

Improving the world through better use of concrete



Introduction

This article is part of our series on materials and resources. In this series we ask how we can improve the way we develop, use and dispose of the materials and resources that power our modern economy in a sustainable manner. The series is tied to [the United Nations Sustainable Development Goals](#).

The ubiquitous material of concrete is everywhere we look. Viewed through the lenses of the 17 SDGs, it is clear that, whilst it provides humanity with many benefits, these benefits come at a cost to the sustainability of our planet.

This article describes our use of concrete, the impact it has, and what we can all do to help ensure the materials used in concrete production, and our consumption of this material, is done in a more sustainable way.



Concrete, concrete, everywhere...

If you work or spend time in urban environments, you can't fail to see the abundance of concrete in our constructed world. There's plenty of it in rural areas, too. Concrete is inescapable, and everywhere we look – it is part of modern life all around the world. This versatile product, in its various forms, has provided us with the means to create and to sculpt our environment. The infrastructure and physical structures we use it for play a vital part to powering the world economy, which includes raising and improving living standards for a great many people.

On a global scale, we use massive amounts of it, with some fantastic structures to show for our efforts. Here are a few points to consider about our consumption of concrete:

- Every few seconds, the world's construction and engineering firms [pour more than 19,000 bathtubs of concrete](#). If the average bathtub is 40cm high, that's a stack of them 7,600m high, every few seconds. For context, Mount Everest is 8,848m above sea level.
- Each day, it is estimated that enough concrete is poured to just about match the amount used for China's massive Three Gorges Dam – currently the world's largest concrete structure, containing some 16 million cubic metres of it.
- In the space of a year, it is estimated that [approximately 4.2 billion cubic metres \(which is approx. 10 billion tonnes\) is produced](#). That's about 1,680,000 Olympic-sized swimming pools. That's a lot of concrete.



The Three Gorges Dam in China (image credit: Britannica.com)

As the world economy continues to grow, and we continue to urbanise and change our landscape, concrete demand will continue to increase. The expanding region of Asia – and [China in particular](#) – is an especially large and growing producer and consumer of concrete today. In future, geographies such as India and Africa will likely play a significant part in greater demand and use.

What is concrete?

In its basic form, concrete can be thought of as [a mixture of paste with coarse and fine aggregate](#). The “paste” is traditionally composed of Portland cement and water. The cement acts as a binding agent when mixed with the aggregate and water. A chemical reaction takes place called hydration, in which the paste hardens and gains strength which creates the hard substance that we call concrete (more on the chemistry of concrete is available [here](#)).

Concrete has an important trait which makes it very adaptable and flexible: it is plastic and malleable when freshly mixed, and strong and durable when hardened. These qualities allow us to build all manner of structures, from skyscrapers to bridges, roads and highways, houses and dams.

Various other elements exist that are used for concrete structures, such as reinforcement in the form of steel (which just happens to expand at the same rate as concrete), and the use of additional components such as plasticisers.

COMPONENTS OF CONCRETE

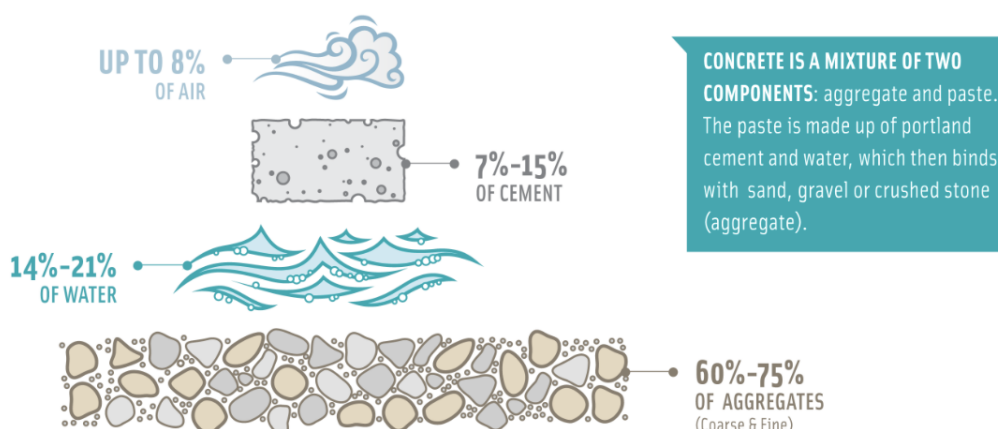


Image credit: [The Portland Cement Association](#)

Our global concrete footprint

Here are a few points about concrete, to give you just a snapshot of its importance and its impact on the planet (detailed reports about the industry size are available from various sources):

1. Employment, work and economic growth:
 - a. The concrete industry, including the extractive and quarry industries from where we source the base materials, is a large employer globally, including in the developing world, and it plays a part in lifting people out of poverty.

2. Infrastructure, Sustainable Cities & Communities:
 - a. Concrete has an important role to play in improving global infrastructure, including for vital matters such as sanitation and health.
 - b. More people are moving to cities, and this in turn is part of the continuing demand for concrete use.
3. Consumption & Production:
 - a. Concrete is the [second-most used substance](#) on Earth – second only to water.
 - b. Globally, it is estimated that we produce [over 10 billion tonnes of concrete](#) each year (a figure which many forecast to rise in future).
 - c. Global cement production, a core ingredient for concrete, is estimated by the Global Cement and Concrete Association to be [some 4.65 billion tonnes](#) annually. To put this in context, it's estimated only 8 billion metric tons of plastic have been produced in the last 60 years (albeit our consumption of plastic is also an important matter, something we write about in another article).
 - d. The industry consumes a vast amount of water. [By one estimate](#), 1 billion cubic metres of water is used to make concrete each year (plus there is the water used for wash and curing when it is being laid). It's thought it may constitute [up to a tenth of the world's industrial water use](#). This often strains supplies for drinking and irrigation, because [75% of this consumption is in drought and water-stressed regions](#).
 - e. The demand for particular types of sand and stone, used as aggregate in concrete, is driving the [destruction of beaches, lakes and river beds](#).
 - f. With more concrete use comes more use of steel, for reinforcement.
4. Health & wellbeing:
 - a. Dust generated in concrete materials extraction, concrete production and use causes problems such as silicosis and other respiratory diseases.
5. Climate impact:
 - a. Concrete is very energy-intensive to produce.
 - b. Cement, a key ingredient in concrete production, is estimated [to contribute between 5-8% of GHG emissions](#) (this estimate is supported by [Chatham House analysis](#)).
 - c. If the concrete industry were a country, it would be [the third largest emitter of carbon dioxide on the planet](#), with up to 2.8 bn tonnes, surpassed only by China and the US.

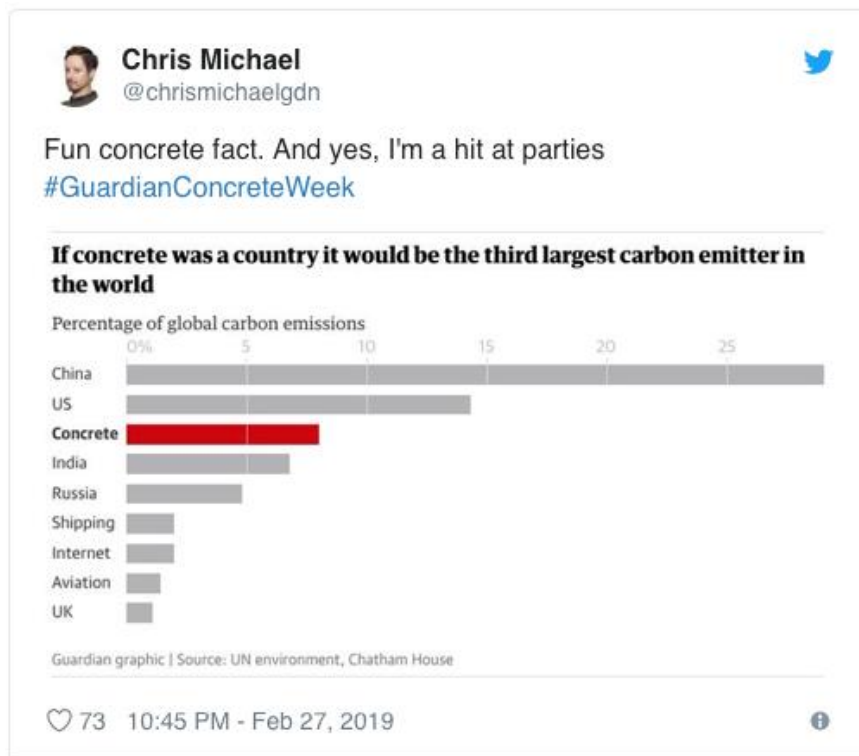


Image credit: The Guardian

6. Life on land:

- Our use of concrete (and other materials, of course) is steadily replacing the natural environment. By [one calculation](#), concrete may now weigh more than the combined carbon mass of every tree, bush and shrub on the planet. Thanks in large part to concrete laying, our built environment is growing larger than the natural one.

Relating our use of concrete to the Sustainable Development Goals

The pointers about concrete that we have described above are linked to six of the United Nations 17 Sustainable Development Goals (the SDGs). Concrete impacts more than the six SDGs we highlighted. We just provided a number of examples.

Three SDGs in particular that we wish to highlight for their relevance to how we produce and use (including the disposal of) concrete are as follows:

- [9 - Industries, Innovation & Infra-structure](#);
- [11 Sustainable cities & communities](#); and
- [12 Responsible consumption & production](#).





Concrete will continue to play a key role as we continue to urbanise our environment, and to drive sustainability in cities. There are many people living in poor living conditions who need affordable housing and infrastructure – and concrete has a major role to play in helping to improve their living standards (SDG 11). We need to see continued innovation in industry in how we approach its use, and we need to be responsible in its use and disposal as part of lifecycle planning.

[As the World Economic Forum has emphasised](#), reducing the environmental harm of concrete and cement is an important factor to reducing carbon emissions and limiting global warming to less than 2°C.

It is estimated that the cement and concrete industry will need to reduce its emissions by [at least 16% by 2030](#) to contribute towards this goal. This is in the context of an industry that is still [expanding rapidly](#) - production is on track to exceed 5 billion metric tons a year around the world (up from the already huge amount of 4.65 billion metric tons).

Some challenges to being more sustainable with concrete

The challenges we face to using concrete in a more sustainable manner include:

1. Can we reduce the demand for concrete as a key starting point?
 - a. Most concrete structures are wasteful in their use of the material. If we only use what we need, and no more, significant reductions in concrete consumption would occur.



2. How can we improve the efficiency in design of concrete structures, so that we do not require as much concrete for our built environment?
 - a. This includes better durability (increasing life of product) and strength characteristics of concrete (reducing quantities required).
 - b. Alternative “binders” for concrete, to move away from cement, need to be considered. As described earlier, cement production makes CO². To reduce CO² from concrete production, we have to use less cement. As described later, there are possible options, but we don't have enough of these options on the planet to replace all our cement use.
3. How do we ensure sustainable extraction of the resources required to make concrete?
 - a. As we mentioned earlier, the demand for sand (with properties required, such as being angular and gritty as found in riverbeds, not beaches) is one such challenge. There are also cases of materials, sand in particular, [being illegally dredged](#). As sand becomes scarcer, prices could rise, and there could be risks of using inappropriate sand in the product, with resulting quality problems.
4. How can we reduce water usage throughout the whole lifecycle of concrete, from the extraction of materials through to concrete production and laying?
 - a. In all parts of the world, we need to focus very hard on how we achieve greater efficiencies in water usage, and this is certainly true for our use of concrete.
5. How can we reduce the energy required to make cement, and concrete?
 - a. Concrete is an energy-intensive process. What techniques can be applied to lessen the energy required, and research into fuel sources that are used?
6. Can we use less carbon-emitting materials and more sustainable materials?
 - a. To make carbon-negative cement possible, [cement manufacturers must adopt new technologies](#).
7. How can we ensure more recycling of all materials used in the concrete process, and concrete itself, and reuse existing concrete components where possible?
 - a. If we have to take down a building / piece of infrastructure, rather than demolish it into a pile of rubble, can we re-use some of its components in a structural manner (i.e. upcycle not downcycle)?
 - b. [Recycled concrete](#) is a viable source of aggregate and has been satisfactorily used in granular subbases, soil-cement, and in new concrete also. The use of Recycled Aggregate or Recycled Concrete Aggregate continues to grow in many parts of the world.
 - c. Used tyres make an ideal kiln fuel for the production of cement, without any adverse environmental effects. Kiln temperatures are very high, and tyres burn without fumes or flame, plus the residue from burning tyres can be chemically treated and reused again as fuel.

These points relate particularly to the three SDGs highlighted earlier.

Governments and policy-makers can, and do, play an important role in moving towards more sustainable concrete use. They also play a major role in how industries evolve.

As an example of the influence of government policy, the [UK aggregates levy](#), “[AGL1](#)” which is currently charged at a flat rate of £2 for every tonne of rock, sand or gravel extracted, and proportionally for any amount under that weight, has had a major impact on how quarrying companies and the extractive industry performs its business.

A brief industry perspective

There are of course big players in the industry, with specific interests. There are many smaller, local concrete businesses around the world that have an equally important a role to play in the future of concrete use in a sustainable and balanced way. The industry contends with tough times when construction and engineering demand falls away, and R&D investment is always a challenging balancing act.

How can all businesses involved in concrete production (including the extractive industry) and its use (such as construction) play their part in helping the world to tackle its economic needs whilst also meeting collective sustainability needs?

From an investor standpoint, there is increasing evidence that investors in materials suppliers (including concrete suppliers and related extractive businesses) want to see evidence of well-thought-out plans to reduce carbon emissions, and to tackle all other aspects of sustainability.

Some large concrete industry players are part of a major report by the Energy Transitions Commission, titled “[Mission Possible](#)”, which is about how heavy industry can help to reduce carbon emissions. Major businesses involved in concrete materials extraction, concrete production and concrete use are [publicly stating their plans on how they are responding](#) to the challenge.

The [Global Cement and Concrete Association](#) makes a prominent feature of sustainability on their website. Their stated aims in their Mission Statement include:

- We aim to drive responsible industry leadership in the manufacture and use of cement and concrete.
- We will strive to improve the global social and environmental impact of the sector’s activities and products.

Around the world, there are some excellent initiatives that are collaboration efforts between industry, academia and government, such as the [SmartCrete Cooperative Research Centre initiative in Australia](#). Such initiatives are focusing on the vital matter of how to ensure concrete remains viable for the future (part of the focus of this particular initiative is to ensure a sustainable supply chain is in place).

What can Risk and Operations teams in various industries do?

If you are a Risk Manager, you can play a valuable role in helping your organisation to contribute towards its sustainability objectives. This is a business-critical matter today, as investors are demanding to see that such strategies in place.

With regard to concrete use, Risk Managers and Risk teams should work with their colleagues in Sustainability and Operations to think through how, for their organisation's particular circumstances, they can and will use concrete in a sustainable way, as part of achieving important sustainability objectives.

Below are a couple of example pointers to consider. Using good Risk tools and thinking carefully through your operations can help you to find out what is most feasible and impactful to you.

Consideration	Ideas and thoughts for consideration
1. Where do you operate in the world?	If you operate in areas that have a growing need and use for concrete (for example, Asia, Africa and India), are there ways that you can play a part in helping people and businesses to think through how to ensure their use of it is sustainable?
2. Is your business a client of the construction industry?	- Your first response might be "No", but you probably are – if you are a reasonable-sized organisation you will operate out of one of several buildings as offices. - If you have a Real Estate or Property Management arm, are you including in your requirements for buildings / infrastructure that designers and constructors must use concrete sustainably?
3. Does your business use, procure or "own" a lot of concrete, in one form or another?	- How is efficient design being achieved (including understanding the impact of concrete strength grade) - How does your supply chain procure and use it? - How can you reduce waste on site? Wastage is a big issue to be tackled. - Are you pushing for innovation to be used, not just "accepting traditional ways"?
4. Is your business in a position to provide materials that can help the concrete industry cut its emissions?	Some examples (detailed research provides more info): - Supplementary Cementitious Materials (SCM): - Ground Granulated Blast Furnace Slag (GGBFS) to replace Portland cement; - Fly ash, a by-product of coal combustion in power stations, can be used in cement; - One potentially interesting option is LC3 (limestone and calcined clay); - Silica fume - a by-product of the semiconductor industry which can improve the strength and durability of concrete, although it is difficult to

Consideration	Ideas and thoughts for consideration
	handle because of its extreme fineness, and cannot always be used; • Rice husk ash may sometimes be suitable for use. • Crushed and recycled glass can be extremely useful in certain situations (e.g. road pavement construction), as a replacement for sand. • The ash from waste that is burnt may be useful for concrete production, saving on Portland cement (if the right technology can be applied to it).
5. Are you an investor with investments in heavy industries that use a lot of concrete?	• Are you asking industries about how they plan to use concrete in a more sustainable way? • Can you influence how government authorities around the world use concrete – for example, better solutions for roads, highways and pavements?

The importance of research and trying new things collectively

As highlighted earlier with the example of SmartCrete in Australia, collaboration between academic research, government and industry can reap dividends.

Governments can help, with policies that can encourage sustainable materials to be used. The Standards associations that determine usage specifications need to be open to different ways of achieving good outcomes in a high-quality manner. For example, the use of crushed glass in aggregate to replace sand could be very beneficial in some geographies, if the cost to wash, blend and use it as a sand replacement can be agreed as the right thing to do as an industry. Concrete producers of all sizes need to be open to trying such measures.

More research in various areas is still required. For example, researchers have found that finely ground glass powder has cementitious properties. Perhaps it can be used as replacement to Portland cement in certain situations.

Conclusion

This article has discussed how organisations, large and small, and across numerous industries can play their part in improving how the world produces and uses concrete, for the betterment of the planet.

It's not only heavy industry and the asset-intensive industries that typically use a lot of concrete that can, and should, play a part in us all improving the sustainability of concrete production, use and disposal. We can all play our part.

We need to stop and think about how the concrete industry, its supply chain, and all its end clients can play a part in helping the world to develop and implement responsible strategies for using this material in a sustainable and viable manner.

Further suggested reading

In February and March 2019, [The Guardian Newspaper](#) published a feature, [Guardian Concrete Week](#), containing an excellent series of articles about this ubiquitous material.

Their coverage includes comprehensive information about [the history of concrete, including its use in Roman times through to the modern day](#); its [popularity in architecture](#); its [social history](#); its use in modern day [China](#); and [the destructive nature of concrete](#) in its current form. The features also include a piece on the many various [alternatives and innovations](#) currently being developed to reduce our reliance on concrete.

An example of industry, government and academia collaboration into concrete usage is the [SmartCrete Cooperative Research Centre in Australia](#).

About the author

Gareth Byatt is Principal Consultant of Risk Insight Consulting and a Director of Satarla Australia. His background is in construction and engineering, which has included various projects involving concrete as a key material.

