International Journal of Creative and Open Research in Engineering and Management
ISSN: 3108-1754 (Online)
Volume 02 Issue 11 November-2026 | Impact Factor: 3.5



Application of Lightweight Concrete in the Construction Industry: Properties, Performance, Challenges and Future Prospects

Dr. Riya Dey[1], Ms. Sushmita Ghosh[2], Mr. Chayan Biswas[3]

[1] Associate Professor, Department of Civil Engineering, Global Institute of Management & Technology, Krishnanagar, W.B., India.

[2,3] Assistant Professor, Department of Civil Engineering, Swami Vivekananda University, Barrackpore, W.B., India.

How to Cite this Article:

Dey, R., Ghosh, S. & Biswas, C. (2026). Application of Lightweight Concrete in the Construction Industry: Properties, Performance, Challenges and Future Prospects. International Journal of Creative and Open Research in Engineering and Management, 02(11), 1-9. https://doi.org/10.55041/ijcope.v2i11.156

License:

This article is published under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) and the source are credited.

© The Author(s). Published by International Journal of Creative and Open Research in Engineering and Management.





https://doi.org/10.55041/ijcope.v2i11.156

Abstract

Lightweight concrete (LWC) is increasingly used in modern construction because its lower density can reduce structural dead load while offering opportunities for improved thermal and acoustic performance. This review paper discusses the principal categories of lightweight concrete, the materials used in their production, key fresh and hardened properties, construction applications, benefits and practical limitations. The paper adopts a narrative literature-review approach based on peer-reviewed review articles and recognised technical guidance. Lightweight aggregate concrete, foamed concrete, autoclaved aerated concrete and no-fines concrete are considered, with emphasis on the relationship between aggregate characteristics, pore structure, density, strength, water absorption and durability. Applications in building envelopes, partition walls, structural floors, precast components, bridge elements and rehabilitation works are examined. The review indicates that lightweight concrete should not be treated as a single uniform material: its suitability depends on the intended function, density class, strength requirement, exposure condition and quality-control regime. Reduced self-weight can create structural and construction efficiencies, but higher absorption, variability of lightweight aggregates, shrinkage, curing sensitivity and connection detailing require careful attention. The paper concludes that mix optimisation, reliable local material supply, life-cycle assessment and performance-based quality control are important for wider adoption. The discussion is intended as an academic sample and should be adapted to the target journal and supported by project-specific or laboratory data before submission.

Keywords: Lightweight concrete; lightweight aggregate; foamed concrete; autoclaved aerated concrete; density; compressive strength; sustainable construction.

1. INTRODUCTION

Concrete is one of the most widely used construction materials, but its relatively high unit weight contributes significantly to the dead load of buildings and infrastructure. In situations where structural self-weight governs design, reducing concrete density can provide benefits such as smaller member forces, lower foundation demand, easier handling of precast units and improved construction efficiency. Lightweight concrete (LWC) is therefore of interest in high-rise buildings, long-span structures, precast construction and building-envelope systems [1–3].

The term lightweight concrete covers several material systems that differ in composition and production. Lightweight aggregate concrete uses porous natural or manufactured aggregates; foamed concrete incorporates a stable preformed foam; autoclaved aerated concrete (AAC) is produced through gas formation and autoclave curing; and no-fines concrete contains little or no fine aggregate, creating an interconnected void structure. These materials do not have identical mechanical or durability characteristics, and their design applications must be selected accordingly [1,2].

Recent reviews identify engineered lightweight aggregates, supplementary cementitious materials, fibres and alternative binders as important areas of development. At the same time, practical adoption depends on consistent aggregate quality, moisture correction, mixing procedures, curing, workmanship and compliance with applicable design standards [2,4]. This paper summarises the main considerations for selecting and applying lightweight concrete in the construction industry.



2. OBJECTIVES AND REVIEW METHODOLOGY

The objectives of this paper are to: (i) describe the principal types and constituent materials of lightweight concrete; (ii) review the influence of lightweight constituents on density and engineering properties; (iii) identify major construction applications; (iv) discuss benefits, limitations and quality-control requirements; and (v) highlight research needs for wider and more reliable use.

A narrative review approach was adopted. The discussion draws on published review papers and technical guidance dealing with lightweight concrete, lightweight aggregates, structural performance and construction applications. The selected literature includes a foundational review of lightweight concrete [1], a recent comprehensive review of aggregate types and performance [2], a review of recent innovations [4], and the American Concrete Institute guide for structural lightweight-aggregate concrete [5]. This is not a systematic review or meta-analysis; no new laboratory tests or original experimental dataset are claimed.

3. CLASSIFICATION AND CONSTITUENT MATERIALS

3.1 Lightweight aggregate concrete

Lightweight aggregate concrete (LWAC) is produced by replacing some or all conventional coarse and/or fine aggregate with low-density aggregate. Common options include expanded clay, expanded shale, expanded slate, pumice, scoria, sintered fly-ash aggregate and other processed or recycled lightweight materials. Aggregate density, particle strength, grading, absorption and surface texture strongly influence fresh concrete behaviour and hardened performance [1,2,5].

3.2 Foamed concrete

Foamed concrete is a cementitious slurry into which preformed foam is introduced to create a cellular structure. It is commonly used for non-structural or lightly loaded applications such as void filling, roof insulation, trench reinstatement, levelling layers and selected partition systems. Its density and strength can be adjusted over a broad range, but stability of the foam, uniformity of cell distribution and curing conditions are critical.

3.3 Autoclaved aerated concrete

AAC is a factory-produced cellular masonry material generally made from silica-rich material, cement or lime, water and a small quantity of an expansion agent. Gas formation creates a porous structure, followed by high-pressure steam curing in an autoclaves. AAC blocks and panels are valued for low mass, dimensional accuracy and thermal insulation. Their use requires suitable mortar or adhesive, reinforcement detailing for panels, and protection against moisture ingress.

3.4 No-fines concrete

No-fines concrete is made mainly from coarse aggregate, cement and water, with fine aggregate omitted or substantially reduced. The resulting interconnected voids lower density and may provide drainage. Its lower strength and relatively open pore structure limit its use in applications requiring impermeability, high abrasion resistance or conventional reinforced-concrete behaviour.

Type	Basic production principle	Common applications	Main design consideration
Lightweight aggregate concrete	Porous natural or manufactured aggregate replaces normal aggregate	Structural slabs, beams, bridge decks, precast units	Aggregate strength, absorption, density and moisture correction
Foamed concrete	Stable preformed foam is mixed into cementitious slurry	Void filling, insulation layers, trench filling, non-load-bearing units	Foam stability, density uniformity and curing
AAC	Gas-forming reaction followed by autoclave curing	Blocks, wall panels, roof/floor panels	Moisture protection, joints, fixing and reinforcement details
No-fines concrete	Coarse aggregate bonded with cement paste; little/no fine aggregate	Drainage layers, low-strength walls and selected fills	Connected porosity, strength and permeability

Table 1. Main types of lightweight concrete and typical applications

4. ENGINEERING PROPERTIES

4.1 Density and unit weight

The defining practical feature of LWC is reduced density compared with conventional normal-weight concrete. The achieved density depends on aggregate type, air-void content, paste volume, moisture condition and compaction. Density should be specified and measured using the method required by the relevant standard and project specification. Oven-dry density, equilibrium density and



fresh density are different quantities and should not be interchanged when reporting results.

4.2 Compressive and tensile strength

Compressive strength is influenced by the strength and stiffness of the lightweight aggregate, the interfacial transition zone, water-to-binder ratio, curing and overall porosity. In structural LWAC, suitable mix design can provide useful strength at lower density; however, strength does not increase automatically when density decreases. Tensile and flexural performance also depend on aggregate fracture, paste quality and reinforcement. Design values should be established from relevant test data rather than inferred from density alone [1,5].

4.3 Modulus of elasticity and deformation

The modulus of elasticity of lightweight concrete is generally lower than that of normal-weight concrete of comparable compressive strength because many lightweight aggregates are more deformable. This can affect deflection, vibration, crack width and prestress losses. Structural design should use the expressions and modification factors permitted by the governing code, supported by measured properties where required.

4.4 Thermal and acoustic performance

The cellular or porous structure of many lightweight concretes reduces heat transfer and can improve thermal insulation relative to dense concrete. Acoustic behaviour is more complex and depends on density, thickness, pore structure, surface finish and the complete wall or floor assembly. Product-level claims should therefore be supported by standardised thermal and acoustic test reports.

4.5 Water absorption and durability

Porous lightweight aggregates and cellular matrices may exhibit higher water absorption than dense conventional concrete. Pre-wetting or controlled moisture conditioning of aggregates may be necessary to limit rapid water withdrawal from the paste and to maintain workability. Durability assessment should consider permeability, carbonation, chloride exposure, freeze-thaw where relevant, sulphate exposure, reinforcement protection, shrinkage and curing. The exposure class and intended service life should govern material selection and protective measures [1,5].

5. APPLICATIONS IN THE CONSTRUCTION INDUSTRY

5.1 Structural buildings

Structural LWAC may be used in slabs, beams, columns, floor systems and other elements where reduced dead load is beneficial. Lower self-weight can reduce gravity effects and, in seismic design, may reduce inertia forces. The actual benefit depends on the complete structural system and must be evaluated alongside stiffness, ductility, connection behaviour and code requirements.

5.2 Precast and prefabricated construction

Lower unit weight can make precast panels, façade units, stair flights and modular components easier to transport, lift and install. Reduced lifting loads may improve site logistics and permit larger prefabricated elements, subject to lifting insert design, handling stresses, dimensional control and transport limitations.

5.3 Bridges and transportation infrastructure

Structural lightweight aggregate concrete has been used in bridge decks, girders and other components where reducing dead load can be particularly valuable. Lower superstructure weight may create opportunities for longer spans or reduced demands on substructure elements. Bridge use requires rigorous control of fatigue, shrinkage, creep, deck durability, reinforcement cover and construction joints [5].

5.4 Building envelope and partition systems

AAC blocks and panels, lightweight aggregate blocks and other low-density units are widely suited to non-load-bearing partitions and envelope systems. Their low mass can reduce floor and frame loads, while thermal performance can support energy-efficient building design. Detailing must address rain penetration, vapour movement, fixings, impact resistance, fire performance and compatibility with finishes.



5.5 Geotechnical works and void filling

Foamed concrete and selected lightweight fills can reduce vertical stress on weak subsoil, retaining structures and buried services. Applications include abandoned pipeline filling, embankment widening, trench reinstatement and backfilling behind retaining walls. Geotechnical design should account for compressibility, strength development, buoyancy, drainage and long-term settlement.

6. BENEFITS AND LIMITATIONS

Potential benefits	Limitations / risks
Reduced dead load and potentially lower foundation demand	Lower stiffness may increase deflection and vibration response
Improved handling and installation of precast components	Lightweight aggregate may be costly or regionally unavailable
Potentially improved thermal insulation	Higher absorption and moisture sensitivity in some systems
Potential for lower transport and structural loads	Mixing, pumping, curing and quality control may require adaptation

7. MIX DESIGN, CONSTRUCTION PRACTICE AND QUALITY CONTROL

A successful LWC project begins with a clearly defined performance requirement: target density, compressive strength, workability, exposure class, thermal requirement and intended placement method. Trial mixes should establish aggregate moisture condition, water demand, admixture dosage, fresh density, air content where applicable, strength development and dimensional stability. Lightweight aggregates may absorb mixing water; moisture corrections and preconditioning should follow the aggregate supplier's guidance and trial results.

Batching and mixing procedures may need adjustment to prevent segregation, floating of lightweight particles or damage to cellular structures. Pumping trials should be undertaken for mixes intended for pumping. Curing is particularly important because porous constituents and high surface-area systems can be sensitive to moisture loss. Site quality assurance should include material certificates, calibration of weighing equipment, fresh-concrete checks, specimen preparation, density measurement and strength testing. For structural LWAC, design and construction should follow the applicable national code and recognised guidance, including ACI PRC-213 where relevant [5].

8. SUSTAINABILITY AND FUTURE RESEARCH

Lightweight concrete can contribute to resource-efficient construction through reduced material transport loads, lower structural self-weight and the incorporation of suitable industrial by-products or recycled aggregates. Nevertheless, lower density alone does not prove lower environmental impact. A credible sustainability comparison should use a defined functional unit and consider binder content, aggregate processing, transport distance, energy use, durability, maintenance and end-of-life scenarios. Life-cycle assessment is therefore recommended when comparing LWC with conventional concrete.

Future research should focus on (i) durable lightweight aggregates produced from local and recycled resources; (ii) low-carbon binders and geopolymer-based lightweight systems; (iii) reliable prediction of creep, shrinkage and long-term deformation; (iv) fire, fatigue and exposure performance; (v) digital monitoring and quality control in precast production; and (vi) life-cycle and cost assessment under local construction conditions. Recent reviews highlight the growing role of engineered aggregates, fibres and alternative binders, but field validation remains essential [2,4].

9. CONCLUSIONS

Lightweight concrete is a family of materials rather than a single mix type. Lightweight aggregate concrete, foamed concrete, AAC and no-fines concrete have different production methods, properties and appropriate applications. Their shared advantage is the potential to reduce density, but the magnitude of structural, thermal, construction and environmental benefits depends on the specific material system and project conditions.

For structural applications, density reduction must be balanced against strength, stiffness, creep, shrinkage, durability and connection requirements. For non-structural and geotechnical applications, the required performance may instead be dominated by insulation, low bearing pressure, flowability or ease of installation. Proper mix design, aggregate moisture control, curing and systematic quality assurance are essential for dependable performance.

The construction industry can expand the responsible use of lightweight concrete through locally validated mix designs,



performance-based specifications, life-cycle assessment and greater coordination between designers, material suppliers and contractors. Further experimental and field studies are recommended to establish the suitability of locally available lightweight materials under regional climatic and exposure conditions.

REFERENCES

[1] Thienel, K.-C., Haller, T., & Beuntner, N. (2020). Lightweight Concrete—From Basics to Innovations. *Materials*, 13(5), 1120. https://doi.org/10.3390/ma13051120.

[2] Dwarampudi, M., & Venkateshwari, B. (2024). Performance of light weight concrete with different aggregates—a comprehensive review.
Discover Civil Engineering, 1, Article 46. https://doi.org/10.1007/s44290-024-00015-9.

[3] Elango, K. S., Sanfeer, J., Gopi, R., Shalini, A., Saravankumar, R., & Prabhu, L. (2021). Properties of light weight concrete – A state of the art review. *Materials Today: Proceedings*, 46(Part 9), 4059–4062. https://doi.org/10.1016/j.matpr.2021.02.571.

[4] Behera, D., Liu, K.-Y., Rachman, F., & Worku, A. M. (2025). Innovations and Applications in Lightweight Concrete: Review of Current Practices and Future Directions. *Buildings*, 15(12), 2113. https://doi.org/10.3390/buildings15122113.

[5] ACI Committee 213. (2014; reapproved 2023). *ACI PRC-213-14(23): Guide for Structural Lightweight-Aggregate Concrete*. American Concrete Institute.

[6] Omran, (2024). A Review of Lightweight Concrete in Civil Engineering. *Journal of Civil Engineering and Urbanism*, 14(4), 378–404. https://doi.org/10.54203/jceu.2024.42.