Department of Climate Change, Energy, the Environment and Water

Low Carbon Concrete - Frequently Asked Questions

Fact sheet

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Acknowledgment of Country

We acknowledge that Aboriginal and Torres Strait Islander peoples are the First Peoples and Traditional Custodians of Australia, and the oldest continuing culture in human history.

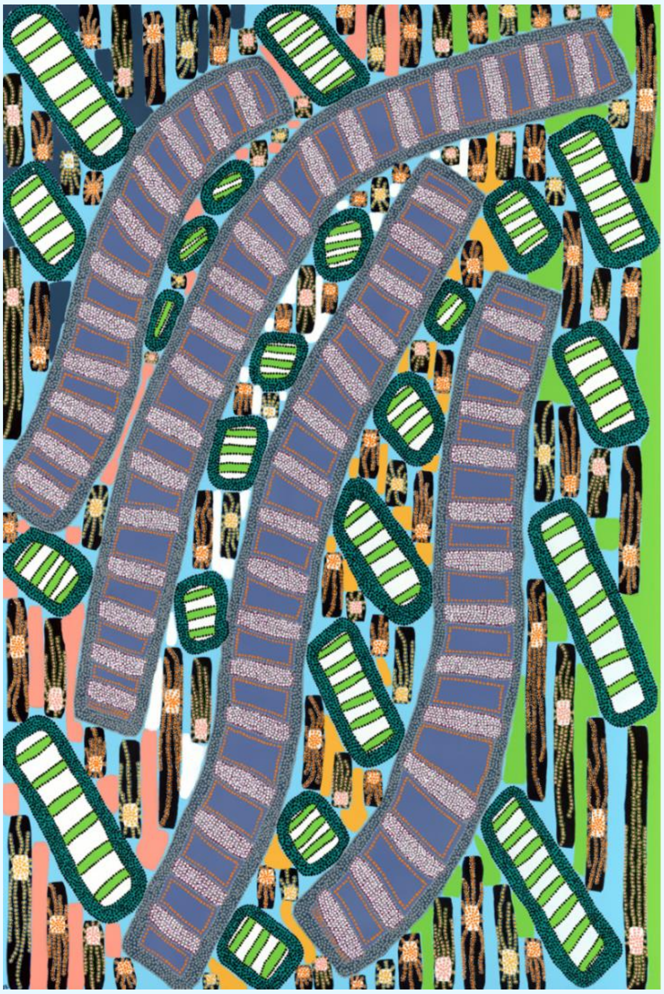
We pay respect to Elders past and present and commit to respecting the lands we walk on, and the communities we walk with.

We celebrate the deep and enduring connection of Aboriginal and Torres Strait Islander peoples to Country and acknowledge their continuing custodianship of the land, seas and sky.

We acknowledge the ongoing stewardship of Aboriginal and Torres Strait Islander peoples, and the important contribution they make to our communities and economies.

We reflect on the continuing impact of government policies and practices, and recognise our responsibility to work together with and for Aboriginal and Torres Strait Islander peoples, families and communities, towards improved economic, social and cultural outcomes.

Artwork:
Regeneration by Josie Rose



FACT SHEET: Frequently Asked Questions

This fact sheet has been developed to provide responses to questions asked during Stage 1 of the NSW Government Low Emissions Specification (LES) Program. It is written for a target audience of stakeholders within NSW government agencies.

1 What is Low Carbon Concrete (LCC)?

A low carbon product is a product with a lower carbon footprint relative to their equivalents in the market. For concrete the term low carbon concrete is often used. Low carbon concrete (LCC) generally refers to concrete produced with a reduction in cementitious content when compared to Ordinary Portland Cement (OPC) concrete. This can be achieved by using supplementary cementitious materials (SCMs) that are used in replacement of percentages of the cement. There are other opportunities for cement and concrete manufacturers to reduce their carbon footprint through the use of more sustainable energy processes and sources or implementing proven technologies that capture carbon.

2 How much reduction in carbon can be expected from LCC?

When considering SCM replacement, a 45% SCM mix can achieve an estimated carbon reduction of 35 to 40% when compared to an OPC concrete mix. Note the actual percent carbon reduction is dependent on the manufacturer and concrete mix and is different for fly ash and blast furnace slag.

Environmental product declarations should be used where available to provide verified data and demonstrate a carbon reduction. See ‘How to calculate concrete embodied carbon’ fact sheet for further information.

3 How readily available is LCC?

There are a variety of ready-mix concrete suppliers (both local and national/international sized suppliers) across metropolitan and regional areas that offer a range of LCC products. Many of these suppliers provide Environmental Product Declarations (EPDs) for their concrete mixes, which can be obtained directly from them or the EPD Australasia website. Available products offer varying levels of performance improvement in factors such as early strength and drying shrinkage compared to traditional LCC concretes and can achieve cement reductions ranging up to 80%.

3 Is geopolymer concrete commercially available?

Yes, geopolymer concrete is currently available from selected suppliers. Australian Standards published SA TS199:2003 “Design of geopolymer and alkali-activated binder concrete structures”, providing guidelines for designers in the use of geopolymer and alkali-activated binder concrete for structural and non-structural applications on projects.

4 Can suppliers achieve the low carbon requirements?

Major concrete suppliers in Australia have been engaged during the consultation process and have confirmed that they can generally provide LCC that meet the requirements to the market. Currently, there are high SCM concrete mixes supplied by these major suppliers used in the industry. However, special concrete mixers may be required when implementing high SCM concrete, which might require modernisation of batch plants and precast facilities including changes in storage, batching techniques, and the type/size of mixers used.

5 Can low carbon concrete be supplied in regional areas?

Suppliers are in the process of transitioning to supply high levels of SCM to regional areas. For many locations high levels of SCM can be provided however at other sites the application of high levels of SCMs may require adjustments to plant and equipment at the batching plant. Suppliers have confirmed that they are committed to expanding the availability of low carbon concrete statewide. Early engagement with suppliers is crucial. Early engagement allows suppliers to schedule and manage their supply chain upgrades and reduces costs for all parties.

6 What are the cost increases associated with high SCM contents?

The inclusion of SCMs in concrete does not impact long-term costs but can lead to an increase in upfront costs. Typically, there is a 0-5% increase in cost for a high SCM mix and a 20% increase for a high SCM mix with the same early-age strength as OPC concrete. Early engagement with the suppliers regarding the desire to adopt LCC is encouraged to achieve the strongest commercial outcomes.

7 Are high SCM mixes suitable for all concrete projects and applications?

Yes, the high SCM mixes are suitable for all concrete types and applications. Concrete mixes with high SCM levels can meet the same performance requirements as OPC concrete and have been used widely across all types of concrete applications including major road and rail applications, prestressed and precast elements as well as columns, beams and slabs in high rise buildings.

8 Are high SCM concrete mixes allowed within standards?

AS 1379, the concrete supply standard, does not specify the replacement levels for SCMs. AS 3600, which relates to structures with a 50-year design life, does not set specific requirements for concrete mix, including cement content or SCM content and does not limit the use of SCMs. AS 5100:2017, for structures with a 100-year design life, specifies SCM levels from a durability perspective, particularly to prevent chloride and sulfate ingress in aggressive environments. Amendments to AS 5100: 2017 to be published in 2024 nominate the use of a minimum of 30% SCM in every exposure class.

9 What is the impact of SCM on design life, particularly beyond 100 years?

AS 5100 already specifies high SCM mixes as a requirement for aggressive environments. Chloride and carbonation modelling can be conducted to understand SCM's impact, with SCM replacement percentages tailored to different design lives and environment conditions. For example, modelling has demonstrated that 30-60% SCM replacement can be used for structures with a 120-year design life with covers nominated in AS 5100.5.

10 Are there any long-term durability issues associated with SCM replaced concrete mixes?

Pozzolanic SCMs like fly ash and silica fume are known for their durability benefits. AS 5100 nominates SCM be used in aggressive environments illustrating the ability of SCM to achieve the improved durability in aggressive exposures. As is consistent with OPC concrete, regular maintenance for high SCM concrete is recommended to be undertaken. The inspection and maintenance approach for high SCM concrete is the same as that of OPC concrete.

11 What is the risk of carbonation with high SCM content?

Carbonation rates of concrete containing SCMs are influenced by the types of materials used and the levels of replacement in the mix. Concrete with very high levels of SCMs may exhibit increased carbonation rates due to the reduced alkaline content of hydration products. However, early-stage curing can help mitigate potentially higher carbonation rates associated with fly ash and GGBS replaced concrete.

Other properties of concrete, such as permeability, porosity, and pore connectivity, also affect the carbonation process. The presence of pozzolans from fly ash and GGBS helps reduce the porosity and permeability of concrete, enhancing its durability performance and resistance to carbonation. This reduction occurs through a chemical reaction with calcium hydroxide and water, forming calcium silicate hydrate, which is the primary cohesive force in concrete.

Durability modelling and accelerated carbonation testing has demonstrated that concrete with high levels of SCM’s are able to achieve service lives in excess of 120 years.

12 Have tests confirmed the achievable concrete strengths with the maximum cementitious materials limit and minimum SCM replacement requirement?

Yes, the leading concrete suppliers in Australia currently provide concrete mixes with high SCM. These mixes have achieved the nominated strengths across various applications using the specified limits and replacement levels, as confirmed by cross-checking with Australian road authority standards.

13 Can the required workability be achieved with high SCM contents?

The inclusion of SCMs in concrete can affect the workability of the mixes. Techniques such as using superplasticizers and adjusting the water-to-binder ratio are effective in achieving the desired workability while ensuring the required strength and durability. The concrete suppliers are able to advise on the most suitable mix for the application.

14 Can high SCM contents achieve the required early-age strength?

SCMs are traditionally known to enhance the long-term strength of concrete through the pozzolanic reaction while potentially reducing early-age strength due to cement dilution. Accelerating admixtures can be utilised in the mix to achieve the required early-age strength of concrete. This may be required when setting time, early strength development and production timelines for stripping and shipping of precast elements are of importance.

For high SCM mixes, conducting concrete trials is recommended to establish the appropriate strength/maturity relationship before using them in elements that require early stripping. Maturity testing is advised for large-sized elements with greater than 50% SCMs to evaluate their early strength development, allowing for optimised stripping times and minimising impacts on the project program.

15 Can high SCM concrete be used on precast and prestressed?

Yes, SCMs are currently being effectively used in concrete mix designs for precast/prestressed construction. In Australian infrastructure projects, the use of SCMs is required due to their ability to enhance the durability of concrete. While SCM replaced mixes have advantages and disadvantages in various scenarios, any drawbacks can often be mitigated through the use of chemical admixtures and carefully optimised mix designs. For any application there is range of low emission concrete options available, and it is important to understand the potential outcomes associated with each application.

16 Do high SCM concretes impact on serviceability?

The use of SCMs positively impacts concrete serviceability by improving its durability, enhancing overall performance and decreasing resource consumption over time. To ensure the desired serviceability and durability requirements are met when using high levels of SCMs in concrete, several key considerations and practices should be followed. These include optimising the mix design to meet both durability and serviceability requirements, controlling the setting time with admixtures, implementing proper curing methods, conducting thorough quality control and testing, considering the impact of environmental conditions and adhering to proper construction practices. Collaboration between designers, engineers, contractors, and material suppliers is important for the successful use of high SCM content in concrete construction.

17 How can durability and structural performance requirements be ensured despite variability in material quality?

All SCMs undergo detailed quality control testing that follow to Australian Standards during different stages of supply, to ensure the quality of the as supplied product.

18 What are the temperature restrictions for placing concrete with high SCM contents?

There are no specific temperature restrictions for placing concrete that has high SCMs content. The placement temperature should be the same as is for OPC concrete (typically be between 5°C to 35°C).

However, fly ash and GGBS are beneficial in reducing temperature rise in concrete, with the extent of reduction influenced by the replacement level adopted. For larger components, higher SCM replacement levels can further reduce peak and differential temperatures. This makes them useful in mass concrete applications or in hot-weather concreting, where it's desirable to slow the setting time and limit heat generation.

19 What is the consistent availability or market capacity of SCMs?

Currently, SCMs such as fly ash, GGBS, and silica fume are widely available in many regions, particularly in areas with active construction industries. Fluctuations in supply and demand, as well as logistical challenges, can impact their availability at times. There are also concerns about future availability due to changes in the industries that produce these materials. For example, the closure of coal-fired power plants by 2048 will impact the supply of fly ash after 2030. Additionally, GGBS production is currently only around 10% of the cement produced, and the steel industry's blast furnaces are transitioning, which will affect GGBS availability.

To address potential supply shortages and cost volatility, as well as to reduce carbon emissions, there is a growing interest in exploring a wider range of by-product and waste materials as potential future SCM sources such as lithium slag, calcined clay, dam ash etc. While promising results have been achieved with many of these materials, further research and development efforts are needed to fully understand their impact on cement and concrete properties and use in the industry.

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