Valorization of Specially Designed Concrete by Using Sugarcane Bagasse Ash and Inducing the Special Benefits of Waste Tin Fiber Reinforced Concrete

VM Sounthararajan, S. Sivasankar, R. Vinodh Kumar, Nabajyoti Modak, K. Dilli Bai

Abstract: This research work has been investigated the agriculture solid waste of sugarcane bagasse ash (SCBA) materials replacing Portland cement and produces the assured quality of concrete. The current research work for various mixes of experimental test results shows the higher compressive strength was 37.51MPa at 28-days, 38.10 MPa at 56-days, the best mix consisting of SCBA (wet sieving method) content up to 15% (by weight of binding materials) along with 1.5% of waste tin fibers and also an excellent improvement trend was noted in flexural rigidity of concrete to addition of tin fibers shows the higher bending stress for all mixes except reference as well as more than 15% of SCBA concrete at different curing days. However, this study focused on the indirect measurement of tensile strength in SCBA concrete obtained the higher split tensile strength was 3.75MPa at 28-days, 3.95MPa at 56-days. It is concluded based on the various test results for different curing days the optimum replacement level of SCBA up to 15% of Portland cement was fixed and achieve the target strength of M25 grade of Portland cement concrete at 28 days.

Keywords: Solid waste sugar industry bagasse ash, strength enhancement, Waste tin steel fibers

I. INTRODUCTION

The major commercial growing agricultural crop in India is Sugarcane and produced around 500 million tons from various agro-based sugarcane industries. After the extraction of fibrous residue around 40 to 50% for reuse purpose of the same industry for heat generation boilers as fuel remaining leftover the ash up to 8 -10 % residue that's sugarcane bagasse ash. This type of residue contains high amounts of un-burnt matter, silicon, aluminium and calcium oxides therefore so many remedial precautions required to improve the fineness of the particle after preheated the ash from 300 to 600-degree Celsius by using muffle furnace after that this type of waste by-product materials is more suitable for conventional concrete and partially replacing to Portland cement. A limited study has been reported that the more amount consumption of sugarcane bagasse ash was introduced into the binding materials there is no response in the pozzolanic activity index and affects the binding particle for various mixes. A few research works have been identified based on the experimental work shows the decrease the workability in fresh concrete to affect the slump values and improper compaction due to harsh mixes because without introducing any chemical admixtures, therefore, to avoid this type factor while using the superplasticizers for various mixes [1-2]. Further, some of the experimental research work has been reported that the strength gains properties for replacing 0 to 10% in Portland cement with proper curing and also noted the less amount of water observed in the case of the sorptivity coefficient for various mixes. Also, fewer studies concluded that the usage of SCBA at different percentage 0 to 40% replaced to fine aggregate to make the bricks manufacturing, tiles and other purposes for filling the area for various sectors [3-4]. It was concluded that the preparation of tiles consisting of 50% clay, 15% quartz, and 35% feldspar was obtained from a local manufacturer and feldspar as partially replaced in sugarcane bagasse ash. The sugarcane bagasse ash materials are used mostly as other structural elements compounds like fly ash bricks as a replacement-level up to 20% of SCBA along with lime content thus resulting the various strength attainment in the fly ash bricks with different curing days and also noted that the less water absorption due to improvement of pozzolanic reaction over period of hydration to produce the gel formation [5-6]. The chemical reaction between the binding materials along with water to form an addition gel formation while addition of SCBA content in Portland cement due to more amount of silica oxides presents in the SCBA which gives the fewer chloride ions permeability in concrete when compared to fly ash and slag or cementitious materials in conventional concrete for different curing days and all the values are satisfied as prescribed in various codes [7-8]. Further proceeding with the SCBA addition in concrete used for pavement construction works and also improves the mechanical and durability test results than compared to plain cement flexible pavement [9-10]. Now a days more number of research work is concentrating on solid waste materials like sugarcane bagasse ash after preheating the materials while using in concrete shows the

Revised Manuscript Received on October 10, 2019

Dr VM SOUNTHARARAJAN*, Professor, Department of Civil Engineering, CMR Technical Campus, Kandlakoya, Medchal Road, Hyderabad – 501401, Telangana, India. Email: sounthararajan.civil@cmrtc.ac.in, researchsoundar@yahoo.in

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, drsssphd@gmail.com

Mr. R Vinodh Kumar: Assistant Professor, Department of Civil Engineering,, Meenakshi College of Engineering, Chennai, Tamil Nadu. Email: er.r.rvinodhkumar@gmail.com

Mr. Nabajyoti Modak: Assistant Professor, Department of Civil Engineering, Anand Institute of Higher Technology, Chennai, Tamil Nadu, India. Email: modaknabajyoti84@gmail.com

K. Dilli Bai, Pursuing M.Tech – Structural Engineering at CMR Institute of Technology, Kandlakoya, Medchal Road, Hyderabad – 501401, Telangana, India. Email: knandhini304@gmail.com

better improvement in various construction industries therefore this current research work is strived to produce the quality of sugarcane bagasse ash as a partial replacement of Portland cement along with waste tin fibers to acts as metal matrix in flexural rigidity of concrete as a result to utilize the waste materials in construction industries to reduce the overburden of carbon dioxide emission to act as ecological and eco-friendly in the environmental conditions.

II. MATERIAL INVESTIGATION DETAILS

A. Cement

From Table I provide the various test results for Portland cement (53 Grade) and this type of cement used for various mixes of M20 grade of concrete to cast, curing and testing all the concrete specimens at different age of curing.

Table-I: Lab test value for OPC (Physical- Properties)

Property of Cement	Values
Fineness of Cement	7.3%
Grade of Cement	53
Specific Gravity	2.65
Initial Setting time	35 min
Final Setting Time	640 min

B. Standard Consistency Test on Portland cement

Table II shows the standard consistency of Portland cement test values is given below:

Table-II: Consistency test for Portland cement test values

Overall cement content = 450 grams	
Water (%)	**Depth of Penetration from bottom (mm)**
30	27
31	22
32	21
33	10
34	6

C. Fine aggregates

Table III gives the various physical test results for river sand (fine aggregates) and quarry dust stone powder to meets all requirements based on the specification as prescribed in the codes. For ensuring adequate strength to minimize the voids and also shows the good packing modulus to improve the excellent performance in conventional concrete thus results without honeycombed after demould the concrete specimens.

Table-III: Various test results for river sand (Physical-properties)

Test-name	Sand to quarry dust	Quarry dust to sand
Percentage	**0 to 50**	**0 to 50**
Fineness Modulus	7.40	6.85
Specific gravity	2.70	2.65
Water absorption	1.3%	1.5%

D. Coarse aggregates

This type of crushed stone aggregates is the important constituents for various mixes in SCBA concrete. The present investigation, easily available of crushed normal stone aggregate particle size in between 10 to 20 mm was used and the various tests carried out on the aggregates are given below for Table IV as prescribed in codes.

Table-IV: Test value for coarse aggregates

Properties	Value
Specific-gravity	2.50
Fineness-modulus	7.15
Water-absorption	1.20 (%)
Crushing -strength	13.80 (%)
Impact-strength	15.50 (%)

E. Water

The main ingredient is potable water is to acts as a chemical reaction between the various percentage of binding material along with filling materials thus resulting to get easy workability in fresh condition therefore without water is not easy to make the conventional concrete.

F. Sugarcane bagasse

The collection of raw materials from sugarcane industrial by-product waste materials with preheat up to 600^0C after that using wet sieve method for all particle passing through sieve size 90 microns (Indian Standard) and then used for various mixes in Portland cement. The following various properties of the experimental lab test results are given below Table V and Table VI respectively.

Table-V: Lab test results (Physical)

Property	Value
Specific gravity	2.16
Density (g/cm^3)	2.2
Specific surface area (cm^2/g)	4710
Average size (µm) (where 50% of the particle passes)	40.1

Table- VI: Various percentages of oxides (Chemical)

Oxides	% (mass)
SiO_2	76.18
Fe_2O_3	1.96
Al_2O_3	1.07
P_2O_5	6.4
Na_2O	1.96
CaO	2.91
MgO	2.3
K_2O	2.54
SO_3	0.45
LOI	4.23

Retrieval Number L35891081219/2019©BEIESP
DOI: 10.35940/ijitee.L3589.1081219

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Fig. 1. Image for SCBA before preheat the particle

G. Waste tin fibers

Figure 2 shows the waste tin bottle cut it manually and recovered from steel milling for different shops. This type of tin fibers has functionally to be used in conventional concrete and produce excellent desirable flexibility and tensile strength.

Fig. 2. Image of waste tin fibers and industrial waste steel fibers

III. METHODOLOGY

Figure 3 provides the necessary schematic flow chart for various stages are involved to reach the target strength of M25-grade of concrete for various mixes.

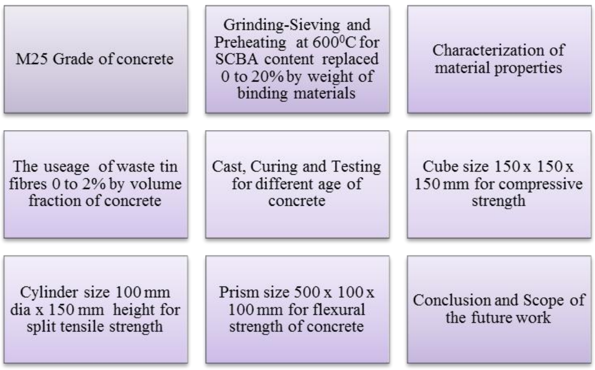


Fig. 3. Schematic flow chart for various stages are involved

A. Mix details

From Table IV shows the detailed mix proportion for M25 grade concrete consisting of twenty-one mixes were prepared under IS 10262-2019 [21].

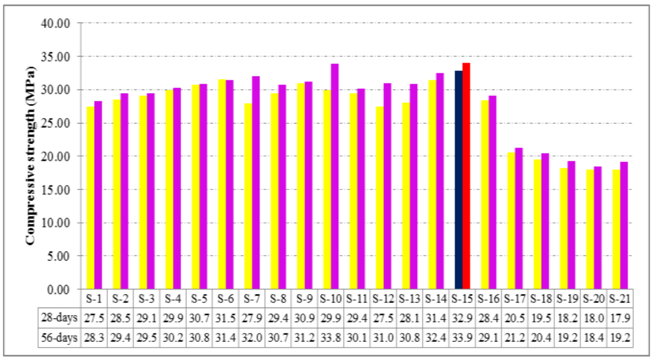
Table- IV: Mix particulars

Mix id	Binder content required (kg/m^3)		Fine Aggregate		Coarse Aggregate	Tin steel-fiber (waste)	50 kg of cement required for Raid chemical admixtures
	Cement	SCBA	Sand	Quarry dust		%	
	(kg/m^3)						
	w/b ratio = 0.42						
S-1	480	120	0	600	1200	0.0	9.60
S-2	456	24	480	120	1200	0	9.12
S-3	456	24	480	120	1200	0.5	9.12
S-4	456	24	480	120	1200	1.0	9.12
S-5	456	24	480	120	1200	1.5	9.12
S-6	456	24	480	120	1200	2.0	9.12
S-7	432	48	480	120	1200	0	8.64
S-8	432	48	480	120	1200	0.5	8.64
S-9	432	48	480	120	1200	1.0	8.64
S-10	432	48	480	120	1200	1.5	8.64
S-11	432	48	480	120	1200	2.0	8.64
S-12	408	72	480	120	1200	0	8.16
S-13	408	72	480	120	1200	0.5	8.16
S-14	408	72	480	120	1200	1.0	8.16
S-15	408	72	480	120	1200	1.5	8.16
S-16	408	72	480	120	1200	2.0	8.16
S-17	384	96	480	120	1200	0	7.68
S-18	384	96	480	120	1200	0.5	7.68
S-19	384	96	480	120	1200	1.0	7.68
S-20	384	96	480	120	1200	1.5	7.68
S-21	384	96	480	120	1200	2.0	7.68

IV. RESULTS

A. Compressive strength of concrete

Figure 4 indicates that the various test results for compressive strength of concrete at different curing days. It is noted that the maximum strength in the case of 15% of SCBA along with 1.5% of waste tin fibers produces the excellent compressive strength was 31.50MPa at 28 days, 32.80MPa at 56-days nearly 24.50% was increased when compared to reference concrete. The optimum level of SCBA content up to 15% by weight of binding materials for various mixes produce the good strength further addition of SCBA content there is a drastic fall.

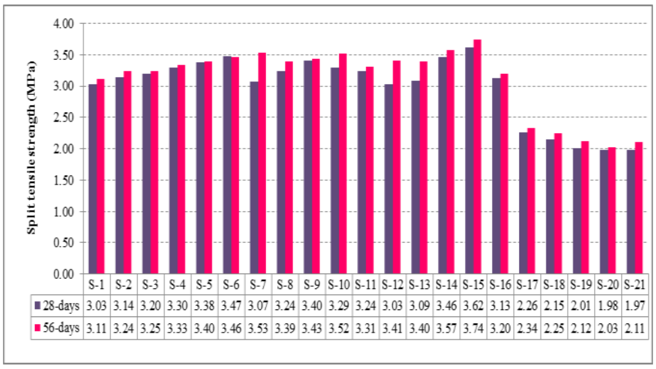


	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16	S-17	S-18	S-19	S-20	S-21
28-days	27.5	28.5	29.1	29.9	30.7	31.5	27.9	29.4	30.9	29.9	29.4	27.5	28.1	31.4	32.9	28.4	20.5	19.5	18.2	18.0	17.9
56-days	28.3	29.4	29.5	30.2	30.8	31.4	32.0	30.7	31.2	33.8	30.1	31.0	30.8	32.4	33.9	29.1	21.2	20.4	19.2	18.4	19.2

Fig. 4. Compressive strength for various mixes

B. Split tensile strength of concrete

Figure 5 shows the essential target split tensile strength for various mixes concrete at different curing days. It is proved that the waste tin fibers addition of 1.5% in concrete mix along with 15% of SCBA binding materials react with Portland cement produce the maximum tensile strength was 3.62MPa at 28-days and 3.74MPa at 56-days of concrete (S-15 mix id) and remaining all concrete mix showing the strength improvement when compared to 20% SCBA with varying percentage of tin fiber reinforced concrete due to delay the setting reaction between supplementary materials along with Portland cement over a long period of curing does not work properly.

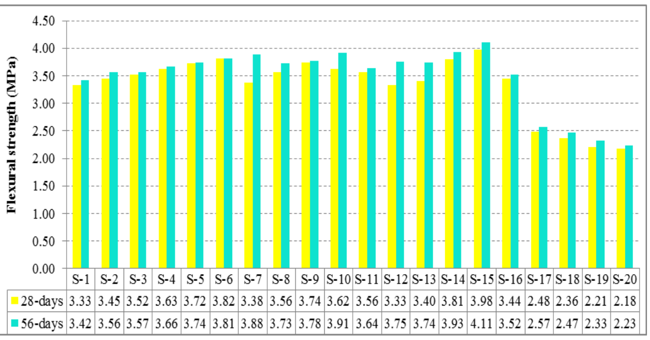


	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16	S-17	S-18	S-19	S-20	S-21
28-days	3.03	3.14	3.20	3.30	3.38	3.47	3.07	3.24	3.40	3.29	3.24	3.03	3.09	3.46	3.62	3.13	2.26	2.15	2.01	1.98	1.97
56-days	3.11	3.24	3.25	3.33	3.40	3.46	3.53	3.39	3.43	3.52	3.31	3.41	3.40	3.57	3.74	3.20	2.34	2.25	2.12	2.03	2.11

Fig. 5. Split tensile for various mixes

C. Flexural strength of concrete

Figure 6 observed that the flexural rigidity test results for different percentage of SCBA binding material replaced to Portland cement along with waste tin fiber addition up to 0 to 2% (by volume fraction) for various mixes of concrete. It was noted that the exhibited the higher flexural strength was 3.98 MPa at 28 days and 4.11 MPa at 56 days for S-15 mix consisting of 15% of wet sieving method (IS 90 microns) particle of SCBA along with 1.5% of waste tin fibers. Further addition of 20% of SCBA with 0 to 2% of fibers exhibited the lower flexural strength than compared to the reference mix.



	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15	S-16	S-17	S-18	S-19	S-20
28-days	3.33	3.45	3.52	3.63	3.72	3.82	3.38	3.56	3.74	3.62	3.56	3.33	3.40	3.81	3.98	3.44	2.48	2.36	2.21	2.18
56-days	3.42	3.56	3.57	3.66	3.74	3.81	3.88	3.73	3.78	3.91	3.64	3.75	3.74	3.93	4.11	3.52	2.57	2.47	2.33	2.23

Fig.6. Flexural strength for various mixes

D. Petrography analyses

The main important parameter is to increase the concrete strength, with an increase in the Portland cement content in concrete thus resulting to increase the shrinkage and creep of concrete over a long period of hydration process due to avoid this type of major problem to introduce various mineral admixtures in conventional concrete. Also, chloride ions permeability will drastically decrease and increase their life span of concrete durability. Figure 7 gives the image of sliced concrete consisting the best mix of 15% of SCBA along with 1.5% of tin waste fiber improved the microstructures due to bonding effects and settlement of their binder particles to each other, thus resulting to improve the packing module with less porosity content that's evidently proved based on the image of sliced concrete.

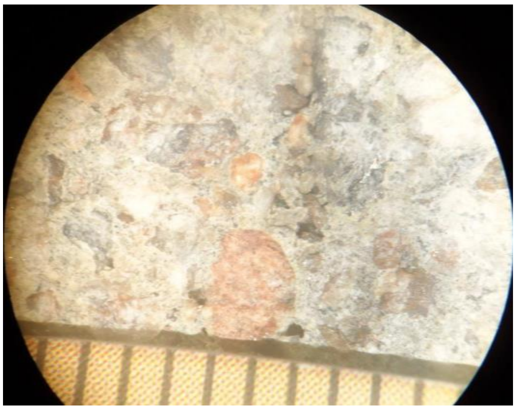


Fig. 7. Image for Sliced concrete by using petrography

V. CONCLUSION

The following conclusion from various test results of SCBA concrete to be satisfied with the objectives of the current research work The utilization of waste by-product of sugarcane bagasse ash by partially replaced to Portland cement as to improve pozzolanic reaction from Sio2 and $Ca(OH)_2$ thus results to form the addition gel formation during the hydration process of binding materials thus results to attained the strength gain for various mixes. The experimental test results showed that the reference concrete with 15% of wet sieving of SCBA binding materials replaced to Portland cement after 28-days of water curing exhibited the higher strength gain than that of reference concrete.

Based on the laboratory experiments test results shows the higher compressive, flexural, split tensile of wet sieving method of SCBA substituted concrete along with major role for waste tin fibers produce the excellent improvement in the case of axial loading thus results to produce the higher bending stress that's also up to 1.5% of waste tin fibers (by volume fraction)

This type of sugarcane industrial waste (SCBA) is strongly recommended to construction building industries to reduce to chloride ions permeability, cost-saving project due to economic point of view and carbon-di-oxide emission was considerably minimize and also to resolve the disposal problems thereby it is eco-friendly from environmental pollution.

REFERENCES

1. Aigbodion V. S., Hassan S. B., Ause, T Nyior G.B., 2010. Potential Utilization of Solid Waste (Bagasse Ash), Journal of Minerals & Materials Characterization & Engineering 9, p.67-77.
2. Ganesan K., Rajagopal K., Thangavel K. 2007. "Evaluation of bagasse ash as supplementary cementitious material". Cement and Concrete Composites, 29, 515-524.
3. Hariharan V., Shanmugam M., Amutha K., Sivakumar G., "Preparation and characterization of ceramic products using sugarcane bagasse ash waste," Research Journal of Recent Sciences, vol. 3, pp. 67–70, 2014.
4. Kulkarni S. Raje, Rajgor M., "Bagasse ash as an effective replacement in fly ash bricks," International Journal of Engineering Trends and Technology, vol. 4, no. 10, pp. 4484–4489, 2013.
5. Rajkumar P. R., Krishnan K. D., Ravichandran P. T., Harini T. A., "Study on the use of bagasse ash paver blocks in low volume traffic road pavement," Indian Journal of Science and Technology, vol. 9, no. 5, pp. 1–6, 2016.
6. Balakrishnan M., Batra V. S., "Valorization of solid waste in sugar factories with possible applications in India: a review," Journal of Environmental Management, vol. 92, no. 11, pp. 2886–2891, 2011.
7. Piyanut uangtong Suvimol Sujjavanich, Sansanee Boonsalee, Duangrudee Chaysuwan "Effect of fine baggase ash on workability and compressive strength of mortar," Chaing Mai J.sci vol. 40, no.1, pp. 126-134, 2013.
8. Cordeiro G.C., R.D. Toledo Filho, Fairbairn E.M.R., "Effect of calcination temperature on the pozzolanic activity of sugarcane bagasse ash," Construction and Building Materials, vol. 23, pp. 3301–3303, 2009.
9. Numtachai Chusilp, Chai Jaturapitakkul, Kraiwood Kiattikomol, "Utilization of bagasse ash as a pozzolanic material in concrete," Construction Building Materials., vol. 23, pp.3352-3358, 2009.
10. Anderson, D.; Roy, A.; Seals, R. K.; Cartledge, F. K.; Akhter, H.; Jones, S. C., "A preliminary assessment of the use of an amorphous silica residue as a supplementary cementing material," Cement and Concrete Research, vol. 30, pp. 437-445, 2000.
11. Southararajan V.M., Sivasankar S., Ramadasu T.L., "High Early strength of slag based Fibre Reinforced concrete", International Journal of Engineering and Advanced Technology. vol. 8, pp. 1146-1150-1156, 2019.
12. Southararajan V.M., Sivasankar S., Ramadasu T.L., '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.
13. Southararajan V.M., Ramadasu T.L., Sivasankar S., 'Strength Development Properties of Sugar Cane Bagasse ash Blended Geopolymer Concrete," International Journal of Engineering and Advanced Technology. vol. 8, pp. 1151-1156, 2019.
14. Dillibai K., Krishna Rao A. Southararajan V.M. "Conventional Concrete Mix Design For Producing The Low And High Volume of Fly Ash Based Fiber Reinforced Concrete," International Journal of Engineering and Advanced Technology. vol. 8, pp. 1157-1162, 2019.
15. Southararajan V.M., Ramadasu T.L., Sivasankar S., 'Efficiency of Fiber Reinforced Concrete Containing Waste Marble dust and Waste Foundry Sand," International Journal of Engineering and Advanced Technology. vol. 8, pp. 2384-2390, 2019.
16. Southararajan V.M., Sivasankar S., Krishna Rao A., 'Effects of Calcium Nitrate in Sugar Cane Bagasse Ash and Partial Replacement of Fine aggregate by Stone Dust," International Journal of Engineering and Advanced Technology. vol. 8, pp. 5155-5160, 2019.

AUTHORS PROFILE

Dr V.M. Southararajan 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 S. Sivasankar, working as an Associate professor in the Department of Civil Engineering at 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 12 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.

Mr. R Vinodh Kumar: Working as an Assistant Professor in Meenakshi College of Engineering, Chennai, Tamil Nadu, having 6 years of teaching experience and 4 years of industrial experience. He completed his ME Structural Engineering from Annamalai University. He guided six ME projects and 35 BE projects. He is having interest in concrete technology and research work. He is also a member of ISTE.

Mr. Nabajyoti Modak: Completed B.E. CIVIL Engineering from Sathyabama Institute of Science and Technology (Deemed to be University) in 2016 and M.E. Structural Engineering from Anna University in 2018. Currently working as an assistant professor in CIVIL Engineering department in Anand Institute of Higher Technology, Chennai, Tamil Nadu, India. He is interested in structural engineering and research woks. His area includes concrete and steel structures, strengthening and retrofication of concrete and steel structures, polymer resin concrete, Polymer composites, composite structures and their applications. He is having a teaching experience of one year. He guided 6 BE projects and one ME project.

K. Dilli Bai, Pursing M.Tech in Structural Engineering at CMR Institute of Technology, Hyderabad, India. She has published Two International Journal papers.