Low Carbon Concrete: Frequently Asked Questions

This fact sheet answer commonly asked questions about Low Carbon Concrete.

Common acronyms

EPD	Environmental Product Declaration
GGBFS	Ground Granulated Blast Furnace Slag
LCC	Low Carbon Concrete
OPC	Ordinary Portland Cement
SCM	Supplementary Cementitious Material

1. What is Low Carbon Concrete (LCC)?

A low carbon product is a product with a lower carbon footprint than equivalent products in the market. For concrete, the term low carbon concrete is often used. Low carbon concrete (**LCC**) generally refers to concrete produced with less cementitious content than Ordinary Portland Cement (**OPC**) concrete. This can be achieved by replacing a percentage of the cement with supplementary cementitious materials (SCMs). There are other ways for cement and concrete manufacturers to reduce their carbon footprint by using more sustainable energy processes and sources.

2. How much can LCC reduce carbon emissions?

A 45% SCM mix can reduce carbon emissions by an estimated 35-40% compared to an OPC concrete mix. The exact reduction depends on the manufacturer and concrete mix, and is different for fly ash and blast furnace slag.

Use Environmental Product Declarations (EPDs) where available to provide verified data and show a carbon reduction. See the ‘How to calculate concrete embodied carbon’ factsheet for more information.

3. How readily available is LCC?

There are a variety of ready-mix concrete suppliers across metropolitan and regional areas that offer LCC products. Many suppliers provide EPDs for their concrete mixes, which are available from the suppliers or the EPD Australasia website. Different products offer different levels of performance, such as early strength and drying shrinkage compared to traditional LCC concretes, and can achieve cement reductions of up to 80%.

4. 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.

5. Can suppliers achieve low carbon requirements?

Major concrete suppliers in Australia have been consulted and confirmed that they can generally provide LCC that meets market requirements. Suppliers currently provide high SCM concrete mixes used in industry. However, using high SCM concrete may require special mixers and modernising batch plants and precast facilities, including changes in storage, batching techniques, and the type/size of mixers used.

6. Can LCC 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 using high levels of SCMs may require changes to plant and equipment at the batching plant. Suppliers have confirmed that they are committed to expanding the availability of low carbon concrete statewide. Engaging with suppliers early is crucial, as it allows suppliers time to schedule and manage their supply chain upgrades and reduces costs for all parties.

7. What are the cost increases associated with high SCM contents?

The inclusion of SCMs in concrete does not impact long-term costs but can increase 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. Engaging suppliers early is encouraged to get the best commercial outcomes.

8. Are high SCM mixes suitable for all concrete uses?

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, including major road and rail uses, prestressed and precast elements, as well as columns, beams and slabs in high rise buildings.

9. 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 nominate the use of a minimum of 30% SCM in every exposure class.

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

AS 5100 specifies, high SCM mixes as a requirement for aggressive environments. You can undertake chloride and carbonation modelling to understand SCM's impact, with SCM replacement percentages tailored to different design lives and environmental 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.

11. 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. AS 5100 nominates SCM use in aggressive environments, illustrating SCM's ability to achieve better durability in aggressive environments. Just like with OPC concrete, regular maintenance is recommended for high SCM concrete. The inspection and maintenance approach for high SCM concrete is the same as for OPC concrete.

12. What is the risk of carbonation with high SCM content?

The carbonation rate of concrete with SCMs depends on the types of materials used and the replacement levels in the mix. Concrete with very high levels of SCMs may exhibit higher carbonation rates due to the lower 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 carbonation. The presence of pozzolans from fly ash and GGBS helps reduce the porosity and permeability of concrete, enhancing its durability 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 shown that concrete with high levels of SCMs can achieve service lives greater than 120 years.

13. Have tests confirmed that the concrete can achieve the required strength while meeting the cement limit and minimum SCM replacement?

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

14. Can the required workability be achieved with high SCM contents?

Using SCMs in concrete can affect the workability of mixes. Techniques such as using superplasticizers and adjusting the water-to-binder ratio can help achieve the desired workability while ensuring the required strength and durability. Concrete suppliers can advise on the most suitable mix for you.

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

SCMs 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 used 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 important.

, Conducting trials is recommended to establish the appropriate strength/maturity relationship before using high SCM mixes 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.

16. Can high SCM concrete be used on precast and prestressed construction?

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, 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.

17. Do high SCM concretes impact on serviceability?

The use of SCMs improves concrete's 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.

18. Can durability and structural performance requirements be ensured despite variability in material quality?

All SCMs undergo quality control testing that in line with Australian Standards during different stages of supply, to ensure quality.

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

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

However, fly ash and Ground Granulated Blast Furnace Slags (**GGBFS)** help to reduce temperature rise in concrete, with the extent of the reduction influenced by the replacement level used. 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.

20. What is the consistent availability or market capacity of SCMs?

Currently, SCMs such as fly ash, GGBFS, 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. 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, GGBFS production is currently only around 10% of the cement produced, and the steel industry's blast furnaces are transitioning, which will affect GGBFS 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.