CONCRETE
THE RESPONSIBLE CHOICE

CEMENT CONCRETE & AGGREGATES AUSTRALIA

concrete the responsible choice

Leading Knowledge-Sharing Information

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CONCRETE – THE RESPONSIBLE CHOICE

Concrete is, quite literally, the foundation upon which our modern societies and economies are built.

Without concrete and its constituent parts – sand, aggregate and cement – we would not have the roads, footpaths, bridges, schools, hospitals, homes and workplaces we take for granted.

In fact, a life without concrete is unimaginable. Next to water, it is the most consumed substance on the planet. Worldwide, three tonnes of concrete are used per person every year.

In Australia, the cement, concrete and aggregate industries are worth $7 billion in revenues to the economy, and contribute $11.7 billion to GDP. They underpin building and construction and are therefore critical to the health of our economy.

Concrete – the responsible choice is the story of this industry, its products and its commitment to sustainable development.

Thermal mass, durable, low-maintenance
aesthetic, flexible, secure
cost-effective, warmer-in-winter
cooler-in-summer, quiet, fire-resistant
strong, impact-resistant
energy-efficient, safe
non-toxic, fast-build
termite-proof, low-risk

CONCRETE FOR A SUSTAINABLE FUTURE

The World Commission on Environment and Development (WCED) defines sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs[1].

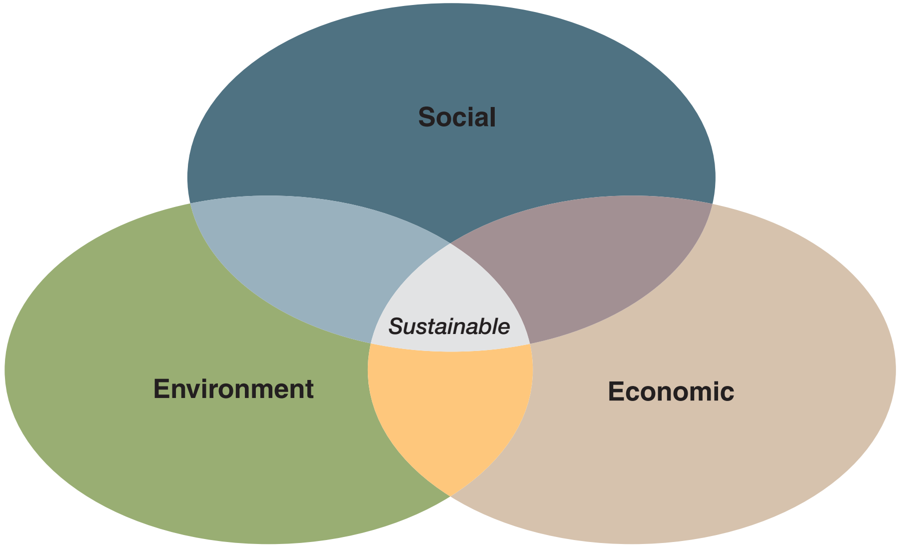
Sustainable development can be conceptually broken into three constituent parts – social, environmental and economic.

'Social' sustainability refers to the quality of life of individuals and their communities; 'environmental' references the management and preservation of our air, water, land and ecosystems; and 'economic' the level of prosperity for organisations and individuals.

'Sustainability' is achieved where all three of these parts overlap Figure 1.

The cement, concrete and aggregate industries are continually striving to ensure their processes and practices are consistent with the principles of sustainable development.

Figure 1 Sustainability depicted as the overlapping area between social, environmental and economic performance



Industry Fast Facts

- As part of the Australian Government's Greenhouse Challenge, the cement industry voluntarily reduced CO_2 emissions by 23% between 1991 and 2009.
- Town water used in premixed concrete, extractive industries and cement production has fallen as a result of increasingly sophisticated water-recycling initiatives.
- In 2008/09, the concrete industry supplied close to 24 million cubic metres of concrete – enough to build 293 Eureka Towers or three-quarters of a million house floor slabs.
- The industry has actively promoted the contribution that concrete makes to energy efficient building design, by way of its thermal mass qualities.
- The industry directly and indirectly employs nearly 100,000 Australians.
- It contributes nearly $12 billion to Australia's GDP.
- The industry has continuously improved its workplace safety record.
- Across the industry there has been an increased uptake of environmental management systems.

Notes 1 Bruntland Report World Commission on Environment and Development 1987

What is concrete?

In its simplest form, concrete is a mixture of cement, aggregates (rock and/or sand) and water. The cement and water react in a chemical process known as hydration, binding the other ingredients together as the compound hardens. The resulting rock-like mass is concrete.

Coupled with these industry achievements, the end-product, concrete, makes a significant contribution to sustainability through its various properties and in its applications.

- Concrete is fire-resistant, flood resilient, termite-resistant, robust and strong.
- It is manufactured from abundant and readily available materials – cement, aggregates and water.
- It is durable. Concrete structures are incredibly long lasting – we still have examples from Roman times.
- It is inert and non-toxic. Its chemical composition is void of known carcinogens such as volatile organic compounds and formaldehyde.
- It has high thermal mass, helping to reduce household and building energy consumption.
- It reduces sound transmission – making for quieter homes and buildings.
- It affords design flexibility. In its fluid or 'plastic' state, it can be moulded to just about any form.
- A wide range of finishes can be achieved.
- Its use can negate the need for additional finishing (eg plasterboard linings, painting or floor coverings) – supporting the important concept of dematerialisation.
- It can be manufactured to a wide range of technical specifications to suit just about any application.
- It is low-cost.
- It is recyclable. Concrete can be recycled into road base materials for paving construction, or recycled as concrete aggregate.
- It is manufactured in towns and suburbs Australia-wide, close to its markets, supporting jobs and reducing transport impacts.
- The use of natural sand in concrete can be replaced by manufactured sand.

CONCRETE THROUGH THE AGES, FOR THE AGES

Concrete has had a huge impact on the rise of civilisation across the millennia.

One of the oldest examples was found on the banks of the River Danube. Here, fishermen's huts dating back to 5600 BC used a form of concrete – a red lime glue – to bind stone together.

Later the Egyptians, followed by the Greeks and Romans, used various forms of natural 'cement'. The Egyptians favoured mixtures of lime, gypsum and water, while the Greeks and Babylonians used lime, clay and water.

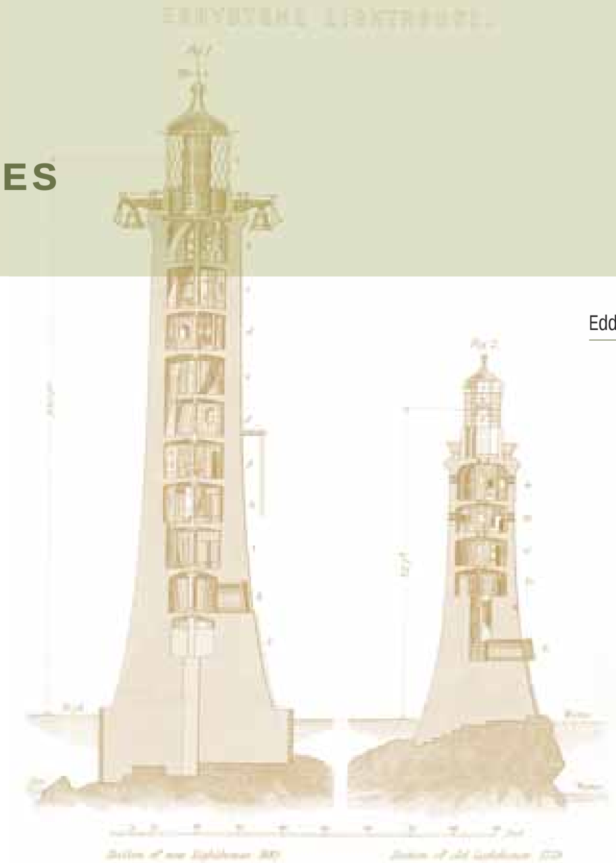
The Romans went a step further, using a natural pozzolan sourced from near Mount Vesuvius, together with lime and water, to build sewers, water pipes, baths, piers, breakwaters, aqueducts and other fine structures. On many of these structures concrete was used as an infill between outer skins of masonry or stone, thus adding both strength and weight to the structure.

In more recent times, the story of concrete is closely related to the development of portland cement. In 1824, Joseph Aspdin, a bricklayer from Leeds, took out a patent for Portland Cement, so named for its resemblance to the stone quarried on the Isle of Portland.

But others had been working on similar products well ahead of Aspdin. One of these was an engineer called John Smeaton, who some 60 years earlier developed cement that would set under water. This was used to build the Eddystone Lighthouse off the coast of Cornwall in 1756. (The lighthouse was moved to Plymouth Hoe in 1882, where it remains to this day.)

In Australia, two of the earliest examples of concrete construction are the Lamington Bridge at Maryborough, Queensland, and a sewage aqueduct at Forest Lodge, NSW – both dating from 1896. Since then concrete has gone through many development phases, resulting in the product we know today.

It enjoys a reputation for durability, efficiency, cost effectiveness and architectural flexibility that is unmatched by any other material.



Eddystone Lighthouse (1756)

Sydney (2010)

As concern for the future of our planet has grown, so too has our understanding of the importance of sustainable development and construction. Buildings are one of the heaviest consumers of natural resources, and account for a significant proportion of energy consumption and greenhouse gas emissions. In fact, the building sector is responsible for around 40% of global energy consumption and over 30% of global greenhouse emissions[2].

Achieving sustainable development requires methods and tools to help quantify and compare the environmental impacts of creating and providing the goods and services used by our society.

Every product has a 'life'. It starts with design/development and continues through various stages – resource extraction, production of materials, manufacturing and/or provision of the product, use/consumption, and finally end-of-life activities (collection/sorting, reuse, recycling, waste disposal). All of these stages, or processes, have environmental consequences.

Life Cycle Assessment (LCA)

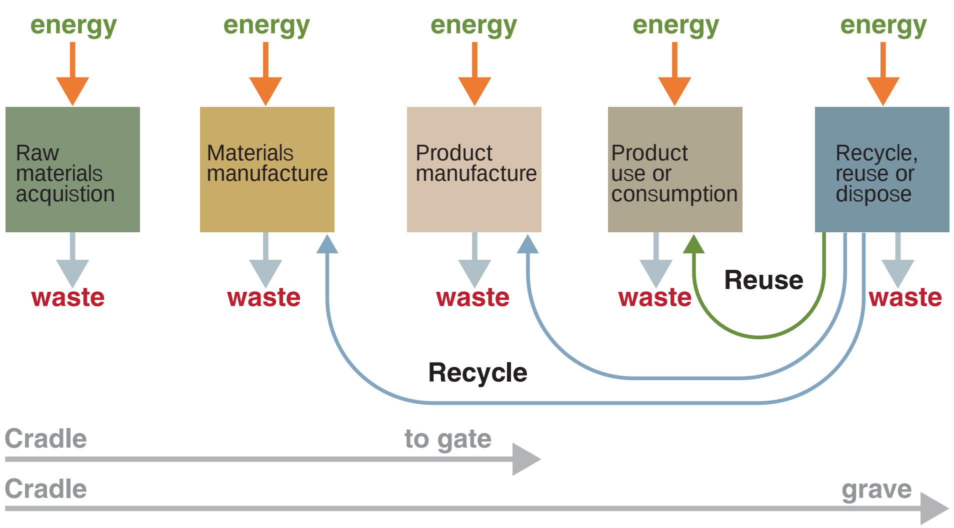
Life Cycle Assessment (LCA) is a tool that can be used to examine the environmental impact of any building system or product.

To be truly meaningful, an LCA must be 'cradle to cradle' (ie from the time the resources are first removed from the ground, through their manufacturing stage, considering their effect on the operational impact of the building, to when they are recycled and reused in material manufacture at the end of the system or product's life). An LCA must account for all relevant effects of the system or product on the energy and emissions associated with the building throughout its life, ie an LCA must consider "whole of building – whole of life".

Sometimes, data is collected for only part of the life-cycle, for example from "cradle to the factory gate" Figure 2. It must be recognized that, while this is useful information (available for use in a full LCA), it is only part of the story. "Cradle-to-gate" information cannot account for the intrinsic environmental benefits such as thermal mass, ease of recycling, economic sustainability and the like. The real benefits of these properties become apparent only in a full "whole of building – whole of life" LCA.

Across industry, environmental impacts are being measured in many ways – upstream during the manufacturing process and downstream, and also how products are designed, built and operated. However, when viewed in isolation the assessment of a single stage or process tells us very little about the overall environmental impact of the product. Each stage should be judged in the context of an overall assessment of the product in the context of the whole building during the whole of the life cycle.

Figure 2 LCA – Holistic measurement of environmental impact



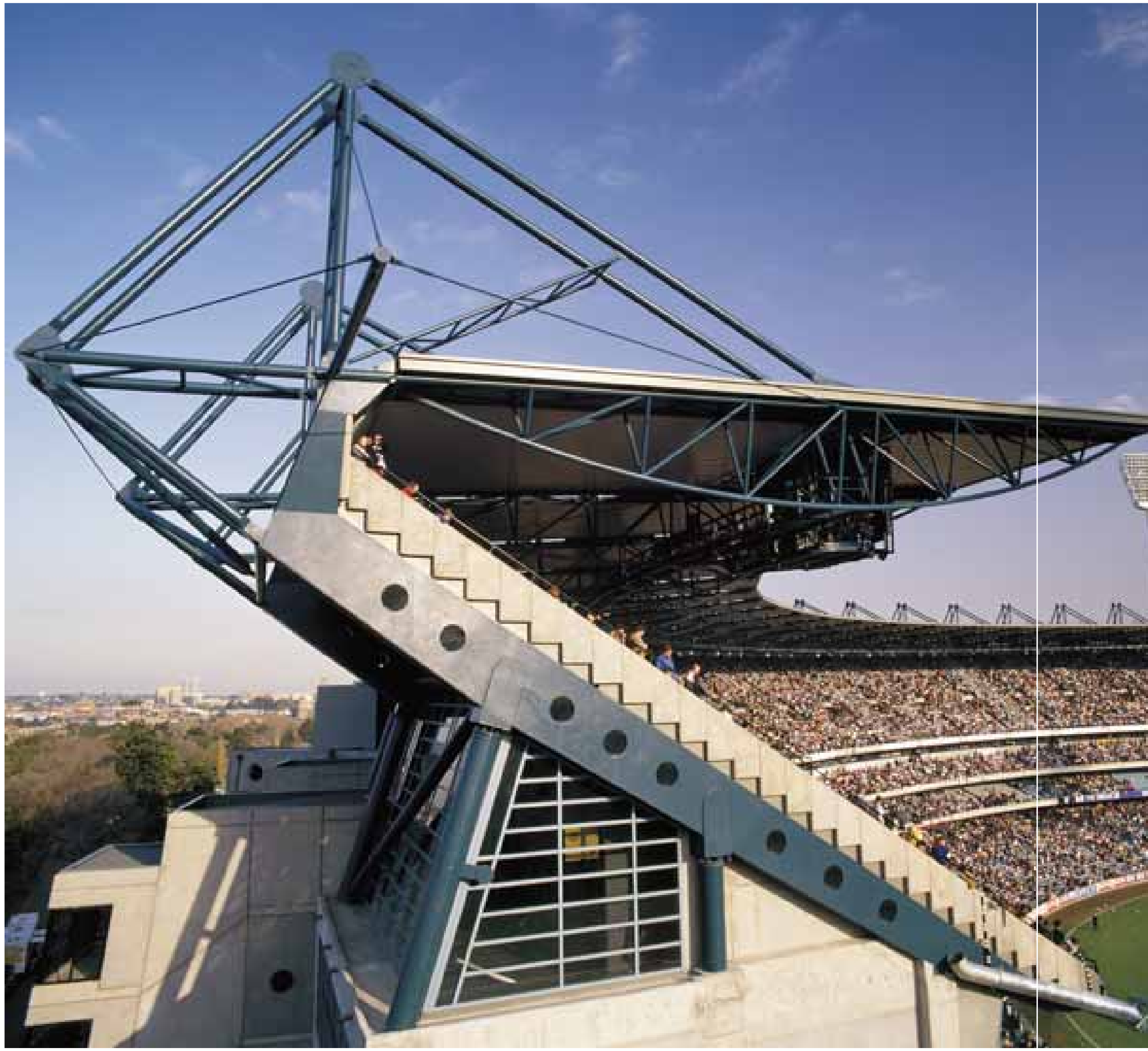
Relevant environmental impacts include greenhouse effect, ozone depletion, heavy metals, nutriphication, acidification, carcinogenesis, summer smog and winter smog, water usage, the depletion of resources, land use – and others. The measured quantities may be counted in the life cycle inventory when they pass through the system boundary. The collection of LCA information can be summarised as the quantification of inputs and outputs to a system. Both the inputs and outputs can have environmental impacts Figure 3.

The procedures to carry out an LCA assessment involve:

- defining and describing the product or process, establishing fully the context in which the assessment is being made;
- identifying all of the life cycle stages (raw materials extraction, manufacture, transport, construction, operational effect, demolition and recycling);
- evaluating and quantifying the energy, water and materials usage and the environmental releases at each stage;

Notes 2 UNEP Sustainable Buildings and Climate Initiative, Common Carbon Metric for measuring Energy Use & Reporting Greenhouse Gas Emissions from Building Operations, 2010. Reported in Public Discussion Paper: National Building Energy Standard-Setting, Assessment and Rating Framework National Strategy on Energy Efficiency, March 2010.

Melbourne, Victoria



Great Southern Stand, Melbourne Cricket Ground
Photograph John Gollings

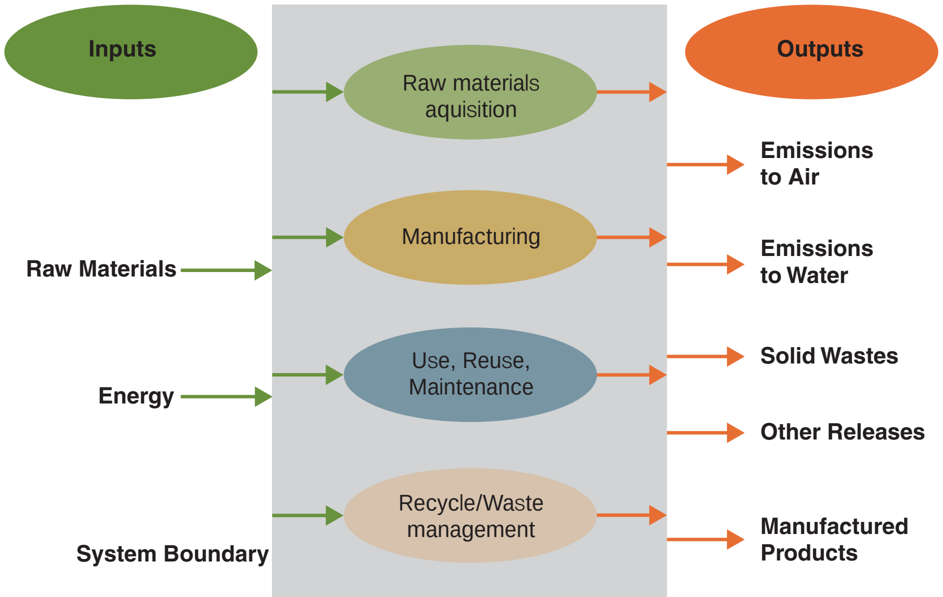
- determining the impacts of the release and developing opportunities to effect environmental improvements;
- summing all of the impacts, to gain an overall view of the total environmental impact over the whole of the building during the whole of its life.

LCA Case Studies

The results of a series of comprehensive LCA case studies have been published on Cement Concrete & Aggregates Australia's website, www.ccaa.com.au. These studies were carried out for CCAA by the Department of Services, Technology and Administration (formerly the NSW Department of Public Works and Services) to demonstrate the use of LCA as a tool for assessing and comparing the environmental impact of buildings over their entire life cycle.

The case studies were conducted on a detached house, an office building and a

Figure 3 Schematic diagram of the LCA process and system boundary



warehouse, with each study examining a range of construction material options to provide an overall comparative assessment of the performance of the different materials in the context of the fully functioning building.

LCAid™, developed by the Department of Commerce's own Environmental Services group, was used to conduct the studies. This software tool allows building designers to evaluate the environmental performance and impacts of designs and options over the whole life cycle of a building.

House

The study on the detached house Figure 4 revealed that the energy used to produce materials to make the house itself (embodied energy) was generally less than 10 per cent of the operational energy (energy used to heat and cool, provide lighting, heat water and run other appliances and refrigeration) over a fifty-year life (Figure 5).

Note: The operational energy impact became even more significant when a longer life cycle of 100 years was considered.

Facade

Figure 4 House Case Study – Optimised Floor Plan

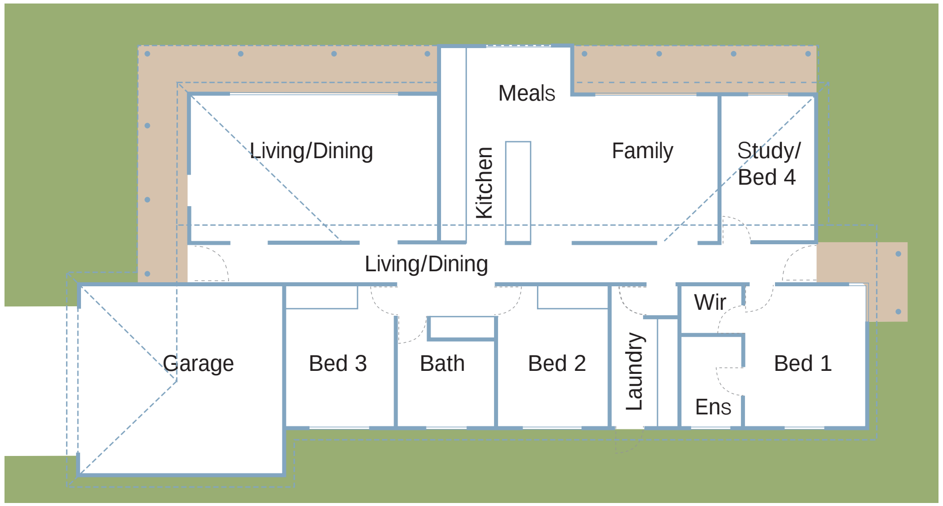


Figure 5 House Case Study – Embodied and Operational Energy

Energy used during a house's 50-year lifecycle

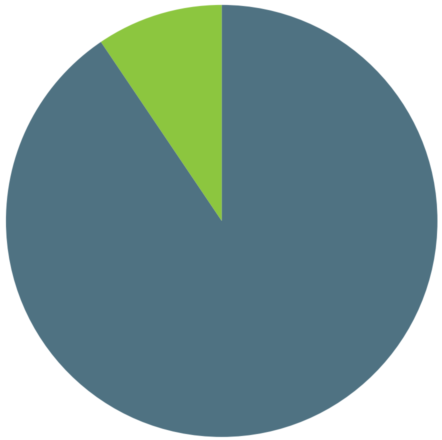
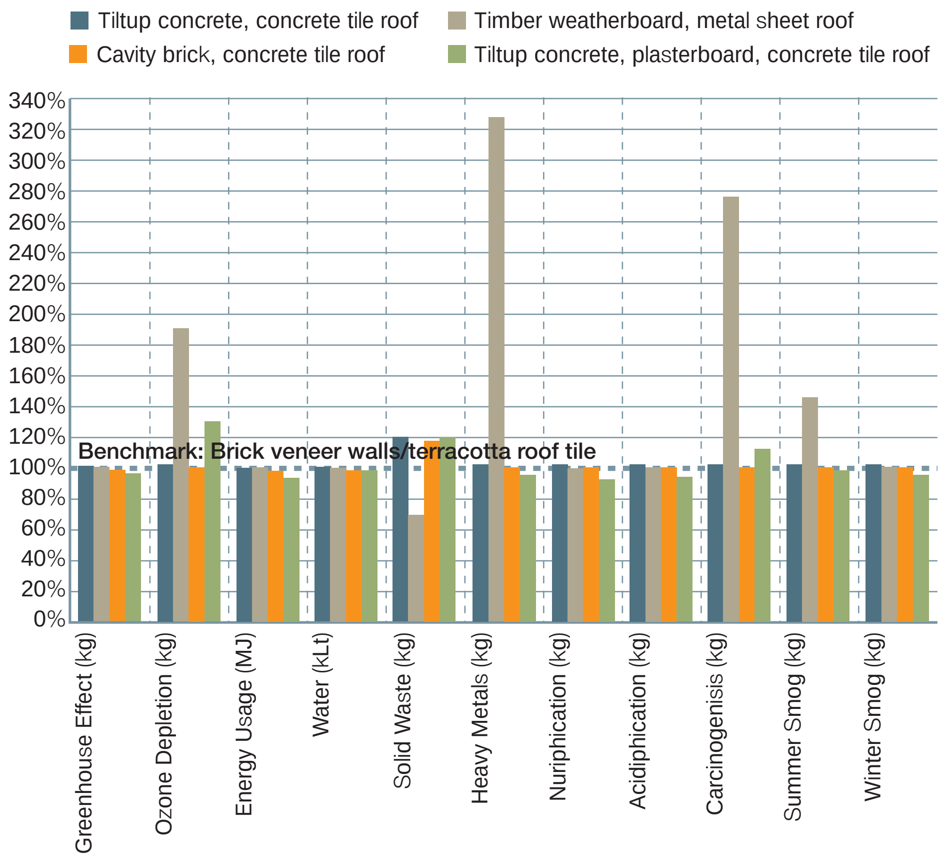


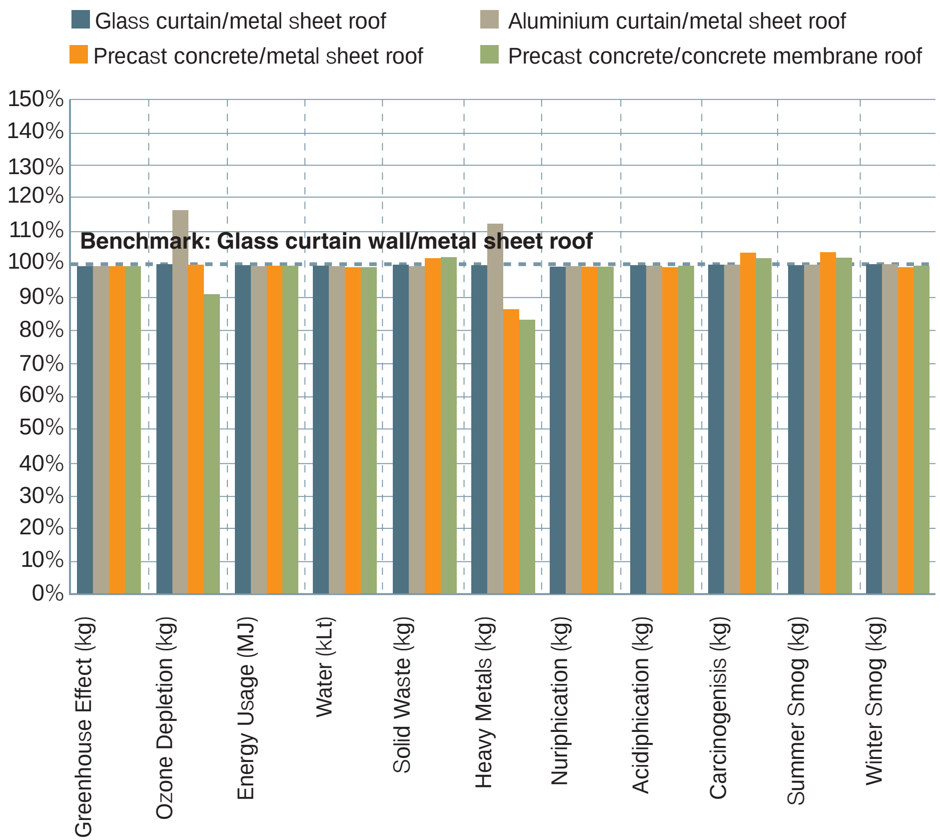
Figure 6 Environmental impact of different building material solutions for the detached house case study



Office Building

The office building life cycle assessment was conducted on a structure comprising 20 storeys of office space, 2 basement levels of car parking and a net lettable area per floor of 1323 m².

Figure 7 Environmental Impact – office building case study



Warehouse

The warehouse life cycle assessment was conducted on building that included a small office mezzanine and a net floor area of 12,558 m^2.

Figure 8 Environmental impact – warehouse case study

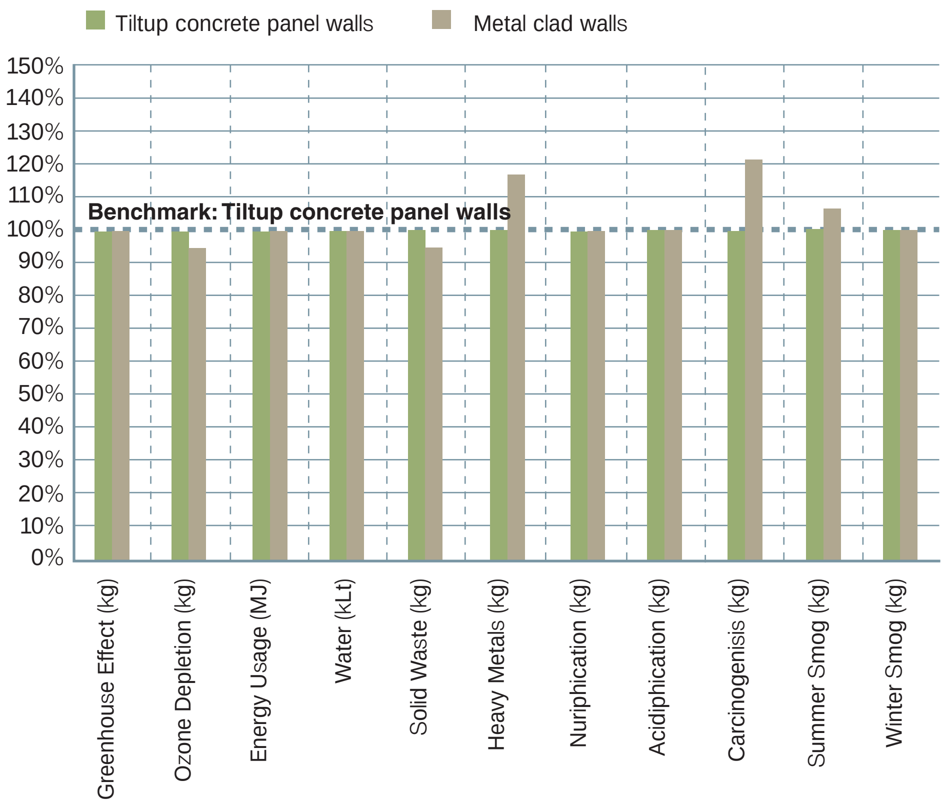
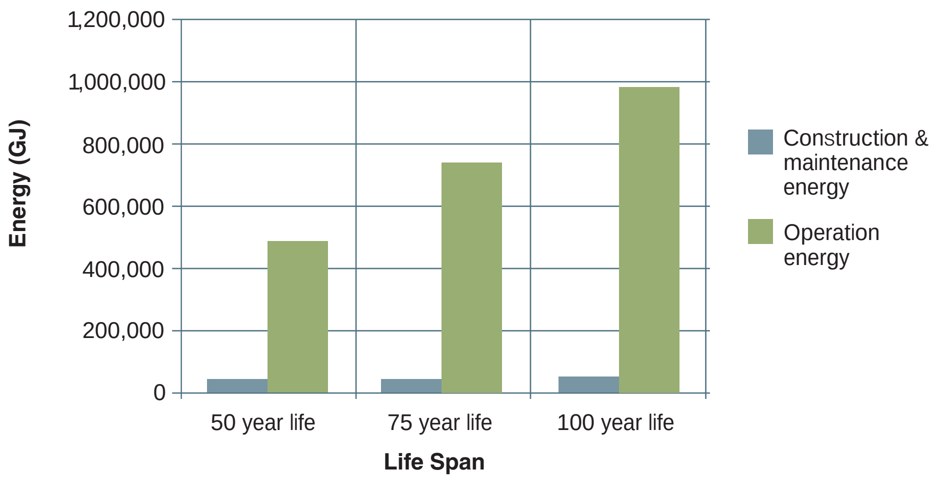


Figure 9 Sensitivity Analysis of construction and operation over various lifecycles – Commercial



Case study key findings

The case studies found that operation of the buildings over their projected lives had a far greater impact than the choice of building materials, which alone had only a very small impact.

In particular, the LCA case studies established that:

- there is no significant difference between the alternative constructions for each of the three building types studied (detached house, office building and warehouse building) in terms of the common environmental indicators (energy and greenhouse gas emissions);
- a building's environmental assessment cannot be based on just one or two indicators;
- examination of only the building materials or the building operation alone will not give an accurate measure of the building's environmental performance;
- operation of the building dominates most of its environmental indicators; the choice of building materials alone has a lesser impact; and
- LCA gives a broader view and hence a more balanced appraisal of the environmental performance of buildings and their materials.

From a concrete perspective, the case studies confirm that cement and concrete-based construction of houses, commercial and industrial buildings provides good environmental performance.

The CCAA work in this area to date represents a major contribution to the ongoing understanding of sustainable development. Perhaps more importantly, the studies underline the need for regulators and consumers to take a broader "whole of building – whole of life" view, and hence a more balanced appraisal of the environmental performance of buildings and their materials.

Passive Solar Design and Thermal Mass

Life cycle assessment shows that the majority of energy consumed by a building occurs during the occupancy phase of its life, ie operational energy.

A universally accepted method for reducing the energy required to 'run' a house or building is to apply passive solar principles in the design and construction processes.

One of the most important aspects of this approach is in the use of durable, long-life materials with high thermal mass.

It has been reported that the use of heavyweight materials, such as concrete, with innate thermal mass, is one of the most effective ways of minimising greenhouse gas emissions[3]. The whole of life CO_2 savings provided by the appropriate use of thermal mass can far outweigh any increase in embodied impacts resulting from the use of concrete[4].

These materials work by absorbing, storing and then releasing heat in response to internal temperature changes in the house or building. This process of absorption, storage and release helps to stabilise conditions inside the building, reducing the requirement for energy-consuming air conditioning or heating.

Notes 3 Arup reports (2005) as cited in Can we afford not to build affordable homes out of concrete? www.allbusiness.com/manufacturing/nonmetallic-mineral-product-manufacturing/1142576-1
4 Sustainable Concrete – The Concrete Centre www.sustainableconcrete.org.uk/

Kew House Photograph Peter Bennetts

For a material to provide a useful level of thermal mass a combination of three basic properties is required[4]:

- High specific heat capacity – to maximise the heat that can be stored per kg of material.
- High density – to maximise the overall weight of the material used.
- Moderate thermal conductivity – so that heat conduction is roughly in synchronisation with the diurnal heat flow in and out of the building.

Concrete satisfies all three properties Figure 10.

To be most effective in terms of its thermal mass qualities, the use of concrete needs to be integrated with other sound passive solar design principles.

For example, simple design interventions such as north orientation (in southern hemisphere) and correct siting of thermal mass in the building can significantly reduce energy consumption.

Cool in summer, warm in winter

Buildings that utilise thermal mass in conjunction with these broader passive solar design principles are making a positive contribution to the environment, both in the short and long term, by reducing the consumption of energy derived from fossil fuels, all year round.

Cooler in summer

In summer, thermal mass works effectively in tandem with other passive solar design principles, such as natural ventilation and solar shading. During the day, the mass in concrete walls and floors absorbs the radiant heat from outside to help stabilise the internal temperature. At night, as the external air temperature drops, natural ventilation effectively removes this accumulated heat.

To be most effective, concrete floor slabs and walls must be thermally exposed to allow heat to move freely between the internal environment and the concrete[5].

Warmer in winter

In Australia, solar energy – entering through walls and windows – provides a significant component of heating in homes. This can be increased by virtue of thermal mass and passive solar design principles, including larger, north-facing windows combined with a medium-to-high level of thermal mass.

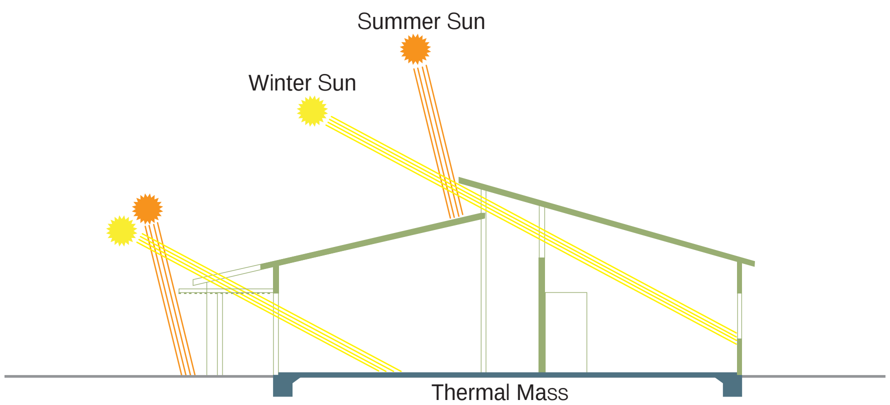
During the day concrete acts as a heat bank, storing solar energy. At night, as the temperature drops, this stored heat is slowly released, reducing the need for artificial heating[6].

Figure 10 Thermal properties of common construction materials

Building material	Density (kg/m^3)	Thermal conductivity (W/mK)	Specific heat capacity (J/kg.K)	Effective thermal mass
Timber	500	0.13	1600	Low
Steel	7800	50	450	Low
Lightweight aggregate block	1400	0.57	1000	Medium-high
Precast and in situ concrete	2300	1.75	1000	High
Brick	1750	0.77	1000	High
Sandstone	2300	1.8	1000	High

Source: Concrete Centre – Thermal Mass Explained

Figure 11 Solar Access



Notes
5 Thermal Mass www.sustainableconcrete.org.uk/main.asp?page=113 viewed 26 March 2010
6 Ibid

Case Study:
Thermo House, Victoria.

An example of a low energy building is Thermo House, Toorak, Victoria.

The predominantly concrete Thermo House is a three-level residence that showcases the benefits of high thermal mass. The architects have achieved a feeling of lightness with heavyweight materials through careful management of proportioning and finishing of the building envelope.

The principal concrete structural elements are Thermomass, insulated concrete sandwich panel walls, and Hollowcore, precast concrete planks for floor and roof slabs.

The home provides a high comfort level, requiring minimal heating and no cooling, except during extreme climatic conditions, due to the temperature lag of the system, and the ability of the exposed internal mass to absorb and release excess energy as required.

This project exemplifies the potential for low energy designs and the significant operational cost savings that can be achieved through harnessing the thermal properties of solid concrete construction.

Thermo House, Victoria

CONCRETE, SUSTAINABILITY AND THE BUILT ENVIRONMENT

The inherent qualities and unrivalled benefits of concrete make it an ideal choice for sustainable housing and other buildings.

Sustainable developments have been defined as:

> Places where people want to live and work, now and in the future. They meet the diverse needs of existing and future residents, are sensitive to their environment and contribute to a high quality of life. They are safe and inclusive, well planned, built and run and offer equality of opportunity and good services for all[7].

Concrete contributes to sustainable living on a number of levels.

Indoor air quality and safe living

Increasingly, exposed concrete finishes are a design feature of modern dwellings – thick walls, floors and, in more recent times, furniture.

The beauty of concrete in these applications is that it not only looks good, but it is inert and non-toxic. Its chemical composition is void of known carcinogens, such as volatile organic compounds and formaldehyde. Its use can therefore contribute to a healthier indoor air quality, as well as help to reduce the incidence of sick-building syndrome[8].

Dematerialisation

The term 'dematerialisation' describes the process of using fewer materials to maintain or improve a product or service – essentially 'doing more with less'. Because it can simultaneously satisfy both structural and aesthetic needs off-form concrete makes a considerable contribution to dematerialisation. For example, a polished concrete floor negates the need for carpets or floating timber flooring; an off-form wall can 'stand alone' as a design feature without the need for painting.

Thermal mass

The thermal mass of concrete can be harnessed in design to contribute to the energy efficiency of a building, both in residential and commercial construction (see Passive Solar Design and Thermal Mass page 9.)

Acoustics

Apart from delivering thermal benefits, the 'mass' of concrete also acts to reduce the transmission of sound – be it sourced from neighbours, traffic, nature or plant and equipment. Innovative composite systems, combining the performance of concrete with other materials, can economically achieve levels of sound insulation performance far exceeding expectations.

Vibration

When designed and detailed in accordance with well established principles, concrete walls and floors are particularly good at resisting vibration.

Sea Cliff Bridge, NSW

Notes

7 Maliene V, Howe J and Malys N (2008). 'Sustainable communities: affordable housing and socio-economic relations' Local Economy 23 (4) pp 267–276. McDonald S, Malys N and Maliene V (2009). 'Urban regeneration for sustainable communities: a case study' Technologic and Economic Development of Economy 15 (1) pp 49–59.

8 Social Credentials, Sustainable Concrete, <http://www.sustainableconcrete.org.uk/main.asp?page=94> viewed 26 March 2010

National Portrait Gallery, Canberra

Fire resistance

Concrete structures provide excellent structural adequacy, integrity and insulation when subjected to fire. When designed appropriately, concrete structures can provide fire resistance well in excess of the required Fire Resistance Levels (FRLs) specified in the Building Code of Australia and AS 1530.4[9].

Bushfire resistance

Bushfires are the most common and devastating natural disasters in Australia, resulting in loss of life and property. Houses on bushland fringes of urban areas, or individual rural dwellings, face the greatest potential exposure to bushfire. However, houses more than a kilometre away can be threatened by wind-borne burning debris.

Concrete both insulates and resists structural deformation and failure when exposed to bushfire. Even at high temperatures, it does not fail dramatically. Its unique thermal properties protect reinforcing steel and prestressing steel[10]. Concrete, unlike many composite manufactured building products, does not emit toxic fumes when subjected to high/extreme temperatures[11].

Designers can be confident that concrete buildings will meet the bushfire requirements of the Building Code of Australia and AS 3959, the Australian Standard for building in bushfire-prone areas[12].

Notes 9 AS 1530.4-2005 Methods for fire tests on building materials, components and structures Part 4: Fire-resistance test of elements of construction 10 The Fire Resistance of Concrete Concrete Construction, Dec 2004, Bernard Erlin, William Hime http://findarticles.com/p/articles/mi_mONSX/is_12_49/ai_n8590878/, viewed 26 March 2010 11 Concrete and Sustainability: An Introduction Cement Concrete & Aggregates Australia n.d.
12 Building in bushfire-prone sites, Cement Concrete & Aggregates Australia, 2005

The population challenge

The world population is expected to increase by almost 2 billion between 2000 and 2030[15], placing huge demands on the natural environment. In the context of increased construction activity, the durability of concrete will be ever more important to ensure the overall impact on our natural resources is minimised.

Case Study – High-rise addition

Condor Tower, a 29-level residential high-rise building in Perth's CBD, is a good example of sustainable building practice in action. It has quite literally 'grown off the back' of an existing10-storey office complex, with the old building structure re-used and incorporated into the new building design.

In effect, the old structure has been recycled into something economically and socially viable. At the same time, the project clearly demonstrates the cost-efficiency, speed and versatility of concrete in projects such as this.

The Roman Pantheon 125 AD – a true testament to concrete's enduring qualities

Durability

Concrete is a byword for durability. It has an innate ability to withstand expected wear and deterioration throughout its intended life, with only minimal maintenance[13].

The longer a product lasts and the less maintenance it requires, the more economical it is and the lower its impact on the environment. Concrete is such a product. Its use helps conserve resources and reduce waste otherwise associated with repair and replacement. In fact, most concrete buildings can last 100 years or more. When they are demolished it is more likely to be because of obsolescence rather than deterioration[14]. Even this can be avoided if structures are strategically designed at the outset to accommodate future possible uses.

High Compressive Strength

Concrete is characterised by high compressive strength, which allows its use as a self-supporting system in domed or arched construction.

This characteristic was exploited by the Romans; and best illustrated in the construction of the Pantheon (c. 124 AD) featuring a hemispherical dome or cupola, which is predominantly insitu concrete, spanning 42 metres. This remains a formidable achievement, given that it still stands today. Along with other Roman landmarks of antiquity, it lends a persuasive argument to the life cycle performance of concrete construction.

In Australia, the reinforced concrete dome of the Melbourne Public (now State) Library (1908-13), spanning 34.8 metres (by architects Bates, Peebles and Smart with initial concrete design by John Monash) was an unparalleled engineering feat, and the largest reinforced concrete dome in the world at the time[16].

Termite-proof

The results of a number of studies conducted over the years all validate the deemed-to-satisfy condition in AS 3660.1, that is, concrete slabs designed and constructed in accordance with AS 2870 or AS 3600 can be used as a termite barrier.

Design flexibility

The plasticity of concrete in its 'wet' state provides scope to mould and sculpt virtually any built form imaginable. This affords architects and designers enormous creative latitude in the design process.

This applies not just to form, but to finish. The introduction of colour additives and different sized, shaped and coloured aggregates allows for the creation of unique concrete mixes. The various finishing techniques, from trowelling and staining through to sandblasting and polishing, add to the range of possible finishes.

Notes

13 AS 3600 Concrete Structures Standards Australia, as cited in Durable Concrete Structures TN57, Cement Concrete & Aggregates Australia.

14 Concrete stands up to natural forces, Portland Cement Association, n.d. <http://www.cement.org/newsroom/Greenbuild_2007/Durable.htm>, viewed 26 March 2010

15 Mora, E. Life Cycle, Sustainability and the Transcendent Quality of Building Materials, Science Direct, Building and Environment, 2005

16 Cement Concrete & Aggregates Australia Concrete and Sustainability: An Introduction n.d.

A magic is released that spirals and soars and flies breathtakingly through the air on eggshell like surfaces. Lamellas, vaults, petals, flutes, drapes, hyperboloids, lend shape to signature names like Candela, Saarinen, Nervi, Utzon; the, mystery of Ronchamp by Le Corbusier, the cantilevers of Fallingwater by Frank Lloyd Wright, probing space in new ways. The range is extreme; the tallest buildings need concrete cores, minimum storey heights are won with beamless flat slabs. Folded plates or a warp of any kind builds more readily in the plastic medium[17].

Sydney Opera House Photograph Max Dupain

Autobus Station – Casar de Cáceres, Spain
Photograph Hisao Suzuki

Notes 17 Rollo, J. Concrete Poetry, Cement Concrete & Aggregates Australia, 2004

Well designed concrete structures contribute to economic growth, environmental protection and societal well-being.

Commercial and multi-rise solutions

The Australian commercial construction industry leads the world in concrete- framed a construction, design and technologies.

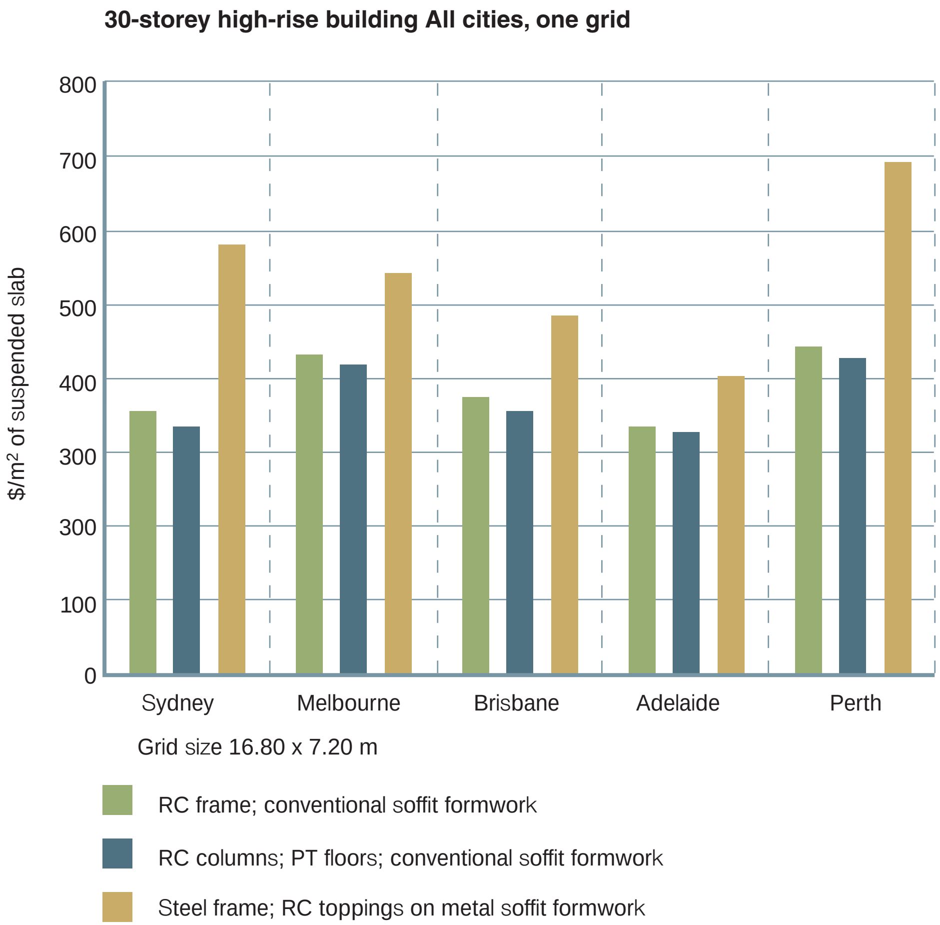
The economies and efficiencies derived from this innovation flow on in the delivery of affordable, high-rise residential buildings, as well as non-residential buildings that support business and the economy, as well as vital social services in education, health, roads and railways, defence, and recreation and entertainment.

Multi-rise buildings in Australia are predominantly concrete-framed structures[18] with landmark projects such as Melbourne's Eureka Tower and Q1 in Surfers Paradise ranking among the tallest reinforced concrete buildings in the world.

Concrete-framed constructions have consistently delivered low cost, low risk, high speed and high quality medium- and high-rise building solutions, in a highly competitive market. Indeed, a recent independent costing study by WT Partnership confirmed concrete construction's competitive edge in Australia over other systems Figure 12.

Q1 (meaning Queensland Number One) is a super-tall skyscraper located in Surfers Paradise, on the Gold Coast, the world's tallest residential tower, and the tallest building in the Southern Hemisphere

Figure 12 Comparative costs of high-rise construction systems



Notes 18 Mills, A. Cost Performance of Multi-rise structures in Australia, The Building Economist, 2009

< Melbourne's Eureka Tower, a 300-m-high 92-storey tower, was the world's tallest apartment tower at the time of construction. In one lift concrete was pumped to the full height of the tower

Deutsche Bank Building in Sydney – concrete delivered a lower risk, faster construction cycle, resulting in cost savings >

Case Study

A concrete-framed construction solution, chosen for its cost and time efficiencies and low risk, helped to deliver Australia's largest office building, the ANZ Centre in Melbourne.

ANZ wanted an environmentally responsible building, in line with its progressive culture and values. Builder Bovis Lend Lease met these criteria through a range of innovative measures, including the provision of natural lighting to floors via a central full-height atrium, displacement air handling, passive exterior shading, water and waste management, and wind and solar energy collection. Concrete's inherent thermal mass was also an important part of the ecollogically sustainable development solution. >

Kew House Photograph Peter Bennetts

Case Study

< Concrete was central to the sustainability solution chosen to reinvigorate the main courtyard at Sydney's Macquarie University.

The Courtyard features a pavement of permeable concrete unit pavers. This provides not only a durable and easily maintained surface, but also helps sustain the established urban forest.

This project won the 2009 CCAA Public Domain Award for Sustainability.

Residential solutions

Apart from dominating the commercial construction scene, concrete also plays a fundamental role in delivering residential building solutions.

BIS Shrapnel, one of Australia's leading providers of industry research, analysis and forecasting services, has confirmed concrete's dominance of flooring market (77%) and (market paving-87%), and a growing share of the external walling market (11.1%).

Although one of the oldest and most popular construction materials, concrete continues to offer up new and innovative solutions. Concrete wall panel technology, widely used in the civil, commercial, industrial and residential apartment sectors for decades, is increasingly being adopted in the housing industry.

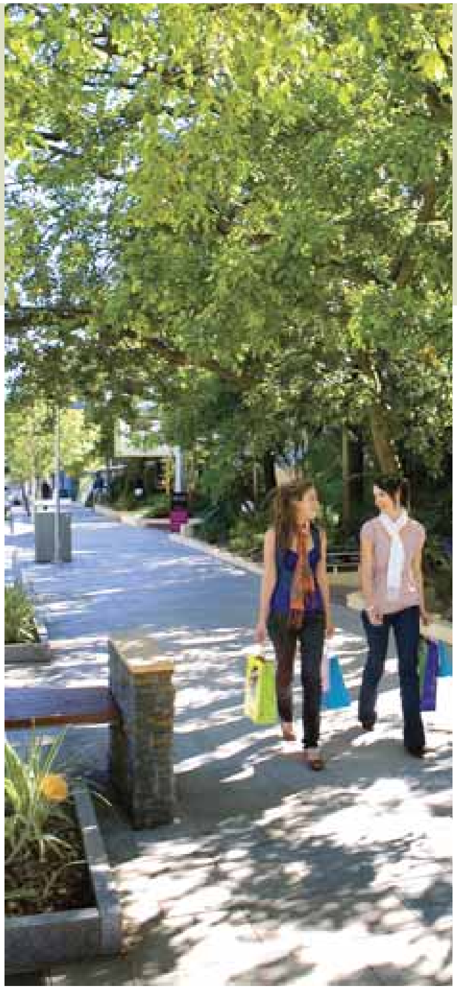
In particular, concrete panels have found a niche on narrow inner-urban sites and in architecturally distinctive homes. Since 2001, the use of precast concrete wall panels in Australian residential construction has more than tripled[19] underscoring the market's increasingly positive predisposition towards an integrated sustainable concrete solution for housing.

Infrastructure solutions

Concrete is used prolifically in vital infrastructure such as wharves, dams, bridges, buildings, warehouses, roads, airports, water and sewerage lines, and processing plants. Without concrete, efficient and affordable infrastructure to service society would not exist.

At the same time concrete has been successfully integrated into our urban landscape, enhancing the liveability of our cities and towns. Virtually any public space, parkland or streetscape features concrete in some form – pathways, stairways, seating, retaining walls, public artworks. These various forms take advantage of concrete's innate ability to deliver solutions that are at the same time functional and aesthetically pleasing.

Many of these unique and beautiful landscape solutions are celebrated in the biennial CCAA Public Domain Awards.



It is critical that building materials/systems used in infrastructure projects are durable and, in particular, resistant to corrosion, insect attack, abrasion, collision, impact, explosion, vandalism, flooding, drought, low and high temperature extremes, wind, fire, earthquake and salt, acid and chemical attack. In addition, the material must be in abundant supply, readily available and affordable.

Concrete clearly satisfies these performance criteria.

Notes 19 Building Materials and Fittings in Australia - External Wall Cladding, BIS Shrapnel, 2000/01 and 2008/09

Roxburgh Park Railway Station, in Victoria, demonstrates how concrete, as a robust material, can achieve experiential interest as well as longevity.

SUSTAINABILITY IN PRACTICE: WHAT THE INDUSTRY IS DOING UPSTREAM

The heavy construction materials industry has made great progress in terms of sustainable production practices.

Extractive Resources

Extracted resources – commonly known as aggregates – include sand, gravel and rock. Aggregates are an essential ingredient in concrete and therefore critical to the building and construction industry, and to the health of the broader economy.

As with all production processes, there is an environmental cost to the extraction and supply of these resources. The quarrying industry understands this and is working hard to reduce the impact of its processes – through its own initiatives and in co-operation and consultation with relevant government agencies.

The industry is committed to continuous improvement in water conservation, waste and resource management, recycling and re-use, land protection, remediation and rehabilitation, environment and ecosystem protection and community engagement.

With a structured, long-term approach to the planning and development of quarrying sites and the land that surrounds them, quarrying successfully co-exists with other land uses, both during and after the economic life of the operations.

Recycling

All three industry sectors – extractive, cement and concrete – are committed to recycling initiatives aimed at reducing their usage of natural resources.

Water recycling

With growing pressure on potable water supplies around Australia, the concrete industry is taking action to source suitable alternative supplies. For example, concrete producers are making more use of recycled wash water and slurry from the concrete production operation itself. The South East Queensland concrete industry achieved a 7% reduction in town water use between 2004 and 2007.

The cement and quarrying industries are also playing their part by decreasing their mains water consumption, through the use of on-site captured water, improved storage facilities and technological solutions.

Case Study

Remediation on the Nepean

Among the best examples of quarrying site remediation is the award-winning Penrith Lakes Scheme. Covering an area of 2000 hectares, the Penrith Lakes Scheme is the result of three quarrying companies Boral, Holcim and Hanson coming together in 1979 to achieve the coordinated extraction and rehabilitation of the flood plain north of Penrith.

The site has supplied nearly 75% of Sydney's sand and gravel requirements, provided 450 jobs and injected over $50 million annually into the local economy. Quarry operations were expected to cease in 2010.

While the Olympic rowing and white-water-rafting venues at Penrith are the best known examples of rehabilitation on the site to date, other significant achievements include the planting of more than 40000 native trees, the successful introduction of native fish, the restoration of heritage buildings, and the construction of an environmental education centre and an Aboriginal cultural centre.

Eventually the site will provide 400 hectares of residential/commercial development, 900 hectares of open space and 700 hectares of lakes. This includes five major recreational lakes and a series of smaller lakes covering an area of about one third the size of Sydney Harbour, offering swimming, boating and other water sports, as well as 55 km of foreshore and 11 km of walking tracks along the Nepean River.

Notes

Brisbane, Queensland

Riverside Park, Brisbane, Queensland

Manufactured sand

Manufactured sand can be produced as a dedicated product, or as a by-product of the aggregate crushing process. This approach has been steadily growing over recent years, particularly along the eastern seaboard of Australia. As a supplement to natural sand, its use helps prolong the life of our natural sand stocks. At the same time, it is a recycling success story.

Recyclable concrete

While there is plenty of evidence of the industry's commitment to recycling in the production process, arguably its greatest success story is the end product itself. In the past, concrete from demolished buildings and infrastructure was crushed and dumped as landfill. 'Old' concrete is now reused in a variety of products and applications – as the 'aggregate' for new concrete, as road base for highways and roads, and other applications[20].

Cement Manufacture

Reductions in greenhouse gases

Cement is a major constituent of concrete; and the cement manufacturing industry has contributed to the sustainability of concrete in a number of key areas.

Clinker production in cement manufacturing contributes around 1.2% to Australia's carbon dioxide (CO_2) emissions, with fifty per cent of this amount being attributed to the calcination process [21]

Between 1991 and 2009 the cement industry voluntarily reduced its CO_2 emissions by more than 23%[22], equivalent to almost 1.5 million tonnes of CO_2 per annum, as part of the Australian Government's Greenhouse Challenge. This result was achieved by the adoption of advanced technologies, the use of alternative fuels and raw materials, and a strong commitment to the principles of sustainability.

Technology

The Australian cement industry has invested over one billion dollars in technology improvements in the last 15 years. This has resulted in reduced emissions, improved manufacturing efficiency and better product into the marketplace. Notwithstanding the considerable investment to date, the industry has identified opportunities for further technical improvements, with the aim of reducing manufacturing costs, reducing energy consumption (and greenhouse gas emissions), increasing the use of alternative fuels and cement additives, and creating commercial opportunities for by-products of the manufacturing process.

Notes
20 CSIRO, http://www.csiro.au/promos/ozadvances/Series8ConcreteL.htm viewed March 20, 2010
21 Huntzinger, D. and Eatmon, T.2009 A life-cycle assessment of Portland cement manufacturing, Journal of Cleaner Production
22 Cement Industry Federation, Australian Cement Industry Statistics 2009

Energy efficiency

Cement production is an energy intensive manufacturing process. Fossil fuels (typically natural gas or coal) are used to fire the massive kilns that produce clinker, while electrical energy is consumed in powering the kiln and grinding the materials.

In recent years the industry has made great inroads in reducing consumption of fossil fuels via the use of alternative fuels. Examples of alternative fuels that can be used to fire cement kilns include old tyres, demolition timber, tallow, carbon or anode fines, spent cell liners, waste oil, coke breeze, blended solvents and sewer sludge. Most of these products would otherwise end up as landfill or require expensive processing and storage.

Since 1991 kiln fuel efficiency has improved by 32%[23]. These improvements in energy efficiency have contributed to the 23% reduction in greenhouse gas emissions from 1991 to 2009.

Clinker reduction

There are two main types of alternative materials used to supplement clinker - mineral additions and supplementary cementitious materials (SCMs).

- Minerals such as ground limestone can be added in small amounts at the final grinding stage of cement manufacturing.
- Supplementary cementitious materials include fly ash (from coal-burning power stations), ground granulated blast-furnace slag (from the steel industry) and amoprphous silica (eg silica fume). These are added to cement either through intergrinding with cement clinker or by blending with cement after grinding. Alternatively, they can be added during concrete batching to supplement the cement.

By using these alternatives and reducing the amount of clinker produced, savings are achieved in raw materials, electricity, fuel, and emissions[24].

Figure 13 Cementitious material sales and CO_2 emissions[25]

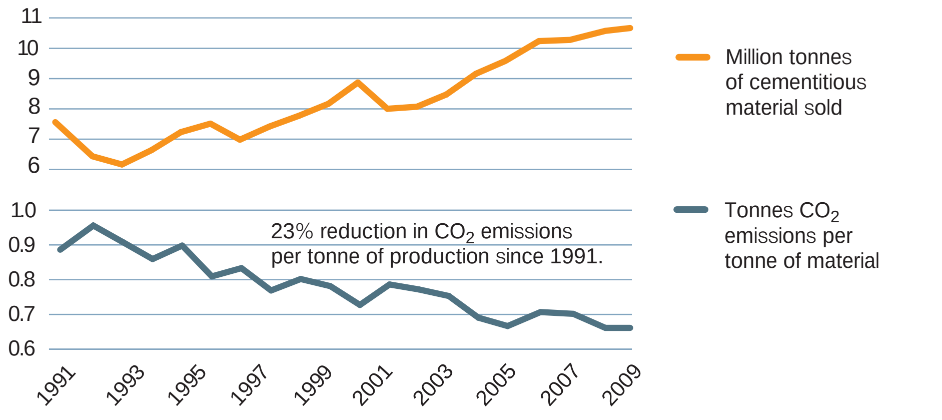
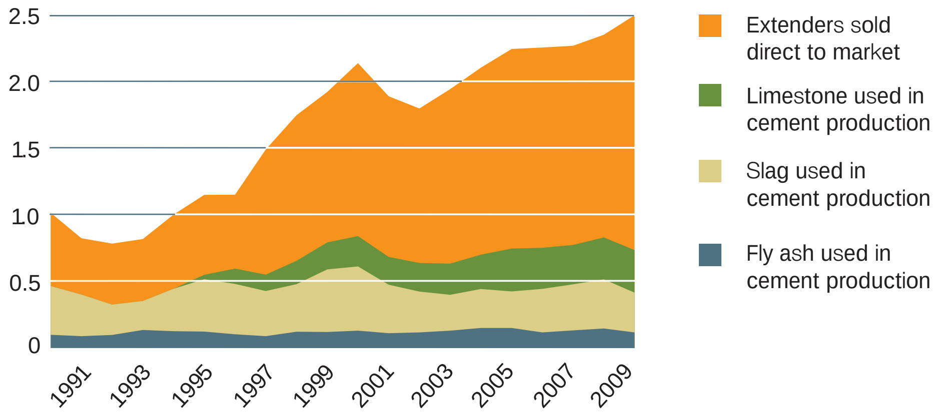


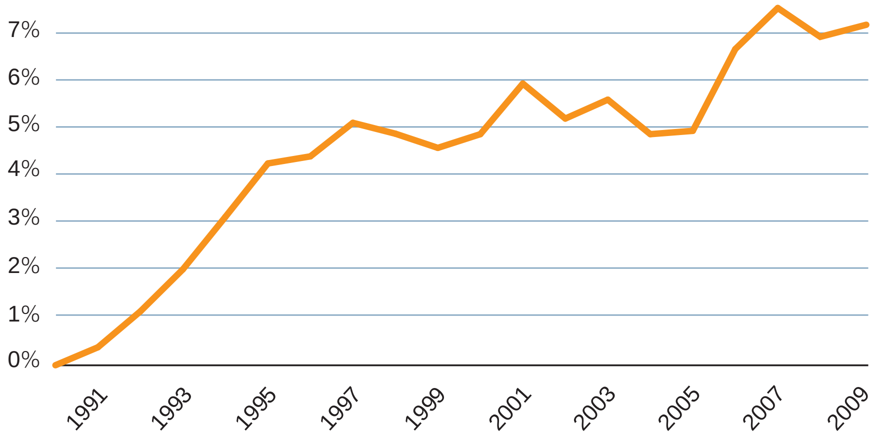
Figure 14 Cement extenders used in cement production and sold for concrete production (million tonnes)[26]



Notes 23, 24, 25 & 26 Cement Industry Federation, Australian Cement Industry Statistics 2009

Adelaide, South Australia

Figure 15 Alternative fuel use as a percentage of total thermal energy use



Case Study

Alternative Fuel – Used Tyres

Alternative fuels are energy rich materials, such as used tyres, used oil and waste carbon, which can replace gas as a source of thermal energy in the cement manufacturing process.

Trials conducted have shown in the controlled conditions of a kiln, tyres were found to perform similarly to coal and that a fuel substitution rate of between 20 and 25 per cent could be achieved without any adverse impact on the process, product or environment.

The energy in these alternative fuels would otherwise be lost if these tyres were landfilled or incinerated. The environmental benefits of using alternative fuels such as tyres is two-fold: non-renewable energy resources are conserved through lower fossil fuel use, and waste disposal problems are alleviated[27].

Notes 27 Australian Cement Industry Federation, Managing our Resources – use of alternative fuels at Blue Circle Southern Cement

Sound Barriers Eastern Freeway Extension, Melbourne
Photograph Tim Griffith

Environmental Management Systems

Increasingly environmental management systems are being adopted across the cement, concrete and aggregate industries improving both management of, and response to, environmental impacts.

Managing local impacts

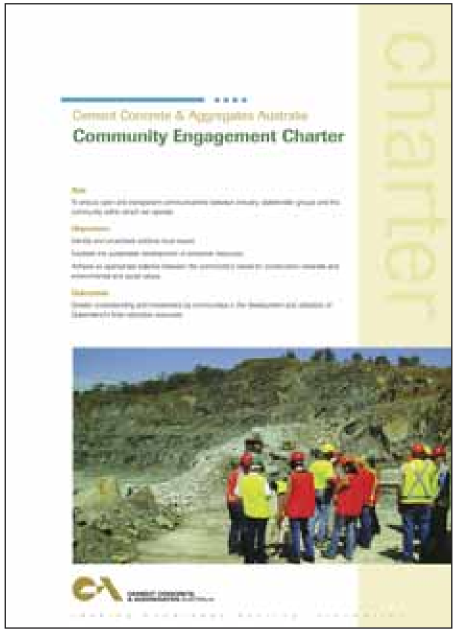
Just as it is important that the industries take active measures to improve their environmental performance, it is also critical to build strong, transparent relationships with local communities. Investment in new technology and environmental monitoring, combined with active community participation, are essential to building relationships. Receiving and investigating a community report on impacts is important for any site in its effort to construct and maintain its relationship with that community.

Cement manufacturers have regular contact with their communities through various public forums such as meetings, open days and newsletters. Environmental improvement plans registered by state environmental authorities also offer opportunities for interested stakeholders to participate and monitor site improvements. As part of its local community, the industries also look for opportunities to celebrate events by supporting local initiatives and celebrating their own milestones.

Perth, Western Australia

The Industries' initiatives include:

- Preservation and restoration of a traditional resting place of the local Watherong people in Waurn Ponds, Vic
- Agricultural education project, Gladstone, Qld
- Sponsorship of Conservation Volunteers Australia and support of the Bushcare Group at Berrima, NSW.
- Rehabilitation of Darra cement works site to build the community Riverside Park in Brisbane, Qld
- Funding world first research in deep water seagrass rehabilitation at Cockburn Sound, WA
- Seed collection for propagation in other local areas from remnant vegetation located in a quarry at Angaston, SA.
- Planting of over 100,000 native trees and establishment of koala fodder plantation, Petrie
- Development of Olympic rowing and whitewater rafting venues, Penrith
- Planting of more than 40,000 native trees, the successful introduction of native fish, the restoration of heritage buildings, and the construction of an environmental education centre and an Aboriginal cultural centre, Penrith
- Industry sponsorship of Health Waterways Awards programs
- Recognising outstanding examples of the principles of sustainability in landscape architecture design and construction in the Sustainability category of the CCAA Public Domain Awards
- Recognising companies that demonstrate the highest standards of continual improvement and long-term environmental sustainability in their local operations in the CCAA Environmental Awards



Case Study

Engaging with the community

Queensland's extractive industry has taken a positive step to improving relationships with local communities with the launch of a Community Engagement Charter.

The initiative, developed through CCAA, pledges members to work closely and openly with the communities in which they operate. The Charter sets out guidelines for industry members to follow to ensure their communities are informed and involved. It also provides a mechanism for community groups to raise issues of concern in relation to the ongoing operation and future development of extractive sites.

The Community Engagement Charter is all about ensuring the extractive industry continues to supply Queensland with the construction materials it needs, in balance with the community's social and environmental values.

Hobart, Tasmania

Beacon Foundation's Something Concrete project Kununurra, Western Australia

Case Study

Something Concrete for Kununurra indigenous community

A project to provide employment opportunities in the construction industry for indigenous Australians living in the remote East Kimberley region of WA is a great example of sustainability in practice.

The Something Concrete project engages all three parts of the sustainable development model – social, environmental and economic. The project is the initiative of the Beacon Foundation, a not-for-profit organisation that helps set up sustainable projects and programmes to tackle youth unemployment and encourage self-help at the local level.

Beacon's catchcry is 'real jobs, no dole'.

Working with the local indigenous community in Kununurra and the concrete industry, Beacon has so far helped create training and employment opportunities for about 30 locals. The original intake of trainees cut their teeth on tilt-up concrete panel construction of four local homes. Subsequently, a small precast factory was established in Kununurra to create further, on-going training opportunities. Trainees in this facility have developed a range of standard precast panels that can be adopted for a wide range of house designs.

Although external funding to build more houses has so far not been forthcoming, the project team is focusing on opportunities to supply precast components for major local infrastructure projects. In the meantime, many of the original trainees have used their skills and experience to find local construction jobs.

The project has created wins on all fronts – in the use of environmentally friendly concrete technology for local houses, in the creation of local training and employment opportunities, and in the social and economic improvements that flow through to the community.

A SAFE WORKING ENVIRONMENT

The health and safety of workers is of paramount concern to the cement, concrete and aggregate industries.

Across these industries many initiatives have been developed to improve safety performance. At an industry level, the CCAA Environment Health and Safety awards reward and encourage best practice in the areas of environment and occupational health and safety in the pre-mixed concrete and quarrying industries. Others include a range of safety brochures couched under the Safety – its No Accident banner, and ongoing initiatives and guidelines addressing fatigue management, safe site delivery, loading and unloading of cement tankers and working safely with concrete.

At an organisational level, programmes such as health and safety management systems and other initiatives encompassing policies, education, training and audits are all examples of initiatives designed to provide a safe and healthy working environment

At a plant level, policies such as Zero Harm[28] and A Decade of Learning[29] have brought about significant and meaningful cultural change aimed at reducing injury frequency and promoting a healthy workplace environment.

Notes 28 Hanson Quarries, Eastern Region
29 Boral Emu Plains

CONCRETE – THE RESPONSIBLE CHOICE

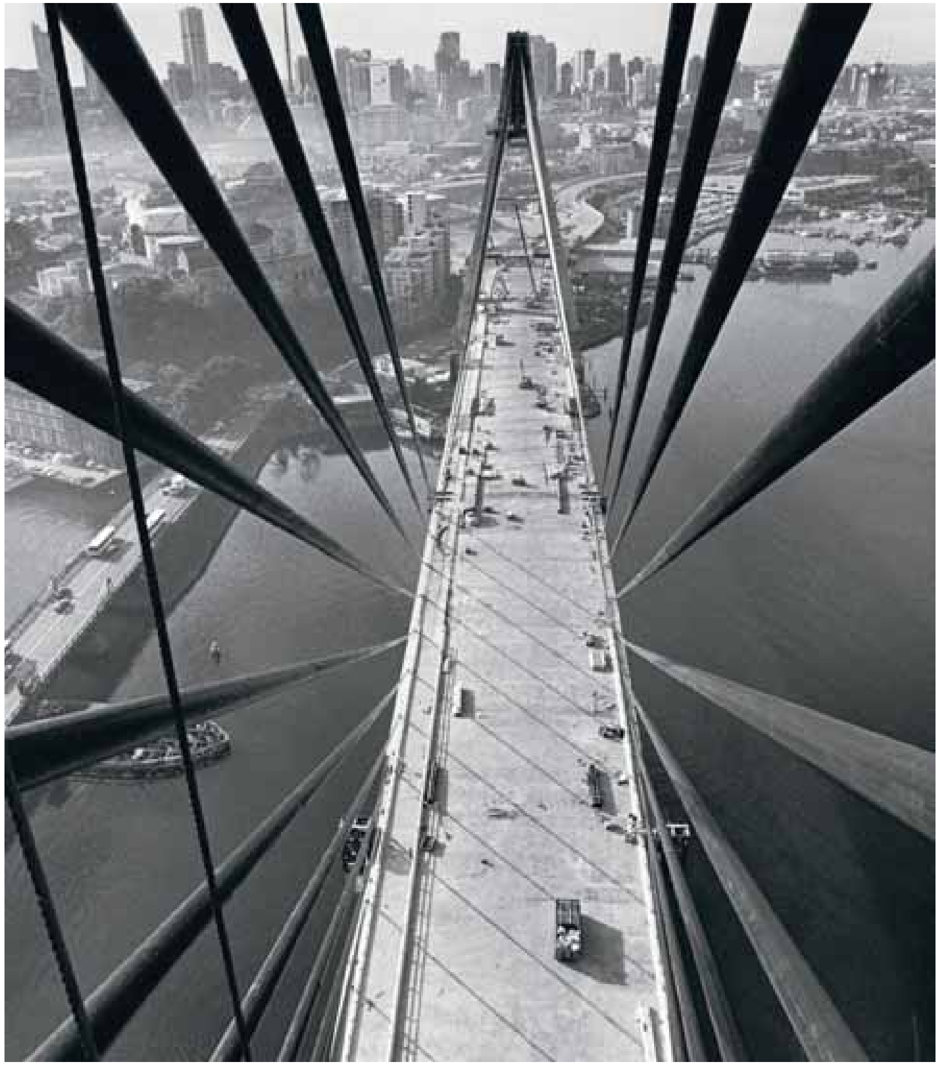
The cement, concrete and aggregate industries are enjoying great success in reducing energy, greenhouse gas emissions and water use.

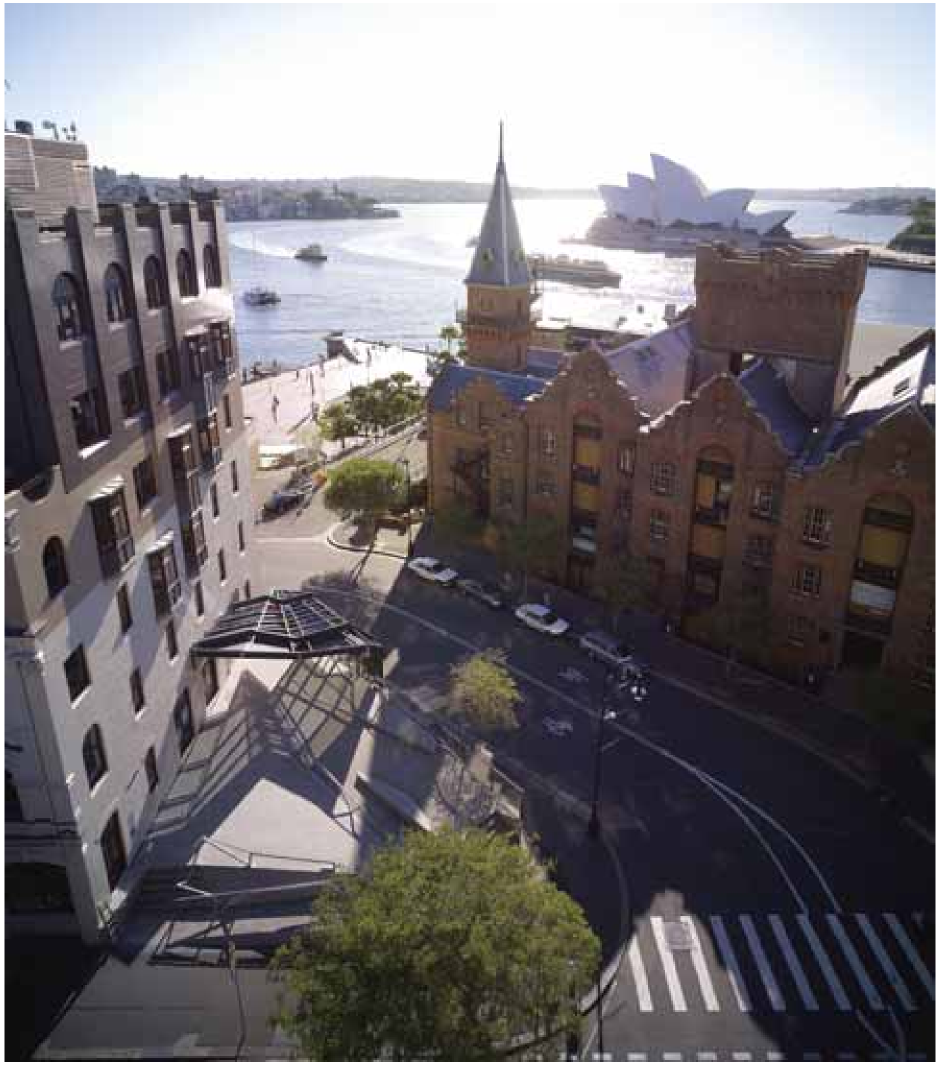
Concrete is fire-and termite-resistant, flood resilient, robust and strong; manufactured from abundant, naturally-occurring and readily-available materials. It is durable and long lasting, without the release of toxic emissions. It is fire resisting and sound attenuating. Concrete can be formed into an infinite number of shapes and can be used to construct an unlimited array of buildings with a multiplicity of attractive finishes.

Above all, concrete enhances our social fabric, is environmentally beneficial, and it is economical. Concrete really is the foundation upon which our modern societies and economies are built – Concrete is the responsible choice.

Melbourne University Carpark
Photograph John Gollings

Anzac Bridge, Sydney
Photograph David Moore





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CEMENT CONCRETE & AGGREGATES AUSTRALIA

concrete the responsible choice

ABOUT CCAA

Cement Concrete & Aggregates Australia (CCAA) is the peak body representing the $7 billion a year cement, concrete and aggregate industries.

CCAA represents the interests of its members to governments and the wider community on issues as diverse as resource access and security, transport, workplace health and safety, and the environment.

Acknowledged nationally and internationally as Australia's foremost cement, concrete and aggregate information body, CCAA takes a leading role in education and training, research and development, technical information and advisory services and is a significant contributor to the preparation of Codes and Standards affecting building and building materials.

CCAA aims to protect and extend the uses of cement, concrete and aggregate by advancing knowledge, skill and professionalism in Australian concrete construction and by promoting awareness of products, their energy-efficiency properties and uses, and of the contribution the industry makes towards a better environment.

CCAA is a not-for-profit organisation.

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