Cite this article
Dunster A (2026)
Editorial: Advances in durability assessment of concrete with innovative and low carbon binders.
Magazine of Concrete Research **78(13–14)**: 781–782,
https://doi.org/10.1680/jmacr.2026.78.13.14.781

Editorial

Magazine of Concrete Research

Editorial: Advances in durability assessment of concrete with innovative and low carbon binders

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Introduction

As a key pillar of the built environment, concrete supports infrastructure, buildings and other critical aspects of modern life. However, its reliance on traditional clinker-based cement contributes 14–17% of global direct industrial greenhouse gas emissions (IPCC, 2022). These impacts are being partially addressed through new cementitious binders and concrete formulations with lower embodied carbon dioxide.

Durability remains a major challenge as concrete assets are increasingly exposed to aggressive environments. Traditional test methods and models developed for traditional Portland cement (PC) concretes can be unsuitable for innovative 'low-carbon' binders and may produce misleading results. Reliable service-life assessment therefore requires a better understanding of deterioration mechanisms together with the development, adaptation and validation of appropriate test methods supported by field experience.

This Special Issue invited contributions of papers on advancing durability and service-life assessment particularly for concretes beyond conventional PC systems. By emphasising test methodologies, the aim was to support more robust assessment tools that bridge laboratory studies and field performance, enabling durable and sustainable concrete structures.

Advances reflected in this special issue

The application of service-life prediction methodologies and field performance data to concrete structures remains insufficiently explored, particularly in the case of alternative cementitious binders. The seven papers collectively address three main challenges: (*a*) assessing and predicting the durability of non-traditional cementitious systems, (*b*) developing appropriate test methods, performance indicators and service-life models and (*c*) evaluating the durability of novel concrete and binder systems.

The two overarching papers by Barbhuiya *et al*. (2026) and Gupta and Podder (2026) highlight the need for durability assessment approaches tailored to low-carbon binders. They demonstrate that durability paradigms developed for PC concretes are often inadequate for alternative systems whose transport properties, reaction mechanisms, pore structures and degradation processes differ substantially. They also emphasise that standardised test methods have not kept pace with emerging binder technologies and applications.

The papers by Clear *et al*. (2026) and Imitini *et al*. (2026) respectively examine the limitations of performance-based test methods, service-life prediction approaches and the use of proxy indicators such as diffusion and electrical resistivity measurements. The remaining three papers by Gong *et al*. (2026), Fan *et al*. (2026) and Wu *et al*. (2026) contribute to the evidence base on alkali-activated materials, calcined clay binders, phosphate cements and related technologies respectively, providing insights into their long-term performance.

Taken together, these papers demonstrate both the opportunities and challenges of moving beyond conventional PC-based durability concepts and highlight the need for robust, material-specific assessment methods and service-life models.

Challenges in testing and assessment of innovative concretes

Earlier literature highlights several challenges in testing and assessing innovative concretes. To meet construction project timescales, accelerated test methods are already widely used for conventional concretes. Bernal and Provis (2014) highlighted that standard accelerated durability tests developed for PC do not always represent degradation processes in alkali-activated materials and that microstructural differences strongly influence outcomes. Conventional durability tests can therefore produce misleading results for novel binders unless validated appropriately. Similar conclusions were drawn by Zhang *et al*. (2020).

One paper in this issue (Barbhuiya *et al*., 2026) highlights that durability tests developed for PC can mis-rank sustainable binders because they are calibrated to PC-specific pore structures, hydration products and transport mechanisms. When applied to blends rich in supplementary cementitious materials, limestone–calcined clay cements and alkali-activated systems, they may measure short-term transport behaviour rather than true long-term degradation processes.

Service-life prediction from performance-based laboratory testing remains an active research area for conventional concretes and is even less developed for alternative concretes, where significant challenges remain. Alexander (2018) emphasised the need to integrate testing, durability indicators and modelling frameworks – an area that remains immature for low-carbon systems.

Opportunities and way forward

The need to accelerate the adoption of low-carbon concrete is pressing, leading to a growing recognition of the need for greater collaboration, with promising signs of pre-competitive cooperation in the UK and EU to pool research resources (LCCG, 2026). There is also a continuing evolution towards performance-based and binder-agnostic standards, such as BS Flex 350 (BSI, 2024), away from existing prescriptive standards.

There remains, however, a strong need for validated tests for alternative binder systems that are integrated with service-life prediction and underpinned by a better understanding of deterioration mechanisms, enabling more meaningful material assessment and performance prediction.

An emerging area of research is the integration of deterioration modelling with artificial intelligence (AI) and life-cycle assessment to design structures that are both low-carbon and durable (Muhit *et al*., 2025). AI has the potential to contribute to the assessment of non-conventional low-carbon cements by integrating experimental, durability and environmental datasets, which may help improve long-term performance prediction in situations when traditional modelling approaches face limitations.

Closing remarks

A common thread running through this special issue is that durability is no longer simply a materials challenge but increasingly an assessment challenge. As low-carbon concretes expand the range of binder chemistries available to engineers, they also expose limitations in many of the tools traditionally used to evaluate long-term performance.

The studies presented here provide valuable contributions towards addressing these limitations, from reviews of durability assessment frameworks to practical investigations of novel materials and durability indicators. Together, they support a future in which durability assessment is increasingly performance-based, binder-agnostic and closely linked to service-life modelling. While significant work remains, the contributions provide confidence that the industry is moving towards a more reliable and scientifically grounded framework for assessing sustainable concrete systems.

REFERENCES

Alexander MG (2018) Durability and service life prediction for concrete structures: developments and challenges. *MATEC Web of Conferences* **149**: 01006.

Barbhuiya S, Kanavaris F, Das BB and Adak D (2026) Reassessing durability testing for sustainable concrete systems: from Portland cement to novel binder technologies. *Magazine of Concrete Research* **78(13–14)**: 783–803, 10.1680/jmacr.26.00024.

Bernal SA and Provis JL (2014) Durability of alkali-activated materials: Progress and perspectives. *Journal of the American Ceramic Society* **97(4)**: 997–1008.

BSI (2024) BSI Flex 350 v2.0:2024-09: Alternative binder systems for lower carbon concrete: code of practice. BSI, London, UK.

Clear CA, McCarthy MJ, Hynard C and Newlands MD (2026) Identifying performance criteria for UK concretes under freeze–thaw exposure test conditions. *Magazine of Concrete Research* **78(13–14)**: 816–828, 10.1680/jmacr.25.00494.

Fan L, Lu B, Sun Y and Zhong W (2026) Synergistic enhancement of mechanical and durability properties in alkali-activated low-grade calcined clay pastes by slag addition. *Magazine of Concrete Research* **78(13–14)**: 857–868, 10.1680/jmacr.25.00399.

Gong Z, McPolin D, Soutsos M and Nanukuttan S (2026) Synergistic effects of acetic acid and sulfate on the degradation of ternary and alkali-activated concretes. *Magazine of Concrete Research* **78(13–14)**: 845–856, 10.1680/jmacr.26.00027.

Gupta A and Podder D (2026) Why current standards fail for CFSTs with alternative binders: closing the gap. *Magazine of Concrete Research* **78(13–14)**: 804–815, 10.1680/jmacr.26.00031.

Imitini EM, Suryanto B, Gupta BS and Basheer PAM (2026) Assessing the chloride-ingress performance of binary and ternary low-clinker concretes through electrical resistivity measurements. *Magazine of Concrete Research* **78(13–14)**: 829–844, 10.1680/jmacr.26.00025.

IPCC (Intergovernmental Panel on Climate Change) (2022) Industry. In *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK.

LCCG (UK Low Carbon Concrete Group) (2026) See https://www.lccg.uk/home (accessed 19/08/2026).

Muhit IB, Al-Fakih A, Suntharalingam T and Michel A (2025) Progress in computational modelling for concrete durability and its integration with artificial intelligence and life-cycle assessment. *Archives of Computational Methods in Engineering* **33(2)**: 2751–2783.

Wu R-J, Ren J-W, Fan Z *et al.* (2026) Experimental investigation of magnesium phosphate cement mortar for the repair of long-term marine-exposed concrete. *Magazine of Concrete Research* **78(13–14)**: 869–880, 10.1680/jmacr.26.00096.

Zhang X, Long K, Liu W, Li L and Long W-J (2020) Carbonation and chloride ions' penetration of alkali-activated materials: a review. *Molecules* **25(21)**: 5074.