Policies to enable Blended Cements and SCMs to reduce Clinker Content

A document to fulfil Cement and Concrete Breakthrough Priority Action C.3 with respect to reducing clinker cement ratio

Introduction to Cement and Concrete Breakthrough
Cement and Concrete Breakthrough is co-led by Canada and United Arab Emirates and has the following country members (as in December, 2025):

- Australia
- Austria
- Congo
- Egypt
- Ethiopia
- Germany
- Ireland
- Kenya
- Kingdom of Saudi Arabia
- Switzerland
- Türkiye
- UAE
- United Kingdom

The inaugural 2024-25 Priority Actions were launched in June 2024 and include deliverables and interim priority actions for COP30.

These priority actions focus on:
C1. Creating common definitions and standards for low carbon cement and concrete
C2. Supporting demand creation for low carbon cement and concrete
C3. Fostering greater innovation, education and collaboration around the decarbonization of the industry; and
C4. Strengthening the finance and investment landscape for decarbonization of the industry.

("C" differentiates cement and concrete actions from those in other sector breakthroughs.)

Cement and Concrete Breakthrough Priority Action C3
Priority Action C3: Support more robust knowledge-sharing and enhanced international assistance for deep decarbonisation of the cement and concrete sector (including for enabling technologies and infrastructure) by COP30, with a goal of accelerating the delivery of a growing number of globally significant priority demonstration projects for near-zero emission cement technologies.

Document Purposes

1. Provide necessary context on SCMs and blended cements for the following sections:
    a. What clients, designers and contractors can do (Section 6.0)
    b. What production industry can do (section 7.0)
    c. What governments can do to support through policy (section 8.0)

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1.0 Introduction

Concrete is the most used man-made material because of its inherent properties including durability, strength, wide availability, and relative ease of use. It is commonplace in many countries to use SCMs, often by-products from other industries (such as fly ash from coal fired power stations and ground granulated blast furnace slag (ggbs) from iron production), and natural materials, (such as pozzolans, ground limestone) and calcined clay as a portion of the blended cement that reduces the clinker to cement ratio, or as a portion of the cementitious materials in concrete to reduce its clinker-to-binder ratio. SCM percentage of the cementitious materials are dependent on available materials, their reactivity, local standards or project specifications, and the concrete performance required for different applications. In many countries typical percentage of SCMs in cementitious systems vary between 30% to 50% and for some applications can exceed 70%.

SCMs allow the production of a range of cements and concretes with reduced CO_2 footprint. For some applications, the properties of the concrete can be enhanced by SCMs, in appropriate amounts, in particular durability and hence service life, further contributing to the reduction of whole life carbon in construction.

SCMs can be incorporated in blended cement manufactured at the cement plant or added to mixtures at the concrete plant. The components that make up the cement and concrete have an impact on their properties, so standards and specifications state the type and proportion of SCMs that can be used to enhance performance or protect against any detrimental impacts. Standards are typically a combination of performance (for example strength) and prescriptive which stipulates, for example, the % of SCMs and/or cement content in concrete. Standards are developed and revised over time and reflect actual performance and commonly agreed experience. GCCA members are actively engaged in development of further performance-based content in standards.

2.0Availability of SCMs

There are a wide range of Supplementary Cementitious Materials and their availability varies geographically and over time.

Fly ash and ggbs, are from coal fired power stations and iron blast furnaces respectively. In many locations, currently, the available supply of fly ash and ggbs exceeds the demand from cement and concrete producers. Both the energy and steel industries are globally undergoing changes leading to fly ash and ggbs becoming less available in many places in coming years, but in some major economies the absolute scale of fly ash and ggbs production is not decreasing (and in some regions is increasing) even in the medium term. For example, in India the research institute TERI[1] forecast that fly ash production of 281 and 256 million tonnes in 2030 and 2050 respectively. This is compared with 271 million tonnes production in 2020.

[1] Communication from The Energy and Resources Institute (TERI) in preparation for forthcoming India Roadmap for cement and concrete industry

With regards ggbs, TERI forecasts this to increase from a 2020 value of 34 million tonnes to 67 and 116 million tonnes in 2030 and 2050 respectively. These values compare with a current use in India of fly ash and ggbs together of 93 Mt (Industry Data Analysis, TERI). Phasing out of coal fired power stations and blast furnaces will be quicker, even far quicker, in some developed economies, and these are often countries where available materials are being well utilised. It is of note that in these countries harvesting of stored/landfilled fly ash is increasing, to provide supplies that might no longer be available due to coal-fired power plants closing. In some cases, beneficiation or other technology is being implemented to make previously unsuitable materials suitable for construction applications. With respect to slags, future low carbon metal processes may produce new slags that are suitable for use as appropriate SCMs.

Limestone is increasingly used as an SCM in blended cement or added at the concrete plant. As an example, in the USA it can be used as an ingredient in a blended cement at a maximum percentage of 15% and uptake has increased rapidly in recent years. In contrast, it has been used extensively for decades in Europe and Latin America. Furthermore, limestone cements are used at higher limestone levels for certain applications, and cutting-edge concrete technology is enabling the use of ever higher limestone percentages. Limestone is both widely available and at scale. In addition, given that it is the main input into cement kilns, it is also available as an SCM in convenient locations.

Natural pozzolans are not as widely available as limestone, but where they are available it is often at a scale that means they can play a significant contribution to decarbonising cement and concrete. For example, natural pozzolans are the most consumed SCM in Guatemala, Chile, Ecuador, the Dominican Republic and Peru, with above 20% in the first two cases.

Calcined clay is an SCM that is based on clays with specific chemistry. These are available at scale and whilst not everywhere they are widely distributed, particularly in tropical regions. Whereas calcination of limestone to make Portland cement clinker produces CO_2, the calcination of clay does not produce CO_2 unless the raw clay contains calcium carbonate. The calcination process of clay is at a lower temperature than that used for production of Portland cement clinker, therefore the CO_2 emissions from generating the heat in the kiln are less than for clinker. Therefore, whilst calcined clay has a higher CO_2 footprint than other SCMs, it can be used to make a cement/binder with lower CO_2 footprint than a Portland cement (which has no SCM). Recent developments have optimised combinations of calcined clays and ground limestone as SCMs, allowing a clinker reduction of up to 50% and maintaining a similar performance to existing cements.[2]

3.0 Specific Sustainability Benefits

The three major sustainability benefits of use of SCMs are decarbonisation, circularity and enhanced durability performance which leads to reduced whole life construction carbon.

Decarbonisation. SCMs can significantly lower the carbon footprint of cement and concrete. Environmental Product Declarations for cement and concrete products can be

[2] ECRA, The ECRA Technology Papers 2022

sourced to check the precise reductions in Global Warming Potential (GWP) achieved through use of SCMs in different locations.

To provide an indication of carbon footprint reductions compared with a concrete with no SCM:

- 30% fly ash concrete and 50% ggbs concrete have 27% and 42% lower carbon footprint [3]
- Portland-limestone cement (PLC) in the USA can contain 5% to 15% limestone and typically achieves a reduction of up to 10% on carbon footprint[4]
- Limestone calcined clay cement (LC3) has a clinker binder ratio of 50% and results in a 40% lower carbon footprint[5]

Circularity. Use of SCMs contributes to circularity. A key circular economy principle is use of unwanted materials from one sector to replace raw materials in another sector. SCMs such as fly ash and ggbs are unwanted materials from the electricity generation and steel sectors respectively and use of these materials by the cement sector reduces use of clinker and hence virgin raw materials. Similarly waste from the ceramic industry, rejected clay, can be suitable for calcined clay.

Durability. SCMs often result in enhanced durability of the final hardened concrete because of improved performance in addressing challenges such as sulfate exposure, chloride ingress and alkali silica reaction. These can be used by designers to deliver long lasting infrastructure with reduce maintenance requirements. This in turn delivers economic, environmental and social sustainability because of lower whole life costs, less frequent material replacement and reduced closures respectively.

4.0 Quality of SCMs, and products incorporating them

Quality control (QC) and quality assurance (QA) practices have been established to ensure confidence in the characteristics and performance of SCMs themselves, blended cements that incorporate SCMs and concretes with SCMs mixed at the concrete plant. Underpinning these are robust standards that set out the requisite properties and test methods for SCMs, cements and concretes. For example, for SCMs, much of the world either uses ASTM or European based-standards.

5.0 Standards and specifications for use of SCMs

There are well established standards, in some locations, for the use of most SCMs either in blended cements or as combinations with cements in the concrete plant. These include standards such as ASTM and EN that are used widely across many countries. However, there are still locations where SCM use is not optimised because of restrictive requirements in standards. These should be addressed through adoption of good practice from other standards. It is to be noted that, inclusion of more performance-based approaches that permit more flexibility compared with prescriptive standards can result in lower clinker binder ratio concretes. ASTM Committee C01, at the time of writing (June 2025), is close to publishing a new standard for performance evaluation for SCMs.

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[3] MPA-The Concrete Centre, Specifying Sustainable Concrete, 2020
[4] PCA, 2024 Portland-Limestone Cement U.S. Fact Sheet,2024
[5] ACEEE, Adoption of Limestone Calcined Clay Cement and Concrete in the U.S. Market, 2024

A performance-based approach to allow for well-tried and proven constituents to be used outside the ranges defined by existing standards, which are often partially prescriptive in nature, can be achieved by technical justification of necessary concrete properties within existing available test methods. A GCCA paper[6] outlines which properties should be tested to guarantee the performance depending on exposure conditions and application. It also provides examples of the appropriate test methods to be used.

Performance-based approaches should also be developed to allow the qualification of new, alternative cementitious materials. These will need to extend beyond usual performance testing to also encompass other aspects such as environmental impact leaching, H&S and durability. For new constituents, particularly those whose chemistry and mineralogy are different from the systems used today, test methods will have to be adjusted to reflect their short-, medium- and long-term performance.

In the medium term, complete freedom by "pure" performance approaches based on a limited set of verification parameters bears too many risks of misuse, misinterpretation and failures, which could jeopardise concrete as a safe and durable construction material.

Design and construction codes refer to material standards and may, in isolated cases, state material requirements. A barrier in some jurisdictions can be a lack of joined up approach across the material standards for cement, concrete and the design and construction standards. This can sometimes be simply overcome by ensuring design and construction codes and standards refer to the most recent material standards.

Client requirements, typically referred to as project specifications, for concrete, both on publicly funded contracts and those used by private designers, should refer to the latest available standards and avoid, for example, requirements to only use Portland Cement (i.e. no SCMs) unless there is a strong technical justification. Where available in standards, performance-based approaches should be permitted in project specifications. The synergy between performance-based requirements and reduction of carbon footprint should be recognized by designers and owners. (For major government clients, their client requirements are sometimes referred to as "building codes" because they are applied across all government department projects at such a scale, it is akin to a code.)

Geographical variation in standards remains, despite globalisation and wide use of ASTM and EN documents. As a consequence, there is scope for transfer of good practice whilst still recognising good geographic reason for differences, such as climate. For example, Brazil has relevant /necessary test methods for performance for pozzolans to be used in cements and this good practice could be applied elsewhere.

Calcined clays are worthy of note because currently they are not widely used but will play an important role in decarbonising the cement sector, and standards and specifications need to be in place to enable their use. The European, US, and Brazilian standards have permitted calcined clays in cements for decades, but only recently, for example, have the standards in the second biggest market of all, India, been updated. It is important that concrete and cement standards are aligned where circumstances allow,

[6] GCCA; GCCA pathway to more flexibility in standards: Performance Based Standards; 2024

and this is not always the case. For example, whilst the EN concrete standards permit cements with calcined clay, local application rules can restrict their use in response to lack of local experience.

6.0 Role of Construction Clients, Contractors and Designers

Construction clients and their contractors/builders and design teams specify the construction works and materials. There are numerous examples where these specifications restrict or hinder the use of SCMs in applications where there is no reason why this should be the case. It happens because of custom, habit or lack of awareness of SCMs.

The public sector is typically the largest construction client, but with multiple tiers and agencies, acceptance of SCMs at the highest level may take years to deliver change on actual projects. In the USA, only recently in the last decade numerous State Departments of Transport have changed their requirements and now allow blended cements. This was despite neighbouring states permitting and successfully using blended cements in the same highway structures that passed through both states. Similar examples are true today across many countries both in public and private procurement.

To maximise the use of SCMs requires client, designer and contractor support in specification requirements.

7.0 Role of Cement and Concrete Production Industry

The role of the production industry is as follows:

1. RESEARCH: Research to increase the use of SCMs in cement and concrete products including evidence to amend standards and increase performance-based approaches.
2. STANDARDS ACTION: actively engage and work with stakeholders in the value chain and especially standardisation bodies to achieve more flexibility in cement /concrete compositions whilst maintaining the essential characteristics of concrete, durability and safety.
3. SUPPLY: Continue and widen supply of cements and concretes that use SCMs.
4. EDUCATION: Engage and provide supporting information, including through academic channels, to build stakeholder awareness and knowhow on blended cements and SCMs.
5. ADVOCACY: Advocating for government agencies to introduce low carbon / green procurement schemes that incentivise all decarbonization levers, including the use of blended cements and SCMs which is a proven lever in this regard.

8.0 Role of Governments and Policy Makers

Use of blended cements and SCMs can be increased in the immediate term with governments and policy makers acting as follows:

1. Ensure necessary support for timely review, approval and publication of standards to ensure latest standards are available.

2. Ensure cement, concrete, design and construction codes and standards, and building regulations where applicable, are aligned and congruent. For example, construction codes must refer and default to latest available material standards.
3. Ensure Government and its agencies take the lead in public projects by specifying low carbon cements and concrete, through use of blended cements and SCMs, while taking into account the whole life carbon and performance of projects. We recommend major government agencies responsible for construction, are asked to review specifications to ensure they permit use of blended cements, SCMs and latest material standards.

Use of blended cements and SCMs can be increased even further with governments and policy makers acting as follows:

4. Promote formal construction and more industrialized uses of cement, understanding that this offers a better scenario to leverage a more efficient, safer, and optimized use of cement and SCMs in concrete production.
5. Provide policy measures that encourage, incentivise and train clients and specifiers to use low carbon cement and concrete, in construction projects, based on a whole life carbon and performance assessment. The use of blended cements and SCMs is a proven decarbonization lever in this regard and policy measures should seek to enable their maximum use.
6. Enable access and avoid barriers to sourcing SCMs both from overseas and domestically. Whilst taking into account the transport carbon impacts, no blanket prevention of importation should be introduced. Domestically, regulations should enable access to materials that are valuable for input into the cement/concrete value chain. Circularity benefits should be considered in this regard.
7. Establish government funding programmes to support development of material standards that will widen and accelerate the use of SCMS and blended cement.
8. Establish government funding programmes for product development and innovation for new SCMs.
9. Establish government funding programmes for development and application of test methods to enable more performance-based approaches.