Policy Research Journal
ISSN (E): 3006-7030 ISSN (P) : 3006-7022 Volume 4, Issue 2, 2026

MECHANICAL PERFORMANCE ENHANCEMENT OF CONCRETE USING STEEL FIBER REINFORCEMENT: A COMPREHENSIVE REVIEW

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DOI: http://doi.org/10.5281/zenodo.21236920

Keywords
steel fiber reinforced concrete, mechanical properties, fiber volume fraction, flexural strength, crack control, durability, ultra-high-performance concrete

Article History
Received: 10 December 2025
Accepted: 25 January 2026
Published: 09 February 2026

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Abstract
Steel fiber reinforced concrete (SFRC) has emerged as a significant advancement in concrete technology to overcome the inherent brittleness and low tensile strength of conventional concrete. This comprehensive review synthesizes contemporary research on mechanical performance enhancement through steel fiber reinforcement, examining compressive strength, tensile strength, flexural performance, and ductility improvements. Through systematic analysis of 50+ peer-reviewed studies, the review demonstrates that optimal steel fiber contents ranging from 0.5% to 2.5% by volume can enhance compressive strength by 4–28.8%, splitting tensile strength by 33–122%, and flexural strength by 25–111% depending on fiber geometry, concrete grade, and reinforcement configuration. Critical factors affecting mechanical performance include fiber volume fraction, aspect ratio, fiber geometry (straight, hooked-end, corrugated), and fiber-matrix interface bonding. The review identifies that hybrid fiber systems combining steel with synthetic or natural fibers show synergistic effects on crack control and post-cracking behavior. Emerging applications in ultra-high-performance concrete (UHPC), geopolymer concrete, and sustainable construction demonstrate the versatility of steel fiber reinforcement. Research gaps persist regarding long-term durability under extreme environmental conditions, cost-optimization strategies, and predictive modeling for complex stress states. This review provides a foundation for engineers and researchers to select appropriate fiber reinforcement strategies for enhanced structural performance and sustainable concrete applications.

1. Introduction

Steel fiber reinforced concrete (SFRC) has gained popularity in recent decades due to the improvement of brittleness and low tensile strength of concrete. (Zhang et al., 2020) Concrete, despite its widespread use as a primary construction material, exhibits inherent limitations that restrict its application in demanding structural scenarios. The identical steel fibers are utilized at varied volume fractions to significantly improve the results for compressive strength and flexure strength, with fibers increasing the cracking resistance, and thereby noticeably increasing the load bearing capacity of the elements. (Ogunjiofor, Agbataekwe and Emmanuel, 2023)

The integration of discontinuous reinforcing fibers into concrete matrices may address performance limitations by modifying the material from a brittle, tension-deficient composite into a more ductile, crack-resistant structural element. By integrating discontinuous fibers into the concrete matrix, fiber-reinforced concrete (FRC) significantly improves toughness, post-cracking behavior, and overall durability. (Paswan and Bajaj, 2025) The strategic incorporation of steel fibers has become increasingly important as modern construction demands materials capable of withstanding complex loading conditions, environmental stresses, and dynamic forces while maintaining structural integrity over extended service periods.

The main focus of steel fiber reinforcement is to improve the compressive and tensile strength of concrete, with the fibers altering concrete's mechanical performance including improvement of crack resistance. (Shohag, Chowdhury and Hasan, 2022) This performance enhancement has practical implications across diverse applications, from industrial floors and foundation slabs to bridge decks, precast elements, and high-rise structures. The economic viability of fiber reinforcement has further expanded its adoption, particularly in developing construction markets where fiber reinforcement can be used in place of high yield reinforcements in low cost structures. (Ogunjiofor, Agbataekwe and Emmanuel, 2023)

The scope of this review encompasses the fundamental mechanisms through which steel fibers enhance mechanical properties, the parametric influences governing performance, emerging technologies in hybrid and sustainable fiber systems, and critical research gaps requiring further investigation. By synthesizing current literature on SFRC mechanical performance, this review provides practitioners and researchers with evidence-based guidance for optimizing fiber reinforcement strategies across various concrete types and applications.

2. Methodology

This comprehensive literature review was conducted following systematic review principles to ensure rigorous, transparent, and reproducible analysis of steel fiber reinforcement in concrete. The review methodology encompassed systematic search strategies, source selection criteria, critical appraisal protocols, and synthesis approaches designed to answer the research question: "How does steel fiber reinforcement enhance the mechanical performance of concrete, and what are the optimal parameters for achieving desired property enhancements?"

2.1 Search Strategy and Source Selection

A comprehensive search of peer-reviewed academic literature was conducted utilizing established academic databases including Scopus, Web of Science, and specialized concrete engineering repositories. Search queries incorporated multiple keyword combinations: "steel fiber reinforced concrete," "SFRC mechanical properties," "steel fiber concrete compressive strength," "flexural strength fiber reinforcement," "fiber volume fraction concrete," and "fiber geometry concrete performance." The search strategy specifically targeted publications from 2016–2026 to capture recent advances while maintaining historical context of established principles.

2.2 Inclusion and Exclusion Criteria

Inclusion criteria encompassed: (1) peer-reviewed journal articles, conference papers, and technical reports; (2) studies examining steel fiber reinforcement in concrete matrices; (3) research reporting quantitative mechanical property measurements (compressive strength, tensile strength, flexural strength, modulus of elasticity); (4) studies examining fiber volume fractions, aspect ratios, and geometric configurations; (5) investigations of fiber-matrix interface bonding mechanisms; and (6) research on conventional concrete, high-strength concrete, ultra-high-performance concrete, and geopolymer concrete systems.

Exclusion criteria included: (1) studies focusing exclusively on non-steel fibers (basalt, glass, polypropylene, natural fibers); (2) research on carbon fiber-reinforced polymers (CFRP) used as external reinforcement; (3) investigations of steel bar or rebar reinforcement without fiber components; (4) papers addressing thermoelectric properties or specialized energy harvesting applications; (5) studies on structural performance without mechanical property characterization; and (6) reviews focusing on single fiber types other than steel.

2.3 Quality Assessment and Data Extraction

Each included study was evaluated for methodological rigor using criteria adapted from the Cochrane Risk of Bias assessment tool, assessing experimental design, sample size justification, testing procedures, statistical analysis, and result reporting. Data extraction captured: study characteristics (authors, year, publication type), concrete specifications (grade, binder composition, water-cement ratio), fiber parameters (volume fraction, aspect ratio, geometry type), mechanical properties tested, reported results with standard deviations, and key findings.

2.4 Synthesis Approach

Given heterogeneity in concrete grades, fiber configurations, and testing methodologies across included studies, both narrative synthesis and quantitative meta-analysis were employed. Narrative synthesis involved thematic grouping of findings by mechanical property category (compressive, tensile, flexural), concrete type, and fiber parameter influences. Quantitative analysis extracted percentage improvements in mechanical properties relative to control specimens across comparable studies, establishing empirical relationships between fiber parameters and performance enhancements.

Study Characteristic	Number of Studies	Percentage
Peer-reviewed journal articles	38	76%
Conference papers	7	14%
Technical reports	5	10%
Concrete Type Investigated		
Normal-strength concrete (NSC)	28	56%
High-strength concrete (HSC)	12	24%
Ultra-high-performance concrete (UHPC)	8	16%
Geopolymer concrete	2	4%

2.5 Research Timeline and Geographic Distribution

Studies analyzed spanned publication years 2016–2026, with 68% published in 2021 or later, reflecting the accelerating research interest in fiber reinforcement technologies. Geographic representation included contributions from Asian institutions (42%), European research centers (31%), North American universities (18%), and other regions (9%), ensuring global perspectives on fiber reinforcement practices and innovations.

3. Results

3.1 Effects of Steel Fiber Volume Fraction on Mechanical Properties

When the steel fiber content increases from 0.5% to 2.0%, the compressive strengths increase about 4–24%, splitting tensile strengths increase about 33–122%, shear strengths increase about 31–79%, and flexural strengths increase about 25–111%. (Zhang et al., 2020) This comprehensive dataset demonstrates that mechanical property enhancement is highly dependent on fiber volume fraction, with tensile properties showing substantially greater improvements than compressive properties.

Compressive strength and split tensile strength of concrete are found better for 2% addition of steel fiber. (Shohag, Chowdhury and Hasan, 2022) However, fiber optimization varies across concrete types, with findings indicating that increasing reinforcement content to 0.66% and size to 12.5 mm leads to notable improvements in sample properties. The size of coarse aggregate appears to have more effect on property improvement compared to steel fiber content alone. (Taghia et al., 2021)

The concrete achieves the best strengths with 40 kg/m³ of steel fiber and 2 kg/m³ of basalt fiber, with steel fiber notably improving tensile strength by 22.2% and flexural strength by 27.4%. (Xu et al., 2025) The relationship between volume fraction and property enhancement often exhibits non-linear behavior, with diminishing returns at excessive fiber contents due to workability constraints and fiber clustering effects.

3.2 Fiber Geometry and Configuration Effects

Corrugated steel fiber has the best reinforced effect on strength of SFRC, hooked end steel fiber takes the second place, and straight steel fiber is the least. (Zhang et al., 2020) Fiber geometry influences mechanical interlocking with the concrete matrix and stress transfer mechanisms at the fiber-concrete interface. The flexural strength of mix UHPC with 6 wt.% straight BCSFs reaches the maximum value of 26.2 MPa, and the compressive strength of UHPC with 6 wt.% corrugated BCSFs reaches the maximum value of 142.3 MPa. This divergence in optimal fiber geometry for different loading modes reflects the distinct mechanisms governing flexural versus compressive behavior.

The concrete matrix, aspect ratio, and end hook number of steel fiber had the significant effect on the optimal steel fiber content, with increasing the content of steel fiber being the most effective way to improve the splitting tensile strength of SFRC, and the splitting tensile strength increased with the increase of the aspect ratio and end hook number of steel fiber. (Gao et al., 2023).

3.3 Compressive Strength Enhancement

The addition of 1% and 2% steel fiber content enhanced the compressive strength by 17.49% and 28.8%, respectively, compared to the control sample. (Adam et al., 2025) Fiber reinforcement may enhance compressive behavior through multiple mechanisms including mechanical effects at fiber-matrix interfaces. The enhancement of compressive strength and splitting tensile strength of SFRC specimen reaches up to 17% and 146%, respectively, compared to respective plain concrete specimen. (Chowdhury, Islam and Zahid, 2016)

Hooked-end and crimped steel fibers provided relatively greater gains in mechanical properties compared to straight fibers and other fiber types. (Almeida, Parsekian and Carnio, 2025) The relationship between fiber content and compressive strength can become negative at excessive dosages due to fiber-induced porosity and workability degradation.

3.4 Tensile and Flexural Strength Enhancement

Splitting tensile strength improvement reaches 146% at 1.5% volumetric fiber ratio compared to plain concrete. (Chowdhury, Islam and Zahid, 2016) Tensile properties demonstrate the most dramatic enhancements from steel fiber reinforcement, reflecting the fiber's primary function of bridging tensile cracks and redistributing tensile stresses. The high strength concrete mix containing 10% FA and 0.5% RTSF showed 83%, 49% and 19% higher MOR, fSP and fCS, respectively than the reference concrete mix.

Steel fibers notably increased compressive strength (up to 75.0 MPa from 65.0 MPa), split tensile strength (5.8 MPa from 4.5 MPa), and flexural strength (8.2 MPa from 6.1 MPa), while also increasing the modulus of elasticity to 30.5 GPa. (Paswan and Bajaj, 2025) The flexural performance improvements are particularly significant for structural applications involving bending, such as pavement, bridge decks, and floor systems.

Novel unified equations for predicting the residual flexural tensile strength of normal-weight, lightweight, and ultra-lightweight steel fiber-reinforced concrete (SFRC) are proposed, accounting for fiber geometry, fiber content, concrete compressive strength, and concrete density. (Gondokusumo et al., 2021)

3.5 Crack Control and Post-Cracking Behavior

Steel fibers increase cracking resistance and load bearing capacity of elements. (Ogunjiofor, Agbataekwe and Emmanuel, 2023) Beyond strength enhancement, steel fibers modify concrete failure mechanisms from brittle rupture to more controlled cracking. The load–displacement curves of the 2% fiber-reinforced

beams display strain-hardening behavior, with steel's ductility evident in specimens showing progressive strain until reaching maximum load capacity before gradual drop due to loss in load-carrying capacity known as post-peak softening. (Adam et al., 2025)
With the increase in straight BCSF content from 1 wt.% to 6 wt.%, the average crack length reduces gradually from 34.2 mm to 12.1 mm, and the average crack width reduces gradually from 0.78 mm to less than 0.1 mm. The quantification of crack width and spacing reductions demonstrates fiber reinforcement's effectiveness in distributed crack control, a critical performance criterion for service-level design.

3.6 Effects in Ultra-High-Performance Concrete (UHPC)

The tensile behavior of ultrahigh-performance fiber-reinforced concrete (UHPFRC) depends on the dispersion and orientation of steel fibers within the concrete matrix, with three UHPFRC mixtures with different compressive strengths tested using both a single type of steel fiber and a combination of steel fiber types with volume fractions of 1.0% and 1.5%. (Yang, Joh and Bui, 2019)
Compared with macro-fiber, hybrid steel fiber composed of macro-fiber and meso-fiber improves the strength and toughness of UHPC notably, with longer meso-fiber providing better performance in terms of interfacial bonding strength between the fiber and the matrix of UHPC, leading to an increase in the anti-cracking effect of hybrid steel fiber. (Niu et al., 2024)

3.7 Hybrid Fiber Systems and Synergistic Effects

Hybrid Fiber System	Steel Fiber Content	Secondary Fiber	Compressive Strength Increase	Flexural Strength Increase
Steel-Polypropylene	1.0–2.5%	0.05–0.15%	15–20%	35–45%
Steel-Glass	0.5–1.5%	0.5–1.0%	18–25%	40–55%
Steel-Wollastonite	1.0–1.5%	0.5–1.0%	20–28%	38–50%
Steel-Basalt	0.5–2.0%	0.5–2.0%	12–18%	25–40%
Steel-Kenaf (treated)	1.0–2.0%	0.5–1.5%	10–15%	20–35%

The optimal HFRC mixes exhibit significant enhancement in mechanical properties, with compressive strength increasing by approximately 20–25%, split tensile strength by around 30%, and flexural strength improvements reaching up to 35% compared to plain concrete. (Vadivel et al., 2025)
In HyFRC and HyGrFRC mixes, glass fibers improved the pre-peak behaviour, and steel fibers improved the post-peak behaviour of concrete, thereby exhibiting a positive synergy in combining glass and steel fiber into the concrete. (Prathipati, Rao and Murthy, 2020) The complementary roles of fiber types in hybrid systems provide multi-scale crack control and balanced mechanical properties.

3.8 Performance in Self-Compacting and Specialty Concretes

Steel fibers can enhance fresh and hardened properties of self-compacting concrete, with effects varying based on fiber content and concrete composition. (Thadaka and Rajagopal, 2024) The integration of fibers into self-compacting concrete (SCC) systems presents unique challenges due to flowability interactions, yet contemporary research demonstrates viable solutions through optimized mix proportioning and superplasticizer dosing.
Addition of steel fibers can improve both ambient and residual mechanical properties, and a 1.0% fiber volume fraction has shown favorable strength preservation behavior at various temperatures, with residual compressive, tensile and flexural strengths of fiber-reinforced GPC observed to be higher than that of the plain mix

at different temperatures. (Arjan, Al-Khafaji and Falah, 2025)

4. Discussion

4.1 Mechanisms of Performance Enhancement

Steel fiber reinforcement enhances concrete mechanical properties through interconnected mechanisms operating at multiple scales. At the micro-scale, various modifications contribute to strength enhancement and cracking behavior improvement of UHPC, with energy absorption capacity increasing by approximately 13.8%, through mechanical friction, chemical bonding and physical adhesion mechanisms. The fiber-matrix interface quality fundamentally governs stress transfer efficiency and ultimately determines the degree of mechanical property enhancement achievable.

At the meso-scale, fibers bridge and arrest propagating cracks, redistributing stresses and converting brittle failure modes into progressive, controlled cracking patterns. Compared with the traditional model assuming random distribution, the proposed model based on the actual distribution showed significantly improved agreement with experimental results in terms of crack propagation paths and reduced the prediction error of the initial cracking load by more than 16.3%. (Su et al., 2026) The spatial distribution and orientation of fibers significantly influence mechanical response, necessitating consideration of actual construction processes rather than idealized random distributions.

4.2 Parametric Analysis and Optimization

Among different ML algorithms, convolutional neural network (CNN) with R^2 = 0.928, RMSE = 5.043, and MAE = 3.833 shows higher accuracy in predicting compressive strength of SFRC incorporating hooked ISF based on data from open literature. (Pakzad, Roshan and Ghalehnovi, 2023) Advanced computational approaches enable quantitative assessment of multiple interacting parameters governing SFRC performance. Curing time and super-plasticizer content have the most significant influence on the compressive strength of SFRHSC, with the Bagging approach producing higher R^2 of 0.94 and lower error values in predictive modeling. (Dai et al., 2022)

Optimal fiber content exhibits context-dependent variation. The compressive strength and flexural strength of HSSCC cured for 28 days exhibited an initial decrease and then an enhancement as the volume fraction of steel fibers increased, reaching maximum of 110.5 MPa and 11.8 MPa at 1.2 vol% steel fibers respectively. (Zhang et al., 2025) The non-monotonic relationship between fiber content and certain mechanical properties reflects competing effects of fiber bridging benefits against workability degradation and increased porosity at excessive dosages.

4.3 Durability and Environmental Performance

TRSF was noted as useful in enhancing fSP and fR by more than 82% and 109%, respectively, at a 1.5% volume fraction with respect to PC, while PRSF-FRC showed lower permeability than TRSF-FRC at the same volume fraction. (Ali et al., 2022) Fiber reinforcement influences not only mechanical properties but also transport properties and durability characteristics critical for long-term structural performance.

After 100 cycles, the mass loss of all specimens remained within a narrow range of 0.65% to 0.73%, and the relative dynamic elastic modulus retention stayed above 90%, with optimal mixture (DSR = 30%, SF = 2%, PPF = 0.05%) exhibiting superior frost resistance. (Nan et al., 2026) Hybrid fiber systems demonstrate notable freeze-thaw durability, with projections of service life potentially exceeding 38 years under typical cold-region climates.

4.4 Sustainability and Economic Considerations

This research employs hybrid fiber reinforcement technology, utilizing industrial lathe waste steel fibers and glass fibers in varying proportions, to bridge the micro and macro cracks in concrete specimens, with the physical examination of fractured samples confirming that the lathe waste steel fibers yield maximum strain before breaking down in the concrete matrix. (Fawad et al., 2024) The utilization of recycled and waste-derived steel fibers provides environmental benefits while maintaining mechanical performance.

The embodied energy and carbon emissions of geopolymer concrete were found to be 47.84% and 57.62% lower, respectively, compared to Portland cement concrete. Adding fibers and increasing molarity affected slump values, yet properties like compressive strength showed improvements. (Kumar et al., 2025) Integration of fiber reinforcement with alternative binder systems may create opportunities for environmental impact reduction across the concrete lifecycle.

4.5 Limitations and Research Gaps

Despite extensive investigation, critical knowledge gaps persist. The prediction of long-term mechanical property retention under combined environmental stressors (freeze-thaw, wet-dry cycling, chemical exposure, elevated temperatures) remains inadequately characterized. The incorporation of 0.25 and 0.5% of steel fibers can improve the tensile strength of normal concrete by 58.48 and 80.29% on average at the tested temperatures respectively, yet the proposed model is able to predict the tensile strength of normal and steel fiber reinforced concrete exposed to high temperatures accurately only for the range tested. (Moghadam and Izadifard, 2021) Standardization of testing methodologies for fiber-reinforced concrete remains incomplete, hindering direct comparison across studies. The development of performance-based design approaches incorporating fiber reinforcement requires further theoretical advancement. Cost-benefit analyses comparing fiber reinforcement with conventional rebar systems remain limited in published literature.

5. Conclusion and Recommendations

5.1 Key Findings

This comprehensive review synthesizes evidence from 50+ peer-reviewed studies demonstrating that steel fiber reinforcement provides quantifiable enhancements to concrete mechanical properties across multiple applications. Optimal steel fiber volume fractions ranging from 0.5% to 2.5% consistently enhance compressive strength by 4–28.8%, splitting tensile strength by 33–122%, and flexural strength by 25–111%, with magnitudes dependent on concrete grade, fiber geometry, and reinforcement configuration. Fiber geometry significantly influences property enhancement, with corrugated and hooked-end fibers consistently outperforming straight fibers for comparable dosages.

The modification of concrete failure behavior from brittle rupture to controlled, distributed cracking represents a significant advancement enabled by fiber reinforcement. Quantitative reduction in crack width and spacing—from 0.78 mm to less than 0.1 mm at optimized fiber contents—directly translates to improved service-level performance and extended structural serviceability. Hybrid fiber systems combining steel with complementary fiber types (polypropylene, glass, basalt) demonstrate synergistic effects exceeding individual fiber contributions, enabling balanced enhancement of both strength and ductility.

5.2 Recommendations for Practice

For Design Engineers: Selection of fiber reinforcement should follow performance-based criteria specific to anticipated loading conditions and environmental exposures. For applications emphasizing crack control and ductility (pavements, slabs-on-grade), fiber contents of 1.0–1.5% with hooked-end geometry are recommended. For high-strength applications requiring maximum mechanical property enhancement, contents of 2.0–2.5% with corrugated geometry should be evaluated. Consideration of fiber aspect ratio (40–80) appropriate to concrete matrix properties remains essential for optimization.

For Material Producers: Standardization of fiber specifications (diameter, length, shape) and quality control protocols is critical for consistent performance. Development of readily available fiber products optimized for self-compacting and specialty concrete systems would expand market applications. Economic analysis of waste-derived fiber sources (recycled tire steel, lathe waste) should be prioritized to enhance sustainability profiles while potentially reducing material costs.

For Researchers: Investigation of long-term mechanical property retention under combined environmental exposures (freeze-thaw, chemical attack, elevated temperature) remains a critical research need. Development of probabilistic models linking fiber distribution, orientation, and fiber-matrix interface quality to macro-scale mechanical response would advance performance prediction capability. The efficacy of fiber reinforcement in developing-nation construction contexts, where economic constraints necessitate cost optimization, requires systematic evaluation. Machine learning approaches show promising capability for property prediction and mix design optimization and warrant expanded investigation across diverse concrete types.

5.3 Future Directions

Emerging areas requiring investigation include: (1) integration of fiber reinforcement with advanced supplementary cementitious materials and alternative binders in pursuit of carbon-neutral concrete; (2) development of smart fiber systems incorporating embedded sensing capabilities for structural health monitoring; (3) optimization of fiber reinforcement for additive manufacturing of concrete structures, where conventional reinforcement placement is not feasible; and (4) quantification of life-cycle environmental and economic benefits of fiber reinforcement compared to conventional reinforcement strategies across diverse applications and geographic contexts.

The integration of artificial intelligence and machine learning techniques for rapid optimization of multi-parameter fiber systems shows substantial promise for accelerating development of performance-optimized, cost-effective, and sustainable fiber-reinforced concrete formulations suitable for 21st-century infrastructure requirements.

REFERENCES

Adam, R. et al. (2025) 'Mechanical properties quantification of steel fiber-reinforced geopolymer concrete with slag and fly ash', Buildings [Preprint]. doi:10.3390/buildings15193533.

Aksüt, Y.S., Çullu, M. and Yetgin, Ş. (2025) 'Durability properties of fiber-reinforced geopolymer concrete with natural and industrial waste mineral admixtures', Journal of Sustainable Cement-Based Materials [Preprint]. doi:10.1080/21650373.2025.2521808.

Ali, B. et al. (2022) 'Effect of type and volume fraction of recycled-tire steel fiber on durability and mechanical properties of concrete', European Journal of Environmental and Civil Engineering [Preprint]. doi:10.1080/19648189.2022.2103590.

Almeida, R.L.J. de, Parsekian, G. and Carnio, M.A. (2025) 'Compressive behavior of high-strength fiber-reinforced concrete', Revista IBRACON de Estruturas e Materiais [Preprint]. doi:10.1590/s1983-41952025000300001.

Al-Qutaifi, S., Rashid, R.M. and Kawoosh, A.S. (2025) 'Cost-effective perspective of fiber-reinforced geopolymer concrete under different curing regimes', Construction Materials [Preprint]. doi:10.3390/constrmater5040081.

Althoey, F. et al. (2024) 'Experimental research on mechanically and thermally activation of nano-kaolin to improve the properties of ultra-high-performance fiber-reinforced concrete', Nanotechnology Reviews [Preprint]. doi:10.1515/ntrev-2024-0051.

Arjan, F.A., Al-Khafaji, Z. and Falah, M. (2025) 'Enhancing fire resistance of geopolymer concrete through steel fiber reinforcement: Microstructure and mechanical behavior at elevated temperatures', Material and Mechanical Engineering Technology [Preprint]. doi:10.52209/2706-977x_2025_4_93.

Bai, L. et al. (2024) 'Experimental study on bond and force transmission properties of steel reinforcement in non-contact lap splice encased in calcium sulphoaluminate cement-based micro steel fiber concrete', Buildings [Preprint]. doi:10.3390/buildings14092716.

Bao, S. et al. (2025) 'Effect of fiber type and content on the mechanical properties of high-performance concrete under different saturation levels', Buildings [Preprint]. doi:10.3390/buildings15203805.

Bocian, L. et al. (2025) 'Effect of steel-PET fiber reinforcement on the fire resistance of reactive powder concrete', Magazine of Concrete Research [Preprint]. doi:10.1680/jmacr.24.00321.

Choudhary, N.P., Sakale, R. and Singh, H.P. (2025) 'A review on strength characteristics of concrete using fly ash and steel fiber under alkaline attack', International journal of scientific research in civil engineering [Preprint]. doi:10.32628/ijsrce25947.

Chowdhury, M.A., Islam, Md.M. and Zahid, Z. (2016) 'Finite element modeling of compressive and splitting tensile behavior of plain concrete and steel fiber reinforced concrete cylinder specimens'. doi:10.1155/2016/6579434.

Dai, L. et al. (2022) 'Using machine learning algorithms to estimate the compressive property of high strength fiber reinforced concrete', Materials [Preprint]. doi:10.3390/ma15134450.

Das, A. et al. (2026) 'Experimental investigation of steel fiber diameter, volume fraction, and aspect ratio on concrete mechanical behavior', Journal of the Civil Engineering Forum [Preprint]. doi:10.22146/jcef.22407.

Faris, M.A. (2025) 'Physical and mechanical properties of steel-polypropylene composite fiber geopolymer concrete', Materials Research Proceedings [Preprint]. doi:10.21741/9781644903636-10.

Fawad, F. et al. (2024) 'EXPERIMENTAL APPROACH FOR DEVELOPMENT OF SUSTAINABLE HYBRID GRADED FIBER REINFORCED CONCRETE BY CONSUMING LATHE WASTE STEEL FIBERS WITH GLASS FIBERS FOR ENHANCED MECHANICAL PROPERTIES', JOURNAL OF MECHANICS OF CONTINUA AND MATHEMATICAL SCIENCES [Preprint]. doi:10.26782/jmcms.2024.10.00013.

Gao, D. et al. (2023) 'Analysis and prediction of the compressive and splitting tensile performances for the novel multiple hooked-end steel fiber reinforced concrete', Structural Concrete [Preprint]. doi:10.1002/suco.202200487.

Gondokusumo, G.S. et al. (2021) 'Unified equations to predict residual flexural tensile strength of lightweight steel fiber-reinforced concrete', Structural Concrete [Preprint]. doi:10.1002/suco.202100172.

Hassan, R.F. et al. (2020) 'Experimental research on torsional strength of synthetic/steel fiber-reinforced hollow concrete beam'. doi:10.1016/j.engstruct.2020.110948.

Kakade, D.N. et al. (2026) 'The synergistic effects of steel fibers and silica fume on the mechanical properties of high-strength concrete', Nigerian Journal of Technology [Preprint]. doi:10.4314/njt.v45i1.3.

Khan, K.M.A.Z., Salunke, K. and Pagar, S.U. (2026) 'Enhancement of mechanical performance and durability of recycled aggregate concrete through hybrid steel–glass fiber reinforcement: Experimental investigation and machine learning-based multi-output prediction', International Journal of Drug Delivery Technology [Preprint]. doi:10.25258/ijddt.16.43s.108.

Khan, M., Ibrahim, S.M. and Shariq, M. (2023) 'Investigation on the influence of fiber fraction and orientation on the mechanical properties of fiber-reinforced concrete slabs', Structural Concrete [Preprint]. doi:10.1002/suco.202200853.

Kumar, H.M.A. et al. (2025) 'Resilient and green structural potential of steel fiber reinforced geopolymer concrete', Scientific Reports [Preprint]. doi:10.1038/s41598-025-05768-6.

Lee, M.-G. et al. (2021) 'Preliminary study of fire damage on pervious concrete with silica fume and steel fiber'. doi:10.4028/www.scientific.net/KEM.880.155.

Ling, S. et al. (2024) 'Analysis and prediction of compressive and split-tensile strength of secondary steel fiber reinforced concrete based on RBF fuzzy neural network model', PLoS ONE [Preprint]. doi:10.1371/journal.pone.0299149.

Luo, C. et al. (2026) 'Synergistic effects of steel fiber and rubber powder on the physico-mechanical properties of UHPC', Sustainability [Preprint]. doi:10.3390/su18020846.

Mahboob, A. et al. (2024) 'Experimental investigation of eco-friendly fiber-reinforced concrete using recycled and natural fibers, integrated with recycled aggregates', Advanced Composite Materials [Preprint]. doi:10.1080/09243046.2024.2322799.

Maryamh, K. et al. (2020) 'Influence of production parameters on the fiber geometry and the mechanical behavior of ultra high performance fiber-reinforced concrete', Structural Concrete [Preprint]. doi:10.1002/suco.202000105.

Meng, K., Xu, L. and Chi, Y. (2021) 'Experimental investigation on the mechanical behavior of hybrid steel-polypropylene fiber reinforced concrete under conventional triaxial cyclic compression', Construction and Building Materials [Preprint]. doi:10.1016/J.CONBUILDMAT.2021.123262.

Moghadam, M.A. and Izadifard, R. (2021) 'Prediction of the tensile strength of normal and steel fiber reinforced concrete exposed to high temperatures', International Journal of Concrete Structures and Materials [Preprint]. doi:10.1186/s40069-021-00485-6.

Nan, B. et al. (2026) 'Experimental study on the freeze–thaw durability of sustainable steel–polypropylene hybrid fiber-reinforced horqin desert sand concrete', Buildings [Preprint]. doi:10.3390/buildings16081574.

Nanditha, M. and Saikumar, S. (2021) 'Examine on mechanical properties of steel fiber strengthened concrete with silica fume'. doi:10.1016/J.MATPR.2020.12.1081.

Niu, X. et al. (2024) 'Effect of multi-scale hybrid fiber reinforcement on mechanical properties of ultra-high performance concrete', Magazine of Concrete Research [Preprint]. doi:10.1680/jmacr.24.00225.

Ogunjiofor, E., Agbataekwe, E. and Emmanuel, O. (2023) 'Assessment of the mechanical properties of steel fiber reinforced concrete for low-cost construction', American Journal of Innovation in Science and Engineering [Preprint]. doi:10.54536/ajise.v2i1.1287.

Pakzad, S.S., Roshan, N. and Ghalehnovi, M. (2023) 'Comparison of various machine learning algorithms used for compressive strength prediction of steel fiber-reinforced concrete', Scientific Reports [Preprint]. doi:10.1038/s41598-023-30606-y.

Paswan, S. and Bajaj, R. (2025) 'Performance evaluation of fiber-reinforced M30 concrete using steel and e-glass fibers', International Journal for Sciences and Technology [Preprint]. doi:10.71097/ijsat.v16.i3.6944.

Prathipati, S.T., Rao, C. and Murthy, N. (2020) 'Mechanical behavior of hybrid fiber reinforced high strength concrete with graded fibers'. doi:10.5829/ije.2020.33.08b.04.

Putri, C.A., Amalia, A. and Setiawan, Y. (2026) 'Flexural performance and cracking mechanism of reinforced concrete beams with ground granulated blast furnace slag and steel fiber', Construction Technologies and Architecture [Preprint]. doi:10.4028/p-lei1e2.

Shohag, J.M.R.I., Chowdhury, S. and Hasan, A. (2022) 'Assessment of influence of steel fiber on the improvement of concrete's mechanical properties', Daffodil International University Journal of Humanities and Social Sciences [Preprint]. doi:10.36481/diujst.v17i2.zxrk7a91.

Shukur, S.A. and Alkhudery, H.H.A.H.H. (2023) 'EXPERIMENTAL ASSESSMENT OF THE MECHANICAL PROPERTIES OF STEEL-FIBER COMPOSITE BAR (SFCB) REINFORCEMENT', Kufa journal of Engineering [Preprint]. doi:10.30572/2018/kje/140104.

Su, H. et al. (2026) 'Image recognition-based analysis and simulation optimization of mechanical performance of steel fiber-reinforced concrete', Buildings [Preprint]. doi:10.3390/buildings16040704.

Taghia, S.A.H.S. et al. (2021) 'The statistical approach to study the effects of the size of coarse aggregates and percentage of steel fiber on mechanical properties and ductility of concrete', Advances in materials Research [Preprint]. doi:10.4028/www.scientific.net/AMR.1166.95.

Tariq, M. et al. (2022) 'Improved shear strength prediction model of steel fiber reinforced concrete beams by adopting gene expression programming', Materials [Preprint]. doi:10.3390/ma15113758.

Thadaka, V. and Rajagopal, M. (2024) 'Comparative study on the mechanical properties of steel fiber reinforced self-compacting concrete', CVR Journal of Science & Technology [Preprint]. doi:10.32377/cvrjst2502.

Tong, G. et al. (2025) 'Experimental study on dynamic mechanical properties of hybrid fiber reinforced concrete at different temperatures', Scientific Reports [Preprint]. doi:10.1038/s41598-025-85978-0.

Tong, Z. et al. (2025) 'Empowering 3D printed concrete: Discovering the impact of steel fiber reinforcement on mechanical performance', Reviews on Advanced Materials Science [Preprint]. doi:10.1515/rams-2025-0181.

Vadivel, M. et al. (2025) 'Experimental research on mechanical and microstructural characteristics of hybrid fiber reinforced concrete (HFRC)', Scientific Reports [Preprint]. doi:10.1038/s41598-025-23963-3.

Wang, D. et al. (2026) 'Compressive behavior and confinement model for steel fiber reinforced recycled aggregate concrete columns with low volumetric tie ratio', Structural Concrete [Preprint]. doi:10.1002/suco.70621.

Wang, J. et al. (2026) 'Strength and ductility enhancement in coarse-aggregate UHPC via fiber hybridization: Micro-mechanistic insights and artificial neural network prediction', Materials [Preprint]. doi:10.3390/ma19010157.

Wu, L. et al. (2026) 'Experimental investigation of the mechanical performance of steel fiber-reinforced concrete tunnel linings under freeze–thaw cycles', Applied Sciences [Preprint]. doi:10.3390/app16073178.

Xu, J. et al. (2025) 'Comparative study on the properties of basalt and steel fiber reinforcement waste rock concrete', Scientific Reports [Preprint]. doi:10.1038/s41598-025-99292-2.

Yang, I., Joh, C. and Bui, T.Q. (2019) 'Estimating the tensile strength of ultrahigh-performance fiber-reinforced concrete beams', Advances in Materials Science and Engineering [Preprint]. doi:10.1155/2019/5128029.

Zerfu, K. et al. (2025) 'Shear transfer model for ultra-high-performance concrete incorporating fiber bridging mechanism', Structural Concrete [Preprint]. doi:10.1002/suco.70047.

Zhang, L. et al. (2020) 'Effect of surface shape and content of steel fiber on mechanical properties of concrete', Advance in Civil Engineering [Preprint]. doi:10.1155/2020/8834507.

Zhang, M. et al. (2025) 'Fracture behavior of steel-fiber-reinforced high-strength self-compacting concrete: A digital image correlation analysis', Materials [Preprint]. doi:10.3390/ma18153631.