Alkali-activated cementitious materials

(Photo: Portland Cement Association.)

Work of the technical steering group for BSI's PAS 8820[1] Construction Materials – Alkali Activated Cementitious Materials (AACMs) – Specification has concluded. The Standard was published on 31 March. ***Andrew Frost*** *of* ***Transport Research Laboratory (TRL)*** *reports.*

Concrete has some outstanding sustainability credentials in use, but some significant issues surrounding its embodied upstream impacts – resource depletion, embodied water and effect on global climate change from the release of emissions, such as carbon dioxide (CO_2). Portland cement, a common binder used in concrete, is the worst culprit. Its raw materials such as limestone and clay are non-renewable resources and the production of one tonne of Portland cement consumes 3–6GJ of energy and releases between 0.68 tonnes[2] and 0.85 tonnes[3] of CO_2. Globally the cement industry contributes approximately 5–7% of global CO_2 emissions[4].

Alkali-activated cementitious materials (AACMs) are defined in PAS 8820 as "a substance consisting of an alkali activator and an AACM powder, or blend of such powders, with or without the inclusion of subsidiary constituents, with or without the incorporation of Portland cement, which under aqueous conditions, reacts to produce a hardened monolithic material".

The concept of AACMs as an alternative to Portland cement has been known since at least 1904 and the durability of AACMs in service has been demonstrated over several decades in Belgium, Finland, the former USSR, China, Australia[5] and the British Isles. The development and use of AACMs has advanced rapidly since the 1990s[5]. These materials are now manufactured on a commercial scale around the world for infrastructure, general construction, paving, nuclear waste immobilisation and various other niche applications.

The use of AACMs represents a sizeable opportunity to: reduce the embodied carbon of concrete; reduce the embodied water content; potentially improve the performance of the concrete; reduce waste to landfill (as the precursors of AACMs are mainly industrial by-products or wastes); reduce resource depletion; and support the circular economy, as we face an increasingly resource-constrained future.

The UK's *Construction 2025: Industrial Strategy*[6] sets a range of targets, including:

- lower emissions – a 50% reduction in greenhouse gas emissions in the built environment
- lower costs – a 33% reduction in the initial construction and whole-life cost of built assets
- faster delivery – a 50% reduction in the overall time, from inception to completion, for new build and refurbished assets
- improvement in exports – a 50% reduction in the trade gap between total exports and total imports for construction products and materials.

Sustainability

The Government has stated that there is no doubt that cutting carbon is fundamentally important to long-term global economic, social and environmental sustainability, as outlined in the *Infrastructure Carbon Review*[7]. This report makes clear that reducing carbon not only reduces costs but also saves materials, reduces energy demand and delivers operational efficiencies.

Major projects in the UK, such as High Speed 2 (HS2) (which has a commitment to minimise its carbon footprint as far as practicable[8]) are actively looking for ways to meet the targets set out in *Construction 2025*, particularly in the sector of publicly funded infrastructure development. AACMs can assist in reaching all of the targets in this strategy by:

- reducing the quantity of CO_2 released during the manufacture of cement and concrete
- avoiding increasing costs associated with energy sources and the capture and storage of CO_2 from Portland cement production processes and potentially reducing other production costs

- providing an alternative range of materials for precasting products, as this production mode can enable faster delivery
- helping UK product developers bring their products to market and develop exports.

These new AACM products do not generally fit into the prescriptive standard framework for traditional concretes and common cements covered by BS EN 197-1[9], BS EN 206[10], BS 8500-1[11] and BS 8500-2[11]. While many of the tests and considerations relevant to traditional concretes and common cements may be broadly applied to AACMs, some of the test details do not and this may impede the use of AACMs when the existing Standards are specified for a project, acting as a barrier to innovation. PAS 8820 aims to facilitate the use of AACMs within construction by providing alternative specification approaches, in a move towards performance-based specification.

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Performance requirements

PAS 8820 specifies the performance requirements for AACMs comprising aluminosilicate main constituents and an alkali activator. An AACM (including the activator) may contain Portland cement only at a content of less than 5% mass of binder solids and may contain subsidiary constituents not exceeding 25% of the mass of the cementitious material. PAS 8820 specifies a means of assessing concrete obtained through the use of such cementitious material for performance and durability, and sets requirements for the alkali-activating component and the aluminosilicate powder component of these concretes.

PAS 8820 does not set detailed requirements for the composition of the AACM, neither does it specifically address applications for materials such as renders, screeds, mortars or repair materials (although it does not exclude the possibility that such materials could be used for such purposes), nor cover the use of any material classified as hazardous waste.

A fully restrained, 32m AACM wall, poured in one day. *(Photo: David Ball Group Ltd.)*

The preparation of PAS 8820 has benefited and aligned well with the work of the RILEM Technical Committee 224-AAM. The primary aim of this committee is to develop performance-based specifications and recommendations for the development of Standards that are specifically applicable to AACMs between 2007 and the present, with the production of the *Alkali Activated Materials State of the Art Report*[5] and developing and evaluating testing procedures for AACMs.

The commercial future of alkali-activated materials depends not only on technical readiness but also on the economic and social readiness. Standardisation is an important component of this commercialisation. Fundamental research should now be targeted at the improvement of the application and performance properties of AACMs, including the development of chemical admixtures and analysis of durability, in line with PAS 8820. ■

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