Department of Climate Change, Energy, the Environment and Water

Low Carbon Concrete Specifications

Guidance on Requirements to Implement Low Carbon Concrete

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Authored by Arup Australia, based on a collaboration with DCCEEW and NSW government agencies

NSW GOVERNMENT

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.

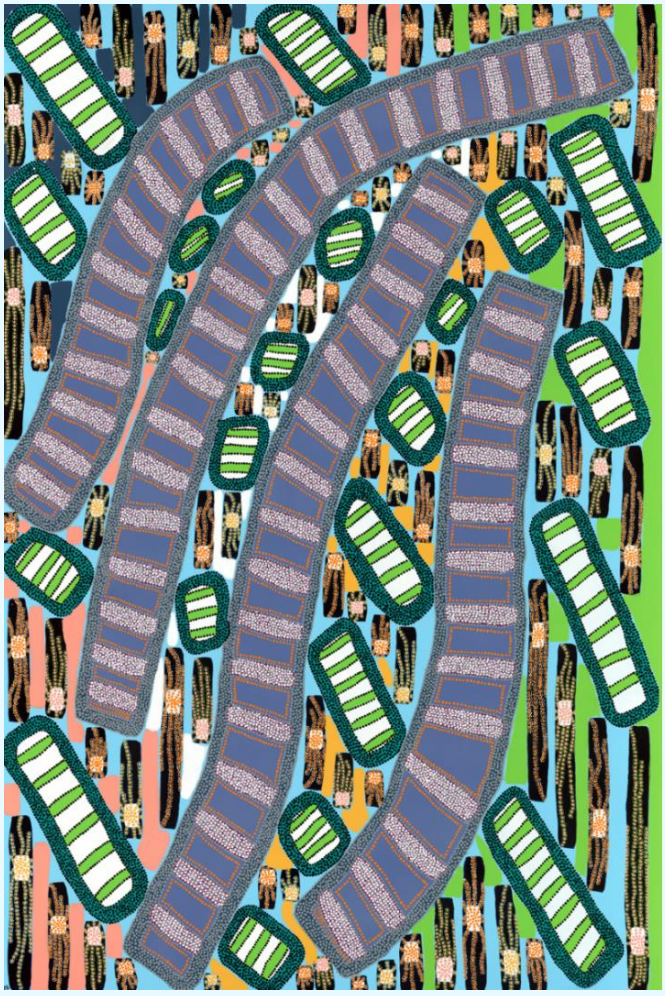
We pay respect to Elders past and present and commit to respecting the lands we walk on, and the communities we walk with.

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



Contents

Low Carbon Concrete Requirements

1. Purpose

The purpose of this specification is to provide practical requirements for sustainability initiatives that reduce greenhouse gas emissions associated with concrete. Consideration has been made to ensure that all requirements nominated in this specification is able to achieve durability, structural performance (including early age strength and shrinkage requirements), constructability (including pumpability, placement and finishing) and sustainability requirements for any type of concrete construction across the state. This specification has been designed to be used with other project requirements and Australian standards.

This specification includes pathways for compliance with either:

1. Reduction in cement use by replacement with supplementary cementitious materials; or
2. Assessment of the reduction in carbon emissions when compared to a business as usual case.

This specification also:

- Set limits for the allowable amount of cementitious materials in concrete mixes; and
- Set targets for alternative aggregate materials to be used as a replacement of natural aggregates, with focus on circularity and use of industrial by-products in concrete mixes.

Implementing low carbon concrete (LCC) in projects involves a multi-stage process from project inception through the design and construction phases. The earlier the low carbon concrete requirements are introduced to the project requirements and communicated to the supply chain, the greater the influence on the project outcomes and the lower the cost.

In Australia the major concrete suppliers are ready to meet an increased demand for low carbon concrete. However, implementing low carbon concrete is a partnership with all parties that requires early engagement with suppliers to enable them to have time to ensure that they can provide required low carbon concrete.

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

Supporting information to support in the adoption of these requirements are provided in accompanying fact sheets.

Wording highlighted in grey indicates guidance on how to use this document when setting requirements on your projects.

2. Definitions

The following definitions shall apply:

Concrete: A thoroughly mixed combination of cement, aggregates and water, with or without the addition of chemical admixtures or other materials, all of which separately and when combined 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 Reduction in the carbon emissions associated with concrete by adopting one of the following pathways: a) cement replacement or b) embodied carbon reductions, with the objective to reduce carbon emissions associated with concrete.

a. If adopting cement replacement pathway:
   - Minimum of 50%* SCM replacement by weight (on average) for all concrete being used on the project (including temporary concrete and both structural and non-structural concrete), where:
     - Minimum SCM levels for structural cast in-situ concrete of 60% slag or 35% fly ash (by weight).
     - Minimum SCM replacement levels for precast and prestressed concrete of 45% slag or 30% fly ash (by weight).

b. If adopting embodied carbon reduction pathway: Minimum 40% embodied carbon reduction (on average) for all concrete being used on the project (temporary concrete and both structural and non-structural concrete), where:
   - Minimum 45% embodied carbon reduction for structural cast in-situ concrete.
   - Minimum 35% embodied carbon reduction for structural precast and prestressed concrete.

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

   EPDs are preferred to demonstrate embodied carbon reduction. 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 and 967 kg CO2e/tonne for Portland Cement (sourced from the AusLCI). Portland Cement concrete must be used as the reference mix.

   This route is recommended where EPDs are available to quantify the environmental credentials of a concrete product, or 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 materials such as geopolymers.

3.2 Maximum amount of cementitious materials per concrete grade OR equivalent maximum embodied carbon per concrete grade (if adopting embodied carbon reduction pathway) as per table below, with the objective to restrict excessive amount of cementitious materials to be added to the concrete mix

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

[1] The amount of cementitious materials includes cement and supplementary cementitious materials.
[2] Admixtures and activators are to be considered for achieving 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 produced during crushing of rock aggregates in quarries. A minimum of 30% of the fine aggregate is to be manufactured sand (measured across all concrete used on the project), with the objective to minimise the extraction of natural sand and reduce the waste of low-value by-products in quarries, AND:

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

   - 20% Coarse aggregate (by weight) as recycled concrete aggregate (non-structural and potentially for structural applications), with focus on circularity.
   - Minimum of 40% coarse aggregate (by weight) as crushed slag aggregate, with the objective to use by-product materials in the concrete mix.

- Recycled plastic in concrete at levels up to 10% (by volume), with the objective to minimise waste sent to landfill.
- Geopolymer concrete (potentially for non-structural and lower risk structural applications), with the objective of minimising cement use and reuse by-product materials in concrete mixes.

* This percentage can be adjusted on a 'project by project' basis and may need to be reduced for remote and regional projects.

For structural concrete applications approval from Superintendent or Project Delivery Authority must be required for mixes that incorporate reused or recycled materials. For these concretes with reused and recycled materials, it is recommended that the mix performance, such as workability, compressive strength development, drying shrinkage, creep, chloride diffusion coefficient, alkali aggregate reaction test reports, be reviewed prior to its application.

3.4 Innovation

The contractor is able to propose additional innovative measures for lowering the carbon cost of as-supplied concrete however these measures must be in addition to the requirements of this specification.

4. Compliance

At minimum, the following verification process must be used 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 must have been provided to demonstrate compliance.

The Superintendent/Principal or their representatives should mandate and check that:

1. For 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 (or references clearly made to the relevant project requirements for low carbon concrete).
    - Consultant specifications must clearly reference the project requirements for low carbon concrete and state that these requirements for low carbon concrete take precedence over any conflicting requirements in the consultant specifications.
2. For verification of the contractor's construction documentation:
    - The contractor must keep a register of all concrete supplied on the project, together with dates of placement, elements of the concrete that were ordered, concrete volumes, the concrete mix ID's, 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 verifying that the proposed mixes satisfy the specified the 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 project and at the end of the project.
3. For 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 in item 2.

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Title: Low Carbon Concrete Specifications

Sub-title: Information, Guidance and Delivery Pathways for [the relevant NSW government agency]

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