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Research Paper

PERFORMANCE EVALUATION OF ULTRA-HIGH-PERFORMANCE CONCRETE INCORPORATING GLASS FIBRES FOR DURABILITY AND RESILIENT STRUCTURES: A CRITICAL REVIEW IN ALIGNMENT WITH THE SUSTAINABLE DEVELOPMENT GOALS (SDGs)

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ABSTRACT
Ultra-high-performance concrete (UHPC) has emerged as an advanced cementitious material with superior mechanical strength, enhanced durability and potential for developing resilient and sustainable infrastructure. The incorporation of glass fibres into UHPC can improve tensile behaviour, crack resistance, ductility and structural performance, while the use of glass-based materials and supplementary cementitious constituents may contribute to reducing environmental impacts associated with conventional concrete production. This paper critically reviews the performance of glass-fibre-reinforced UHPC with particular emphasis on mechanical properties, durability characteristics, structural resilience, sustainability aspects and its correlation with the Sustainable Development Goals (SDGs). Recent research on glass-fibre incorporation, fibre–matrix interaction, compressive and flexural performance, fracture behaviour, resistance to environmental deterioration and sustainable material development is examined and comparatively analysed. The review highlights the potential of glass fibres to enhance the performance of UHPC, while identifying critical challenges associated with fibre dispersion, interfacial bonding, long-term durability, alkali-related degradation, mix optimisation and environmental assessment. The relationship between glass-fibre UHPC and SDGs, particularly SDG 9, SDG 11, SDG 12 and SDG 13, is critically discussed in the context of resilient infrastructure, sustainable construction, resource efficiency and climate-responsive material development. Key research gaps are identified, and future research directions are proposed towards developing durable, resilient and environmentally responsible UHPC-based structural systems.

Keywords— Ultra-high-performance concrete; glass fibres; durability; structural resilience; mechanical performance; sustainable construction; life-cycle assessment; Sustainable Development Goals.

I. INTRODUCTION

Concrete remains a dominant construction material because of its availability, adaptability and capacity to be shaped into diverse structural forms. Its durability, however, is affected by cracking, moisture and ion transport, chemical exposure, thermal cycling, reinforcement corrosion and maintenance practices. Deterioration can compromise serviceability, increase repair frequency and consume additional resources over a structure's life. These concerns have encouraged development of high-performance cementitious materials intended to achieve more reliable structural performance and extend service life under appropriately selected conditions.

Ultra-high-performance concrete (UHPC) is generally designed through fine-particle packing, a low water-to-binder ratio, high-quality constituent materials and controlled production and curing. Definitions and performance thresholds vary across standards and publications; therefore, UHPC should not be treated as a single uniform material. Fibre reinforcement is often used to improve tensile response and crack control, and fibre type and volume can strongly influence workability, mechanical response and failure characteristics [1–3].

Glass fibres offer a non-metallic reinforcement option. Their potential advantages include tensile reinforcement, crack bridging and reduced susceptibility to conventional steel-fibre corrosion. These potential advantages must be balanced against fibre–matrix compatibility, alkaline durability, fibre dispersion, interfacial bond, workability and the particular glass chemistry. Alkali-resistant (AR) glass fibres should not be conflated with ordinary glass fibres: performance depends on fibre specification and the exposure environment.

The literature has investigated glass-fibre UHPC through mechanical testing, modelling and comparisons with other fibre systems. He et al. examined glass-fibre and high-performance polypropylene-fibre UHPC, reporting differences across compressive, tensile and flexural performance and toughness indices [4]. Such findings illustrate why fibre systems should be compared across several response metrics rather than peak strength alone. Broader reviews also address fibre effects in UHPC and the durability and fracture behaviour of fibre-reinforced composites [2,3,5]. A second issue is sustainability. UHPC may support efficient structural design, rehabilitation, reduced maintenance or longer service life in some applications; however, its initial environmental impact may be increased by binder-intensive formulations. Sustainability claims consequently depend on the chosen functional unit, mix design, structural geometry, service-life assumptions, construction, maintenance and end-of-life scenario [6–8]. A material-level comparison per cubic metre may not be equivalent to a comparison between structural systems delivering the same function.

The Sustainable Development Goals (SDGs) offer a framework for connecting infrastructure performance with wider sustainability objectives. In this review, the primary SDG linkages are SDG 9, SDG 11, SDG 12 and SDG 13. These linkages are framed as potential contributions requiring measurable evidence, not as automatic outcomes of adopting UHPC.

The review aims to: (i) critically assess glass-fibre-reinforced UHPC mechanical performance; (ii) examine durability mechanisms and testing; (iii) discuss resilience-related implications and limits of material-to-structure inference; (iv) analyse sustainability and life-cycle assessment considerations; (v) propose measurable SDG linkages; and (vi) identify research gaps and future priorities.

II. REVIEW APPROACH AND SCOPE

This manuscript is structured as a critical narrative review informed by thematic literature searching. It is not presented as a completed systematic review or PRISMA review because a fully reproducible database search, screening record, deduplication process and study-selection audit have not been performed within this draft. Before submission, the authors should conduct and document searches in Scopus, Web of Science, Engineering Village, ScienceDirect and relevant publisher databases, as appropriate to access and scope.

A. Search concepts

Suggested search strings combine terms for UHPC, glass-fibre reinforcement, mechanical performance, durability, structural resilience, life-cycle assessment and sustainability. Examples include: ("ultra-high-performance concrete" OR UHPC OR UHPFRC) AND ("glass fibre" OR "glass fiber" OR AR-glass); and these terms combined with (durability OR chloride OR sulfate OR freeze-thaw OR flexural OR tensile OR fracture OR resilience OR LCA OR carbon OR SDG).

B. Eligibility and evidence classification

Relevant peer-reviewed studies should be included where the material, fibre type, mixture variables, testing methods and principal findings are sufficiently reported. Studies should be classified by fibre chemistry and geometry, matrix design, curing,

mechanical tests, exposure conditions, structural scale and environmental assessment boundary. Glass-fibre studies should be distinguished from studies using glass powder, recycled glass aggregate or glass as a cementitious replacement; these are related but materially different research streams.

C. Critical synthesis

The synthesis should compare reported outcomes while noting differences in test methods, specimen geometry, fibre volume, curing, exposure duration and definitions. Numerical findings should not be pooled unless the studies are sufficiently comparable. Search dates, database coverage, final screening counts and any quality-assessment method must be inserted after the authors complete the search.

III. UHPC MATRIX AND GLASS-FIBRE REINFORCEMENT

A. UHPC matrix characteristics

UHPC commonly employs a low water-to-binder ratio and carefully proportioned fine constituents to produce a dense matrix. Particle packing, hydration, curing, supplementary cementitious materials, admixtures and mixing sequence affect rheology, strength and transport properties. The term UHPC covers a range of formulations and performance classes; mixture composition and curing must therefore be reported rather than inferred from the label.

B. Glass-fibre characteristics

Glass fibres used in cementitious composites vary in chemistry, diameter, length, surface treatment, sizing and alkali-resistance designation. Fibre tensile properties and geometry influence bridging and load transfer, but effective performance also depends on dispersion and orientation. AR-glass fibre products are designed to improve resistance to alkaline environments, yet their long-term behaviour should be assessed under the conditions relevant to the application.

C. Fibre–matrix interface

The fibre–matrix interface governs stress transfer and may involve debonding, frictional pull-out, fibre rupture and bridging across cracks. An interface that is too weak may limit stress transfer; an interface that is too strong may alter pull-out behaviour and energy absorption. These mechanisms are affected by fibre surface characteristics, matrix composition, curing and exposure. Interface descriptions should be supported by fracture observations or testing rather than assumed from strength results.

D. Fresh-state behaviour and fibre dispersion

Fibre addition can modify flow, viscosity and mixing demand. Higher fibre content or aspect ratio may increase the risk of clustering, orientation effects or incomplete consolidation, depending on the mixture and production process. Fresh-state measurements, casting observations and specimen-to-specimen variability are therefore essential to interpreting hardened performance.

TABLE I. KEY VARIABLES GOVERNING GLASS-FIBRE UHPC

Variable	Potential influence	Reporting priority
Fibre chemistry and alkali resistance	Fibre stability under exposure	Product specification and exposure context
Fibre length, diameter and aspect ratio	Bridging, dispersion and bond	Geometry and supplier data
Fibre dosage and orientation	Mechanical response and workability	Mass or volume basis; mixing procedure
Matrix composition	Strength, porosity and interface	Full mixture proportions
Water-to-binder ratio and admixtures	Rheology and pore structure	Dosage and mixing sequence
Curing	Hydration and performance development	Temperature, humidity and duration
Exposure and age	Durability and residual performance	Protocol and test duration

IV. MECHANICAL PERFORMANCE

A. Compressive behaviour

Compressive strength is influenced predominantly by matrix design, packing, hydration and curing. Fibres may affect cracking and failure progression, but their inclusion does not guarantee an increase in compressive strength. Comparative testing should use equivalent matrix formulations and clearly identify whether differences arise from fibre addition, mixture adjustment or processing. Strength should be reported with specimen dimensions, test age, loading protocol and dispersion measures.

B. Tensile behaviour

Tensile response is critical because concrete-like matrices are relatively weak in tension. Glass fibres may bridge cracks and transfer stress across cracked regions. Direct tensile testing, splitting tensile tests and indirect methods provide different information and should not be treated as interchangeable. Direct tensile tests are particularly valuable where strain-hardening, multiple cracking or post-cracking response is claimed, provided specimen geometry and test control are appropriate.

C. Flexural response

Flexural tests can capture pre-cracking stiffness, peak load, crack development and post-peak response. However, flexural strength alone does not fully characterise toughness or ductility. Load–deflection curves, crack patterns, residual loads and energy measures should be reported. The test configuration and calculation method must be specified.

D. Toughness and fracture

Toughness and fracture-energy measures describe energy dissipation and crack propagation, but results are sensitive to specimen geometry, notch configuration, loading control and calculation method. Fibre pull-out and rupture may contribute to post-cracking response. Researchers should report complete curves and avoid comparing indices calculated using incompatible methods.

E. Variability and reproducibility

Fibre orientation and dispersion can create spatial variability. Replicate numbers, variability statistics and casting direction should be documented. Statistical comparisons should be appropriate to the sample size and design; effect sizes and uncertainty are preferable to reporting isolated percentage increases.

TABLE II. MECHANICAL PERFORMANCE METRICS

Property	Suggested metric(s)	Interpretive limitation
Compressive	Strength; stress–strain curve	Peak strength alone does not describe damage tolerance
Tensile	Direct tensile strength; strain; crack pattern	Indirect tests do not provide identical response
Flexural	Strength; load–deflection curve	Peak value omits post-peak behaviour
Toughness	Energy/area; residual loads; defined indices	Method and specimen geometry influence comparison
Cracking	Crack number, width and spacing	Observation method and resolution must be stated
Fracture	Fracture energy; crack-growth response	Notch and test protocol affect results

V. DURABILITY AND ENVIRONMENTAL EXPOSURE

A. Transport properties and permeability

UHPC's refined pore structure can reduce transport of water and aggressive ions under suitable conditions. Transport performance, however, depends on mixture design, curing, cracks, test method and saturation. Absorption, sorptivity, permeability and diffusion-related tests measure distinct phenomena and should be interpreted accordingly. The influence of fibres may be mediated through crack control, but fibre addition can also affect fresh-state quality and defects.

B. Chloride exposure

Chloride transport is relevant to marine, coastal and salt-exposed infrastructure. Evaluation should identify the test method, specimen conditioning, chloride concentration, exposure duration, temperature and whether measurements concern uncracked or cracked material. The connection between fibre-induced crack control and chloride transport should be investigated directly where durability improvement is claimed.

C. Sulphate and chemical exposure

Chemical exposure can affect matrix chemistry, expansion, mass, strength and microstructure. Short-duration immersion tests provide limited evidence of long-term performance. Researchers should report chemical concentration, solution renewal, temperature, exposure duration and control specimens, and interpret mass or dimensional changes alongside residual mechanical properties.

D. Freeze–thaw and thermal exposure

Freeze–thaw response depends on saturation, pore structure, exposure protocol and specimen condition. Thermal exposure involves additional mechanisms, including moisture migration, thermal incompatibility and potential spalling. Residual strength following exposure is not equivalent to a fire-resistance rating. Tests should be interpreted within their specific protocol and not generalised to structural fire performance.

E. Alkali-related glass-fibre durability

The alkaline environment of cementitious matrices is a critical issue for glass fibres. Durability depends on fibre chemistry, AR designation, surface treatment, matrix alkalinity, moisture, temperature and exposure time. Short-term mechanical testing cannot establish long-term fibre stability. Accelerated exposure can be useful but should be related cautiously to real service conditions. Fibre durability should be evaluated through residual properties, microscopy or other suitable evidence.

F. Cracks and durability

Cracks may increase pathways for moisture and ions. Fibres can affect crack formation and opening, but crack control does not automatically prove improved durability. A stronger research design would measure crack widths and distribution, then relate them to transport or exposure outcomes and residual performance under comparable conditions.

TABLE III. DURABILITY TESTING AND REPORTING

Exposure/test	Useful measurements	Minimum contextual reporting
Chloride	Transport coefficient, penetration or profile	Method, conditioning, exposure and specimen age
Water absorption/sorptivity	Mass uptake or absorption rate	Drying/conditioning protocol and duration
Sulphate	Mass, expansion, surface and residual strength	Solution, concentration, duration, temperature
Freeze–thaw	Mass, dynamic modulus, residual strength	Cycle definition and saturation
Thermal exposure	Residual strength, mass, visual damage	Temperature, heating/cooling and duration
Alkaline fibre ageing	Residual fibre/composite performance and microscopy	Fibre type, exposure protocol and time
Crack control	Crack width, spacing and propagation	Measurement method, loading and observation age

VI. STRUCTURAL RESILIENCE AND APPLICATIONS

Resilience is a structural and system-level concept encompassing resistance to damage, preservation or restoration of function and recovery. Material toughness or strength may contribute to structural performance, but neither alone demonstrates resilience. Resilience assessment requires a defined hazard or loading scenario, performance objective, damage state and recovery or functionality metric.

A. Static and cyclic loading

Static and cyclic tests can assess stiffness, crack accumulation, residual capacity and deformation. Repeated loading may alter the interface, crack network and damage progression. Where cyclic performance is claimed, loading amplitude, frequency, cycle count, control mode and failure criteria should be reported.

B. Impact and dynamic loading

Impact or dynamic behaviour requires tests suited to the loading regime. Results from small specimens should not be directly translated into structural-scale impact resistance without validated modelling or testing. Energy absorption and residual damage should be considered alongside peak force.

C. Potential applications

Potential applications include bridge deck rehabilitation, precast components, thin or compact structural elements, repair systems and infrastructure exposed to aggressive environments. Application suitability depends on design, construction, cost, connection details, reinforcement, code provisions and verified performance. Claims regarding reduced maintenance or longer service life require application-specific evidence.

TABLE IV. APPLICATION-LEVEL PERFORMANCE QUESTIONS

Application	Potential value	Evidence required
Bridge rehabilitation	Repair durability and reduced intervention potential	Bond, fatigue, exposure and system-level tests
Precast elements	Controlled production and component efficiency	Manufacturing quality, connections and design
Thin/compact components	Geometry or material efficiency	Structural comparison on equal functional basis
Aggressive exposure	Potential durability benefit	Exposure testing, crack and residual performance
Repair/overlay systems	Rehabilitation rather than replacement	Substrate interface, durability and field validation

VII. SUSTAINABILITY AND LIFE-CYCLE PERFORMANCE

A. The UHPC sustainability trade-off

UHPC may have high initial embodied impacts because of its binder content and processing. Potential life-cycle advantages may arise where it reduces structural volume, enables efficient design, limits maintenance or extends service life. These benefits are application-specific and should be quantified rather than inferred from material strength or durability claims [6–8].

B. Functional units and system boundaries

Comparisons should use a functional unit representing equivalent service, such as a defined bridge-deck area meeting specified load, durability and service-life requirements. A per-cubic-metre comparison may be useful for material inventories but cannot alone establish structural sustainability. System boundaries should identify production, transport, construction, maintenance, rehabilitation, replacement and end-of-life stages as applicable.

C. Life-cycle assessment

LCA should report the method, database, allocation rules, geographic and temporal assumptions, functional unit, system boundaries, impact categories and sensitivity analyses. Global warming potential

may be an important indicator, but broader environmental categories may also be relevant. Maintenance and service-life assumptions should be transparent and supported by evidence.

D. Life-cycle cost

Life-cycle cost analysis can incorporate material and construction costs, inspection, maintenance, rehabilitation, replacement and end-of-life costs. Discount rate, analysis period, cost data and uncertainty should be stated. Higher initial cost may or may not be offset by future savings.

E. Resource efficiency and circularity

Potential circular strategies include supplementary cementitious materials, optimised binder content, recycled constituents where technically compatible, construction waste reduction and reuse or recycling at end of life. Glass fibres and recycled glass powder or aggregate are distinct material streams and must not be treated as synonymous. Compatibility, durability, quality control and environmental effects require validation.

TABLE V. SUSTAINABILITY INDICATORS

Dimension	Indicator	Assessment caution
Climate	Embodied/whole-life GWP	Functional unit and boundary strongly influence results
Energy	Energy use	Include relevant production and construction stages
Resources	Binder, aggregate and fibre consumption	Structural functionality should be comparable
Water	Water use	Include production and process assumptions
Waste	Waste generation and diversion	Avoid double counting and unsupported circular claims
Economic	Initial and life-cycle costs	State analysis period, discounting and uncertainty
Service performance	Maintenance, interventions, service life	Evidence and scenario assumptions must be transparent

VIII. SDG CORRELATION

The SDG mapping presented here is a proposed mechanism–indicator framework. It identifies plausible pathways through which a glass-fibre-reinforced UHPC application could contribute to selected SDGs, while emphasising that material adoption alone is not evidence of achievement.

A. SDG 9—Industry, Innovation and Infrastructure

Potential pathway: infrastructure durability, innovation in construction materials and rehabilitation, and performance-based design. Suggested indicators include measured durability, structural reliability, maintenance interventions and service-life evidence. The linkage is strongest where the material demonstrably supports quality, reliable, sustainable and resilient infrastructure.

B. SDG 11—Sustainable Cities and Communities

Potential pathway: reliable infrastructure and reduced disruption associated with deterioration and maintenance. Suggested indicators include serviceability, maintenance-related disruption, rehabilitation needs and structural performance. Community-level sustainability claims require broader evidence than material tests.

C. SDG 12—Responsible Consumption and Production

Potential pathway: material efficiency, waste minimisation, responsible constituent sourcing and life-cycle resource optimisation. Suggested indicators include material use per functional unit, waste, recycled constituents and life-cycle resource consumption. Higher-strength material does not automatically equate to responsible production.

D. SDG 13—Climate Action

Potential pathway: life-cycle carbon reduction and climate-resilient infrastructure. Suggested indicators include whole-life emissions, maintenance-related emissions, carbon per functional unit and performance under relevant environmental hazards. A higher initial carbon footprint may be offset only where structural and life-cycle benefits are demonstrable.

E. Secondary linkage to SDG 8

SDG 8 may be discussed cautiously in relation to construction productivity, economic efficiency and infrastructure investment, but a direct contribution requires evidence and should not be overstated.

TABLE VI. PROPOSED SDG–MECHANISM–INDICATOR MATRIX

SDG	Potential mechanism	Evidence/indicator
SDG 9	Infrastructure innovation and resilience	Durability, reliability, structural performance and service life
SDG 11	Reliable urban/community infrastructure	Serviceability, intervention frequency and disruption
SDG 12	Resource-efficient production and use	Material use, waste, circularity and LCA indicators
SDG 13	Climate mitigation/adaptation pathway	Whole-life carbon and hazard-related performance
SDG 8 (secondary)	Economic/production efficiency	LCCA, productivity and maintenance cost

IX. CRITICAL COMPARISON AND LIMITATIONS

Evidence for glass-fibre UHPC should be interpreted in context. Different glass fibre products, mixture proportions, testing methods and curing regimes may produce non-comparable outcomes. A reported increase in one strength metric may coincide with reduced workability or different toughness behaviour. Long-term durability evidence may be limited relative to short-term mechanical evidence. Some studies combine glass fibres with other fibres or textile reinforcement, making attribution to glass fibres alone difficult.

The literature review itself has limitations. This draft does not contain an audited systematic search or quantitative synthesis. It cannot establish prevalence, pooled effect sizes or exhaustive coverage of the literature. SDG linkages are conceptual and require indicator-level evidence. Publication-ready claims should be checked against full-text studies and standards, and any literature-search protocol should be completed and reported.

TABLE VII. CLAIMS AND EVIDENCE REQUIRED

Claim	Evidence needed before asserting
Glass fibres improve UHPC strength	Comparable controlled mixture data; statistical and test-method context
Fibres improve durability	Exposure tests, crack measurements and residual performance
Material increases resilience	Structural/hazard-specific evidence and resilience metrics
UHPC reduces carbon	LCA on equivalent functional units and transparent boundaries
UHPC extends service life	Service-life model or long-term/field evidence with assumptions
UHPC supports SDGs	Measurable indicator outcomes and explicit causal pathway

X. RESEARCH GAPS AND FUTURE DIRECTIONS

A. Long-term glass-fibre stability

Long-duration exposure studies should examine fibre chemistry, surface treatment, matrix alkalinity, moisture and temperature, with residual composite properties and microstructural evidence. Accelerated

tests should be interpreted against plausible field exposure.

B. Integrated crack–durability testing

Research should link crack width, crack distribution and fibre bridging to transport properties and deterioration under controlled exposure. Testing should distinguish uncracked, pre-cracked and load-maintained specimens.

C. Standardised comparative testing

A common reporting framework should identify fibre product, dosage basis, geometry, matrix, curing, test method, specimen dimensions, replicates and variability. Standardisation would support meaningful comparison and reproducibility.

D. Structural-scale validation

Component and structural testing should validate material-level findings for selected applications. Cyclic, fatigue, impact or environmental loading should be selected according to the intended structure, and performance objectives should be defined.

E. Multi-objective mix optimisation

Mixture optimisation should balance strength, toughness, workability, durability, fibre dispersion, cost and embodied carbon. Optimisation should be constrained by application-specific requirements rather than maximising a single strength metric.

F. Life-cycle and SDG integration

Future studies should compare equivalent structural systems and integrate LCA, LCCA, maintenance scenarios, service-life assumptions and measurable SDG indicators. Uncertainty and sensitivity analysis should be included.

G. Field and monitoring evidence

Field trials and long-term monitoring are needed to connect laboratory durability and mechanical results with real construction, exposure and maintenance. Monitoring methods should be selected to answer specific performance questions and interpreted with validated baselines.

TABLE VIII. PRIORITISED RESEARCH ROADMAP

Priority	Research direction	Expected contribution
1	Long-term alkaline/exposure durability	Evidence on fibre stability and residual performance
2	Crack–transport–exposure coupling	Quantitative link between crack control and durability
3	Harmonised testing/reporting	Reproducible cross-study comparisons
4	Structural-scale validation	Application-specific performance evidence
5	Multi-objective mix design	Balanced mechanical, durability, cost and carbon optimisation
6	Functional-unit LCA/LCCA	Credible whole-life sustainability comparison
7	SDG indicator validation	Evidence-based rather than rhetorical SDG mapping
8	Field trials and monitoring	Real-world performance and maintenance data

XI. CONCLUSION

Glass-fibre-reinforced UHPC is a promising material system for applications where mechanical performance, crack control, durability and structural efficiency are important. The influence of glass fibres depends on their chemistry, geometry, dosage, dispersion and interface with the UHPC matrix, as well as mixture design, curing and exposure.

Compressive strength alone is insufficient to evaluate the composite; tensile and flexural response, toughness, crack behaviour, durability and residual performance should be considered together.

Durability claims require exposure-specific evidence and a clear distinction between matrix performance and fibre stability. In particular, long-term alkali-related durability of glass fibres and the relationship between crack control and transport remain important research priorities. Resilience should be evaluated at the structural or infrastructure-system level rather than inferred solely from material strength or toughness.

The sustainability of UHPC incorporating glass fibres is conditional. Higher initial environmental impacts may be justified where a demonstrated structural function, material-efficient design, reduced maintenance or longer service life produces life-cycle benefits. Appropriate functional units, transparent LCA and LCCA assumptions, and uncertainty analysis are necessary to evaluate such benefits.

The proposed SDG framework links potential performance pathways to SDG 9, SDG 11, SDG 12 and SDG 13 through measurable indicators. These correlations should be substantiated by evidence and not presented as automatic outcomes. Future research should prioritise long-term durability, integrated crack and exposure assessment, standardised testing, structural-scale validation, low-carbon mixture optimisation and life-cycle evaluation. Ultimately, glass-fibre-reinforced UHPC should be selected on the basis of verified performance and sustainability for a defined structural function and service period.

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TABLE IX. CRITICAL EVIDENCE TABLE: SELECTED RECENT SOURCES

Source	Scope / focus	Value to this review	Limitation / caution
He et al. (2021) [4]	Glass fibre and high-performance PP fibre in UHPC; mechanical response and damage evolution	Direct glass-fibre UHPC evidence; compare multiple response indicators	Long-term exposure and structural-scale transfer not established by this study alone

Source	Scope / focus	Value to this review	Limitation / caution
Guo et al. (2021) [5]	Review of glass in high-performance fibre-reinforced cementitious composites	Context for fibre chemistry, glass reinforcement and research trends	Broad scope; not exclusively UHPC or a durability dataset
Wen et al. (2022) [2]	Review of fibre effects on UHPC mechanical properties and durability	Comparison across fibre families and test themes	Fibre-specific conclusions must be extracted carefully
Kravanja et al. (2024) [6]	Broad UHPC advances, properties, applications and environmental impact	Context for UHPC formulation and sustainability trade-offs	Not focused exclusively on glass fibres
Redondo-Pérez et al. (2024) [7]	Recycled glass as mineral admixture in circular UHPC	Supports circular-material discussion; distinguish glass powder from fibre reinforcement	Material role differs from discrete fibres
Hiew et al. (2026) [12]	Low-carbon UHPC constituents, mechanisms and sustainability	Critical framing for binder reduction and performance trade-offs	General UHPC review rather than glass-fibre-specific
Malik et al. (2026) [10]	AR-glass fibres and textile grid; mechanical, thermal and short sulfate-exposure tests	Recent experimental evidence on AR-glass UHPC systems	Exposure durations and configuration limit generalisation
Alotaibi et al. (2026) [15]	UHPC and SDG framework, sustainability, service life and circularity	SDG framing and life-cycle context	SDG mapping is broader than glass-fibre UHPC
Zaid et al. (2025/2026) [16]	UHPC/UHPFRC standardisation and structural applications	Standards, performance definitions and implementation context	Broad UHPFRC scope
Mandor & Taie (2026) [17]	UHPC design, performance, standards and infrastructure resilience	Design and resilience roadmap context	Not glass-fibre-only