Department of Climate Change, Energy, the Environment and Water

Low Carbon Concrete Specifications

Guidance on requirements to implement low carbon concrete

Revised 03 January 2025

NSW GOVERNMENT

Acknowledgment of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the traditional custodians of the land and pays respect to Elders past, present and future.

We recognise Australian Aboriginal and Torres Strait Islander peoples' unique cultural and spiritual relationships to place and their rich contribution to society.

Artist and designer Nikita Ridgeway from Aboriginal design agency – Boss Lady Creative Designs, created the People and Community symbol.

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More information Authored by Arup Australia, based on a collaboration with DCCEEW and the relevant NSW government agencies.

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1. Purpose

This specification provides practical requirements for sustainability initiatives that reduce greenhouse gas emissions associated with concrete. It ensures that all requirements achieve durability, structural performance (including early age strength and shrinkage requirements) and constructability (including pumpability, placement and finishing) while achieving more positive sustainability outcomes for any type of concrete construction across NSW. This specification is designed to be used with other project requirements and Australian standards.

This specification includes pathways for compliance with:

1. a reduction in cement use by replacing it with supplementary cementitious materials; or
2. an assessment of the reduction in carbon emissions when using low carbon concrete options compared to a business-as-usual case.

This specification also:

- sets limits for the allowable amount of cementitious materials in concrete mixes
- sets targets for replacing natural aggregates in concrete mixes with industrial by-products to focus on circularity.

Implementing low carbon concrete (LCC) in a project is a multi-stage process from project inception through to the design and construction phases. Low carbon concrete requirements should be introduced in the early phases of project planning and communicated to the supply chain as soon as possible. This helps to better influence project outcomes and reduce costs.

In Australia, the major concrete suppliers are ready to meet an increased demand for low carbon concrete. However, increasing the use of low carbon concrete requires project managers to engage with suppliers early in their planning phase. Additional time is needed to ensure there is a sufficient supply of LCC.

For regional areas, suppliers should be engaged 6-9 months in advance, and for Sydney metropolitan areas suppliers should be engaged 4-5 months in advance. Early engagement allows suppliers to schedule and manage their supply chain upgrades, and reduces costs for all parties.

The fact sheets that accompany this guide provide supporting information to facilitate the adoption of these requirements.

The guidance that follows is designed to be copied into your project specifications. Wording highlighted in grey provides guidance on how to use this document when you set project requirements. You can remove it when incorporating the below information into a specification.

2. Definitions

The following definitions shall apply:

Concrete: A thoroughly mixed blend of cement, aggregates and water — with or without chemical admixtures or other materials — that conform to the current Australian Standards.

Embodied Carbon (Upfront Embodied Carbon): The greenhouse gasses emitted in material extraction, transportation and manufacturing of a material corresponding to life cycle stages A1 (extraction and upstream production), A2 (transportation), and A3 (manufacturing). Definition is as noted in ISO 21930.

Environmental Product Declaration (EPD): EPDs present quantified environmental information on the life cycle of a product to enable comparisons between products fulfilling the same function. EPDs must conform to ISO 14025, and EN 15804 or ISO 21930, and have at least a “cradle to gate” scope (which covers product life cycle from resource extraction to the factory).

Supplementary Cementitious Materials (SCM): Material complying with AS 3582, usually comprising fly ash and ground granulated blast furnace slag (GGBFS). Silica fume or metakaolin are also classified as SCMs.

3. Low carbon concrete objectives for all projects

All concrete installed as part of [INSERT NAME] project, except shotcrete, must achieve low carbon outcomes by complying with requirements 3.1, 3.2 and 3.3 (a), and shall aspire to comply with requirements 3.3 (b) and 3.4.

3.1 Reduce carbon emissions by adopting a cement replacement or embodied carbon reductions

a) If adopting a cement replacement pathway:

i) Minimum of 50%* SCM replacement by weight (on average) for all concrete used in the project, including temporary concrete and both structural and non-structural concrete. This applies where there are:

(1) Minimum SCM levels for structural cast in-situ concrete of 60%* slag or 35%* fly ash (by weight).

(2) Minimum SCM replacement levels for precast and prestressed concrete of 45%* slag or 30%* fly ash (by weight).

* This percentage can be adjusted on a 'project by project' basis. It can be subject to local supply chain capability, and therefore may need to be reduced for regionally located projects.

b) If adopting an embodied carbon reduction pathway:

i) Minimum 40% embodied carbon reduction (on average) for all concrete used in the project, including temporary concrete and both structural and non-structural concrete. This applies where there are:

(1) Minimum 45%* embodied carbon reduction for structural cast in-situ concrete.

(2) Minimum 35%* embodied carbon reduction for structural precast and prestressed concrete.

* This percentage can be adjusted on a project by project basis. It may be subject to local supply chain capability, and therefore may need to be reduced for regionally located projects.

These reductions are in comparison with a reference concrete produced with Portland cement, without supplementary cementitious replacement, while maintaining the same mix design.

EPDs are a preferred method to reduce embodied carbon. When EPDs are not available, the embodied carbon of concrete mix must be calculated based on greenhouse gas intensity factors of:

- 19.8 kg CO2e/tonne for fly ash
- 192 kg CO2e/tonne for slag
- 967 kg CO2e/tonne for Portland Cement (sourced from the AusLCI).

Portland Cement concrete must be used as the reference mix.

Setting minimum embodied carbon reduction targets is recommended where EPDs are available to quantify the environmental credentials of a concrete product. In projects where slag or fly ash are not available, embodied carbon reduction targets must be used to achieve equivalent carbon reductions. Embodied carbon reduction must also be used to incentivise the use of supplementary cementitious materials such as geopolymers.

3.2 Maximum amount of cementitious material per concrete grade or equivalent maximum embodied carbon per concrete grade

If adopting embodied carbon reduction pathway method, use the below table to calculate the maximum amount of cementitious material per concrete grade or equivalent maximum embodied carbon per concrete. The objective is to restrict excessive amounts of cementitious materials in the concrete mix.

Compressive strength grade (MPa)	Maximum cementitious content [1, 2, 3] (kg/m^3)	Maximum embodied carbon for baseline mix (AusLCI database)[3, 4] ($CO_2eq\ kg/m^3$)
20	280	320
25	310	350
32	360	400
40	440	480
50	550	590
65	550	590
80	610	650
100	660	700

https://www.energy.nsw.gov.au/business-and-industry/programs-grants-and-schemes/low-emissions-specifications

[1] The number of cementitious materials includes cement and supplementary cementitious materials such as fly ash and, or slag.

[2] Admixtures and activators must be considered in order to achieve higher early age strength requirements.

[3] Triple blends are permitted.

[4] The maximum embodied carbon figures are for the baseline concrete. The carbon reduction targets from 3.1(b) are to be applied for compliance against carbon reduction requirements.

3.3 Alternative sustainable materials with the objective to promote circularity and reuse of materials.

(a) Manufactured sand is a by-product generated by the crushing of rock aggregates in quarries. In concrete production, a minimum of 30% of the fine aggregate is to be manufactured sand and measured across all concrete used on the project. The objective is to minimise the extraction of natural sand and reduce the waste of low-value by-products in quarries.

(b) One or a combination of the following alternatives must typically be incorporated for at least 10%* of the total concrete used on the project:

  (i) 20% coarse aggregate (by weight) as recycled concrete aggregate (non-structural and potentially for structural applications), with a focus on circularity.

  (ii) Minimum of 40% coarse aggregate (by weight) as crushed slag aggregate, with the objective to use by-product materials in the concrete mix.

  (iii) Geopolymer concrete for non-structural and lower risk structural applications, with the objective of minimising cement use and promoting the reuse of by-product materials in concrete mixes.

* This percentage can be adjusted on a 'project by project' basis. It may be subject to local supply chain capability, and therefore may need to be reduced for regionally located projects.

You must obtain approval from a Superintendent/Principal or Project Delivery Authority for structural concrete applications that incorporate reused or recycled materials. For concretes with reused and recycled materials, mix performance should be reviewed prior to its

application, to determine its workability, compressive strength development, drying shrinkage, creep, chloride diffusion coefficient, and alkali aggregate reaction.

3.4 Innovation

The contractor can propose additional innovative measures for lowering the embodied carbon of as-supplied concrete. However, these measures must be made in addition to the requirements outlined in this specification.

4. Compliance

At a minimum, you must use the following verification process to demonstrate that requirements of this specification have been incorporated into the design and the as-built product. It is the Superintendent/Principal's responsibility to verify that sufficient evidence has been provided to demonstrate compliance.

The Superintendent/Principal or their representatives should mandate and check the factors below.

4.1 Verification of design documentation

- The requirements regarding SCM replacement and recycled content in concrete mixes must be nominated on drawings or 'general notes' pages in the drawing package. Alternatively, references must be clearly made to the relevant project requirements for low carbon concrete.
- Specifications for consultants must clearly reference the project requirements for low carbon concrete. The specifications must state that these requirements for low carbon concrete take precedence over any conflicting requirements in the consultant specifications.

4.2 Verification of the contractor's construction documentation

- The contractor must keep a register of all concrete supplied for the project. The register must include dates of placement, elements of the concrete that were ordered, concrete volumes, the concrete mix IDs, date of pour, concrete SCM replacement levels, cementitious content, and levels of recycled content which have been adopted on the project.
- The contractor must submit certificates or evidence from the concrete supplier to verify that the proposed mixes satisfy the specified targets and limits on SCM replacement, recycled content, and cementitious materials.
- If using the embodied carbon pathway (3.1b) the contractor must submit calculations demonstrating the specified embodied carbon reductions from the baseline, either using product EPDs or using the specified GHG emissions factors. The contractor must provide this information as part of sustainability performance tracking documentation provided progressively during the delivery of project and when the project is complete.

4.3 Verification of the as-built condition

- The contractor must demonstrate in their QA/QC documentation that the procured and poured concrete are in accordance with the specified targets and limits for SCM replacement, recycled content and cementitious materials. This must be recorded on the date of pour and must be incorporated as part of the contractor's register.

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For more information

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