Decarbonisation of cement inputs

As the cement sector explores promising levers to maximise emissions reduction potential, SonoAsh process sonochemistry is one such pathway. Given tightening supply trends, the process can engineer legacy coal ash to an exact specification, thereby creating recovered material for cement manufacture and decrease concrete's carbon footprint.

■ *by **Ian MacKenzie** and **Claudio Arato**, SonoAsh LLC, Canada*

This decade will see a big shift in business practices as the world navigates its way toward a low-carbon, net zero future. Cement, with an annual contribution of approximately eight per cent of the world's greenhouse gas emissions, is at the forefront of this shift. One tonne of produced cement equates to one tonne of CO_2 released into our atmosphere. The challenge for the industry is to take meaningful steps to bring its carbon output down and still satisfy an insatiable global need for building and re-building of the modern world's infrastructure.

Much has been written about managing carbon outputs of the cement-making process. Carbon capture, alternative fuels and energy efficiency are all compelling pathways and must be considered in overall industry carbon reduction strategies in the coming decades. However, it simply will not be enough. To achieve a meaningful reduction, the cement industry needs to address more dynamically a looming innovation gap regarding the carbon intensity of the cement production process.

According to the Global Cement and Concrete Association (GCCA), Figure 1 shows "the additional innovative approaches needed, including new technologies and alternative building materials, to achieving carbon-reduction targets by 2050." The most promising levers to maximise emissions reduction potential are still in development and have only been piloted or implemented on a small scale.[1]

The sonochemistry pathway

To fill part of the technology innovation gap, SonoAsh process sonochemistry offers one such pathway. While coal ash has commonly been viewed as a carbon energy production waste, it is already an accepted ingredient in ready-mix concrete formulas if the ash chemistry is compliant with ASTM guidelines. Compliant coal ash is generated under certain burn conditions at coal power plants and often referred to as production ash.

The larger, increasing global trend of decommissioning coal as a viable power source is not without consequences. The demand for cement and concrete is expected to reach more than 5bnta by 2050. Coal ash is created from burn conditions at the coal power plants. The global push to decommission these plants deprives cement makers of a key, compliant ingredient in ready-mix formulas. Tightening supply trends are already in evidence as compliant ash prices are increasing as with demand and shrinking supplies. Bridging the innovation gap between a declining power source and creating the optimal compliant coal ash for cement ready mix is already a challenge.

"Tightening supply trends are already in evidence as compliant ash prices are increasing as with demand and shrinking supplies."

Still, there are billions of tonnes of legacy coal ash in storage around the globe. Most of the chemistry in these coal ash impoundments is non-compliant. There is now a way to engineer the legacy coal ash to an exact specification, creating a cost-effective supply of recovered material for the cement making process to address the carbon question.

Process

Applying targeted, low-frequency sound

Figure 1: emission reduction pathways to 2050

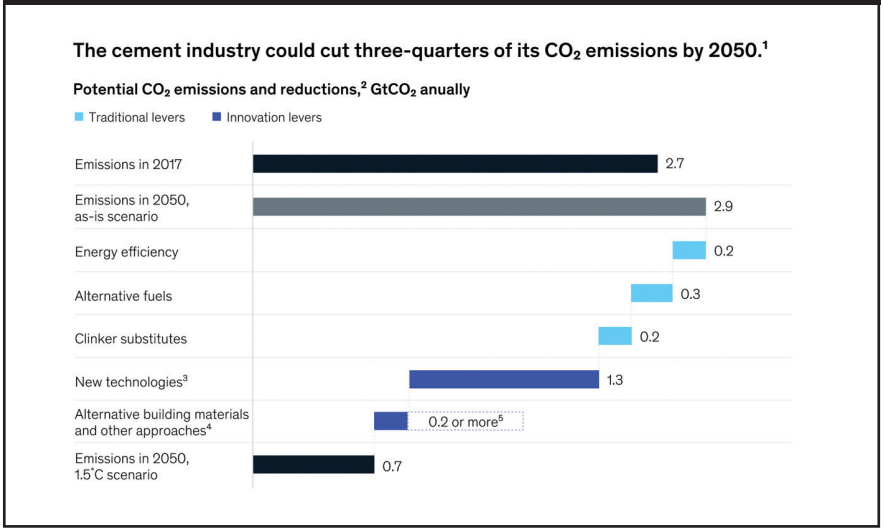
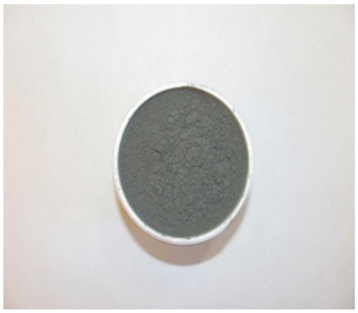


Figure 2: before and after ash comparison



PRODUCTION ASH
(11.52% CARBON)

SONICATED ASH
(0.48% CARBON)

"After the coal ash is processed through sonochemical treatment, the carbon content is reduced consistently to a low LOI (0.48 per cent) carbon content. This engineered ash is well within ASTM guidelines for coal ash use in the cement manufacturing process."

in a wet, closed-loop, low emissions process fractures coal ash. This creates an ultra-low carbon, uniform particle size, supplemental coal ash product that can be used as a cement replacement in ready-mix formulas. This allows cement manufacturers and precast concrete suppliers to flexibly address high carbon intensity and emissions on the input side.

The SonoAsh process applies its six patents to wet, variable, legacy coal ash. Processing this coal ash has never been economically viable due to market availability of suitable production ash required for cement.

As seen in Figure 2, the untreated ash on the left contains a high LOI (11.52 per cent), variable size ash before SonoAsh processing. After the coal ash is processed through sonochemical treatment, the carbon content is reduced consistently to a low LOI (0.48 per cent) carbon content. This engineered ash is well within ASTM guidelines for coal ash use in the cement manufacturing process.

With the carbon content of the engineered coal ash reduced by 96 per cent, cement manufacturers can use this product with increased confidence as a replacement for virgin ordinary Portland cement (OPC) to more than 30 per cent of the mix. When combined with carbon mitigation technologies on the output side, one can see an integrated path for an industrywide carbon mitigation strategy that would meaningfully create solutions to bridge the innovation gap.

Addressing high carbon intensity inputs for cement making go nowhere unless there are efficient, cost-effective end products in which an ultra-low carbon, engineered coal ash product is in demand. The building materials supply chain will have to account for its carbon generation as the world's population approaches 10bn by 2050 and global building stock is expected to double in size. Carbon emissions released before the built asset is used, referred to as 'upfront carbon', will be responsible for half the entire carbon footprint of new construction between now and 2050, threatening to consume a large part of our remaining carbon budget.[3]

Applications

A final concrete product made with ultra-low carbon, engineered coal ash cement replacement has numerous high-performance applications, from blended cements incorporating waste organic materials, increased flowability for high tech innovations such as 3D-printed housing and marine shoreline restoration applications. Extensive research has investigated the high strength and good durability can be achieved by using pozzolanic materials blended with fly ash showing long-term gains in strength. In addition, the low carbon fly ash at <10µm size specifications reduce concrete void spacing, decreasing permeability.[4]

Rising sea levels exacerbated by climate change is a very real scenario for coastal cities and communities, globally. As carbon emissions continue to increase, building seawalls and shoreline restoration are one way to protect people and property. Billions of dollars in projects have already been announced or are currently under construction.

Ensuring the challenge is met

Addressing carbon emissions over the coming decades will affect every sector, in every industry. Striking the balance between protecting our environment, preserving living standards and elevating the aspirations of people around the world is the challenge. The construction industry must ensure the challenge is met. Already in March 2022, the procurement arm of the US federal government imposed new limitations on high carbon-emitting building materials for all its major projects, a move that will affect billions of dollars of federal infrastructure investments. The new General Services Administration (GSA) standards will require that federal contractors use climate-friendly concrete and asphalt in all the agency's major projects.[5] These answers to our carbon abatement questions are not "either/or" – it is how we apply all the technological possibilities together to reach more complete answers that work for every facet of life and global circumstances. ■

REFERENCES

[1] GLOBAL CEMENT AND CONCRETE ASSOCIATION (2017) 'Getting the numbers right' *https://gccassociation.org/sustainability-innovation/gnr-gcca-in-numbers/* [Accessed on 28 March 2022]

[2] CHATHAM HOUSE (2018) 'Cement sector: seven reasons why it needs to change' *https://www.chathamhouse.org/2018/06/cement-sector-seven-reasons-why-it-needs-change* [Accessed on 28 March 2022]

[3] WORLD GREEN BUILDING COUNCIL (2021) 'Bringing embodied carbon upfront: coordinated action for the building and construction sector to tackle embodied carbon' *https://www.worldgbc.org/news-media/bringing-embodied-carbon-upfront* [Accessed on 15 March 2022]

[4] BEHADH, MA, JAAFAR, MS (2018) 'Ultra high-performance concrete utilizing fly ash as cement replacement under autoclaving technique' in: *Case studies in construction materials*, 9, p2.

[5] US GENERAL SERVICES ADMINISTRATION STANDARDS 'Facilities Standards (P100) Overview' *https://www.gsa.gov/real-estate/design-construction/engineering-and-architecture/facilities-standards-p100-overview* [Accessed on 17 March 2022]