Life Cycle Assessment
& Environmental Product Declaration

Adbri Concrete Products EPD— South Australia

Programme: The International EPD ® System, www.environdec.com
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In accordance with ISO 14025:2016, EN15804+A2:2019

AUSTRALASIA EPD® ENVIRONMENTAL PRODUCT DECLARATION

ECO PLATFORM EPD VERIFIED

ADBRI Building Australia since 1882

ADBRI Concrete

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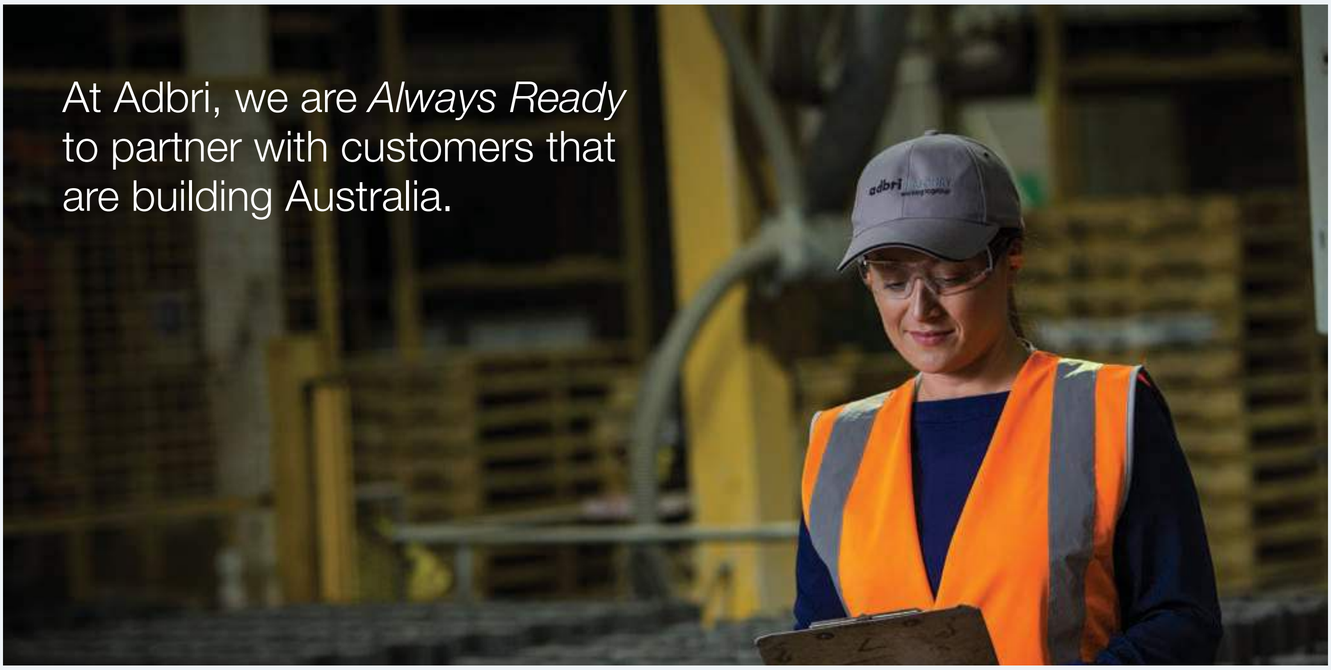
Adbri is *Building a Better Australia* with its locally manufactured cement, lime, concrete, aggregates, industrial minerals and concrete products.

About Adbri

We believe in doing business responsibly; keeping our people and communities safe; meeting the needs of our customers; and creating long-term value for our shareholders.

We contribute to a sustainable future. Since our origins in 1882, we have focused on building long-term partnerships that add value. We are a proud Australian company with an extensive local manufacturing presence which allows us to be agile in meeting customer needs.



A proud Australian manufacturer and supplier

As one of Australia's most experienced construction materials companies, we have helped build the foundations of our communities.

Today our 1500+ strong team located across 200 locations, continue to work closely with our customers, partners and communities to develop solutions that enhance the quality of lives of Australians.

Technical expertise you can rely on.

We are committed to supplying innovative and quality products, supported by our leading technical advice. Our in-house technical experts are highly experienced in developing and managing quality control and assurance systems for our industry.

Adbri operates a centralised laboratory complex in Birkenhead (South Australia) that provides leading capability in the Australian heavy construction materials industry.

We were the first Australasian laboratory to commission a robotic quality control cement testing facility which improves testing accuracy and efficiencies.

Our customers are also supported by a national team of in-field technical specialists who work closely with our laboratory-based experts. All our laboratories have achieved ISO 9001 endorsement for Quality Management Systems and our centralised Birkenhead laboratory is also NATA accredited to ISO/IEC 17025 for a range of cementitious, lime, concrete and aggregate test methods.

Sustainability at Adbri

Contributing to a safe, healthy and sustainable future for Australians, our communities and the environment is a fundamental part of Adbri's culture.

Our sustainability approach is built on strong relationships with our people, customers, suppliers, partners, shareholders and the communities in which we operate, coupled with continuous improvement across our value chains.

Cement, lime, concrete, aggregates, and masonry are essential materials to the global economy. Our products will play a critical role in the transition to a lower carbon environment, supplying key industries including construction, infrastructure, energy, mining, and agriculture.

Our goal at Adbri is to be net zero emissions by 2050.

We operate two emissions-intensive and hard-to-abate processes – the integrated manufacture of clinker and lime production. Our key decarbonisation challenge is associated with unavoidable process emissions that are chemically liberated from the high-temperature processing of limestone, which accounts for approximately 60% of Adbri's Scope 1 and Scope 2 greenhouse gas emissions.

In 2022 we released our Net Zero Emissions Roadmap which sets out the steps we will take to achieve our goal of net zero emissions by 2050, based on the three key actions of reducing emissions, creating new lower carbon products, and collaborating with key partners.

Refuse Derived Fuel

At our Adelaide Brighton cement plant where we manufacture clinker, Adbri pioneered in the use of refuse derived fuel (RDF) in Australia in 2003. Since then, we've used over 1.3 million tonnes of RDF which has significantly reduced the Group's GHG emissions and reduced our GWP in states where the use of ABC cement is used.

RDF is produced by a third party who processes industrial waste products to produce an alternative fuel source. As well as reducing demand for fossil fuels, it diverts waste from landfill.

Our Environmental Product Declarations

Adbri is committed to a sustainable future and this includes providing transparency about our products' environmental credentials via an Environmental Product Declaration (EPD).

Underpinning our EPDs is a Life Cycle Assessment (LCA) which identifies the environmental footprint throughout the life cycle of a product and is compliant with the ISO standards 14040 and 14044.

Having an EPD allows Adbri to understand the roles and contributions of different materials to the total environmental impacts, thus, meeting market demand for science-based, transparent, and verified environmental product information. Adbri has engaged Edge Environment for the production of this EPD.

This report presents the methodology, data, results, and interpretation of the LCA. The LCA has been through several iterations of internal review to refine the life cycle data and assumptions.

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General guidance

EPDs are independently verified documents that include information about the environmental impact of products throughout their life cycle.

EPDs require the completion of a Life Cycle Inventory (LCI), LCA and verification to best practice international and Australian standards.

— LCI is the collection of data on the inputs, processes and outputs within a defined system boundary.

— LCA is the modelling of LCI in accordance with ISO 14040, 14044 and 14025 standards.

— EN 15804+A2:2019: Sustainability of construction works – Environmental Product Declarations – core rules for the product category of construction products.

— General Programme Instructions (GPI) for the International EPD System V3.01 – containing instructions regarding methodology and the content that must be included in EPDs registered under the International EPD System.

— Third party verification of the output of the LCA in the format of an EPD.

— Product Category Rules (PCR) 2019:14, v1.11 – construction products.

EPDs are not always comparable

When comparing EPDs it is important to recognise:

— EPDs within the same product category from different programmes may not be comparable.

— EPDs of construction products may not be comparable if they do not comply with ISO 14025:2006 or if they are produced using different PCRs.

— Understanding the detail is important in comparisons. Expert analysis is required to ensure data is truly comparable to avoid unintended distortions.

Benefits of using this EPD

Results derived from this EPD can be used as a component for customers, for the purpose of compiling their own LCA calculation and modelling for EPDs. The 37 environmental impact indicators align with EN15804 +A2 and are used to support lower carbon concrete initiatives, and to establish the global warming potential of materials used for material selection or decision making.

General information

Programme Information

Programme Operator	EPD Australasia
Address	EPD Australasia Limited 315a Hardy Street Nelson 7010 New Zealand
Website	www.epd-australasia.com
E-mail	info@epd-australasia.com
CEN standard	EN 15804 +A2:2019 serves as the core PCR
Product category rules (PCR) 2019	Product Category Rules (PCR) 2019:14 Construction products, Version 1.11, 2021-02-05 Complementary Product Category Rules (C-PCR) to PCR 2019:14 Concrete and concrete elements (EN 16757), Version 2019-12-20 Product Group Classification: UN CPC 375
PCR review was conducted by	*The Technical Committee of the International EPD ® System. Chair: Claudia A. Peña. Contact via info@environdec.com*
Independent third-party verification	Independent third-party verification of the declaration and data, according to ISO 14025:2006: ☐ EPD process certification ☒ EPD verification
Third-party verifier	*Epsten Group* *101 Marietta St. NW, Suite 2600, Atlanta, Georgia 30303, USA* *www.epstengroup.com* Accredited by: A2LA, Certificate #3142.03
Procedure for follow-up	Procedure for follow-up of data during EPD validity involves third party verifier: ☐ Yes ☒ No

The EPD owner has the sole ownership, liability, and responsibility for the EPD.

EPDs within the same product category but from different programmes may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804. For further information about comparability, see EN 15804 and ISO 14025.


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Company Information

Owner of the EPD	Adbri Limited Level 1 157 Grenfell Street Adelaide SA 5001 +61 8 8223 8000
Description of the organisation	Adbri is a leading Australian construction and building materials company that manufactures and distributes cement, lime, concrete, aggregates, masonry products and industrial minerals. With its origins dating back to 1882, Adbri is a vertically integrated business with operations spanning Australia. The Group employs more than 1,500 people and serves customers in the residential and non-residential construction, engineering construction, infrastructure, alumina production and mining markets through its portfolio of respected brands.
Name and location of production sites	Manufacturing and distribution of Adbri concrete is undertaken in the states of Queensland (QLD), New South Wales (NSW), Victoria (VIC), South Australia (SA), and Northern Territory (NT). This EPD report presents the methodology, data, results, and interpretation for concrete produced in South Australia. Table 1 below shows all concrete manufacturing sites across South Australia.

Table 1 | Concrete sites in South Australia

Concrete sites in South Australia	
1	Burton
2	Dry Creek
3	Gawler
4	Gillman
5	Littlehampton
6	Lonsdale
7	Murray Bridge
8	Sellicks
9	Victor Harbor
10	Welland

Product Information

Adbri manufactures premixed concrete from over 90 strategically located concrete batching plants throughout Queensland, Northern Territory, New South Wales and Victoria through our Hy-Tec and Central Premix Concrete brands, and throughout South Australia through our Adbri Concrete brand.

The process of manufacturing concrete involves the careful proportioning and mixing of cement, supplementary cementitious materials (SCMs), aggregates, water, chemical admixtures and additives including colour oxides in some instances. As owners and operators of large parts of our supply chain, raw materials are sourced from within the Adbri supply chain where possible.

These raw materials are mixed in batching plants according to specific concrete product mix designs which have been created to satisfy a range of project requirements. In most instances, when the concrete mix required for a specific customer project is selected, materials are batched using calibrated weigh scales before being mixed and transferred to a concrete agitator which continually mixes the product during the delivery process to a customer worksite. In some other instances, mobile wet batch plants can be set up at a project site where mixing occurs, removing the need for concrete agitator trucks.

The products covered in this EPD reflect concrete supplied in accordance with AS1379 – Specification and supply of concrete, for normal class and special class concrete. Normal class concrete specifies nominated characteristics where concrete is designed to meet slump and compressive strength parameters at the point of delivery, and where additional characteristics such as air content may be specified. Special class concretes have characteristics that include additional fresh and hardened properties specified outside of the normal class range.

Introducing Futurecrete®, the lower carbon concrete

For the past 15 years, we've been providing Australians with sustainable products like our lower carbon concretes that have been used on iconic projects such as South Australia's Northern Connector, without compromising performance.

We created the Futurecrete® range, which reduces the embodied carbon of concrete by replacing up to 40% of the cement content with SCMs. For more significant carbon reductions, our advanced Futurecrete® Ultra range can substitute up to 65% of the cement content with SCMs, further reducing embodied carbon of concrete.

Now wherever you're working, Futurecrete®, the lower carbon concrete, is available through our Hy-Tec, Adbri Concrete, Central Premix and Zanows' brands so you can join us to Build a Better Australia.

For this EPD, normal class concrete products are grouped according to cementitious type. The distinguishing feature in these classifications relate to the use of lower carbon SCMs and are characterised as Adbri Normal and Special class concretes, Futurecrete® Normal and Special class and Futurecrete® Ultra Normal and Special class.

Table 2 | SCM percentages for concrete groups and associated brands

Brand	Adbri Concrete		Futurecrete®		Futurecrete® Ultra	
Class	Normal	Special	Normal	Special	Normal	Special
SCM content (%)	0-24%	0-24%	25-40%	25-40%	41-65%	41-65%

Product Identification

Normal class concrete, Futurecrete® and Futurecrete® Ultra lower carbon concrete, and special class concrete are manufactured to comply with AS 1379.

The products considered for the EPD are categorised as follows: lower carbon concretes which are promoted by Adbri under the Futurecrete® and Futurecrete® Ultra range names, normal class concrete products and special class concrete products.

To help customers understand the differences, a basic description for each concrete type has been provided below.

Futurecrete®	Futurecrete® lower carbon concretes relate to concrete mixes where the total proportion of SCMs used in the mix ranges between 25 and 40%. The SCMs used include fly ash and slag and vary according to the state and plant of manufacturer. The increased use of SCMs reduces the total volume of Portland cement, resulting in lower embodied carbon in the concrete mix.
Futurecrete® Ultra	Futurecrete® Ultra lower carbon concretes relate to mixes where the total proportion of SCMs used in the mix ranges between 41-65%. The increased use of SCMs reduces the total volume of Portland cement, resulting in lower embodied carbon in the concrete mix.
Normal class concretes	Designed to meet the requirements of AS 1379 Specification and supply of concrete, these concrete mixes are suitable for general applications.
Special class concretes	Adbri's special class concrete mixes satisfy the requirements of AS 1379, and meet specific project requirements which may include additional requirements for early strength, low shrinkage, high flexural strength etc. These products are designed to meet strict engineering requirements for civil works, commercial and multi-residential buildings and infrastructure projects.

Table 3 | SCM type for concrete groups and associated brands

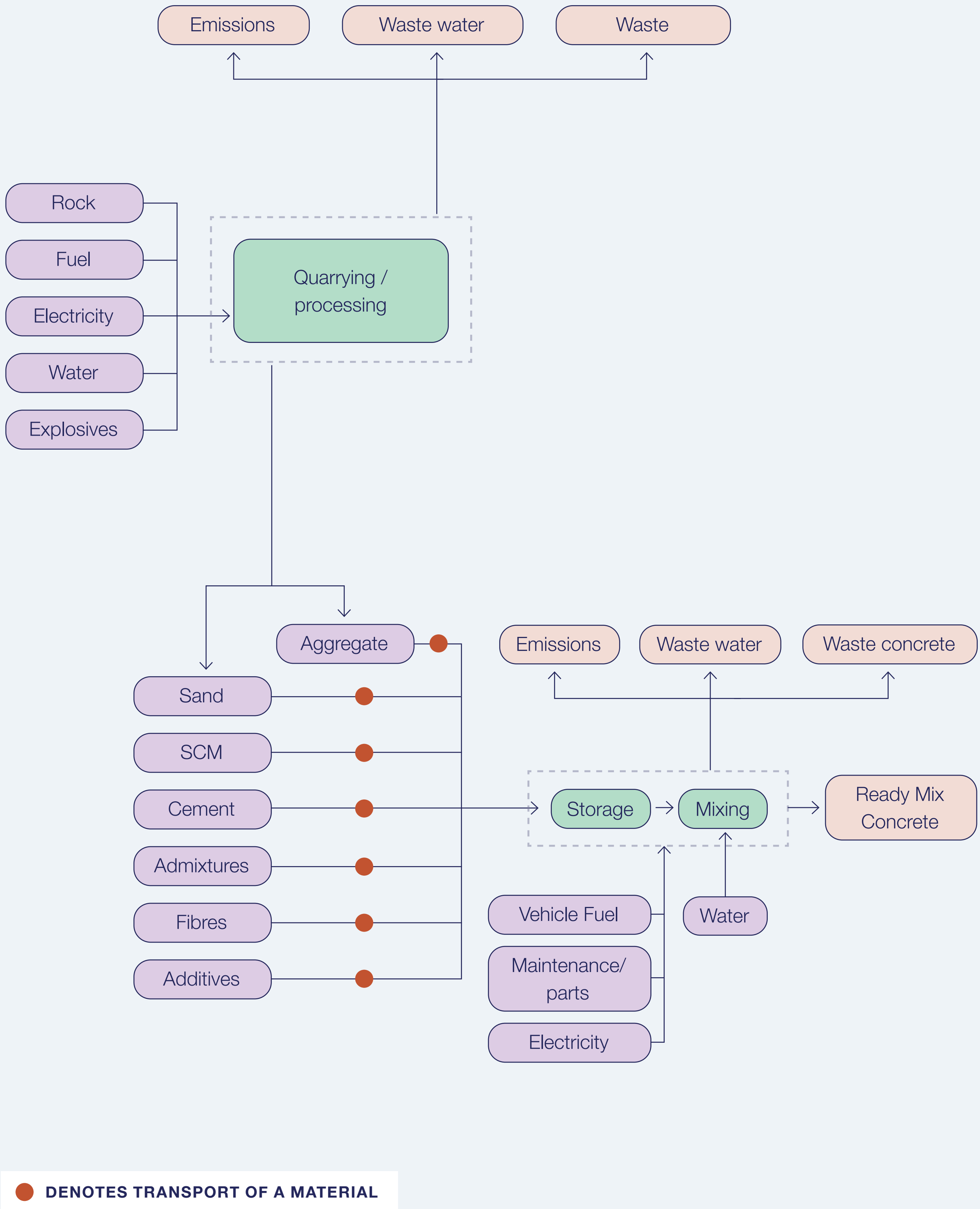
QLD, NSW, VIC, SA, NT	Hy-Tec and other concrete	Futurecrete® Concrete		Futurecrete® Ultra Concrete	
		Normal Class	Special Class	Normal Class	Special Class
Cement type and blend	0-24%	25-40%	25-40%	41-65%	41-65%
GP/GL	Adbri N class concrete	Futurecrete® N class concrete	Futurecrete® S Class concrete		
GP/GL:FA	Adbri N class concrete	Futurecrete® N class concrete	Futurecrete® S Class concrete		
GP/GL:Slag	Adbri N class concrete	Futurecrete® N class concrete	Futurecrete® S Class concrete	Futurecrete® Ultra N class concrete	Futurecrete® Ultra S Class concrete
Ternary		Futurecrete® N class concrete	Futurecrete® S Class concrete	Futurecrete® Ultra N class concrete	Futurecrete® Ultra S Class concrete

Use of SCMs in concrete

For decades, SCMs have been used in the production of concrete as a supplementary binder for use with cement. SCMs are used as a supplement to traditional cement which can result in reduced carbon intensity of the concrete mix as a result of the reduced Portland cement content. The use of SCMs may also improve the fresh properties of concrete and if incorporated optimally, increase the overall durability of in-situ concrete, provided due care is taken during the early stages of placing and curing. SCMs are traditionally derived from by-products of processing plants and conform to the requirements of AS3582.

The presence of strong and sustainable local manufacturing of key materials, such as cement and concrete, is closely linked to the economic prosperity of Australia and its regional communities.

Figure 1 | Typical Concrete Process Flow



The environmental impacts of Adbri's products listed in this EPD are grouped under the Futurecrete® and Futurecrete® Ultra range names, normal class concrete products and special class concrete products by cementitious type and compressive strength. The impact of variance in nominal aggregate size and slump class have been modelled to ensure the grouping of similar mix designs that do not vary by more than +/-10% in terms of Global Warming Potential (GWP).

Table 4 | Concrete assessed in this study

Concrete Production Sites	**Lower Carbon Concrete**					
	Futurecrete® Normal Class (25 - 40% SCM)			Futurecrete® Special Class (25 - 40% SCM)		
	GP:GL 20 MPa; 25MPa; 32MPa; 40MPa; 50MPa	GP/GL:FA 20 MPa; 25MPa; 32MPa; 40MPa; 50MPa	GP/GL:Slag 20 MPa; 25MPa; 32MPa; 40MPa; 50MPa	GP 32MPa; 40MPa	GP/GL:FA 32MPa; 40MPa	GP/GL:Slag 32MPa; 40MPa; 50MPa
Burton	X	X	X	X	X	X
Dry Creek	X	X	X	X	X	X
Gawler	X	X	X	X	X	X
Gillman	X	X	X	X	X	X
Littlehampton	X	X	X	X	X	X
Lonsdale	X	X	X	X	X	X
Murray Bridge	X	X	X	X	X	X
Sellicks	X	X	X			X
Victor Harbor	X	X	X			X
Welland	X	X	X	X	X	X

LCA information

Declared unit and Reference Service Life (RSL)

The declared unit adopted is one cubic metre (1m³) of manufactured concrete.

Databases and LCA software used

The software used was SimaPro® LCA software (v 9.4.0.1). The inventory data for the processes are entered in the LCA software and linked to the pre-existing background data for upstream feedstocks and services. Inventory data was selected per the standards, in the following order of preference:

1. The Australian Life Cycle Inventory Shadow Database (AusLCI shadow database) v1.27 is a National Life Cycle Inventory (LCI) database developed by the Australian Life Cycle Assessment Society (ALCAS) – this data will comply with the AusLCI Data Guidelines (Australian Life Cycle Inventory Database Initiative (ALCAS, 2017). At the time of this report, the AusLCI shadow database was 5 years old.[1]
2. The Australian Life Cycle Inventory (AusLCI) v1.36 was compiled by the Australian Life Cycle Assessment Society (ALCAS) – this data will comply with the AusLCI Data Guidelines (Australian Life Cycle Inventory Database Initiative (ALCAS, 2021). At the time of this report, the AusLCI database was 1 years old.[2]
3. Ecoinvent 3.8 database (Ecoinvent Centre, 2021) for all processes taking place overseas i.e. outside Australia, using global average processes. At the time of this report, the Ecoinvent database was 1 year old.[3]

Description of system boundaries and excluded life cycle stages

The scope of LCA for this EPD is cradle-to-gate with options for modules A4, A5, C1 – C4 and D. Emissions from the use stages (B1 – B7) were excluded as the assumption is different in each project archetype.

All modules included in this EPD are marked as X in the table below and those excluded are marked as 'module not declared' (MND). The system boundary for this EPD is depicted in the figure below.

Table 5 | Life cycle of building products: stages and modules included in this EPD

GPI module		Asset life cycle stage	Information module	LCI section
Upstream	A1	Raw material supply	A1-3. Manufacturing stage	X
Core	A2	Transport		X
	A3	Manufacturing		X
Downstream	A4	Transport	A4-5. Construction stage	X
	A5	Construction, installation process		MND
	B1	Material emissions from usage	B. Usage stage	MND
	B2	Maintenance		MND
	B3	Repair		MND
	B4	Replacement		MND
	B5	Refurbishment		MND
	C1	Deconstruction and demolition	C. End of life	MND
	C2	Transport		MND
	C3	Waste Processing		MND
	C4	Disposal		MND
Other environmental information	D	Reuse, recycle or recovery	D. Recyclability potentials	MND

MND = Module Not Declared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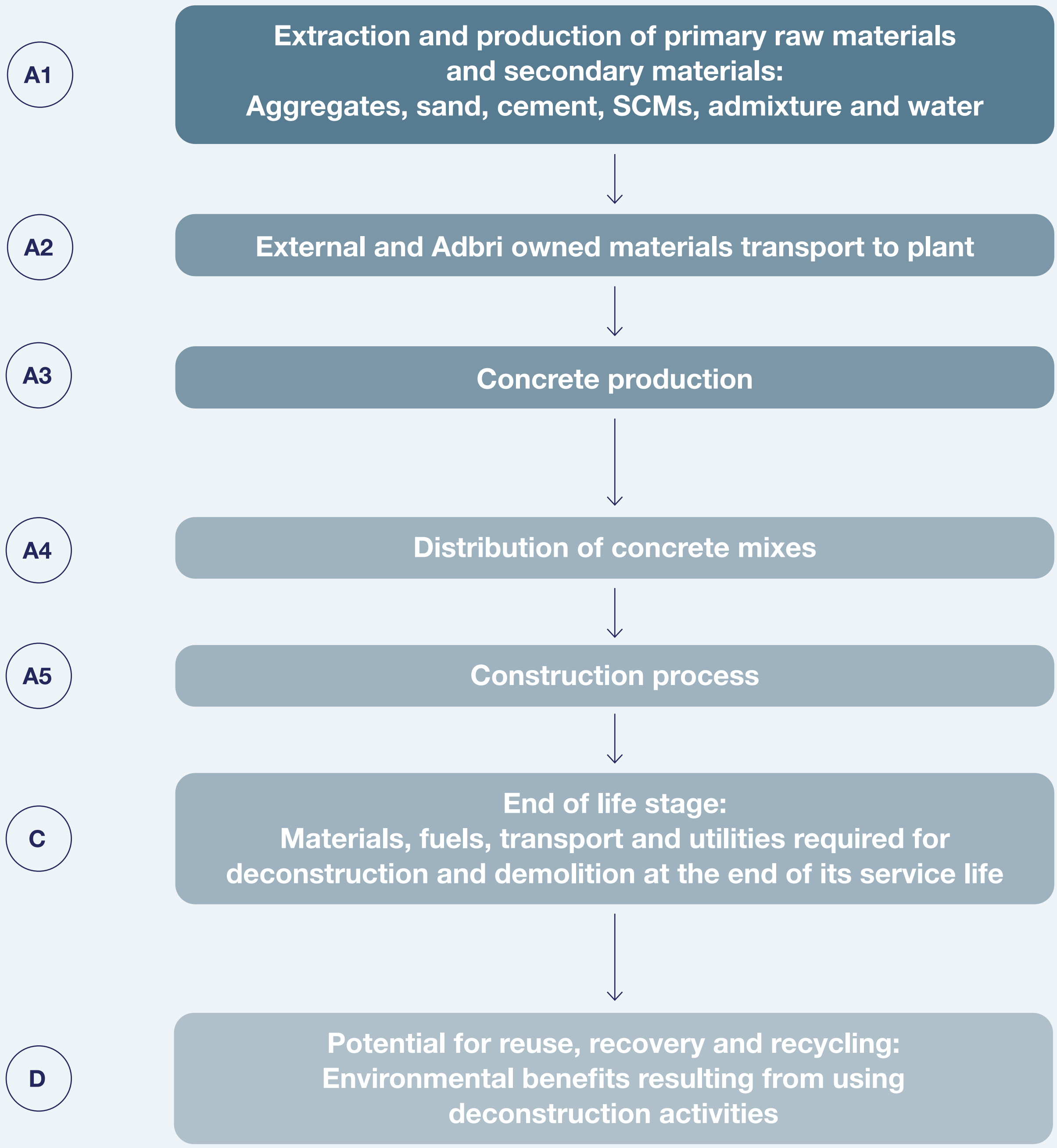
Process diagram

The processes included in the LCA are presented in a process diagram in the figure below:

Figure 2 | System diagram



Upstream processes

The upstream processes include those involved in Module A1 – Raw material supply.
This module includes:

- Extraction, transport and manufacturing of raw materials.
- Generation of electricity from primary and secondary energy resources, also including their extraction, refining and transport for Modules A1 and A3.

Electricity inputs in foreground processes based in Australia were modelled based on the state-specific grid. The AusLCI database was used to model electricity in the foreground processes. The AusLCI dataset was updated using state specific grid data sourced from the Department of the Environment and Energy, December 2020.

Core processes

The core processes include those involved in Module A2 and Module A3, including:

- External transportation of materials to the core processes and internal transport.
- Manufacturing of the concrete mixes.
- Treatment of external recycled materials for reuse.

Data quality

Foreground data on raw material requirements, manufacture, construction, use and end of life inputs is for FY2020-2021. The data sources and their assessed quality are detailed in Table 6. Overall, the data quality for this LCA was considered High.

Table 6 | Data quality

Module	Asset life cycle stage	Primary Data	Generic Data	Primary Data Quality	Generic Data Quality
A1	Raw material supply	Source and quantities of materials of feed mix Inputs: electricity, diesel and gas	Extraction of raw materials	Very good	
A2	Transport from supplier	Transport mode and distance	Fuel consumption embedded in process	Very good	
A3	Manufacturing	Inputs: water use Outputs: manufactured product quantities, packaging, waste		Very good	
A4	Transport to customer		Transport mode and average distances to sites	Very good	
A5	Construction, installation		Construction energy and waste (e.g. cut offs) - assumptions		Good
C1	Deconstruction and demolition		Deconstruction energy and waste, and lifespan – assumptions		Good
C2	Transport to waste processing		Transportation to landfill-reprocessing – assumption		Good
C3	Waste processing		Waste processing scenario and rates from industry data		Good
C4	Disposal		Waste to landfill scenario and rates from industry data		Good
D	Reuse, recycling, or recovery		Recycling scenario and rates from industry data		Good

The EPD will be updated if changes in its lifecycle inventory lead to a variation of 10% or more in any of the included environmental indicators during its validity period.

Cut-off rules and exclusion of small amounts

It is common practice in LCA/LCI protocols to propose exclusion limits for inputs and outputs that fall below a threshold % of the total, but with the exception that where the input/output has a 'significant' impact it should be included. According to the PCR 2019:14 v1.11, LCI data shall according to EN 15804 A2 include a minimum of 95% of total inflows (mass and energy) per module. Inflows not included in the LCA shall be documented in the EPD. Data gaps in included stages in the downstream modules shall be reported in the EPD, including an evaluation of their significance. In accordance with the PCR 2019:14 v1.11, the following system boundaries are applied to manufacturing equipment and employees:

- Environmental impact from infrastructure, construction, production equipment, and tools that are not directly consumed in the production process are not accounted for in the LCI. Capital equipment and buildings typically account for less than a few percent of nearly all LCIs and this is usually smaller than the error in the inventory data itself. For this project, it is assumed that capital equipment makes a negligible contribution to the impacts as per Frischknecht et al. (Frischknecht, 2007) with no further investigation.
- Personnel-related impacts, such as transportation to and from work, are also not accounted for in the LCI. The impacts of employees are also excluded from inventory impacts on the basis that if they were not employed for this production or service function, they would be employed for another. It is very hard to decide what proportion of the impacts from their whole lives should count towards their employment. For this project, the impacts of employees are excluded.
- Transport for raw materials accounting for less than 1% of the feed mix was excluded. This is because the impact contribution is considerably small.

Based on this guidance, no energy or mass flows, except packaging of materials were excluded. All materials required for manufacturing are delivered via trucks and ships without packaging.

Key assumptions

1. All foreground data used for the manufacturing processes (up to factory gate), transportation to the concrete plant, distribution in Australia, via a 'Request for Information' spreadsheet. This data was collected for the period September 2020 to September 2021 referred as financial year 2020 -2021 (FY20-21).
2. The assumptions for construction and construction waste were made based on the GCCA tool.
3. Recycling and reuse of concrete can provide economic benefits along with environmental benefits compared to manufacture from raw materials. Concrete is durable and lasts long term. As a result, it can be reused or recycled for aggregate production without exploiting from natural resources. The distance for waste collecting from construction site to landfill/ recycling plant is assumed 50km.
4. The information in Module D may contain technical information as well as LCA results from post-consumer recycling, i.e., environmental benefits or loads resulting from reusable products, recyclable materials and/or useful energy carriers leaving a product system e.g., as secondary materials or fuels. Avoided impacts from co-products from Module A to C shall not be included in Module D. The benefit in this case is the avoided production of gravel from natural source. The recycling process is modelled as using the rock crusher to produce recycled aggregate. The recycling rate for concrete is assumed 72%.

5

Content declaration

EPD product description

Product stage (A1 – A3)

Three main types of concrete with varying mix designs have been included in this EPD. These mixes have differences in term of compositions and amount of components (see Table 7) EPD product description.

Table 7 | Percentage of material composition included in this EPD

Material description	lower Carbon Concrete				
	20 MPa	25 MPa	32 MPa	40 MPa	50 MPa
General Purpose/Limestone Cement	7% - 11%	7% - 12%	8% - 14%	10% - 17%	14% - 22%
Coarse Aggregate	36% - 43%	36% - 43%	38% - 44%	38% - 46%	37% - 48%
Sand	38% - 44%	37% - 42%	34% - 40%	24% - 35%	22% - 30%
SCM	3% - 4%	3% - 4%	3% - 4%	4% - 6%	6% - 7%
Admixtures	<1%	<1%	<1%	<1%	<1%
Water	6% - 8%	7% - 8%	7% - 8%	6% - 9%	6% - 8%

Specific data for module A2 was obtained for Adbri operated processes. All the materials used for concrete mixes were transported in bulk via trucks.

Adbri operates and manages the transport of aggregate and sand from its quarries to its concrete batching plants. Data for the quantity (i.e. load), number of trips and transport distance between every origin quarry and destination concrete plant was provided by Adbri. This data was converted to a kg.km transport unit.

The transport of all other raw materials to the concrete batching plants was modelled using actual transport distances, based on the transport modes for each raw material ingredient (provided by Adbri) and the supplier origin information.

The electricity used for concrete production in South Australia is modelled based on the state-specific grid. The AusLCI database was used to model electricity in the foreground processes. The AusLCI dataset was last updated in 2021. To assess whether an average of the manufacturing sites can be applied without justification, it's necessary to ensure that the variation in the GWP- GHG impact between sites isn't higher than 10% in modules A1-A3.

Concrete manufacturing is undertaken primarily at Adbri branded concrete batching plants. All plants have the same site resource use profile, management systems and operating systems. In addition, concrete batching plant resource use constitutes less than 1% of impact in each impact category.

Allocation

According to EN 15804 A2:2019, in a process step where more than one type of product is generated, it is necessary to allocate the environmental stressors (inputs and outputs) from the process to the different products (functional outputs) in order to get product-based inventory data instead of process-based data. An allocation problem also occurs for multi-input processes.

In an allocation procedure, the sum of the allocated inputs and outputs to the products shall be equal to the unallocated inputs and outputs of the unit process.

The following stepwise allocation principles shall be applied for multi-input/output allocations:

- The initial allocation step includes dividing up the system sub-processes and collecting the input and output data related to these sub-processes.
- The first (preferably) allocation procedure step for each sub-process is to partition the inputs and outputs of the system into their different products in a way that reflects the underlying physical relationships between them.
- The second (worst case) allocation procedure step is needed when physical relationship alone cannot be established or used as the basis for allocation. In this case, the remaining environmental inputs and outputs from a sub-process must be allocated between the products in a way that reflects other relationships between them, such as the economic value of the products.

In the case of co-production, where the processes cannot be subdivided the coherence of the process must be followed. The allocation procedure criteria are as follows in Table 8.

Table 8 | Allocation procedure criteria

Revenue Classification	Revenue Contribution	Allocation Type
Very Low	Processes generating overall revenue of the order of 1% or less	The process may be neglected
High	A difference in revenue of more than 25%	Allocation shall be based on economic values
Low	A difference in revenue of less than 25%	Allocation shall be based on physical properties, e.g. mass, volume.

Material flow carrying specific inherent properties, e.g. energy content, elementary composition, shall always be allocated reflecting the physical flows, irrespective of the allocation chosen for the process.

In the case of combined heat and power production, a distribution based on the best efficiency for the (potential) separate generation of electricity or heat shall be considered.

Data provided by Adbri for this assessment includes both product (recycled content in mixes) and production site (energy use) specific data.

Allocation of recycled content

Adbri's concrete mixes incorporate varying levels of SCMs, i.e., granulated blast furnace slag and fly ash. BS EN 16757:2017 specifically lists these materials relevant to the study as co-products. As such, the above materials are considered as co-products of their production process and the impacts for their production process are allocated according to PCR 2019:14 Construction Products (co-produced goods, multi-output allocation).

Ground granulated blast furnace slag: The AusLCI process for slag is allocated based on economic value, as the product has significant economic value at the point of collection.

Fly ash: In the AusLCI process, fly ash is treated as a waste material and only includes transport impacts. If the dust was not utilised as a supplementary cementitious material, this material would otherwise have been landfilled and hence is classified as waste.

Allocation in background data

The allocation approach for the generic databases utilised in this LCA is also compliant with the PCR. More specifically, the burden of primary production of materials is always allocated to the primary user of a material, while secondary (recycled) materials bear only the impacts of the recycling processes.

The allocation approach of the AusLCI LCA database was adopted as a default for secondary data and processes (e.g., secondary fuel in concrete production). The AusLCI dataset conforms to EN 15804 when applying allocation to its various processes and sub-processes.

Adbri quarry data

Adbri produce three main types of aggregate for concrete:

— Coarse aggregate;

— Manufactured sand (a type of fine aggregate); and

— Natural sand (a type of fine aggregate).

Coarse aggregate and manufactured sand are produced at the same sites in a combined process. Manufactured sand is produced from a process of further crushing coarse aggregate until it is sufficiently sized to be used as a substitute for natural sand. Natural sand is quarried and processed at specific sites via a different production process. At all aggregate sites, the resource use and discharge data (e.g. energy, water, wastewater, waste and air emissions) describe inputs and outputs that are shared with other product systems (i.e. aggregates produced for road base etc.). Allocation was thus required to determine the site resource use and discharge amounts that is allocated to each product.

The allocation was undertaken following the guidelines in the relevant PCR (2019:14, outlined above). The inputs and outputs to the various aggregate manufacturing sites were first identified and collected. The basis of allocation differed between the inputs and outputs based on their properties: all inputs and outputs were partitioned for the sub-systems based on their underlying physical relationships (i.e. the proportion of total production at each site, by weight).

Averaging production site data

Adbri produces a range of concrete mixes at each of their concrete batching plants, with the range dependent on customer demand. Due to the random nature of which mixes are produced and the large number of concrete mixes (993 mixes), allocation was required to determine the amount of site resource use, discharges and emissions associated with each mix. Allocation was simply carried out based on physical relationships (i.e., production amount, by volume). It was assumed that all mixes require or result in an equal amount of site resources, discharges, and emissions (per m^3). Therefore, each site's total production volume could be used to perform the calculation of inputs and outputs per m^3 – i.e., physical allocation.

Adbri's ready-mixed concrete production operations span many states (refer to Table 9). The allocated inputs and outputs of each site (concrete batching plant) were averaged to create state average input and output values and modelled using state-specific electricity processes from AusLCI. This approach applies only to site resource data for concrete batching (A3). Product specific data (e.g., cement, fly ash, slag, aggregates, admixtures etc.) was treated at the product grouping stage.

Table 9 | Adbri concrete production sites across South Australia

Concrete sites in South Australia	
1	Burton
2	Dry Creek
3	Gawler
4	Gillman
5	Littlehampton
6	Lonsdale
7	Murray Bridge
8	Sellicks
9	Victor Harbor
10	Welland

Approach to product grouping

In South Australia, Adbri produces 993 normal class, lower carbon and special class concrete mixes that fall within the scope of the LCA study. As such, mixes were grouped into discrete groups based on a range of variables that are highly correlated to their environmental impact and easily interpreted by customers. The approach to determining the variables for grouping mixes was iterative and involved close collaboration with the Adbri South Australia project team. The variables considered included:

— State: SA

— Strength properties (MPa),

— Blend (referring to the type and number of SCMs included in the mix design),

The process of grouping the normal-class mixes involved the following aims and considerations:

— **Provide a simple and readable EPD:** minimise the number and complexity of product groups presented within the EPD to ensure the EPD is reasonably aggregated and summarised for practical use by EPD users.

— **Offer certainty to EPD users:** to provide reliable figures for Adbri customers and industry practitioners, with sufficient specificity as to offer more representative and specific data compared to current average life cycle assessment data for concrete.

— **Future-proof the EPD:** to keep product category groupings consistent over time.

The final variables chosen to group the products are:

— **State:** SA

— **Strength (MPa):** 20, 25, 32, 40, 50

— **Blend:** GP cement (GP) or GL cement (GL), fly ash (FA), slag (B), ternary (T)

The selected special class concrete mixes included in the LCA study were grouped using the same approach as normal class concrete and declared for specific mix code.

Distribution - A4

Data regarding distribution of concrete ready-mix was calculated based on annual figures provided by Adbri, including transport modes and distance. Distances were calculated using Google Maps (road transport) and the weighted average transport from each plant and cement type to consumers was calculated. Tables below summarise the data provided for weighted average distance between manufacture site and consumers, and modelled data for assessment.

Table 10 | Average distance GWP for distribution to construction sites

Location	Mode of transport	Average Distance (km)	GWP CO_2eq
South Australia	Concrete truck	13	9.64

Compliance with standards

The LCA and EPD have been developed to comply with:

1. BS EN 15804:2012+A2:2019. Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products. British Standards Institution, 2019.[3]
2. BS EN 16757:2017. Sustainability of construction works – Environmental product declarations – Product Category Rules for concrete and concrete elements. British Standards Institution, 2017.[4]
3. ISO 14040:2006 and ISO14044:2006+A1:2018 which describe the principles, framework, requirements and provides guidelines for life cycle assessment (LCA) (ISO, 2006; ISO, 2018).[7-8]
4. ISO 14025:2006 Environmental labels and declarations – Type III environmental declarations -- Principles and procedures, which establishes the principles and specifies the procedures for developing Type III environmental declaration programmes and Type III environmental declarations (ISO, 2006).[9]
5. General Programme Instructions (GPI) for the International EPD System V3.01 – containing instructions regarding methodology and the content that must be included in EPDs registered under the International EPD System.[10]
6. PCR 2019:14 Construction Products (Version 1.11), 2021-02-05.[11]
7. Complementary Product Category Rules (C-PCR) to PCR 2019:14 Concrete and Concrete elements, Version 2019-12-20.

Environmental performance results

The potential environmental impacts, use of resources and waste categories included in this EPD were calculated using the SimaPro v9.4.0.1 tool and are listed in Table 11. All tables from this point will contain the abbreviation only.

The LCA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds and safety margins or risks. The impact assessment results are presented in the next sections.

Table 11 | Life Cycle Impact, Resource and Waste Assessment Categories, Measurements and Methods

Impact category	Abbreviation	Measurement unit	Assessment method and implementation	Disclaimer
POTENTIAL ENVIRONMENTAL IMPACTS				
Global warming potential (fossil)	GWPF	kg CO_2 equivalents (GWP100)	Baseline model of 100 years of the IPCC based on IPCC 2013	None
Global warming potential (biogenic)	GWPB	kg CO_2 equivalents (GWP100)	Baseline model of 100 years of the IPCC based on IPCC 2013	None
Global warming potential (land use/ land transformation)	GWPL	kg CO_2 equivalents (GWP100)	Baseline model of 100 years of the IPCC based on IPCC 2013	None
Total global warming potential	GWPT	kg CO_2 equivalents (GWP100)	Baseline model of 100 years of the IPCC based on IPCC 2013	None
Acidification potential	AP	mol H+ eq.	Accumulated Exceedance, Seppälä et al. 2006, Posch et al., 2008	None
Eutrophication – aquatic freshwater	EP - freshwater	kg PO_4^{3-} equivalents	CML (v4.1)	None
Eutrophication – aquatic freshwater	EP - freshwater	kg P equivalent	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe[1]	None
Eutrophication – aquatic marine	EP - marine	kg N equivalent	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe	None
Eutrophication – terrestrial	EP – terrestrial	mol N equlivalent	Accumulated Exceedance, Seppälä et al. 2006, Posch et al.	None
Photochemical ozone creation potential	POCP	kg NMVOC equivalents	LOTOS-EUROS ,Van Zelm et al., 2008, as applied in ReCiPe	None
Abiotic depletion potential (elements)	ADPE	kg Sb equivalents	CML (v4.1)	2
Abiotic depletion potential (fossil fuels)	ADPF	MJ net calorific value	CML (v4.1)	2
Ozone depletion potential	ODP	kg CFC 11 equivalents	Steady-state ODPs, WMO 2014	None
Water depletion potential	WDP	m^3 equivalent deprived	Available WAter REmaining (AWARE) Boulay et al., 2016	2

Table 11 (Cont.) | Life Cycle Impact, Resource and Waste Assessment Categories, Measurements and Methods

Impact category	Abbreviation	Measurement unit	Assessment method and implementation	Disclaimer
ADDITIONAL ENVIRONMENTAL IMPACTS				
Global warming potential, excluding biogenic uptake, emissions and storage	GWP-GHG	kg CO_2 equivalents (GWP100)	CML (v4.1)	None
Particulate matter	PM	disease incidence	SETAC-UNEP, Fantke et al. 2016[2]	None
Ionising radiation - human health	IRP	kBq U-235 eq	Human health effect model as developed by Dreicer et al.[3] 1995 update by Frischknecht et al., 2000[4]	1 (Refer to the bottom of the table)
Eco-toxicity (freshwater)	ETP-fw	CTUe	Usetox version 2 until the modified USEtox model is available from EC-JRC	2 (Refer to the bottom of the table)
Human toxicity potential - cancer effects	HTP-c	CTUh	Usetox version 2 until the modified Usetox model is available from EC-JRC	2 (Refer to the bottom of the table)
Human toxicity potential - non cancer effects	HTP-nc	CTUh	Usetox version 2 until the modified Usetox model is available from EC-JRC	2 (Refer to the bottom of the table)
Soil quality	SQP	dimensionless	Soil quality index based on LANCA	2 (Refer to the bottom of the table)
RESOURCE USE				
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	PERE	MJ, net calorific value	Ecoinvent version 3.6 and expanded by PRé Consultants[5 6]	None
Use of renewable primary energy resources used as raw materials	PERM	MJ, net calorific value	Manual for direct inputs[7]	None
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	PERT	MJ, net calorific value	Ecoinvent version 3.6 and expanded by PRé Consultants[8]	None
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	PENRE	MJ, net calorific value	Manual for direct inputs[9]	None
Use of non- renewable primary energy resources used as raw materials	PENRM	MJ, net calorific value	Ecoinvent version 3.6 and expanded by PRé Consultants	None
Total use of non- renewable primary energy resources (primary energy and primary energy resources used as raw materials)	PENRT	MJ, net calorific value	Ecoinvent version 3.6 and expanded by PRé Consultants[10]	None
Use of secondary material	SM	kg	Manual for direct inputs	None
Use of renewable secondary fuels	RSF	MJ, net calorific value	Manual for direct inputs	None
Use of non-renewable secondary fuels	NRSF	MJ, net calorific value	Manual for direct inputs	None
Use of net fresh water	FW	m^3	ReCiPe 2016	None

Table 11 (Cont.) | Life Cycle Impact, Resource and Waste Assessment Categories, Measurements and Methods

Impact category	Abbreviation	Measurement unit	Assessment method and implementation	Disclaimer
ADDITIONAL ENVIRONMENTAL IMPACTS				
Hazardous waste disposed	HWD	kg	EDIP 2003 (v1.05)	None
Non-hazardous waste disposed	NHWD	kg	EDIP 2003 (v1.05)[11]	None
Radioactive waste disposed/stored	RWD	kg	EDIP 2003 (v1.05)	None
RESOURCE USE				
Components for reuse	CRU	kg	Manual for direct inputs	None
Materials for recycling	MFR	kg	Manual for direct inputs	None
Materials for energy recovery	MFRE	kg	Manual for direct inputs	None
Exported energy	EE	MJ per energy carrier	Manual for direct inputs	None

Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionising radiation from the soil, from radon and from some construction materials is also not measured by this indicator.[12]

Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.

[1] EN 15804:2012+A2:2019 specifies that the unit for the indicator for Eutrophication aquatic freshwater shall be kg PO43- eq, although the reference given ("EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe") uses the unit kg P eq. This is likely a typographical error in EN 15804+A2, which is expected to be corrected in a future revision. Until this has been corrected, results for Eutrophication aquatic freshwater shall be given in both kg PO4 eq and kg P eq. in the EPD.

[2] Fantke et al., Global Guidance for Life Cycle Impact Assessment Indicators: Volume 1. UNEP/SETAC Life Cycle Initiative, Paris, pp. 76-99

[3] Dreicer et al., 1995. ExternE, Externalities of Energy, Vol. 5. Nuclear, Science, Research and Development JOULE, Luxembourg.

[4] Frischknecht et al., R., 2000. Environmental impact assessment Review, 20, pp.159-189.

[5-6] Method to calculate Cumulative Energy Demand (CED), based on the method published by Ecoinvent version 2.0 and expanded by PRé Consultants for raw materials available in the SimaPro database.

[7] Calculated based on the lower heating value of renewable raw materials.

[8] Calculated as sum of *Renewable, biomass, Renewable, wind, solar, geothermal and Renewable, water.*

[9] Calculated based on the higher heating value of non-renewable raw materials.

[10] Calculated as sum of *Non-renewable, fossil, Non-renewable, nuclear and Non-renewable, biomass.*

[11] Calculated as sum of *Bulk waste and Slags/ash.*

[12] Aligned with PCR 2019:14

Environmental performance results

Product stage (A1-A3) results per m³ concrete

Table 12 | Potential environmental impacts of Product stage (A1 – A3)

POTENTIAL ENVIRONMENTAL IMPACTS	GWP-fossil	GWP-biogenic	GWP-luluc	GWP-total	ODP	AP	EP freshwater	EP freshwater	EP-marine	EP terrestrial	POCP	ADP-minerals & metals	ADP-fossil fuels	WDP
Product group	kg CO_2 eq.	kg CO_2 eq.	kg CO_2 eq.	kg CO_2 eq.	kg CFC 11 eq.	mol H^+ eq.	kg PO_4^{3-} eq.	kg P eq.	kg N eq.	mol N eq.	kg NMVOC eq.	kg Sb eq.	MJ	m^3 deprived
Adbri N Class GP/GL 20 MPa	199.88	0.03	1.53E-02	199.92	1.69E-05	1.92	0.27	4.83E-03	0.71	7.89	2.05	5.64E-04	2448.72	1564.49
Adbri N Class GP/GL 25 MPa	220.49	0.04	1.43E-02	220.53	1.83E-05	2.12	0.3	5.31E-03	0.78	8.75	2.27	6.22E-04	2680.36	1725.43
Adbri N Class GP/GL 32 MPa	240.16	0.03	1.54E-02	240.2	1.96E-05	2.31	0.32	5.76E-03	0.86	9.58	2.48	6.79E-04	2904.65	1873.78
Adbri N Class GP/GL 40 MPa	290.93	0.06	8.50E-03	291	2.30E-05	2.81	0.39	6.91E-03	1.05	11.7	3.02	8.25E-04	3488.11	2250.09
Adbri N Class GP/GL 50 MPa	389.16	0.07	1.82E-02	389.23	2.96E-05	3.78	0.53	9.13E-03	1.42	15.8	4.07	1.11E-03	4626.54	2970.27
Futurecrete® N Class GP/GL:Slag 20 MPa	158.09	0.03	1.51E-02	158.13	1.35E-05	1.45	0.2	3.81E-03	0.52	5.84	1.53	4.27E-04	1964.73	1309.78
Futurecrete® N Class GP/GL:Slag 25 MPa	173.54	0.04	1.40E-02	173.59	1.44E-05	1.6	0.22	4.16E-03	0.58	6.43	1.68	4.68E-04	2136.84	1440.13
Futurecrete® N Class GP/GL:Slag 32 MPa	188.35	0.03	1.51E-02	188.39	1.54E-05	1.74	0.24	4.50E-03	0.63	7.02	1.83	5.09E-04	2304.77	1559
Futurecrete® N Class GP/GL:Slag 40 MPa	226.99	0.07	8.33E-03	227.06	1.77E-05	2.1	0.29	5.35E-03	0.77	8.54	2.22	6.15E-04	2747.65	1863.2
Futurecrete® N Class GP/GL:Slag 50 MPa	299.37	0.12	6.38E-03	299.49	2.23E-05	2.78	0.38	6.97E-03	1.02	11.39	2.95	8.02E-04	3569.13	2439.16
Futurecrete® N Class GP/GL:FA 20 MPa	162.67	0.02	1.52E-02	162.7	1.56E-05	1.5	0.2	4.10E-03	0.54	5.97	1.58	4.65E-04	2056.57	1298.12

Where 'Adbri concrete' is used, this refers to concrete manufactured and sold by Adbri Concrete in South Australia.

Table 12 (cont.) | Potential environmental impacts of Product stage (A1 – A3)

POTENTIAL ENVIRONMENTAL IMPACTS	GWP-fossil	GWP-biogenic	GWP-luluc	GWP-total	ODP	AP	EP freshwater	EP freshwater	EP-marine	EP terrestrial	POCP	ADP-minerals & metals	ADP-fossil fuels	WDP
Product group	kg CO_2 eq.	kg CO_2 eq.	kg CO_2 eq.	kg CO_2 eq.	kg CFC 11 eq.	mol H^+ eq.	kg PO_4^{3-} eq.	kg P eq.	kg N eq.	mol N eq.	kg NMVOC eq.	kg Sb eq.	MJ	m^3 deprived
Futurecrete® N Class GP/GL:FA 25 MPa	178.48	0.03	1.41E-02	178.52	1.67E-05	1.65	0.23	4.48E-03	0.59	6.58	1.74	5.10E-04	2236.79	1423.6
Futurecrete® N Class GP/GL:FA 32 MPa	194.02	0.04	6.21E-03	194.07	1.79E-05	1.8	0.25	4.85E-03	0.65	7.2	1.9	5.56E-04	2416.44	1543.36
Futurecrete® N Class GP/GL:FA 40 MPa	233.57	0.06	4.31E-03	233.63	2.09E-05	2.17	0.3	5.78E-03	0.78	8.74	2.29	6.72E-04	2881.99	1838.77
Futurecrete® N Class GP/GL:FA 50 MPa	311.17	0.05	1.65E-02	311.22	2.71E-05	2.89	0.4	7.64E-03	1.05	11.69	3.06	9.03E-04	3809.56	2418.28
Futurecrete® S Class GP/GL 32 MPa	251.97	0.04	1.60E-02	252.02	1.98E-05	2.37	0.33	5.97E-03	0.87	9.72	2.52	6.89E-04	3035.74	2033.23
Futurecrete® S Class GP/GL 40 MPa	305.74	0.07	9.75E-03	305.82	2.33E-05	2.88	0.4	7.18E-03	1.06	11.86	3.07	8.39E-04	3651.58	2454.35
Futurecrete® S Class GP/GL:FA 32 MPa	194.72	0.05	1.70E-03	194.77	1.81E-05	1.8	0.25	4.87E-03	0.65	7.23	1.9	5.59E-04	2430.75	1539.18
Futurecrete® S Class GP/GL:FA 40 MPa	234.76	0.06	2.33E-03	234.81	2.12E-05	2.18	0.3	5.82E-03	0.79	8.76	2.3	6.78E-04	2903.07	1840.43
Futurecrete® S Class GP/GL:Slag 50 MPa	303.49	0.17	2.65E-03	303.64	2.26E-05	2.81	0.39	7.06E-03	1.03	11.51	2.98	8.03E-04	3614.71	2474.88
Futurecrete® Special GP/GL:Slag 40 MPa 4D 85/60	226.9	0.16	1.61E-01	227.21	1.74E-05	2.03	0.3	3.92E-02	0.69	7.94	2.08	6.18E-04	2734.84	1661.98
Futurecrete® S Class GP/GL:Slag 32 MPa	188.13	0.03	1.57E-02	188.17	1.53E-05	1.74	0.24	4.48E-03	0.63	7.05	1.84	5.09E-04	2305.77	1545.65
Futurecrete® S Class GP/GL:Slag 40 MPa	225.92	0.06	9.12E-03	225.98	1.77E-05	2.09	0.29	5.31E-03	0.76	8.53	2.22	6.13E-04	2738.58	1844.34

Acronyms: GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption

Table 13 | Resource use of Product stage (A1 – A3)

RESOURCE USE	PERE	PERM	PERT	PENRE	PENRM	PENT	SM	RSF	NRSF	FW
Product Group	MJ	MJ	MJ	MJ	MJ	MJ	kg	MJ	MJ	m^3
Adbri N Class GP/GL 20 MPa	64.53	0	64.53	2499.03	0	2499.03	0	0	0	0.51
Adbri N Class GP/GL 25 MPa	70.65	0	70.65	2738.62	0	2738.62	0	0	0	0.56
Adbri N Class GP/GL 32 MPa	76.67	0	76.67	2968.31	0	2968.31	0	0	0	0.58
Adbri N Class GP/GL 40 MPa	91.6	0	91.6	3553.04	0	3553.04	0	0	0	0.62
Adbri N Class GP/GL 50 MPa	119.44	0	119.44	4682.06	0	4682.06	0	0	0	0.62
Futurecrete® N Class GP/GL:FA 20 MPa	51.69	0	51.69	2098.97	0	2098.97	74.27	0	0	0.48
Futurecrete® N Class GP/GL:FA 25 MPa	56.2	0	56.2	2285.96	0	2285.96	83.49	0	0	0.52
Futurecrete® N Class GP/GL:FA 32 MPa	60.81	0	60.81	2473.07	0	2473.07	92.45	0	0	0.53
Futurecrete® N Class GP/GL:FA 40 MPa	71.84	0	71.84	2935.68	0	2935.68	114.88	0	0	0.57
Futurecrete® N Class GP/GL:FA 50 MPa	92.16	0	92.16	3859.58	0	3859.58	156.25	0	0	0.55
Futurecrete® N Class GP/GL:Slag 20 MPa	52.77	0	52.77	1997.11	0	1997.11	0	0	0	0.45
Futurecrete® N Class GP/GL:Slag 25 MPa	57.43	0	57.43	2174.99	0	2174.99	0	0	0	0.5

Table 13 (cont.) | Resource use of Product stage (A1 – A3)

RESOURCE USE	PERE	PERM	PERT	PENRE	PENRM	PENT	SM	RSF	NRSF	FW
Product Group	MJ	MJ	MJ	MJ	MJ	MJ	kg	MJ	MJ	m^3
Futurecrete® N Class GP/ GL:Slag 32 MPa	62.09	0	62.09	2346.24	0	2346.24	0	0	0	0.51
Futurecrete® N Class GP/ GL:Slag 40 MPa	73.57	0	73.57	2784.65	0	2784.65	0	0	0	0.55
Futurecrete® N Class GP/ GL:Slag 50 MPa	94.36	0	94.36	3612.67	0	3612.67	0	0	0	0.58
Futurecrete® S Class GP/ GL:Slag 32 MPa	62.11	0	62.11	2347.22	0	2347.22	0	0	0	0.47
Futurecrete® S Class GP/ GL:Slag 40 MPa	73.32	0	73.32	2776.05	0	2776.05	0	0	0	0.5
Futurecrete® S Class GP/GL 32 MPa	80.78	0	80.78	3100.46	0	3100.46	0	0	0	0.55
Futurecrete® S Class GP/GL 40 MPa	96.62	0	96.62	3717.55	0	3717.55	0	0	0	0.61
Futurecrete® S Class GP/ GL:FA 32 MPa	60.9	0	60.9	2489.93	0	2489.93	92.38	0	0	0.49
Futurecrete® S Class GP/ GL:FA 40 MPa	71.93	0	71.93	2958.91	0	2958.91	114.66	0	0	0.54
Futurecrete® S Class GP/ GL:Slag 50 MPa	95.2	0	95.2	3656.53	0	3656.53	0	0	0	0.57
Futurecrete® Special GP/ GL:Slag 40 MPa 4D 85/60	92.9	0	92.9	2816.16	0	2816.16	20	0	0	0.83

Acronyms: PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

Table 14 | Waste and Output flow indicators

WASTE CATEGORIES AND OUTPUT FLOWS	Hazardous waste disposed	Non-hazardous waste disposed	Radioactive waste disposed	Components for re-use	Material for recycling	Materials for energy recovery	Exported energy, electricity	Exported energy, thermal
Product Group	kg	kg	kg	kg	kg	kg	MJ	MJ
Adbri N Class GP/GL 20 MPa	2.65E-03	5.68E+03	7.79E-04	0	0	0	0	0
Adbri N Class GP/GL 25 MPa	2.85E-03	6.37E+03	7.95E-04	0	0	0	0	0
Adbri N Class GP/GL 32 MPa	3.08E-03	7.05E+03	8.01E-04	0	0	0	0	0
Adbri N Class GP/GL 40 MPa	3.62E-03	8.75E+03	1.14E-03	0	0	0	0	0
Adbri N Class GP/GL 50 MPa	4.78E-03	1.20E+04	1.98E-03	0	0	0	0	0
Futurecrete® N Class GP/GL:FA 20 MPa	2.33E-03	3.99E+03	7.78E-04	0	0	0	0	0
Futurecrete® N Class GP/GL:FA 25 MPa	2.48E-03	4.48E+03	7.93E-04	0	0	0	0	0
Futurecrete® N Class GP/GL:FA 32 MPa	2.65E-03	4.96E+03	7.30E-04	0	0	0	0	0
Futurecrete® N Class GP/GL:FA 40 MPa	3.11E-03	6.16E+03	1.11E-03	0	0	0	0	0
Futurecrete® N Class GP/GL:FA 50 MPa	4.14E-03	8.38E+03	1.75E-03	0	0	0	0	0
Futurecrete® N Class GP/GL:Slag 20 MPa	2.28E-03	3.98E+03	7.77E-04	0	0	0	0	0
Futurecrete® N Class GP/GL:Slag 25 MPa	2.43E-03	4.46E+03	7.92E-04	0	0	0	0	0

Table 14 (cont.) | Waste and Output flow indicators

WASTE CATEGORIES AND OUTPUT FLOWS	Hazardous waste disposed	Non-hazardous waste disposed	Radioactive waste disposed	Components for re-use	Material for recycling	Materials for energy recovery	Exported energy, electricity	Exported energy, thermal
Product Group	kg	kg	kg	kg	kg	kg	MJ	MJ
Futurecrete® N Class GP/GL:Slag 32 MPa	2.62E-03	4.93E+03	7.98E-04	0	0	0	0	0
Futurecrete® N Class GP/GL:Slag 40 MPa	3.05E-03	6.14E+03	1.15E-03	0	0	0	0	0
Futurecrete® N Class GP/GL:Slag 50 MPa	3.84E-03	8.39E+03	1.62E-03	0	0	0	0	0
Futurecrete® S Class GP/GL:Slag 32 MPa	2.62E-03	4.95E+03	7.88E-04	0	0	0	0	0
Futurecrete® S Class GP/GL:Slag 40 MPa	3.03E-03	6.12E+03	1.14E-03	0	0	0	0	0
Futurecrete® S Class GP/GL 32 MPa	3.33E-03	7.07E+03	7.91E-04	0	0	0	0	0
Futurecrete® S Class GP/GL 40 MPa	3.92E-03	8.77E+03	1.15E-03	0	0	0	0	0
Futurecrete® S Class GP/GL:FA 32 MPa	2.65E-03	4.96E+03	6.82E-04	0	0	0	0	0
Futurecrete® S Class GP/GL:FA 40 MPa	3.11E-03	6.15E+03	1.09E-03	0	0	0	0	0
Futurecrete® S Class GP/GL:Slag 50 MPa	3.84E-03	8.48E+03	1.82E-03	0	0	0	0	0
Futurecrete® Special GP/GL:Slag 40 MPa 4D 85/60	2.69E-03	5.54E+03	1.23E-03	0	0	0	0	0

Table 15 | Additional Environmental Impact of Product Stage (A1 – A3)

ADDITIONAL ENVIRONMENTAL OUTPUTS	GWP-GHG	PM	IRP	ETP - fw	HTP - c	HTP - nc	SQP
Product Group	kg CO^2 eq	disease incidence	kBq U-235 eq	CTUe	CTUh	CTUh	Pt
Adbri N Class GP/GL 20 MPa	1.93E+02	9.12E-06	1.09E-01	1.47E+03	5.24E-08	2.71E-06	6.56E+02
Adbri N Class GP/GL 25 MPa	2.13E+02	9.91E-06	1.16E-01	1.62E+03	5.76E-08	3.00E-06	7.23E+02
Adbri N Class GP/GL 32 MPa	2.32E+02	1.07E-05	1.23E-01	1.76E+03	6.25E-08	3.27E-06	7.87E+02
Adbri N Class GP/GL 40 MPa	2.80E+02	1.26E-05	1.41E-01	2.12E+03	7.51E-08	3.98E-06	9.49E+02
Adbri N Class GP/GL 50 MPa	3.74E+02	1.63E-05	1.75E-01	2.82E+03	9.95E-08	5.34E-06	1.26E+03
Futurecrete® N Class GP/GL:FA 20 MPa	1.57E+02	8.21E-06	9.86E-02	1.21E+03	4.35E-08	2.15E-06	5.35E+02
Futurecrete® N Class GP/GL:FA 25 MPa	1.72E+02	8.87E-06	1.05E-01	1.32E+03	4.75E-08	2.37E-06	5.87E+02
Futurecrete® N Class GP/GL:FA 32 MPa	1.87E+02	9.52E-06	1.11E-01	1.44E+03	5.15E-08	2.59E-06	6.38E+02
Futurecrete® N Class GP/GL:FA 40 MPa	2.25E+02	1.11E-05	1.25E-01	1.72E+03	6.14E-08	3.13E-06	7.63E+02
Futurecrete® N Class GP/GL:FA 50 MPa	2.99E+02	1.45E-05	1.54E-01	2.28E+03	8.11E-08	4.18E-06	1.01E+03
Futurecrete® N Class GP/GL:Slag 20 MPa	1.52E+02	7.54E-06	9.17E-02	1.14E+03	4.07E-08	2.06E-06	5.04E+02
Futurecrete® N Class GP/GL:Slag 25 MPa	1.67E+02	8.14E-06	9.71E-02	1.25E+03	4.45E-08	2.27E-06	5.53E+02

Table 15 (cont.) | Additional Environmental Impact of Product Stage (A1 – A3)

ADDITIONAL ENVIRONMENTAL OUTPUTS	GWP-GHG	PM	IRP	ETP - fw	HTP - c	HTP - nc	SQP
Product Group	kg CO^2 eq	disease incidence	kBq U-235 eq	CTUe	CTUh	CTUh	Pt
Futurecrete® N Class GP/GL:Slag 32 MPa	1.82E+02	8.70E-06	1.02E-01	1.36E+03	4.80E-08	2.48E-06	5.99E+02
Futurecrete® N Class GP/GL:Slag 40 MPa	2.18E+02	1.02E-05	1.15E-01	1.62E+03	5.72E-08	2.99E-06	7.16E+02
Futurecrete® N Class GP/GL:Slag 50 MPa	2.88E+02	1.29E-05	1.39E-01	2.13E+03	7.46E-08	3.97E-06	9.39E+02
Futurecrete® S Class GP/GL:Slag 32 MPa	1.81E+02	8.68E-06	1.02E-01	1.36E+03	4.80E-08	2.48E-06	5.97E+02
Futurecrete® S Class GP/GL:Slag 40 MPa	2.17E+02	1.01E-05	1.14E-01	1.62E+03	5.70E-08	2.98E-06	7.12E+02
Futurecrete® S Class GP/GL 32 MPa	2.43E+02	1.12E-05	1.25E-01	1.82E+03	6.42E-08	3.37E-06	8.05E+02
Futurecrete® S Class GP/GL 40 MPa	2.95E+02	1.33E-05	1.43E-01	2.20E+03	7.73E-08	4.10E-06	9.72E+02
Futurecrete® S Class GP/GL:FA 32 MPa	1.88E+02	9.60E-06	1.11E-01	1.45E+03	5.18E-08	2.60E-06	6.39E+02
Futurecrete® S Class GP/GL:FA 40 MPa	2.26E+02	1.13E-05	1.26E-01	1.73E+03	6.18E-08	3.14E-06	7.66E+02
Futurecrete® S Class GP/GL:Slag 50 MPa	2.91E+02	1.31E-05	1.40E-01	2.15E+03	7.56E-08	4.02E-06	9.51E+02
Futurecrete® Special GP/GL:Slag 40 MPa 4D 85/60	1.95E+02	1.16E-05	2.08E+03	1.64E+03	1.62E-05	5.52E-05	6.37E+02

Acronyms: GWP-GHG = Global warming potential, excluding biogenic uptake, emissions and storage; PM = Particulate matter; IRP = Ionising radiation - human health; ETP - fw = Ecotoxicity - freshwater; HTP - c = Human toxicity potential - cancer effects; HTP - nc = Human toxicity potential - non cancer effects; SQP = Soil quality.

LCA results for Distribution stage (Module A4)

Table 16 | Potential environmental impacts of Distribution stage (A4)

POTENTIAL ENVIRONMENTAL IMPACTS	GWP-fossil	GWP-biogenic	GWP-luluc	GWP-total	ODP	AP	EP freshwater	EP freshwater	EP-marine	EP terrestrial	POCP	ADP-minerals & metals	ADP-fossil fuels	WDP
Product group	kg CO_2 eq.	kg CO_2 eq.	kg CO_2 eq.	kg CO_2 eq.	kg CFC 11 eq.	mol H^+ eq.	kg PO_4^{3-} eq.	kg P eq.	kg N eq.	mol N eq.	kg NMVOC eq.	kg Sb eq.	MJ	m^3 deprived
Concrete produced at South Australia	9.64	0.00	1.65E-05	9.64	1.78E-07	0.05	0.00	8.60E-05	0.01	0.15	0.05	8.16E-06	17.88	28.14

Acronyms: GWP-fossil = Global Warming Potential fossil fuels; GWP-biogenic = Global Warming Potential biogenic; GWP-luluc = Global Warming Potential land use and land use change; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP-freshwater = Eutrophication potential, fraction of nutrients reaching freshwater end compartment; EP-marine = Eutrophication potential, fraction of nutrients reaching marine end compartment; EP-terrestrial = Eutrophication potential, Accumulated Exceedance; POCP = Formation potential of tropospheric ozone; ADP-minerals&metals = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion for fossil resources potential; WDP = Water (user) deprivation potential, deprivation-weighted water consumption

Table 17 | Resource use of Distribution stage (A4)

RESOURCE USE	PERE	PERM	PERT	PENRE	PENRM	PENT	SM	RSF	NRSF	FW
Product Group	MJ	MJ	MJ	MJ	MJ	MJ	kg	MJ	MJ	m^3
Concrete produced at South Australia	0.36	0.00	0.36	18.64	0.00	18.64	0.00	0.00	0.00	0.01

Acronyms: PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

Table 18 | Waste and output flows of Distribution stage (A4)

WASTE CATEGORIES AND OUTPUT FLOWS	Hazardous waste disposed	Non-hazardous waste disposed	Radioactive waste disposed	Components for re-use	Material for recycling	Materials for energy recovery	Exported energy, electricity	Exported energy, thermal
Product Group	kg	kg	kg	kg	kg	kg	MJ	MJ
Concrete produced at South Australia	3.73E-05	4.90E-01	1.96E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 19 | Additional Environmental Impact of Product Stage (A4)

ADDITIONAL ENVIRONMENTAL OUTPUTS	GWP-GHG	PM	IRP	ETP - fw	HTP - c	HTP - nc	SQP
Product Group	kg CO^2 eq	disease incidence	kBq U-235 eq	CTUe	CTUh	CTUh	Pt
Concrete produced at South Australia	9.52E+00	7.98E-07	1.37E-03	2.14E+02	2.40E-09	1.47E-07	7.01E+00

Acronyms: GWP-GHG = Global warming potential, excluding biogenic uptake, emissions and storage; PM = Particulate matter; IRP = Ionising radiation - human health; ETP - fw = Ecotoxicity - freshwater; HTP - c = Human toxicity potential - cancer effects; HTP - nc = Human toxicity potential - non cancer effects; SQP = Soil quality.

7 Interpretation of results

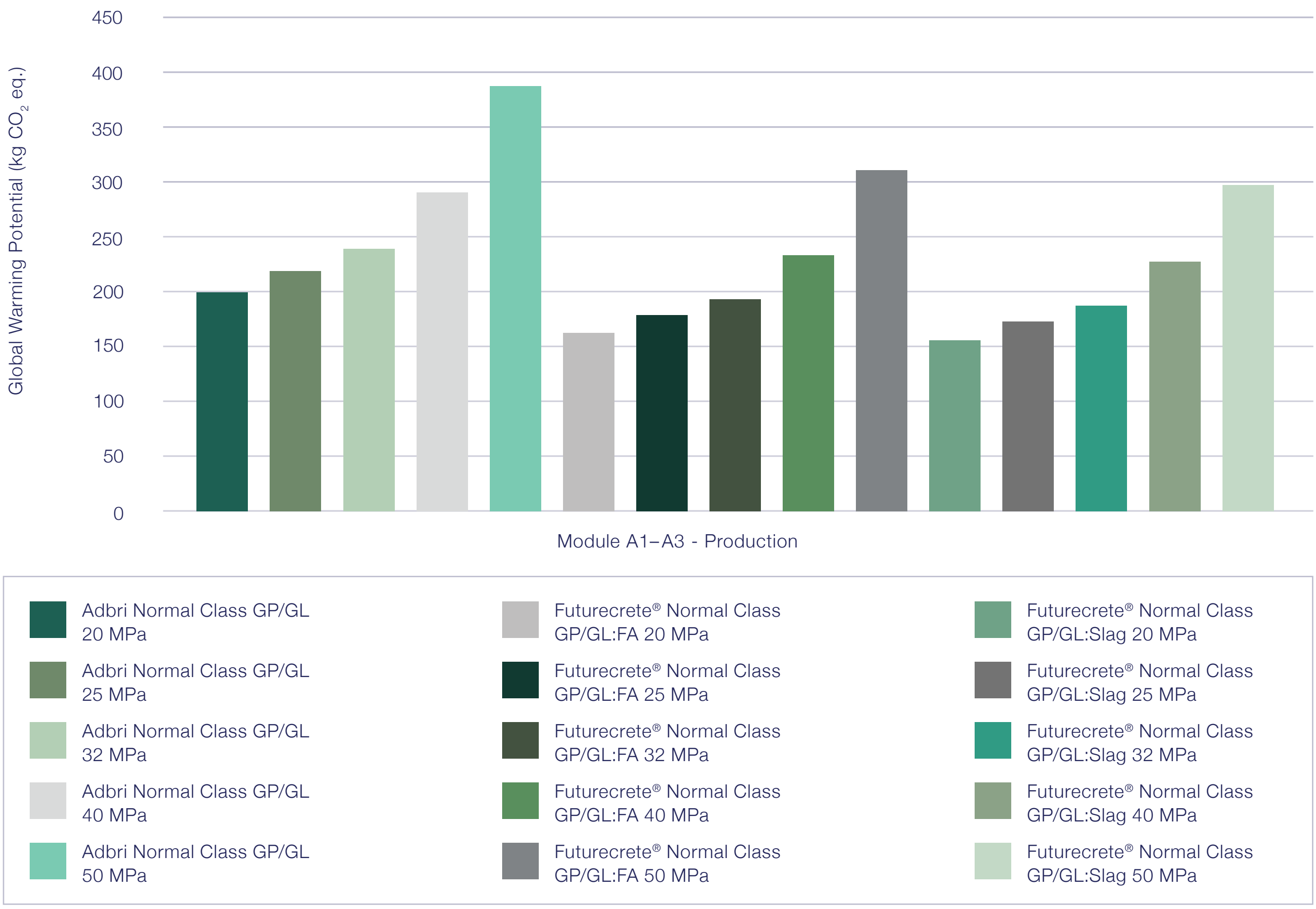
For Adbri concrete's environmental GWP, it is typical to identify the product you are seeking for its normal versus special class, SCM replacement levels which Adbri have branded as Adbri, Futurecrete® and Futurecrete® Ultra concrete and use the Cradle to Gate (A1-A3) GWP total number expressed as kgCO_2eq. For additional information pertaining to the transport to site component, for your convenience, Adbri have calculated the data and therefore the GWP number for transport A4 should be added to the A1-A3 GWP value.

Example: John from ABC construction is ordering 32 MPa Futurecrete Ultra concrete and he has established from table 12 that the GWP is 188.35kgCO_2eq. As John's preference is to have the calculation he has established from table 10 that he would need to add 9.64 kgCO_2eq to his final order.

Table 20 | Contributors to GWPT impacts of Adbri Normal Class Concrete in the different life cycle stages

	GWPT (kg CO_2 eq.)	
Product Group	**A1-A3 Production**	**A4 Distribution**
Adbri Normal Class GP/GL 20 MPa	199.92	9.64
Adbri Normal Class GP/GL 25 MPa	220.53	9.64
Adbri Normal Class GP/GL 32 MPa	240.20	9.64
Adbri Normal Class GP/GL 40 MPa	291.00	9.64
Adbri Normal Class GP/GL 50 MPa	389.23	9.64
Futurecrete® Normal Class GP/GL:FA 20 MPa	162.70	9.64
Futurecrete® Normal Class GP/GL:FA 25 MPa	178.52	9.64
Futurecrete® Normal Class GP/GL:FA 32 MPa	194.07	9.64
Futurecrete® Normal Class GP/GL:FA 40 MPa	233.63	9.64
Futurecrete® Normal Class GP/GL:FA 50 MPa	311.22	9.64
Futurecrete® Normal Class GP/GL:Slag 20 MPa	158.13	9.64
Futurecrete® Normal Class GP/GL:Slag 25 MPa	173.59	9.64
Futurecrete® Normal Class GP/GL:Slag 32 MPa	188.39	9.64
Futurecrete® Normal Class GP/GL:Slag 40 MPa	227.06	9.64
Futurecrete® Normal Class GP/GL:Slag 50 MPa	299.49	9.64

Figure 3 | Contributors to GWPT impacts of Adbri Normal, Futurecrete® and Futurecrete® Ultra Class Concrete in the different life cycle stages



Key findings of this LCA for all are:

Potential environmental impacts:

- 80 – 92% of GWP impacts come from product stage. Within the product stage, general purpose cement carries the highest impact, contributing up to 83% of total GWP.
- GP/GL cement is the highest GWP contributor (58-83%) in the product stage (module A1 – A3).
- The material (A1 and A2) is the largest contributor to the product stage's WDP (94%).
- Distribution (A4) accounts for approximately 2 – 5% of all potential impact categories.

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