Journal of Science Engineering Technology and Management Science
Volume 02, Issue 06, June 2025 *ISSN: 3049-0952*
www.jsetms.com *DOI:10.63590/jsetms.2025.v02.i06.pp30-37*

UTILISATION OF DOMESTIC WASTE MATERIAL IN RECYCLED CONCRETE : A SYSTEMATIC REVIEW

Govind[1], Vineet Kumar[2]
[1] Student, M.Tech Structural Engineering, U.I.E.T, M.D.U, Rohtak, govindce23303@gmail.com
[2] Assistant Professor, Department of Civil Engineering, U.I.E.T, M.D.U, Rohtak

To Cite this Article
Govind, Vineet Kumar, "Utilisation Of Domestic Waste Material In Recycled Concrete : A Systematic Review", Journal of Science Engineering Technology and Management Science, Vol. 02, Issue 06, June 2025, pp:30-37, DOI: http://doi.org/10.63590/jsetms.2025.v02.i06.pp30-37
Submitted: 11-04-2025 *Accepted: 20-05-2025* *Published: 28-05-2025*

Abstract

The growing need for sustainable construction materials has led to increased research on the use of domestic waste in recycled concrete. This review paper examines the potential of incorporating household waste such as glass, plastics, ceramics, and organic residues into concrete production. Using these materials helps reduce landfill waste and supports a circular economy in the construction industry. Studies show that recycled aggregates from domestic waste can enhance concrete properties, including durability, strength, and workability, depending on processing methods and mixing proportions. However, challenges such as variations in waste composition, mechanical performance, and long-term durability must be addressed. This paper also explores advancements in treatment techniques, innovative concrete mix designs, and their compliance with construction standards. The findings suggest that integrating domestic waste into concrete is a viable approach for sustainable construction, reducing dependence on natural resources while maintaining structural integrity.

***Keywords**: Domestic Waste, Recycled Concrete, Sustainability, Waste Management, Circular Economy*

1 INTRODUCTION

The construction industry consumes a large amount of natural resources and plays a significant role in environmental degradation. The production of concrete is particularly significant, as it is the most commonly utilized building material globally. Traditional concrete mainly consists of cement, water, aggregates such as sand, gravel, or crushed stone, and occasionally includes additives. The process of extracting natural aggregates and producing cement significantly impacts the environment, contributing to greenhouse gas emissions, energy use, and disruption of ecosystems. The cement industry accounts for about 8% of global CO2 emissions, which makes it an important focus for sustainability initiatives (Rashad, 2014).

Recently, there has been an increasing emphasis on sustainability in the construction industry, especially through the use of alternative materials and methods that minimize environmental effects. A promising approach involves using recycled and waste materials as substitutes for traditional construction components. Materials that are typically considered waste in various industries can be reprocessed and incorporated into concrete mixes. This approach offers sustainable alternatives and helps decrease contributions to landfills and the need for resource extraction.

1.1 *Motivation for Using Domestic Waste in Concrete*

Domestic waste, including materials like plastics, glass, textiles, and other non-biodegradable substances, presents a valuable resource for incorporation into concrete. The large quantities of plastic and glass waste produced worldwide pose an environmental challenge, as well as a chance for recycling into beneficial products. Through suitable processing, these materials can be transformed into aggregates or binders for concrete, which may assist in addressing the environmental issues related to waste disposal and the extraction of raw materials.

The use of waste materials in concrete supports the concepts of the circular economy, which aims to minimize the environmental impact of products throughout their lifecycle by reusing resources. Substituting virgin materials with recycled waste allows the construction industry to decrease its reliance on natural resources, lower carbon emissions linked to material production, and aid in waste reduction. Nonetheless, incorporating waste-derived materials into concrete presents challenges, as their integration can change the mechanical properties, durability, and long-term performance of the material.

This literature review analyzes existing research on the use of domestic waste in concrete production, focusing on the mechanical, environmental, and economic effects of these practices. The review identifies gaps in knowledge and areas where additional research is needed to facilitate the wider adoption of sustainable practices in the construction industry.

2 GENERAL BACKGROUND

The production of concrete is among the most resource-intensive industries worldwide. The extraction of natural aggregates and the production of cement entail considerable environmental costs. The removal of sand and gravel frequently results in habitat destruction, erosion, and the depletion of local ecosystems. Cement production is also energy-intensive, as it involves the calcination of limestone at high temperatures, resulting in significant carbon dioxide (CO_2) emissions. The environmental impact of concrete production is significant, leading to air pollution, high energy use, and the depletion of resources. A study by Kementerian Pekerjaan Umum dan Perumahan Rakyat (2015) indicates that the cement industry contributes about 5-6% of global CO_2 emissions.

2. 1 Environmental Impacts of Traditional Concrete Production

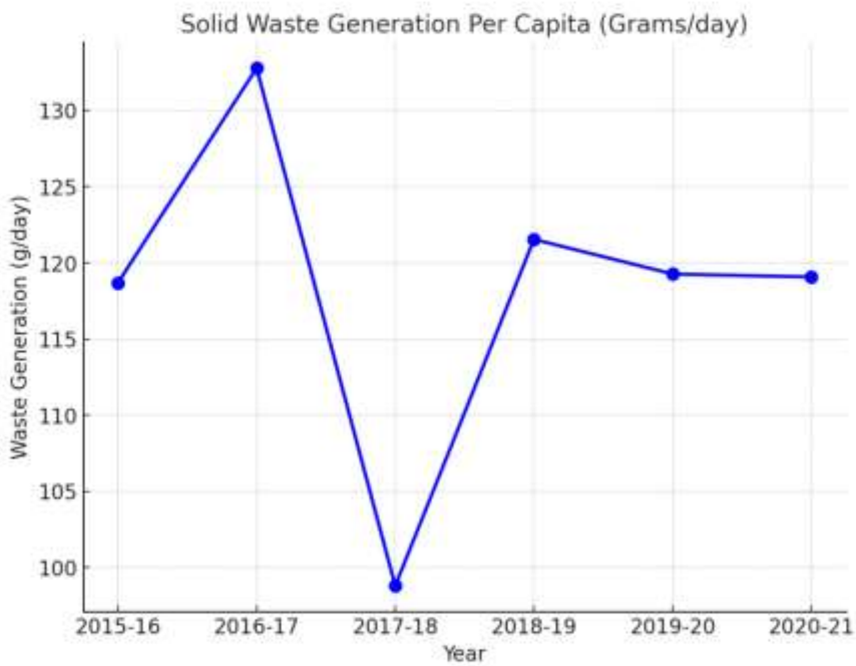

Figure 1: Solid waste generation per capita (in grams per day) for the years 2015-16 to 2020-21 as per CPCB 2022

This figure 1 shows the Solid Waste Generation Per Capita (in grams per day) across several years, demonstrating the yearly per capita solid waste generation.

The figure presents data on the quantity of solid waste produced by each individual daily (measured in grams) over the years 2015 to 2021. The y-axis indicates the quantity of waste produced in grams per day (g/day), with a range from 0 to 140 grams. The x-axis represents the years ranging from 2015-16 to 2020-21.

Given these concerns, the construction industry has started to investigate alternative materials that can replace natural aggregates and decrease the carbon footprint associated with concrete production. The ability to recycle domestic waste into concrete presents a chance to tackle two environmental concerns: decreasing dependence on virgin raw materials and lessening the environmental effects of waste disposal.

2.2 The Importance of Waste Materials in Sustainable Construction

The incorporation of waste materials, including plastics, glass, textiles, and other non-biodegradable substances, in concrete production is an emerging field of study. These materials can be reused as aggregates, binders, or additives, enabling the production of concrete that is environmentally sustainable and structurally reliable. Incorporating waste materials into concrete can lead to several benefits, such as reducing the consumption of raw materials, lowering energy usage, decreasing landfill waste, and supporting a circular economy.

Numerous studies have demonstrated the practicality of incorporating different types of waste into concrete, including the use of recycled plastic, glass, rubber, and construction and demolition waste (CDW) as substitutes for aggregates. The use of waste materials in concrete mixes helps to lessen environmental impact and provides potential cost savings by decreasing the reliance on new raw materials.

Although there are benefits, incorporating waste materials into concrete presents certain challenges. Waste materials frequently exhibit distinct physical and chemical properties in comparison to traditional aggregates, which can influence the workability, strength, durability, and long-term performance of concrete. Thus, it is important to carefully consider the selection, processing, and dosage of waste materials to ensure that the resulting concrete meets the required standards for construction applications.

3 LITERATURE STUDY

3.1 Incorporation of Waste Materials in Concrete

1.1.1 Polyvinyl Alcohol (PVA) Fibres, Crumb Rubber, and Surgical Face Mask Waste

Ahmad Fuad et al. (2024) investigated the use of polyvinyl alcohol (PVA) fibers, crumb rubber, and surgical face mask waste in 3D concrete printing (3DCP) mixtures. The research focused on assessing how these waste materials influence important characteristics of concrete, such as buildability, pumpability, extrudability, and compressive strength. The results showed that both PVA fibers and crumb rubber positively influenced slump flow, which assesses workability, and compressive strength. This suggests they are effective options for enhancing the rheological properties of concrete used in 3D printing applications. The inclusion of surgical face mask waste led to varied results. The enhancement of compressive strength was observed, but it also led to a decrease in slump flow, suggesting a possible compromise between workability and mechanical performance.

The research also investigated the application of sodium gluconate as an additive to enhance the printability of the mixtures, especially when recycled sand was included. This chemical additive assisted in mitigating the high water absorption of recycled sand, which frequently poses a challenge when incorporating recycled materials in concrete. The authors emphasized that the ideal waste content is important for achieving a balance between workability and mechanical properties, pointing out the necessity for further research on the long-term durability and performance of these mixtures in real-world environmental conditions.

1.1.2 Recycled Concrete Aggregates (RCA) in Asphalt

Bastidas-Martínez et al. (2022) conducted a review on the application of recycled concrete aggregates (RCA) in asphalt mixtures. The research indicated that recycled concrete aggregate (RCA) can demonstrate comparable performance to natural aggregates (NA) under specific conditions, but it showed decreased durability when utilized as a complete substitute for NA. The decrease in durability was mainly attributed to the greater water absorption capacity of RCA, resulting in a higher optimum asphalt content (OAC). This finding indicates that RCA can be effectively utilized in low-volume roads; however, it may necessitate pretreatment methods, such as washing or chemical treatment, to enhance its performance in high-volume roads.

The research indicated that although RCA could enhance the adhesion between the asphalt binder and aggregate, it also led to a higher usage of binder. This may present an economic challenge, particularly when RCA is utilized in significant amounts. RCA provides notable environmental advantages, such as decreasing construction and demolition waste, despite the challenges it faces. The study supports the need for enhanced optimization of recycled concrete aggregate (RCA) in asphalt mixtures and promotes further investigation into pretreatment methods that may enhance the performance of asphalt mixtures containing RCA.

1.1.3 Cold Recycling for Asphalt Pavement Restoration

Bieliatynskyi et al. (2022) examined cold recycling methods for the restoration of asphalt pavements, highlighting the notable environmental and economic benefits compared to conventional hot mix techniques. The research investigated the characteristics of asphalt granulate and the impact of adding fibers derived from fly ash into the mixture. The inclusion of fibers improved the bond between the asphalt binder and aggregate, enhanced the pavement's strength, and sped up the hardening process, enabling roads to be reopened to traffic sooner.

This research examined the impact of various asphalt granules, specifically Type M and Type A granules, on the overall strength and crack resistance of the pavement. The findings showed that Type M granules, which contained a cement binder and fibers, exhibited superior strength and crack resistance compared to Type A granules. The study found that the best emulsion content for cold recycling is 4% by mass, which greatly enhances water resistance and durability in the recycled asphalt mix.

The findings highlight the potential of cold recycling as a sustainable and cost-effective method for road construction and maintenance, which can decrease waste and environmental impact.

1.1.4 Recycled Aggregate Hydraulic Asphalt Concrete

Dong et al. (2024) studied the tensile properties of recycled aggregate hydraulic asphalt concrete (RAHAC), with a specific emphasis on the impacts of temperature and strain rate. The study showed that RAHAC had a significant dependence on temperature, with tensile strength and modulus increasing as the temperature lowered. Furthermore, increased strain rates were observed to enhance the tensile strength and modulus, whereas peak strain diminished under these circumstances.

The research indicated that the stress-strain curves of RAHAC exhibited both linear and nonlinear segments, with increased temperatures expanding the range of plasticity. Analyses of damage morphology and fracture evolution revealed notable aggregate fractures, and numerical simulations corroborated the experimental findings. The findings indicate that RAHAC is a potentially sustainable material for asphalt applications. However, the study emphasizes the need for additional research on its performance under different temperature ranges and with varying amounts of recycled aggregate.

4 RECENT STUDIES ON NEW WASTE MATERIALS IN CONCRETE

The recent studies examined in this review have concentrated on the incorporation of new materials, such as recycled brick powder (RBP), steel-reinforced recycled concrete (SRRC), reclaimed asphalt pavement (RAP), fly ash (FA), and various other waste materials into concrete mixtures. These studies are essential for understanding the impact of such materials on the mechanical properties, workability, and long-term performance of concrete. They also offer insights into the optimization of waste materials for sustainable construction, as illustrated in Table 1.

Table 1: Recent Studies on New Waste Materials in Concrete

Author(s)	**Materials Used**	**Outcomes**
Ahmad Fuad et al. (2024)	PVA fibres, crumb rubber, surgical face mask waste	Waste materials improve slump flow, compressive strength, and durability, but concerns exist over long-term performance.
Bastidas-MartÃnez et al. (2022)	Recycled concrete aggregates (RCA)	RCA improves adherence with asphalt binders but causes durability issues when fully replacing natural aggregates.
Bieliatynskyi et al. (2022)	Fiber from fly ash	Fiber addition enhances strength and crack resistance in recycled asphalt pavement.
Dong et al. (2024)	Recycled aggregate hydraulic asphalt concrete (RAHAC)	RAHAC shows improved tensile strength and modulus at low temperatures, suitable for structural applications.
He et al. (2023)	Drinking water sludge ash (DWSA)	DWSA enhances compressive strength and shrinkage resistance, with environmental benefits.
Lee et al. (2021)	Radioactive concrete	Safe disposal and recycling of radioactive concrete is feasible with controlled conditions.
Lei et al. (2023)	Recycled concrete powder (RCP)	RCP enhances high-temperature rutting resistance and bonding, but requires further investigation for cold climates.
Li et al. (2021)	Granulated hydrated binder (GHB)	GHB improves high-temperature resistance, enhancing concreteâ€™s resilience in fire-prone environments.
Li et al. (2024)	Construction and demolition (C&D) plastic waste	ATT and PBC significantly influence recycling behaviors, improving construction sector sustainability.
Lu et al. (2023)	Treated wastewater, aggregates	Optimized water-saving aggregate washing process shows effectiveness in reducing water usage and ensuring concrete performance.
Mohammadinia et al. (2019)	Recycled plastic waste (RPW), recycled crushed glass (RCG)	RPW and RCG as aggregate replacements lead to reduced strength, but still meet performance criteria for footpaths.
Nangyal and Salhotra (2024)	Silica fume (SF)-coated waste PET flakes	SF-coated PET flakes improve mechanical strength and workability in concrete while reducing density for lightweight applications.
Nikookar et al. (2023)	Non-potable water (NPW)	NPW-based concrete shows comparable compressive strength to freshwater-based concrete, with additional challenges in durability.
Olofinnade et al. (2021)	HIPS and LDPE granules	Plastic granules (HIPS and LDPE) reduce strength and workability but are suitable for lightweight concrete applications.
Tu et al. (2023)	Recycled sand	Recycled sand-based mixtures improve concrete properties in 3D printing, balancing sustainability and performance.
Wang et al. (2024)	Waste ceramic particles	Ceramic waste improves concrete's internal curing, reducing shrinkage and enhancing freezing resistance.
Wang et al. (2024)	Waste incineration bottom ash (BA)	Bottom ash-based concrete shows good mechanical strength, sulfate resistance, and reduced drying

		shrinkage.
Wang et al. (2024)	Micro-steel fibres	Micro-steel fiber improves toughness and post-peak load-bearing capacity, enhancing the performance of recycled aggregate concrete.
Wang et al. (2024)	Waste ceramic particles	Recycled ceramic particles reduce shrinkage and improve freezing resistance, making them beneficial for durable concrete.
Wu et al. (2024)	Recycled brick powder (RBP)	Moderate RBP enhances hydration, strength, and durability, but excessive RBP reduces concrete's performance.
Xue et al. (2021)	Recycled concrete aggregates (RCA)	RCA decreases bond strength and energy dissipation under cyclic loading but optimized stirrup ratios improve performance.
Yao et al. (2021)	Reclaimed asphalt pavement (RAP), fly ash (FA)	RAP and FA reduce shrinkage and improve mechanical properties, suitable for rapid construction and repairs.
Zeyad (2023)	Recycled wastewater	Recycled wastewater can replace freshwater in concrete, although some performance issues arise, particularly in compressive strength.
Zhaoyuan et al. (2024)	Recycled rubber aggregates	Rubber aggregate reduces environmental impacts, enhancing structural performance and sustainability in CFST columns.
Zheng et al. (2023)	Fully recycled aggregate concrete (FRAC)	FRAC shows potential in fire-resistant applications with appropriate admixtures and reinforcements improving high-temperature resistance.
Zheng et al. (2024)	Waste glass aggregate (WGAC)	WGAC enhances sustainability with optimal performance at 20% replacement ratio, reducing environmental impact in composite columns.

CONCLUSION

The integration of domestic waste and recycled materials into concrete production offers promising benefits in terms of environmental sustainability and resource efficiency. As highlighted by various studies, the use of materials such as recycled concrete aggregates (RCA), plastic waste, glass, and even wastewater, can significantly reduce the reliance on natural resources, minimize landfill waste, and lower carbon emissions associated with concrete production. Key findings from the research show that incorporating these materials can enhance certain properties of concrete, such as compressive strength, shrinkage resistance, and thermal performance, while also contributing to the development of more eco-friendly construction practices.

However, challenges remain, particularly regarding the long-term durability and mechanical properties of concrete made with recycled and waste materials. Several studies point to issues such as reduced bond strength, increased porosity, and a potential decline in performance when higher amounts of waste materials are used. This underscores the importance of optimizing the types and amounts of waste materials to achieve the best balance between sustainability and material performance. Moreover, while the research has made strides in understanding the impact of domestic waste in concrete, gaps still exist in areas such as the chemical interactions between waste materials and concrete binders, the long-term durability under various environmental conditions, and the development of standardized methods for evaluating waste-based aggregates.

REFERENCES

- Bieliatynskyi, S. Yang, V. Pershakov, M. Shao, and M. Ta, "Peculiarities of the use of the cold recycling method for the restoration of asphalt concrete pavements," Case Stud. Constr. Mater., vol. 16, no. December 2021, p. e00872, 2022, doi: 10.1016/j.cscm.2022.e00872.
- M. Zeyad, "Sustainable concrete Production: Incorporating recycled wastewater as a green building material," Constr. Build. Mater., vol. 407, 2023, doi: 10.1016/j.conbuildmat.2023.133522.
- Mohammadinia, Y. C. Wong, A. Arulrajah, and S. Horpibulsuk, "Strength evaluation of utilizing recycled plastic waste and recycled crushed glass in concrete footpaths," Constr. Build. Mater., vol. 197, pp. 489–496, 2019, doi: 10.1016/j.conbuildmat.2018.11.192.
- Nangyal and S. Salhotra, "Utilization of silica fume coated waste PET flakes in concrete," Mater. Today Proc., no. July, pp. 2–9, 2024, doi: 10.1016/j.matpr.2023.12.052.
- Lei et al., "Performance of asphalt mortar with recycled concrete powder under different filler-to-asphalt weight ratios," Case Stud. Constr. Mater., vol. 18, no. December 2022, p. e01834, 2023, doi: 10.1016/j.cscm.2023.e01834.
- Li et al., "Thermally-induced mechanical degradation analysis of recycled aggregate concrete mixed with glazed hollow beads," Constr. Build. Mater., vol. 301, no. July, p. 124350, 2021, doi: 10.1016/j.conbuildmat.2021.124350.
- W. Lee, H. R. Kim, and S. J. Lee, "Radiological safety evaluation of dismantled radioactive concrete from Kori Unit 1 in the disposal and recycling process," Nucl. Eng. Technol., vol. 53, no. 6, pp. 2019–2024, 2021, doi: 10.1016/j.net.2020.12.017.
- Wang et al., "Study of waste incineration bottom ash as fine aggregate applied to green alkali-activated bottom ash-slag concrete: Mechanical properties, microstructure, durability," Constr. Build. Mater., vol. 449, no. June, p. 138484, 2024, doi: 10.1016/j.conbuildmat.2024.138484.
- Wang, J. Liu, B. Lu, Y. Zhang, and Z. Ma, "Stiffness degradation and mechanical behavior of microfiber-modified high-toughness recycled aggregate concrete under constant load cycling," Eng. Fract. Mech., vol. 312, no. June, 2024, doi: 10.1016/j.engfracmech.2024.110608.
- Yao, Y. Guo, A. Shen, W. Cui, and Z. He, "Recycling of fine-asphalt-pavement solid waste for low-shrinkage rapid hardening Portland cement concrete pavement," Constr. Build. Mater., vol. 289, p. 123132, 2021, doi: 10.1016/j.conbuildmat.2021.123132.
- C.P.C.B. CPCB, "Annual report 2020-21 on implementation of solid waste management rules, 2016," Cent. Pollut. Control Board, 288–446 (2022). https://cpcb.nic.in/uploads/plasticwaste/Annual_Report_2019-20_PWM.pdf.
- H. Tu, Z. Wei, A. Bahrami, N. Ben Kahla, A. Ahmad, and Y. O. Özkılıç, "Recent advancements and future trends in 3D concrete printing using waste materials," Dev. Built Environ., vol. 16, 2023, doi: 10.1016/j.dibe.2023.100187.
- H. Wu, G. Chen, C. Liu, and J. Gao, "Understanding the micro-macro properties of sustainable ultra-high performance concrete incorporating high-volume recycled brick powder as cement and silica fume replacement," Constr. Build. Mater., vol. 448, no. June, p. 138170, 2024, doi: 10.1016/j.conbuildmat.2024.138170.
- J. Dong, Y. Ding, Y. Liu, Z. Ning, and Y. Qi, "Tensile test and discrete element study on recycled aggregate hydraulic asphalt concrete," Constr. Build. Mater., vol. 450, no. June, p. 138538, 2024, doi: 10.1016/j.conbuildmat.2024.138538.
- J. G. Bastidas-Martínez, F. A. Reyes-Lizcano, and H. A. Rondón-Quintana, "Use of recycled concrete aggregates in asphalt mixtures for pavements: A review," J. Traffic Transp. Eng. (English Ed., vol. 9, no. 5, pp. 725–741, 2022, doi: https://doi.org/10.1016/j.jtte.2022.08.001.
- J. Xue, H. Li, R. Ren, and X. Zhang, "The bond behavior of steel reinforced recycled concrete under cyclic reversed load," Eng. Struct., vol. 248, no. July, p. 113238, 2021, doi: 10.1016/j.engstruct.2021.113238.

- L. Li, J. Zuo, L. Du, and R. Chang, "What influences the on-site recycling behaviour of C&D plastic waste in Australia? An action determination model approach," J. Environ. Manage., vol. 371, no. October, p. 123158, 2024, doi: 10.1016/j.jenvman.2024.123158.
- M. A. Ahmad Fuad, A. Ghazali, M. H. Mohd Isa, and H. Awang, "Utilising waste material in a 3DCP mixture: A review on rheological and compressive strength," Eng. Sci. Technol. an Int. J., vol. 59, no. October, p. 101846, 2024, doi: 10.1016/j.jestch.2024.101846.
- M. Nikookar, N. A. Brake, M. Adesina, A. Rahman, and T. Selvaratnam, "Past, current, and future re-use of recycled non-potable water sources in concrete applications to reduce freshwater consumption- a review," Clean. Mater., vol. 9, no. February, p. 100203, 2023, doi: 10.1016/j.clema.2023.100203.
- O. Olofinnade, S. Chandra, and P. Chakraborty, "Recycling of high impact polystyrene and low-density polyethylene plastic wastes in lightweight based concrete for sustainable construction," Mater. Today Proc., vol. 38, pp. 2151–2156, 2020, doi: 10.1016/j.matpr.2020.05.176.
- Q. Lu et al., "Water-saving optimization design of aggregate processing plant and recycled water utilization for producing concrete," Constr. Build. Mater., vol. 396, no. July, 2023, doi: 10.1016/j.conbuildmat.2023.132381.
- X. jun Ke, Z. ren Chen, and W. shu Fu, "Waste rubber recycling in concrete-filled steel tube members: Mechanical performance, reliability and life cycle assessment," J. Build. Eng., vol. 98, no. October, p. 111108, 2024, doi: 10.1016/j.jobe.2024.111108.
- X. Wang, Y. Zhang, and W. Zhang, "Research on humidity field and freezing resistance of green recycled ceramic internal cured concrete at early age," J. Build. Eng., vol. 97, no. July, p. 110802, 2024, doi: 10.1016/j.jobe.2024.110802.
- Y. Zheng, X. Xi, Y. Zhang, P. Zhang, and C. Du, "Review of mechanical properties and strengthening mechanism of fully recycled aggregate concrete under high temperature," Constr. Build. Mater., vol. 394, no. June, p. 132221, 2023, doi: 10.1016/j.conbuildmat.2023.132221.
- Z. H. He, X. D. Han, J. xu Jin, J. shan Li, W. Tang, and J. yan Shi, "Recycling of water treatment sludge in concrete: The role of water-binder ratio from a nanoscale perspective," Sci. Total Environ., vol. 873, no. February, p. 162456, 2023, doi: 10.1016/j.scitotenv.2023.162456.
- Z. Zheng et al., "The performance of waste glass aggregate concrete GFRP-steel double-skin tubular columns under axial compression: Experimental study," Constr. Build. Mater., vol. 447, no. June, p. 138075, 2024, doi: 10.1016/j.conbuildmat.2024.138075.