MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 2135-2140

Experimental Investigation on Epoxy Polymer Modified Concrete Incorporating Sawdust as a Sustainable Partial Replacement

Bharani S[1], Ramesh kumar G[2*], Abishek S R[3], Mohamed Ameen M I[4], Sabarinath S[5]
[1]Assistant Professor, Department of Civil Engineering, KPR Institute of Engineering and Technology, Tamil Nadu, India, bharani.sri69@gmail.com
[*2]Assistant Professor, Department of Civil Engineering, Dr. N.G.P. Institute of Technology, Coimbatore, Tamil Nadu, India, grameshkumar1990@gmail.com
[3]PG Student, Department of Civil Engineering, KPR Institute of Engineering and Technology, Tamil Nadu, India, sivaabi75@gmail.com
[4]Department of Civil Engineering, KPR Institute of Engineering and Technology, Tamil Nadu, India, ameenmms313@gmail.com
[5]Department of Civil Engineering, KPR Institute of Engineering and Technology, Tamil Nadu, India, sabarinaths688@gmail.com

Abstract
The increasing demand for sustainable construction materials has encouraged the utilization of industrial and agricultural waste in concrete production. This study presents an experimental investigation on epoxy resin-based polymer modified concrete incorporating sawdust as a partial replacement for fine aggregate. Sawdust, a biodegradable waste material, was used at an optimum replacement level of 10% by weight of fine aggregate, while epoxy resin was added as 5% and 10% to enhance the binding characteristics of the concrete matrix. experimental program was carried out to evaluate the mechanical properties such as characteristic strength, split tensile strength, and flexural strength were evaluated at 7 and 28 days. The results indicate that the incorporation of epoxy resin significantly improves the bonding between cement paste and sawdust, it leads to increase the strength and reduce the crack propagation. The optimum performance was identified at M4 that is 5% sawdust with addition of 5% epoxy resin. Overall, the study demonstrates that addition of epoxy resin and sawdust can be utilized effectively to develop eco-friendly, high-performance concrete suitable for sustainable construction applications.
Keywords: Polymer Modified Concrete, Epoxy Resin, Sawdust, Mechanical Properties, Fire Test

1. Introduction

Concrete is widely used in construction across the world due to its adaptability, strength and durability. Yet the rapid growth of infrastructure development has led to an increased demand for natural resources such as river sand and aggregates. This resulting in their depletion and causing serious environmental concerns (Ferdous W et al., 2020; Modesti, L. A et al., 2020). At the same time, the large quantities of agricultural and industrial wastes are being generated thus creating disposal challenges (Siddique R et al., 2020). In this context the utilization of waste materials in the concrete production has gained significant attention to sustainable and eco-friendly approach.

Amongst various waste materials sawdust is an ample byproduct of the timber industry and it is a biodegradable material that can be effectively utilized as a partial replacement for fine aggregate (Venkatesh, B., & Kumar, G. R., 2018). This incorporation not only reduces environmental burden but also contributes to the improved ductility and crack resistance of the concrete (Fapohunda, C, et al., 2018). Still the use of wood based materials may affect the strength and bonding characteristics of conventional concrete to enhance its performance.

Polymer modification of the concrete has occurred an effective technique to improve mechanical and durability properties (Jokhio, G. A., et al. 2021). Epoxy resin is the excellent adhesive properties, high strength, and resistance to chemicals and moisture (Nodehi M, 2022; Resan, S. A. F. et al., 2020). The addition of epoxy in the concrete can significantly enhance the bonding between cement paste and aggregates that improves strength and reducing crack propagation. In this study an investigation has been made to develop a sustainable polymer modified concrete by incorporating sawdust as a partial replacement as fine aggregate and adding epoxy resin as a binding agent (M. A. Farooqi & N. Mirza, 2023). The mechanical properties such as compressive strength, split tensile strength, and flexural strength were evaluated at the age of 7 and 28 days (Idrees, M et al., 2022). The objective of the study is to assess the probability of producing high performance and eco-friendly concrete suitable for modern construction applications.

2. Materials used

2.1 Cement, Fine aggregate and Coarse aggregate

In this investigation Portland Pozzolana Cement (PPC) conforming to IS 1489 (Part 1):1991 was used with the measured specific gravity of 3.05. The fineness was 320 m²/kg indicating adequate particle refinement for high strength concrete applications. In this investigation the fine aggregate was used as crushed manufactured sand and selected from a locally approved quarry source. The material exhibited a specific gravity of 2.60 and a water absorption value of 2.5%, indicating stable physical characteristics. Its particle size distribution was well controlled, with angular particles that enhanced internal friction and contributed to improved cohesion and packing within the concrete mix. The coarse aggregate used from crushed granite stone obtained from a local quarry with a size of 20 mm was adopted to ensure compatibility with structural concrete requirements. The aggregate exhibited a specific gravity of 2.60, water absorption of 2% and impact value of 20%. This conformed that adequate resistance to sudden loads.

2.2 Epoxy as modifier

The epoxy resin nitobond EP was used as epoxy resin system as a polymer modifier to enhance the mechanical and durability performance of concrete. The system consisted of a Bisphenol-A–based epoxy resin as the base component and 4,4′-methylenediamine as the curing agent with the dibutyl phthalate incorporated as a plasticizer to improve flexibility and workability. This epoxy system is widely used in structural bonding, surface protection, and repair applications, due to its high adhesive strength, low shrinkage, and excellent chemical resistance. The properties of nitobond EP is presented in the table 1.

Figure 1: Epoxy Resin Nitobond EP

Table 1: Properties of Epoxy Resin Nitobond EP

Property	Typical Value
Specific gravity	1.2
Bulk density	250 kg/m³
Water absorption	75%
Particle size range	< 4.75 mm
Thermal conductivity	Low
Chemical composition	Cellulose, hemicellulose, lignin

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 2135-2140

2.5 Sawdust

Sawdust is a lignocellulosic waste material obtained from wood processing industries and it was used as a partial replacement for fine aggregate to enhance sustainability. The material was collected from a local timber unit and processed through drying and sieving to obtain the uniform particle grading suitable for concrete production. The specific gravity is 1.15, and water absorption is 5%, was found from the experimental investigation. The properties of sawdust is presented in the table 2.

Table 2: Properties of Sawdust

Property	Typical Value
Specific gravity	1.15
Water absorption	5%
Viscosity	Medium
Setting mechanism	Chemical cross-linking reaction
Bond strength	Very high
Shrinkage	Very low
Chemical resistance	Excellent
Permeability	Very low
Thermal stability	Good

3. Methodology, Mix Design and Proportions

The present investigation M40 grade of concrete is made to investigate the mechanical behaviour of polymer modified concrete. The 10% of saw dust is used as partial replacement of fine aggregate for all the mixes. Further epoxy resin nitobond EP is used as a polymer modifier for 5% and 10 % to enhance interfacial bonding and matrix compactness. Sawdust was introduced to reduce material density and improve sustainability. Various specimens are casted to investigate the mechanical properties such as compressive strength, flexural strength, split tensile strength of polymer modified concrete. The different mix proportions of polymer modified concrete is presented in the table 3.

Table 3: Mix proportions of Sawdust and Epoxy Resin for Polymer Modified Concrete

Mix ID	Sawdust (%)	Epoxy (%)	Water
M0 (Control)	0	0	0.45
M1	5	0	0.45
M2	10	0	0.45
M3	0	5	0.45
M4	5	5	0.45
M5	10	5	0.45
M6	0	10	0.45
M7	5	10	0.45
M8	10	10	0.45

4. Experimental investigation

Three categories of concrete specimens were prepared to evaluate the influence of epoxy resin and sawdust on the performance of M40 grade concrete. This included a conventional control concrete mix. The first modified mix containing 5% epoxy resin as partial replacement of cement and 10% sawdust as partial replacement of fine aggregate. The second modified mix containing 10% epoxy resin as a partial replacement of cement with 10% the same level of sawdust substitution. Similarly for each mix category, 12 specimens were cast with six specimens for testing at 7 days and the remaining six at 28 days mechanical properties. Each specimen was clearly labeled with its mix designation such as M1 to M8, and curing age to facilitate systematic evaluation and comparison. The proportions of cement, fine aggregate, coarse aggregate, water, epoxy, and sawdust were calculated to maintain a consistent water-cement ratio of 0.45 across all mixes. Epoxy Polymer and Hardener mixed at 2:1 ratio as per the manufacturer's guidelines into the concrete mix. In accordance with IS 516:1959 the compressive strength testing of M40-grade concrete was carried out at 7 and 28 days to assess its performance. Figure 2 and figure 3 represented the mix preparation and investigation of polymer modified concrete.

Figure 2: Materials mixing and preparations

Figure 3: Testing of Hardened Concrete

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 2135-2140

5. Results and Discussion

5.1 Characteristics Strength of Concrete

The results of the compression test are indicated in the table below where the saw dust is used as constant and the epoxy replacement is varied. The compressive strength of concrete improved with the combined incorporation of sawdust and epoxy resin up to an optimum replacement level (Mix 4), after which a reduction was observed. The 28 days strength increased by about 23% compared to the control mix due to improved interfacial bonding and better particle packing. In contrast concrete with only sawdust replacement showed a continuous decrease in strength with a reduction of about 26% mainly due to higher porosity and weaker bonding of wood aggregates. Epoxy resin alone increased compressive strength by about 22% up to the optimum level. Due to excess epoxy resin and poor aggregate interlocking the strength reduced gradually. At the optimum mix the combined replacement exhibited significantly higher strength. The M1 sawdust only concrete and slightly higher strength than M4 epoxy only concrete demonstrating a synergistic effect between epoxy resin and sawdust in enhancing the concrete performance. The compressive strength of different mix proportions is presented in the figure 4, figure 5 and figure 6. The result shows that the combination of saw dust and epoxy resin in M4 is found to be optimum and giving higher compressive strength comparing to other mixes.

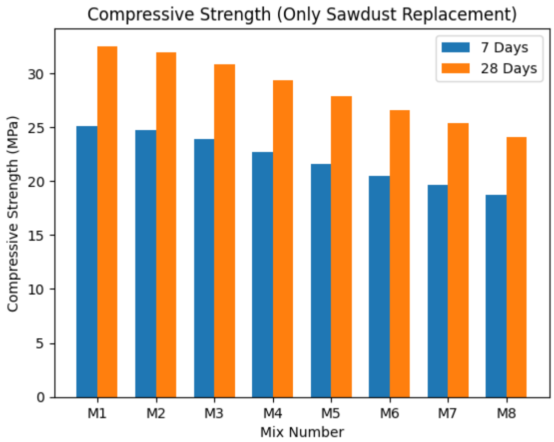

Figure 4: Characteristic Strength of concrete with replacement of sawdust

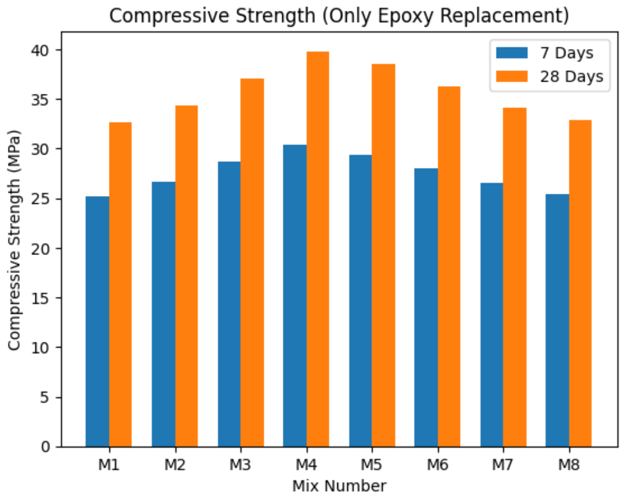

Figure 5: Characteristic Strength of concrete with only Epoxy replacement

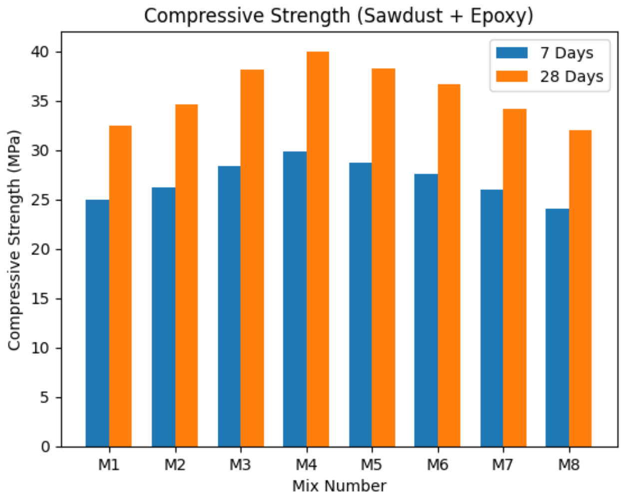

Figure 6: Characteristic Strength of concrete with sawdust and Epoxy replacement

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 2135-2140

5.2 Split Tensile Test

The split tensile strength of polymer modified concrete is investigated at the age of 7 and 28 days. The split tensile strength results are presented in the figure 7 to figure 9 and exhibited a moderate increase with material incorporation. The split tensile strength in the 10% replacement of epoxy resin achieving the highest value at 28 days compared to the control mix. This improvement is primarily due to enhanced interfacial bonding and reduced micro crack propagation under indirect tensile stress. The 5% replacement of epoxy showed only marginal variation indicating that lower replacement levels contribute limited tensile enhancement. The split tensile strength results shows that the addition of sawdust and epoxy resin significantly influences the tensile behaviour of concrete. The combination of sawdust and epoxy resin improved the strength up to the M4 and achieving about 26% higher strength than the control mix. In contrast concrete with only sawdust replacement showed a reduction of about 27% in M4 compared to conventional mix mainly because of the porous nature and lower stiffness of wood particles. Concrete containing only epoxy resin also improved tensile strength by about 26% at the M4, although excessive epoxy slightly reduced strength. Overall, the combined mixture demonstrated the good performance and indicating a beneficial interaction between epoxy resin and sawdust in improving the concrete properties.

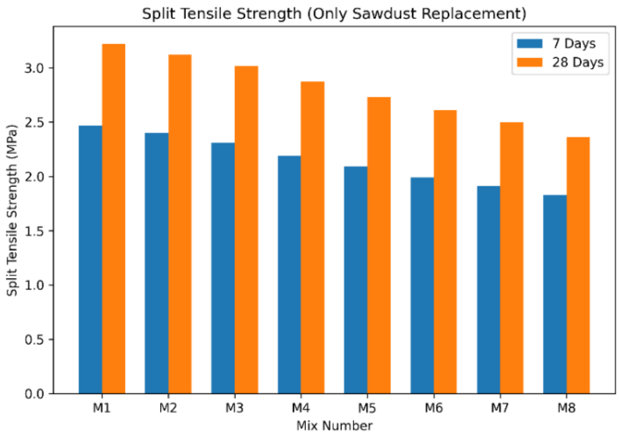

Figure 7: Split tensile Strength of concrete with replacement of sawdust

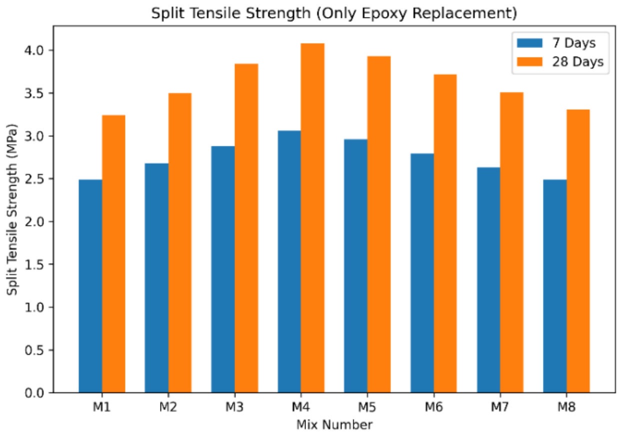

Figure 8: Split tensile Strength of concrete with only Epoxy replacement

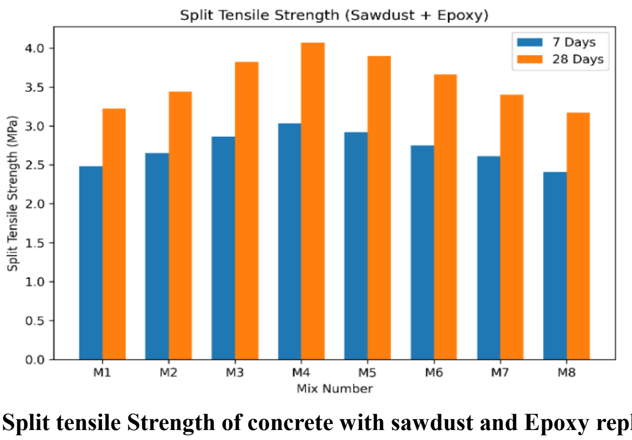

Figure 9: Split tensile Strength of concrete with sawdust and Epoxy replacement

5.3 Flexural Strength

Flexural strength of polymer modified concrete was investigated at 7 and 28 days for various samples from M0 to M8. The figure 10 to figure 12 demonstrated flexural strength of polymer modified concrete. The 10% replacement of epoxy resin mix recorded the maximum value at 28 days. The control and 5% epoxy resin mixes showed nearly similar behaviour, confirming that optimum replacement is necessary for noticeable

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 2135-2140

improvement in the flexural capacity. The flexural strength results indicate that the incorporation of sawdust and epoxy resin significantly affects the bending performance of concrete. The combination of sawdust and epoxy resin mixture exhibited the highest flexural strength and increasing up to the mix M4. The 28 days flexural strength improving by the strength by 22% compared with the control mix (M0). In contrast concrete containing only sawdust showed a reduction in flexural strength of about 26% compared to conventional mix (M0), mainly due to the higher porosity and lower stiffness of wood particles. Concrete incorporating only epoxy resin is also demonstrated improved performance with an increase of about 21% up to the optimum replacement level M4. Overall the results indicate a beneficial interaction between epoxy resin and sawdust which enhances the flexural behaviour of polymer modified concrete.

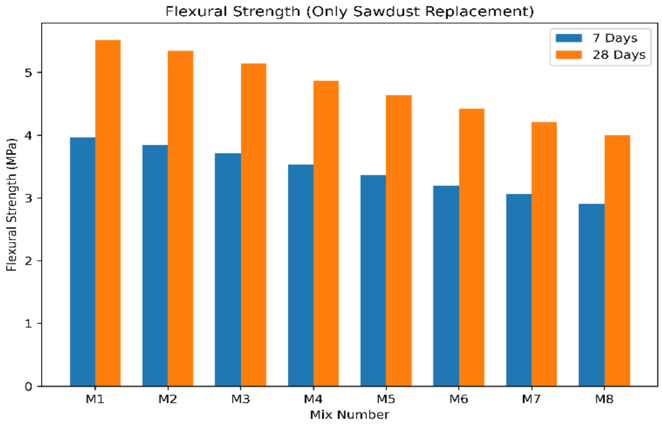

Figure 10: Flexural Strength of concrete with replacement of sawdust

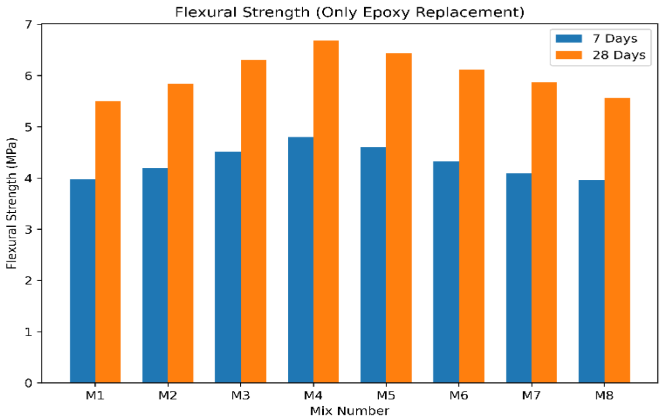

Figure 11: Flexural Strength of concrete with only Epoxy replacement

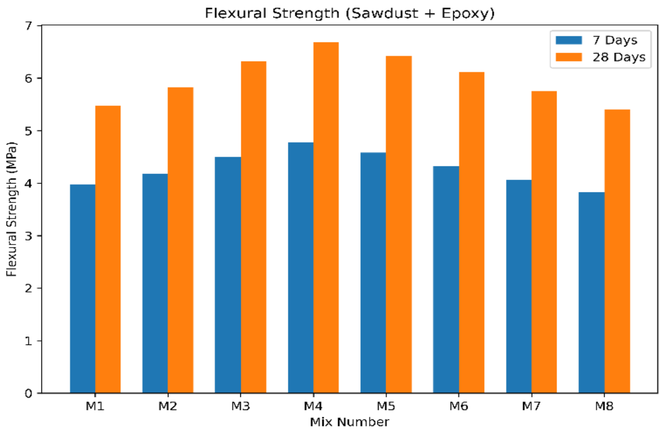

Figure 12: Flexural Strength of concrete with sawdust and Epoxy replacement

5.4 Fire testing

This experiment conducted an assessment of polymer-modified fire resistance. Mortar (PMM) on a 3-hour [22] ISO 834-11: 2014 fire test. Specimens made of concrete with 0, 5, and 10 PMM were made. Tested to determine spalling behavior. Moisture content (4%– Fibres reinforcing and 8%) were also taken into account because they were the ones that had been considered. influence fire performance. The findings show that polymer-modified mortar (PMM) increases the fire resistance to some limit. The 5% PMM mix exhibited the highest fire performance with minimum. spalling, which is consistent with the study, indicating that PMM above 8% content is prone to spalling. To maintain fire resistance and durability, a good PMM range of 5 percent, 8 percent. is recommended. More research can streamline fiber. fire additives and reinforcements.

PMM Content	Spalling Observations	Fire Resistance Performance
0% PMM	Slight to no spalling	Moderate resistance
5% PMM	No to small spalling	Improved resistance
10% PMM	Partial spalling	Increased vulnerability

Table 3: Fire testing results of polymer concrete specimens

6. Conclusion

This study examined the effect of incorporating epoxy resin and wood-based aggregates on the mechanical performance of M40 grade concrete. Based on the experimental results obtained from compressive strength, split tensile strength, and flexural strength tests, it was observed that the combined use of epoxy resin and sawdust significantly enhances the overall behaviour of concrete up to an optimum replacement level (Mix M4). At 28 days, the compressive strength increased by approximately 23%, while the split tensile and flexural strengths improved by about 26% and 22%, respectively, compared with the conventional control mix. The improvement in strength can be attributed to the enhanced bonding characteristics provided by epoxy resin and the improved stress distribution within the concrete matrix. Concrete containing only sawdust replacement showed a gradual reduction in strength with increasing replacement levels. This reduction is mainly connected with the porous nature, lower density, and weaker mechanical properties of wood particles, which reduce the overall stiffness of the concrete matrix.
On the other side the mix containing only epoxy resin demonstrated noticeable improvements in strength up to the optimum level M4, after that a slight decrease was observed due to reduced aggregate interlocking at higher polymer contents in the mechanical behaviour. The results indicate that the combination of epoxy resin and sawdust produces the most balanced and improved mechanical performance among all mixes studied. The findings suggest that this modified concrete has the potential to enhance structural performance that also contributing to the sustainable construction practices through the use of natural wood based materials.

References

1) Resan, S. A. F., Chassib, S. M., Zemam, S. K., & Madhi, M. J. (2020). New approach of concrete tensile strength test. *Case Studies in Construction Materials*, *12*, e00347. https://doi.org/10.1016/j.cscm.2020.e00347
2) Nodehi, M. Epoxy, polyester and vinyl ester based polymer concrete: a review. *Innov. Infrastruct. Solut.* **7**, 64 (2022). https://doi.org/10.1007/s41062-021-00661-3
3) Bourzik, O., Akkouri, N., Baba, K., & Nounah, A. (2022). Study of the effect of wood waste powder on the properties of concrete. *Materials Today: Proceedings*, *58*, 1459-1463. https://doi.org/10.1016/j.matpr.2022.02.5183
4) Batool, F., Islam, K., Cakiroglu, C., & Shahriar, A. (2021). Effectiveness of wood waste sawdust to produce medium-to low-strength concrete materials. *Journal of building engineering*, *44*, 103237. https://doi.org/10.1016/j.jobe.2021.103237
5) Rahman, M.M., Akhtarul Islam, M. Application of epoxy resins in building materials: progress and prospects. *Polym. Bull.* **79**, 1949–1975 (2022). https://doi.org/10.1007/s00289-021-03577-1
6) Kim, T. K., & Park, J. S. (2021). Experimental evaluation of the durability of concrete repair materials. *Applied Sciences*, *11*(5), 2303. https://doi.org/10.3390/app11052303
7) Kim, T. K., & Park, J. S. *Performance Evaluation of Concrete Structures Using Crack Repair Methods. Sustainability 2021, 13, 3217*. https://doi.org/10.3390/su13063217
8) Siddique, R., Singh, M., Mehta, S., & Belarbi, R. (2020). Utilization of treated saw dust in concrete as partial replacement of natural sand. *Journal of cleaner production*, *261*, 121226. https://doi.org/10.1016/j.jclepro.2020.121226
9) Ferdous, W., Manalo, A., Wong, H. S., Abousnina, R., AlAjarmeh, O. S., Zhuge, Y., & Schubel, P. (2020). Optimal design for epoxy polymer concrete based on mechanical properties and durability aspects. *Construction and Building Materials*, *232*, 117229. https://doi.org/10.1016/j.conbuildmat.2019.117229
10) Modesti, L. A., de Vargas, A. S., & Schneider, E. L. (2020). Repairing concrete with epoxy adhesives. *International Journal of Adhesion and Adhesives*, *101*, 102645. https://doi.org/10.1016/j.ijadhadh.2020.102645
11) Venkatesh, B., & Kumar, G. R. (2018). Experimental study on polymer concrete with epoxy resin. *International Journal of Pure and Applied Mathematics*, *119*(17), 3129-3138.
12) Fapohunda, C., Akinbile, B. A., & Oyelade, A. (2018). A review of the properties, structural characteristics and application potentials of concrete containing wood waste as partial replacement of one of its constituent material. *YBL Journal of Built Environment*, *6*(1). https://doi.org/10.2478/jbe-2018-0005
13) Jokhio, G. A., Gul, Y., & Abu-Tair, A. (2021). Using epoxy resin as partial cement replacement in concrete with silica sand as fine aggregate. *Civ. Eng. Archit*, *9*, 1513-1529.
14) Bureau of Indian Standards. (1991). *IS 1489 (Part 1): Specification for Portland pozzolana cement—Part 1: Fly ash based* (3rd rev.)
15) Bureau of Indian Standards. (1970). IS 383: Specification for coarse and fine aggregates from natural sources for concrete (2nd rev.).
16) M. A. Farooqi and N. Mirza, “Experimental study of sawdust blended concrete,” J. Build. Eng., vol. 66, pp. 106008, 2023.
17) M. A. Hossain, A. Islam, and M. K. Islam, “Influence of sawdust ash on properties of cement concrete,” Constr. Build. Mater. vol. 341, 128281, 2024.
18) S. Zafar and M. M. Rahman, “Effect of sawdust as partial sand replacement on the durability of concrete,” Constr. Build. Mater., vol. 345, 130315, 2024.
19) Barbhuiya A, R. Talukdar, and D. D. Sarma, “Mechanical and microstructural behavior of epoxy polymer modified concrete,” J. Mater. Res. Technol., vol. 17, pp. 276–290, 2021.
20) K. Singh, R. Gupta, and A. Kumar, “Properties of epoxy polymer concrete for infrastructure rehabilitation,” Constr. Build. Mater., vol. 282, pp. 122584, 2021.
21) Idrees, M., Akbar, A., Saeed, F., Saleem, H., Hussian, T., & Vatin, N. I. (2022). Improvement in durability and mechanical performance of concrete exposed to aggressive environments by using polymer. *Materials*, *15*(11), 3751. https://doi.org/10.3390/ma15113751
22) Y. H. Choi, Y. J. Kim, and H. J. Lee, “Polymer modified concrete properties at elevated temperatures,” Fire Saf. J., vol. 137, p. 103057, 2023.
23) S. R. Shukla and A. T. Porwal, “Epoxy resin in high-performance concrete: strength and durability evaluations,” J. Build. Eng., vol. 63, 105385, 2023.
24) H. M. Zain, A. H. Kassim, and E. A. Ali, “Sustainable concrete containing sawdust recycled aggregate,” Waste Manag., vol. 153, pp. 1–14, 2022.
25) Z. P. Li, Q. Chen, and J. Zhang, “Hybrid polymer-cement composites: mechanical behavior and microstructure,” Cem. Concr. Compos., vol. 127, 104399, 2022.