E3S Web of Conferences **529**, 01045 (2024) https://doi.org/10.1051/e3sconf/202452901045
ICSMEE'24

An investigation of biopolymers in corrosion resistance under industrial exposure condition

Revathi S, Thirumal B, Mukarram Reza M, Dhamodharan P

Assistant Professor, Department of Civil Engineering, Mahendra Engineering College, Namakkal, India.

Abstract. India, a developed country with a bounty of resources, has produced a large number of biopolymers that were employed in historical construction. If these biopolymers are proven through research to have positive aspects, it would eventually result in the development of environmentally friendly, cost-effective, and long-lastingstructures. Although many of the efficient inhibitors, like chromate and arsenate, are exceedingly poisonous, the price of inorganic inhibitors is generally inexpensive. As neem and turmeric extracts are readily available and may be obtained year-round in concrete, they should be further investigated as corrosion inhibitors in various ratios and combination. This experimental investigation can be used to provide a corrosion inhibitor that is affordable, non-toxic, eco-friendly, and user-friendly.The application of biopolymer in concrete has been supported by the results of the feasibility study, which additionally showed promising result for aexcellent corrosion inhibitor from the phytochemical analysis and results for compressive strength.

Key words: Biopolymer, corrosion inhibitor, Turmeric, Neem, Phytochemical Analysis

1 Introduction

In India, RCC is the primary building material used forconstruction, especially throughout the last century. However, after 10 to 20 years of construction, these structures necessitate repair. Due to the concrete's weakening, the steel reinforcement bars utilized in these constructions are corroding, which is the cause of the early discomfort and degradation. Research in this field has an abundance of potential because of the vast no. of structures that require rapid repair and refurbishment.Metal can corrode due to chemical attack or reactions with surrounding materials. Rust, which forms when steel corrodes, consume vast space thanthe steel itself. Tensile strains imposed on by this expansion may eventually result in spalling, delamination, and cracking in the concrete. In an effort to reduce or avoid rusting, concrete corrosion can be decreased by applying coatings to reinforcement, galvanized

Correspondoing author: vidhya22047@gmail.com

reinforcement, enhancing metallurgy through the addition of copper and chromium, Corrosion inhibitors, nonferrous reinforcement, concrete coatings, concrete quality enhancement, and appropriate stacking and storage of reinforcing steel.The traditional method of repairing the damaged concrete with regular cement composite failed because the old concrete and the repair material did not bond properly for a variety of reasons, including drying shrinkage, the application technique, material selection etc..On the other hand, scientifically approached repairs utilizing high-quality, technically proficient materials (such as epoxies) result in unfeasible fixes. Furthermore, these repair solutions lack the durability necessary to endure the tropical climate we experience.

India, an economically prosperous nation with an abundance of resources, has produced more number of biopolymers that had used in historical construction. If these biopolymers are discovered through experimentation to have beneficial properties, it will pave the way for durable, affordable, and environmentally friendly buildings.One of the popular countermeasures is the application of corrosion inhibitors, as many of the more potent inhibitor quite hazardous.Natural biopolymers are organic compounds derived from certain plants- seeds and fruits extracts. Corrosion-inhibitors made from plant-extracts are inexpensive, non-toxic, and environmentally benign. By adhering to the steelsurface and creating a shielding layer, organic inhibitors provide defense.

A study to examine the inhibitory properties of curcuma longa L. extract at varying temperatures (30, 35, and 40 ˚C) and in different dosage refinery wastewater (0.05% to 2% by wt) was experimented by Aprael S et al [2]The findings shown that the adsorption- process inMS surface and approx.. 1.2% (v/v) of curcuma-extract produced about inhibition 84%, demonstrating its effectiveness on mild-steel corrosion in purified refinery wastewater. Baggaetalusedpotentio dynamic polarization and (EIS) to investigate the suppression of mildsteel corrosion in 1N H_2SO_4 solution by Ficusracemosa (FR) extract from stem. It came to light that inhibitory efficiency decreased with rising temperatures and increased with increasing stem extract content at all temperatures[3]. The synergistic combination of all the extract's adsorbed phytochemical elements is accountable for the observed inhibition. In a 2016 study, Alaneme et al. examined the adsorption properties and corrosion prevention of elephant-grass(Pennisetumpurpureum) extract on themildsteel in 1MHCl solution[7]. The loss in mass and corrosionrate were found to decrease as the extractsconcentration was increased. The impact of using green corrosion inhibitors in reinforced concrete was examined by Lisha C. et al. [9]. The greencorrosioninhibitor used in this study were taken out of aloe vera and Azadirachtaindica, or neem. Azadirachtaindica, or neem, has highcorrosion-inhibition efficacy than Aloe-Vera.Lots of research is going on the sustainable development incorporating various industrial residues in construction.[1,8,12,10,11] The carbon foot print mitigation is the key goal in infrastructure development in the current scenario[13-23]. The present research aims to incorporate biopolymers into concrete to enrich its performance.

2 Experimental Program

The sequence of work consists of material collection, preparation, phytochemical analysis/study, solution preparation, application into concrete at various dosages, and testing of concrete cubes.The details of mix proportion are explained in detail, the basic material properties are found out from the experiments.

2.1 Phytochemical Analysis

Phytochemical screening is done to know the profile of a specific- extract for its chemical makeup, various qualitative chemical tests were done.Turmeric and neem powders that have been dried are to be analyzed in a lab for phytochemical analysis. This will disclose the chemical components found in turmeric and neem. The goal of this test is to detect the organic species that have inhibitive qualities that improve the inhibitor's ability to bind to the steel surface. The concrete is mixed with this chemical extract. This will prevent corrosion and improve the structures' robustness and longevity.

Fig. 1. Neem leaves and Turmeric powder

2.2 Extraction Process Of Turmeric

Turmeric is procured dried and ground to powder. 10grams of turmeric is taken, weighted and soak in 50mL of ethanol for 24 hours. The extracted turmeric and neem is represented in figure 2.

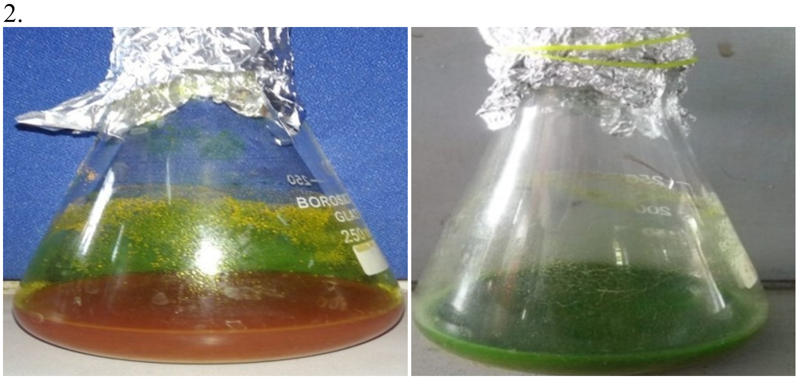

Fig.2. Extraction of Turmeric and neem

2.3 Phytochemical Screening Procedures

To determine the chemical composition profile of a specific extract, various qualitative chemical tests are made. To identify the different phyto components present in the extracts, the following assays were run on them.

2.3.1 Detection of phenolic compound

A few drop of ferric chloride 0.5% solution are to the extract. Phenol was represented by a dark green color.

2.3.2 Detection of glycosides

Add 3–5 drops of pyridine and sodiumnitroprusside (half pellet) to the extract. The presence of glycosides is indicated by a blood red hue.

2.3.3 Detection of terpenoids

Chloroform (2 ml) was added to the the biopolymer extract. To create a layer, 3 milliliters of concentrated H2S04 was carefully applied. The interface's reddish-brown coloring suggests the presence of terpenoids.

2.3.4 Detection of flavonoids

A minimal amount of 1% NaOH solution and a small amount of concentrated H2S04 were added to the extract, respectively. A quick yellow color development indicates the existence of flavonoids.

2.3.5 Detection of tannins

A few drops of 0.5% ferric chloride were supplementary to the extract, and its color was checked for brownish green or blue-black hues.

2.3.6 Detection of steroids

A small amount of strong sulfuric acid was added to the extract after a small amount of acetic anhydride. The progress of brown precipitate suggests a positive steroid result.

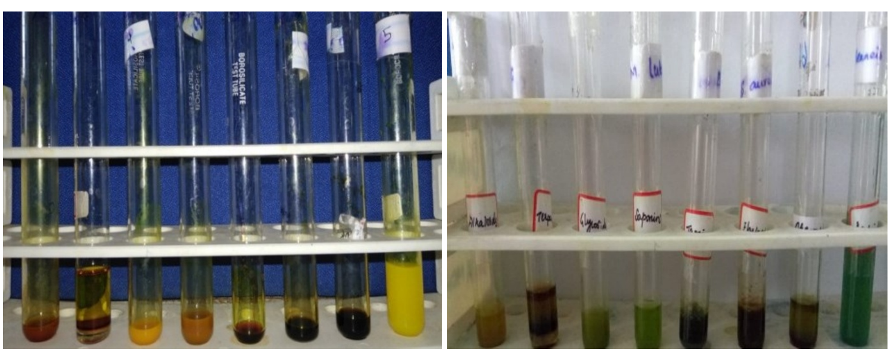

Fig.3. Phytochemicals in Turmeric and neem

Table 1. Sieve Analysis

Sieve size	Weight retained in grams	Percentage retained	Cumulative Percentage retained	Percentage passing
4.75 mm	0	0	0	100
2.36 mm	38	3.8	3.8	96.2
1.18 mm	294	29.4	33.2	66.8

600 microns	198	19.8	53	47
300 microns	257	25.7	78.7	21.3
150 microns	160	16	94.7	5.3
Pan	53	5.3	100	0

From Table 9 of IS 383:2016, the gradation of sand comes under Zone II [6]. The aggregate properties are presented in Table 2.

Table 2. Aggregate properties

S.No.	Parameters	Fine aggregate	Coarse aggregate
1	Bulk-Density(kg/m^3)	1923	1915
2	Specific Gravity	2.66	2.71
3	Fineness modulus	2.68	3.98

2.4 Mix for concrete

M30 grade of concrete is selected for the experiment study and the table shows the mix design for various ingredient in concrete.The mixed proportion is presented in table 3.

Table 3. Mix proportion

Cement (kg/m^3)	Fine aggregate(kg/m^3)	Coarse aggregate(kg/m^3)	Water	W/C
437.8	593.406	1130.976	197	0.45
1	1.36	2.58		

2.5 Mix details

The trail combination of the biopolymers is the concrete mix is presented in table 4.

Table 4. Trial Mix

S.No	Sample	Turmeric	Neem
1	Control	-	-
2	BP1	0.5%	-
3	BP2	-	0.5%
4	BP3	0.5%	0.5%
5	BP4	1%	-
6	BP5	-	1%

2.6 Casting of biopolymer incorporated concrete cubes

The organic based biopolymers such as turmeric and neem are infused in the concrete at various dosages and the 150mm x 150mmx 150 mm concrete cubes are cast. Figure 4 represents the casting of cubes With biopolymers.

Fig. 4. Casting of cubes with 0.5% and 1% Turmeric powder

3 Results and Discussions

A vast series of experiments had been performed to evaluation the features of biopolymer inclusion in the concrete[4,5]. The result of the tests conducted are presented.

3.1 Findings of the photochemical analysis

The photochemical assay is done to investigate the reaction of the biopolymers neem and turmeric interacting with various chemicals. The results of the tests conducted are in Table 5 and 6.

Table 5. Phytochemical element present in turmeric

S.N0	TEST	RESULT
1	Glycoside	Nil
2	Flavonoid	++
3	Tannin	++
4	Phenol	++
5	Saponi	Nil
6	Terpenoid	++
7	Alkaloid	++
8	Steroid	++
9	pH	7.4

The test results of turmeric are positive for Phenols, Flavonoids, Tannins, Alkaloids, Terpenoids and Steroids.

Table 6. Phytochemical element present in Neem

S.NO	TEST	RESULT
1	Tannin	++
2	Flavonoid	++
3	Alkaloid	++
4	Protein	Nil
5	Saponin	Nil
6	Glycoside	Nil
7	Terpenoid	++
8	Steroid	++
9	pH	8

The test results of neem are positive forFlavonoids, Tannins, Alkaloids, Terpenoids and Steroids. Table 7 gives the results of the mechanical characteristics of the biopolymers under compression.

Table 7. Compressive strength of cubes

S.No	Sample	Turmeric	Neem	Compressive Strength (N/mm^2)		
				7	14	28
1	Control (CC)	-	-	15.42	21.45	31.45
2	BP1	0.5%	-	17.43	22.55	32.15
3	BP2	-	0.5%	18.01	24.75	33.45
4	BP3	0.5%	0.5%	20.15	28.45	36.78
5	BP4	1%	-	17.45	23.60	32.15
6	BP5	-	1%	16.15	22.45	31.98

3.2 Results from the compressive strength

The results from the experimental study is represented in the figure 5.

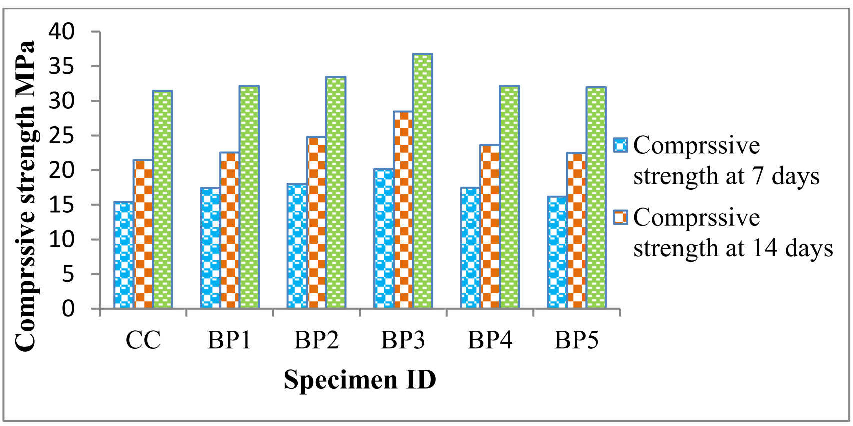

Fig. 5. Compressive strength representation

The results represented in figure 5 reveal that the maximum strength is noticed from the biopolymer combination BP3. The addition of neem and turmeric biopolymer at 0.5% dosage is yielding the maximum compressivestrengthas inferred from the study. This ideal hybrid combination yielded a good combination rather than individual addition of biopolymers.

3.3 Results from the split tensile strength

The results taken from the experimental study for determining the tension effects in concrete is denoted in the figure 6.

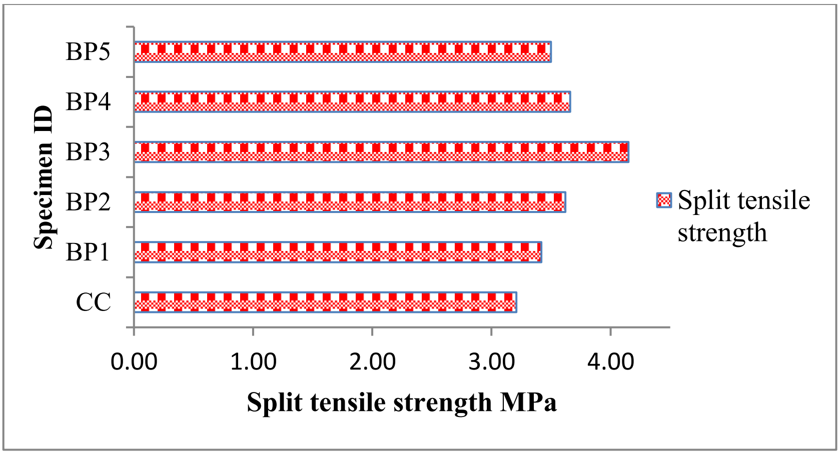

Fig. 6. Split tensile strength representation

The figure 6 portrays the stimulus of the biopolymers as need and turmeric in M30 concrete grade under the effect of the tensile forces. The figure gives a clear identity that the biopolymer inclusion at 0.5% dosage enriches the tensile strength characteristics meritoriously. The same has been in observed in past studies [24-29].

3.4 Results from the flexural strength

The results notice from the experimental study is signifiedin the figure 7.

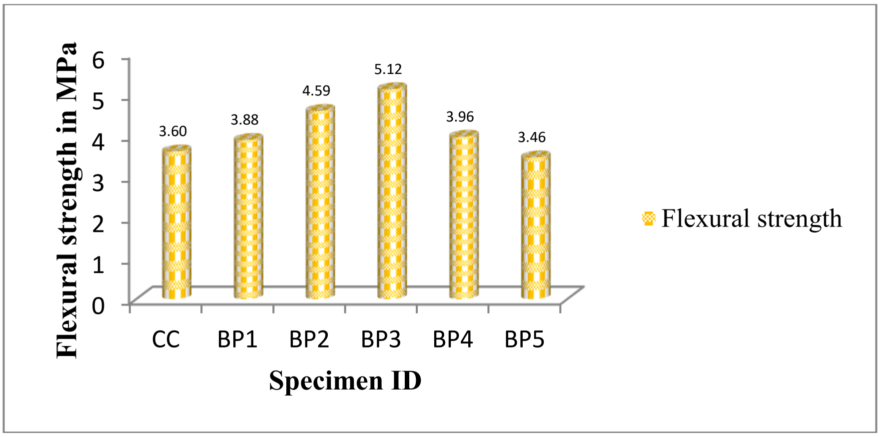

Fig. 7. Flexural strength representation

The figure 7 presents the characteristics of the biopolymers under the flexural characteristics. The flexural strength is high for BP3 combination from the experiment. The results are 42% higher compared with the control concrete specimen.

4 Conclusion

The following findings are the outcome of a concise and thorough investigation into the characteristics of concrete using biopolymers.

- The species of neem and turmeric has substantial quantities of alkaloid, total phenolics, saponins,totalflavonoidandtannin in accordance with a quantitative phytochemical examination.
- The incorporation of the biopolymer in the M30 concrete upto 0.5 percentage greatly enhances the characteristics of concrete.
- The ideal combination of the biopolymer is recognized as 0.5 % neem and 0.5% turmeric dosages.
- The compressive strength of the BP 3 mix recorded 16.9% higher strength comparative to the control mix.
- The mechanical characteristic of the biopolymer inclusion concrete improved significantly.
- Natural biopolymers are cost-effective and prove to bea suitable method for enhancing concrete characteristics.

REFERENCES

1 AmjathB ,Vidhya K and Revathi S, Study on ferrocement-based strengthening of Reinforced concrete column, Emperor Journal of Applied Scientific Research, Vol. 4 Issue–11, pp.1-5, (2022).

2 Aprael S. Yaroa and Kabas F. Talib, Corrosion Inhibition of Mild Steel by Curcuma Extract in Petroleum Refinery Wastewater, Iraqi Journal of Chemical and Petroleum Engineering,Vol.15, pp.9-18, (2014).

3 Bagga, ManpreetGadi, RanuYadav, Ompal Kumar, Raman Chopra, Rashi Singh and Gurmeet, Investigation of phytochemical components and corrosion inhibition property of Ficusracemosa stem extract on Mild steel in H2SO4 medium, Journal of Environmental Chemical Engineering, 4, (2016). 10.1016/j.jece.2016.10.022.

4 IS : 2386 (Part I) – 1963, 'Methods of test for concrete part 1 particle size and shape', Bureau of Indian Standards, NewDelhi.

5 IS 1199 (1959), 'Methods of sampling and Analysis of concrete', Bureau of Indian Standards, NewDelhi.

6 IS 383: 1970, 'Specification for coarse and fine aggregates from natural sources for concrete', Second revision, Bureau of Indian Standards, New Delhi.

7 K.K. Alaneme, S.J. Olusegun, A.W. Alo, Corrosion inhibitory properties of elephant grass (Pennisetumpurpureum) extract: Effect on mild steel corrosion in 1M HCl solution, Alexandria Engineering Journal, Vol.55, Issue 2, pp.1069-1076, (2016).

8 Kavitha E , Vidhya K, Revathi S, Shivasakthivadivelan R A, Development Of Eco-Friendly Masonry Blocks Made From Industrial Residues, International Research Journal of Engineering and Technology (IRJET), 09 (12), pp.799-801, (2022).

9 Lisha C. Rajalingam and Sunilaa George, corrosion resistance of reinforced concrete with green corrosion inhibitors, International Journal of Engineering Science Invention Research & Development, Vol.3, Issue XI, pp.687-691, (2017).

10 Revathi S and Vidhya K, Eco-sustainable alkali activated brick using municipal incinerated ash, International Journal of Coal Preparation and Utilization, 42(3), pp.331-348, (2021).https://doi.org/10.1080/19392699.2021.2007480.

11 Revathi S and R.S Gandhimathi, Experimental Investigation on Mechanical Properties of Hybrid Fibres in M25 Grade Concrete with Partial Replacement of Cement Using GGBS, Recent Trends In Civil Engineering & Technology, 6(2), pp.51-56, (2016).
12 Revathi S, Experimental Investigation On stress - strain behaviour of brick prism, Integrated Journal of Engineering Research and Technology (IJERT), Volume 3,Issue 4, pp.276-282, (2015).
13 Revathi S, Vidhya K, Kavitha E and Shivasakthivadivelan R A, Study on the development and behavior of green geopolymerbricks,International Research Journal of Engineering and Technology (IRJET), Vol. 09, Issue. 12, pp.927-930, (2022).
14 Revathi.S, R.S Gandhimathi and Saranya.S, Experimental Investigation On Structural Behaviour Of Hybrid Fibres In M25 Grade Concrete, International journal of innovations in engineering and technology(IJIET), volume 6, Issue 3, pp. 213-220, (2016).
15 Vidhya K and Revathi S, Performance evaluation of industrial ash geopolymer-based bricks, Journal For Basic Sciences, Volume 23, Issue11, pp. 534-539, (2023).
16 Sudharsan N, S Praburanganathan,YeddulaBharathSimha Reddy &Pavan Kumar P(2022), Interaction of anthracite coal ash and Archishypogaea shell ash on an innovative brick: an experimental and simulation study, Coal Preparation, https://doi.org/10.1080/19392699.2022.2089127
17 Vidhya K, Revathi S and R A Shivasakthivadivelan, Utilization of Industrial Ash in Paver Blocks, Journal of Xi'an University of Architecture & Technology, Volume XII, Issue IV, pp.4883-4889, (2020).
18 Mondikatti, P., Sudharsan, N., Praburanganathan, S., &Aruna, G. (2023). The Impact of castoff aggregate on the fresh and mechanical behaviour of high-range water reducer administered self-compacting concrete. Materials Today: Proceedings. https://doi.org/10.1016/j.matpr.2023.03.061
19 Vidhya K, S.Kandasamy, Experimental Investigations on the Properties of Coal-Ash Brick Units as Green Building Materials, International Journal of Coal Preparation and Utilization 36 (6), volume 36, Issue-6, pp.318-325, (2016).
20 Praburanganathan, S., Sudharsan, N., BharathSimha Reddy, Y., Naga Dheeraj Kumar Reddy, C., Natrayan, L., &Paramasivam, P. (2022). Force-Deformation Study on Glass Fiber Reinforced Concrete Slab Incorporating Waste Paper. Advances in Civil Engineering, 2022. https://doi.org/10.1155/2022/5343128
21 Vidhya K, Shivasakthivadivelan.R A, Kavitha K and Revathi S, Experimental Study on Greener Brick Using Sustainable Materials, Emperor Journal of Applied Scientific Research, 2(8), (2020).
22 Vidhya K, ThamaraiSelvan R, Saradha P, Revathi S and Nithya B, Determination of Mechanical Properties of Industrial Ash Brick, Emperor Journal of Applied Scientific Research Vol 2, Issue 4, pp.21-27, (2020). https://doi.org/10.35337/EJASR.2020.v02i04.004.
23 VidhyaKumarasamy, RevathiSampath and Kandasamy S, Experimental Study on Hardened Mechanical and Durability Properties of Industrial Ash Bricks, Iranian Journal of Science and Technology, Transactions of Civil Engineering, 46, pp.1929-1936, (2022). https://doi.org/10.1007/s40996-021-00783-9.
24 Arunkumar, Kadarkarai, Muthiah Muthukannan, Arunachalam Suresh Kumar, Arunasankar Chithambar Ganesh, and Rangaswamy Kanniga Devi. 2022a. "Cleaner Environment Approach by the Utilization of Low Calcium Wood Ash in Geopolymer Concrete." *Applied Science and Engineering Progress* 15 (1): 1–13. https://doi.org/10.14416/j.asep.2021.06.005.
25 Arunvivek, G. K., and D. Rameshkumar. 2022. "Experimental Investigation on Feasibility of Utilizing Phosphogypsum in E-Glass Fiber-Incorporated Non-Fired Ceramic Wall Tile." *Journal of The Institution of Engineers (India): Series A* 103 (2): 445–51. https://doi.org/10.1007/s40030-021-00604-2.
26 Prithiviraj, Chidambaram, Packirisamy Swaminathan, Deivasigamani Ramesh Kumar, Gunasekaran Murali, and Nikolai Ivanovich Vatin. 2022. "Fresh and Hardened Properties of Self-Compacting Concrete Comprising a Copper Slag." *Buildings* 12 (7). https://doi.org/10.3390/buildings12070965.

27 Sankar, B., and P. Ramadoss. 2022. "Experimental and Statistical Investigations on Alccofine Based Ternary Blended High-Performance Concrete." *International Journal of Engineering, Transactions B: Applications* 35 (8): 1629–40. https://doi.org/10.5829/IJE.2022.35.08B.19.
28 Sankar, B, and P Ramadoss. 2023. "Results in Control and Optimization Modelling the Compressive Strength of High-Performance Concrete Containing Metakaolin Using Distinctive Statistical Techniques." *Results in Control and Optimization* 12 (December 2022): 100241. https://doi.org/10.1016/j.rico.2023.100241.
29 Arunkumar, Kadarkarai, Muthiah Muthukannan, Arunachalam Suresh Kumar, Arunasankar Chithambar Ganesh, and Rangaswamy Kanniga Devi. 2021. "Production of Eco-Friendly Geopolymer Concrete by Using Waste Wood Ash for a Sustainable Environment." *Pollution* 7(4):993–1006. doi: 10.22059/POLL.2021.320857.1039.