C6139.098319
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

The fineness modulus of coarse aggregate was observed to be 6.82 and specific gravity 2.61.

E. Polypropylene fibers (PF)

The properties of polypropylene fibers having a length (l) of 48 mm, diameter (d) 0.6 mm that's aspect ratio (l/d) is 80, tensile strength 552 MPa and failure strain up to 20 % and specific gravity value of 1.35 therefore this type of low modulus fibers used in concrete as shown in Figure 2.

Fig.2. Image of polypropylene fibers

F. Chemical admixtures

1. Superplasticizer (SP)

A commercially available chemical admixture like Conplast 430 is the high range water reducer type of superplasticizers the dosage level of 1.5% (by weight of binder content) was added in concrete to obtain the desired workability with help of slump cone test and measured the various mixes the slump values between the range from 75 to 100 mm

2. **Accelerator**:

It is a hasten setting properties substance such as calcium chloride ($CaCl_2$), added in small dosage level (maximum 1% by weight of the binding materials) in plain concrete to accelerator it's hardening during the hydration process.

G. Water

Normal potable drinking water used for various mixes, which is free from oils, alkalies, and any other organic impurities.

H. Concrete mix proportion details

Table IV shows the concrete mixture proportions has employed for thirteen mixes with water-binding material ratio (w/b) of 0.42. This experimental work for adding the different percentage of SCBA ash from 0 to 15% (by binder weight) replaced in Portland cement with different percentage of polypropylene fibers from 0 to 1% (by volume fraction) along with accelerator (chemical admixture) dosage level was fixed at 1% (by weight of binder content) to improve the rate of hardening in concrete and also additional added with1.5% of Polycarboxylic ether based superplasticizer (PCE) for various mixes to improve the fresh concrete workability.

The orientation of polypropylene fibers is randomly distributed during mixing of fresh concrete up to 3 minutes with the help of titling drum-type pan mixer machine after that it is required for proper compaction for all mixes with help of table vibrator machine. Figure 3 shows the sample of fresh concrete cast in different steel mould cube size (100 x 100 x100 mm) and tested for compressive strength, cylindrical size 100 x 150 mm (height and diameter) and tested for split tensile strength, beam mould size 500 x 100 x 100 mm (length x breadth x depth) and tested as prescribed in IS 516-1959 [18] for flexural strength of concrete for different curing days.

Table- IV Concrete mix details

Mix ID	Binding Material required kg/m^3		w/b ratio	Fine Aggregate kg/m^3		Coarse Aggregate kg/m^3	Polypropylene Fiber (%)	Accelerator	Superplasticizers
	Cement	SCBA		River sand	Stone Dust				
PC-0	380	0		710	0	1280	0	0	0
PC-1	380	0		355	355	1280	0.5	1	1.5
PC-2	380	0		355	355	1280	1.0	1	1.5
PC-3	380	0		355	355	1280	1.5	1	1.5
SP-0	380	19		710	0	1280	0	0	1.5
SP-1	361	19		355	355	1280	0.5	1	1.5
SP-2	361	19	0.42	355	355	1280	1.0	1	1.5
TP-0	342	38		710	0	1280	0	0	1.5
TP-1	342	38		355	355	1280	0.5	1	1.5
TP-2	342	38		355	355	1280	1.0	1	1.5
PP-0	323	57		710	0	1280	0	0	1.5
PP-1	323	57		355	355	1280	0.5	1	1.5
PP-2	323	57		355	355	1280	1.0	1	1.5

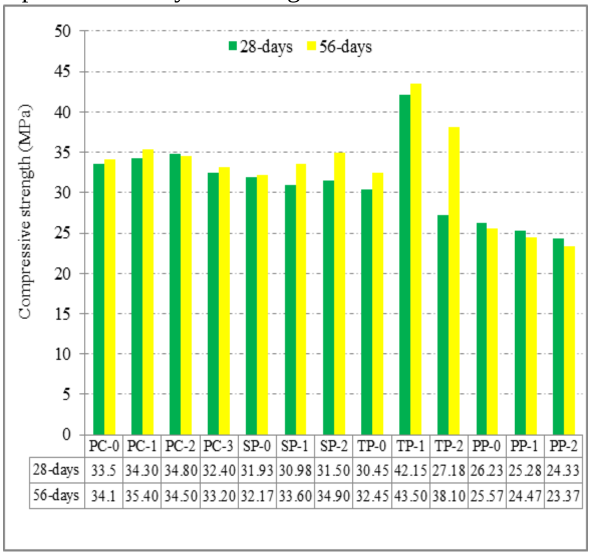
Fig. 3. Image for cast the various size of concrete

IV. EXPERIMENTAL TEST RESULTS AND DISCUSSION

A. Compressive strength

Figure 4 shows the compressive strength of M30 grade of concrete was investigated systematically by varying the different percentage of sugarcane bagasse ash replaced in Portland cement and synergic effects on the calcium nitrate with the addition of polypropylene fiber concrete reached the target compressive strength of concrete. From the experimental test results was perceived that the high strength was 37.10 MPa (TP-1 mix id) at 28 days concrete with lower addition of PP up to 0.5% than the 1.0% addition of PP.

Similarly, in the case of higher addition of PP up to 1.0%, the strength was 38.10 at 56 days (TP-2 mix id) required than compared to 28 days of curing.

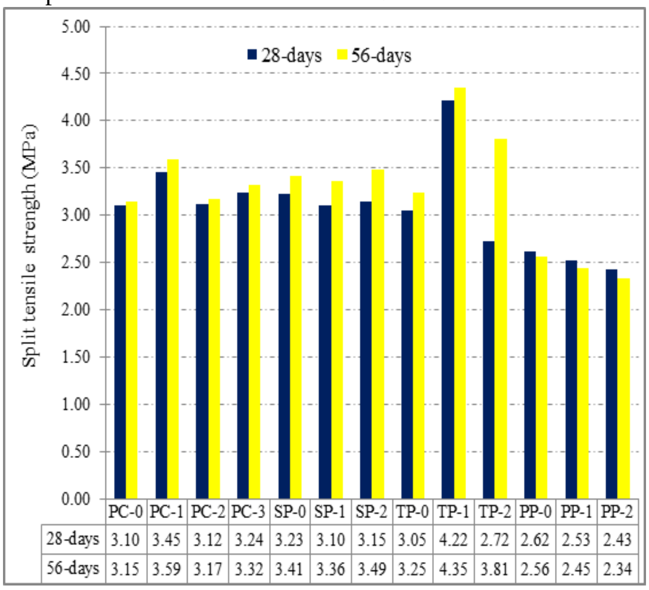


	PC-0	PC-1	PC-2	PC-3	SP-0	SP-1	SP-2	TP-0	TP-1	TP-2	PP-0	PP-1	PP-2
28-days	33.5	34.30	34.80	32.40	31.93	30.98	31.50	30.45	42.15	27.18	26.23	25.28	24.33
56-days	34.1	35.40	34.50	33.20	32.17	33.60	34.90	32.45	43.50	38.10	25.57	24.47	23.37

Fig. 4. Compressive of strength for various given mixes

B. Split tensile strength

Figure 5 represents the various test results for the split tensile strength of concrete by indirect measurement in concrete. The effects of calcium nitrate with different percentage of sugarcane bagasse ash substituted concrete along with polypropylene fiber interaction has more than compared to control concrete and also drastic improvement was observed in the case of 0.5% of PP (by volume fraction) in concrete strength was 36.13% increases when compared to control concrete. Similarly in the case of plain cement with 0.5% of PP shows the strength attainment up to 11.29% increased than compared to without fibers addition.



	PC-0	PC-1	PC-2	PC-3	SP-0	SP-1	SP-2	TP-0	TP-1	TP-2	PP-0	PP-1	PP-2
28-days	3.10	3.45	3.12	3.24	3.23	3.10	3.15	3.05	4.22	2.72	2.62	2.53	2.43
56-days	3.15	3.59	3.17	3.32	3.41	3.36	3.49	3.25	4.35	3.81	2.56	2.45	2.34

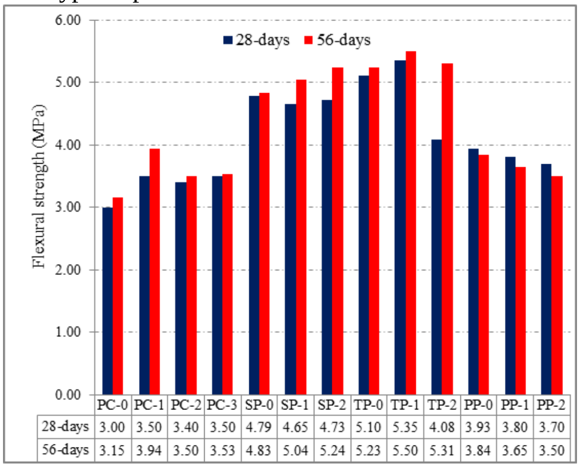
Fig. 5. Split tensile strength for various given mixes

C. Flexural strength of concrete

Figure 6 shows the low modulus of fiber-reinforced concrete consisting of the various percentages of fibrous materials which increases its structural integrity. However, the usage of short discrete fibers which is randomly distributed in fresh concrete after that the rearrangement of fibers that's an alignment of fiber along the beam axis owing to table vibrator so these type of orientation of fibers will absorb the more external load as a results to increase the bending stress in flexural strength (as shown in Figure 7) for different curing days.

It was calculated that the higher flexural strength was 5.35 MPa at 28 days that's consisting of preheated SCBA content and passing through 90 mm sieve size along with 0.5% of PP produced the maximum strength than compared to 1.0% of the addition of polypropylene.

It was also noted that the higher bending in the case of 100% OPC (without SCBA) with 1% of calcium nitrate along with 0.5% of polypropylene fibers produced the higher flexural strength was 3.50 MPa at 28 days than compared to another type of plain cement concrete.



	PC-0	PC-1	PC-2	PC-3	SP-0	SP-1	SP-2	TP-0	TP-1	TP-2	PP-0	PP-1	PP-2
28-days	3.00	3.50	3.40	3.50	4.79	4.65	4.73	5.10	5.35	4.08	3.93	3.80	3.70
56-days	3.15	3.94	3.50	3.53	4.83	5.04	5.24	5.23	5.50	5.31	3.84	3.65	3.50

Fig. 6. Flexural strength for various given mixes

Fig. 7. Image of polypropylene effects on the concrete beam

V. CONCLUSION

Initially, all the mixes of fresh concrete as required the compaction compulsory to improving the strength of concrete with the help of table vibrator thereby to avoid the air pockets and honeycombs thus resulting in to increase the packing density of concrete. The addition of polypropylene fiber in concrete up to 0.5% shows remarkable improvement in bending stress further addition of PP more than1.0% showing the slump reduction, fibrous, harsh mix and very difficult to handle in fresh concrete workability.

Retrieval Number: C6139098319/2019©BEIESP
DOI:10.35940/ijrte.C6139.098319
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

It was identified that the higher strength gain than compared to control concrete which is consisting of an optimum level of sugarcane bagasse ash up to 10% replaced in Portland cement.

The usage of SCBA in conventional concrete to minimize the carbon-di-oxide and also less production of Portland cement and make the building construction is very economical with low-cost benefits for the public.

The addition of SCBA content in Portland cement was found to be decreased the workability owing to more amount of silica present in ash thus resulting it is essentially required to add the chemical admixtures in fresh concrete without altering the water-binding material ratio in concrete mixes.

Therefore, this research work has recommended the building construction industries with a careful selection of materials ingredients and produces the quality of concrete. Further, this study is going to investigate the durability studies in concrete for various mixes.

REFERENCES

1. Guilherme C. Cordeiro and Kimberly E. Kurtis, Effect of mechanical processing on sugar cane bagasse ash Pozzolanicity, *Cement and Concrete Research*, vol.97, pp. 41-49, 2017.
2. https://doi.org/10.1016/j.cemconres.2017.03.008
3. A.Bahurudeen, Deepak Kanraj, V. Gokul Dev and Manu Santhanam, Performance evaluation of sugarcane bagasse ash blended cement in concrete, Cement and Concrete Composites, vol. 59, pp. 77-88, 2015. https://doi.org/10.1016/j.cemconcomp.2015.03.004
4. Mohammed Imran and A.R Anwar Khan, Characterization of Agricultural Waste Sugarcane Bagasse Ash at 1100°C with various hours, ScienceDirect, vol.5 (2) , pp. 3346-3352, 2018.
5. https://doi.org/10.1016/j.matpr.2017.11.577
6. Syed Minhaj Saleem Kazmi , Muhammad Junaid Munir , Indubhushan Patnaikuni and Yu-Fei Wu, Pozzolanic reaction of sugarcane bagasse ash and its role in controlling alkali silica reaction, Construction and Building Materials, vol. 148, pp. 231-240, 2017.
7. https://doi.org/10.1016/j.conbuildmat.2017.05.025
8. Ashi Sudhakar P K, Anitha Babu, Investigation of Effect on various fibers on the Mechanical properties of bagasse ash blended with high performance concrete, International Research Journal of Engineering and Technology, vol.4 (6), pp. 1756-1759, 2017.
9. https://www.irjet.net/archives/V4/i6/IRJET-V4I6333.pdf
10. Surender Singh , G.D. Ransinchung and Praveen Kumar, Effect of mineral admixtures on fresh, mechanical and durability properties of RAP inclusive concrete, Construction and Building Materials, vol.156, pp. 19-27,2017. DOI: 10.1016/j.conbuildmat.2017.08.144
11. Aulia, T. B., "Effects of Polypropylene Fibers on the Properties of High-Strength Concretes." LACER No. 7 (2002), pp.43-59.
12. Waheeb, A. L. K., "Mechanical Properties and Time Dependent Deformations of Polypropylene Fibre Reinforced Concrete," J King Saud Univ., Vol. 7, Eng.Sci. (1) (1993), pp. 67-76.
13. Sukontasukkul, P., "Toughness Valuation of Steel and Polypropylene Fibre Reinforced Concrete Beams under Bending" Thammasat Int. J. Sc. Tech., Vol. 9, No. 3, (2004),pp.35-41.
14. Wang Y., Victor C. Li., Backer S., "Tensile Properties of Synthetic Fiber Reinforced Mortar," Cement and Concrete Composites Vol.12 (1990) pp 29-40.
15. Shiv Kumar, A. & Sathanam,M. "Machanical Properties of High Strength Concrete Reinforced with Metallic and Non Metallic Fibers",Cement & Concrete Composites, Vol.27(2007),pp.603-608.
16. Sumrerng Rukzon and Prinya Chindaprasirt, Utilization of bagasse ash in high-strength concrete, Materials & Design, vol. 34, pp. 45-50, 2012.
17. DOI: 10.1016/j.matdes.2011.07.045
18. V.M. Sounthararajan, S. Sivasankar and T.L. Ramadasu "High Early strength of slag based Fibre Reinforced concrete", International Journal of Engineering and Advanced Technology. vol. 8, pp. 1146-1150-1156, 2019.
19. V.M. Sounthararajan, S. Sivasankar and T.L. Ramadasu 'Flexural Rigidity in concrete beam by using the crimped steel fibers with Rapid Hardening Admixtures," International Journal of Engineering and Advanced Technology. vol. 8, pp. 1677-, 2019.
20. IS10262 - 2009: Indian Standard Concrete Mix Proportioning-Guidelines, Bureau of Indian Standards, New Delhi, India.
21. IS 2386(Part-I)-1963 Indian Standard methods of Test for aggregates for concrete Part-I Particle Size and Shape, Bureau of Indian Standards, New Delhi, India.
22. IS 383:1970 Indian Standard Specifications for coarse and fine aggregates from natural sources for concrete, Bureau of Indian Standards, New Delhi, India
23. IS 516-1959 Indian Standard Methods of Tests for Strength of concrete, Bureau of Indian Standards, New Delhi, India

AUTHORS PROFILE

Dr VM Sounthararajan is presently 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 fifty-two research papers in various National and International journals and conferences.

Dr Y Stalin Jose is presently working as an Associate Professor, Department of Civil Engineering, Malla Reddy Institute of Technology and Science, Maisammaguda, Secunderabad, Telangana. He completed his BE degree in Civil Engineering from Madurai Kamaraj Universityin in 1995 and ME Strctural Engineering from Annamalai University in 2005. He also completed his PhD degree from Noorul Islam University, Kanyakumari in 2016. He did his research in Investigation into flexural behavior of RC beams of varying strength. He has 14 years of teaching and 10 years of industrial experience.

Dr. S. Sivasankar is presently working as an Associate professor in the Department of Civil Engineering, CMR Technical Campus, Hyderabad, Telangana. He has eight years of teaching experience and one year industry experience. Also he has four years of research experience. He published ten research articles in national and international journals. His research area includes steel-concrete composites, strengthening and retrofitting of steel and concrete structures and corrosion assessment in steel and concrete. He is a life member in ISTE, IAE and IE chapters.