The quest for carbon neutrality

The cement industry will only be able to achieve its aspirations to reduce carbon emissions and address climate change by executing several strategies simultaneously. Resha Watkins, president, aggregates and sustainability, Votorantim Cimentos North America, explains the main levers of a multi-faceted approach and outlines how Votorantim Cimentos and St Marys Cement works are working to advance sustainability in the region.

■ *by **Resha Watkins**, Votorantim Cimentos North America*

In order to fully address climate change and achieve the goal of decarbonisation, the cement industry must deploy a range of initiatives simultaneously. These initiatives include using more alternative fuels, producing Portland limestone cement (PLC), and capitalising on carbon capture, utilisation and storage (CCUS) technologies, complemented by energy and efficiency improvements, increased recycling and promotion of energy-efficient buildings. It is only through this multi-faceted approach that inroads can be made to propel the industry forward towards decarbonisation.

The concrete industry's approach to carbon neutrality starts at the cement plant and extends through the entire life cycle of the built environment. Reducing carbon emissions will provide numerous benefits to not only the industry, but also society, by moving towards more efficient and nature-based solutions. This is a message echoed by the missions of organisations throughout the industry and around world. Some of these include:

- United Nations and the Paris Agreement – climate change is a global emergency that goes beyond national borders
- Global Reporting Initiative (GRI) – delivering global best practice for how organisations communicate and demonstrate accountability for their impacts on the environment, economy and people
- Global Cement and Concrete Association (GCCA) – ensuring concrete is recognised as the sustainable building material of choice for today's needs and to meet the global challenges for future generations
- Portland Cement Association (PCA) – supports market-based policies and initiatives that enable the industry's continued reduction of its carbon footprint in a responsible and sustainable manner
- Cement Association of Canada – to create optimal conditions for our industry to lead and thrive in a clean economy.

Votorantim Cimentos North America looks at how the cement industry can reach ambitious low-carbon emissions goals

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Currently, based on US Environmental Protection Agency (EPA) carbon emissions data, the manufacture of cement accounts for 1.25 per cent of US carbon emissions. As the demand for cement and concrete grows to support societal needs with new construction, modernisation and infrastructure improvements, the importance of addressing the carbon emissions of cement and concrete becomes more critical than ever.

The industry has been responding by looking at how and where changes can be made in the production cycle to reduce the output of carbon emissions. This includes using performance-based rather than prescriptive-based policies and approaches, and advocating for specifications to be adjusted accordingly to streamline the introduction and market acceptance of newer lower-carbon alternatives. As the industry progresses on its carbon reduction journey, new policies and technologies will also emerge that will advance further developments and innovations.

Production at the cement plant

Blended cements

One of the first and most impactful strategies is to reduce the clinker content of cement, offsetting an acceptable portion of the clinker with other supplemental cementitious materials, resulting in new, lower-carbon blended cements. For example, an increasingly popular approach is the use of PLC, a blended cement with a higher limestone content than ordinary Portland cement (OPC). According to the PCA, this results in a product "that works the same, measures the same, and performs the same, but with a reduction in carbon footprint of 10 per cent on average." The key to any successful blended cement is that the product's performance characteristics must be maintained, while also achieving significant environmental benefits. This approach provides a more sustainable way to build any project, without modifications to mix designs or placing procedures.

Modifying a concrete mix design to

replace higher-carbon materials with lower-carbon ingredients is an effective strategy to reduce its environmental footprint. The PCA Roadmap to Carbon Neutrality explains that the US standard for OPC allows for up to five per cent of clinker to be replaced by limestone, but the standard for blended cement allows for 5-15 per cent limestone replacement in PLC. Concrete mixes designed with PLC are compatible with other supplementary cementitious materials (SCMs), so when substituting OPC with PLC, other materials can continue to be used for an even greater reduction in carbon footprint. PLC is just one market-ready example of how creating new blended cements using lower-carbon alternative materials can contribute significantly to the reduction of carbon emissions.

Alternative fuels

Alternative fuels are a fraction of the current fuel mix and there is an opportunity to quickly increase their use to displace traditional fossil fuels and replace raw materials with decarbonated materials.

Across the industry, cement plants are pursuing the requisite permitting and seeking lower-carbon materials with sufficient calorific value. These materials must also be available as a continuous supply, making byproducts a natural choice for both raw materials and in the production process.

In its Roadmap to Carbon Neutrality, PCA states that European cement manufacturers currently use about 60 per cent alternative fuels in their fuel mix while in the US, alternative fuel accounts for approximately 14 per cent of fuel-related energy. Through the introduction of policies and regulations, it is possible that alternative fuels could make up 50 per cent of the industry's fuel mix.

Improving energy efficiency

If even a portion of the electricity used in cement and concrete production is switched to renewable sources, like wind, hydro and solar, it will contribute to offsetting the CO_2 created from fossil-fuelled power plants. This is a developing area with undeniable carbon reduction advantages. It is important to note that even these green energy solutions require an abundant amount of cement and concrete to bring to fruition.

The US cement industry has improved energy efficiency 20 per cent since 1990. Today's cement technologies are operating above 80 per cent thermal efficiency, ranking cement manufacturing among the more efficient industrial processes. Because of this, identifying and implementing additional efficiencies is that much more challenging. Yet, increasing energy efficiency is essential to reducing the amount of CO_2 emitted for each ton of product. According to PCA, it currently takes 3.84mBtu of energy to produce 1t of clinker. Through the plant modernisations, upgrades, and even the application of machine learning and artificial intelligence, the goal is to reduce that by more than 25 per cent.

CCUS technologies

CCUS is a critical part of cutting emissions in cement production. CCUS captures CO_2 so it can either be used to produce new materials or be safely – and permanently – sequestered. CCUS directly avoids or reduces a significant portion of cement manufacturing emissions.

Capture technologies undergoing research in the cement industry include a variety of solvent, sorbent and membrane technologies. Carbonation, mineralisation, calcium (or carbonate looping), oxyfuel combustion and calcination, and algae capture are included within that research.

With the right policies, research, investment and funding, carbon capture can become an integral part of any cement plant. Moreover, through collaborative partnerships the industry can speed its rate of adoption to realise the benefits of this new operating paradigm sooner.

Key levers

The main levers towards decarbonisation of the cement and concrete industries are:
- alternative fuels usage
- energy efficiency
- CCUS technologies
- alternative materials (PLC and blends)
- performance-based specifications
- recycled materials
- renewable energy sources
- waste reduction
- service life/use phase

Construction – designing and building

It is also incumbent upon those in the cement and concrete industries to continually educate and collaborate with architects, designers, contractors and master planners on the latest developments, technologies and materials. Designs and specifications will need to shift toward being more performance-based, which will allow for more innovation in cement and concrete manufacturing, as well as market acceptance. By encouraging the use of advanced technologies, the industry can help to improve structural performance, energy efficiency, resiliency, and carbon sequestration.

This entails:
- considering the specific needs of the construction project and using only the materials necessary, avoiding excess emissions.
- switching to solar, wind and other renewable sources of energy to directly reduce emissions from other energy sources.
- increasing the use of recycled materials (including recycled construction materials from demolition), therefore diverting these materials from landfills.
- designing for the specific needs of the construction project to reduce unnecessary overproduction and emissions.

As the benefits are understood as to how alternative mixes and innovative technologies can uphold the same standards, universal acceptance will spread. Producers, contractors and owners can help with this recognition by driving changes in building codes to allow performance-based concrete to be a standard on all projects. The result is life-cycle benefits, such as improved structural performance, energy efficiency, resiliency and carbon sequestration.

Everyday: concrete infrastructure in use

Concrete, including new, more sustainable variants, can decrease the carbon footprint of our buildings — increasing the building's energy efficiency and cutting energy use. The result is reduced emissions generated by heating and cooling. In addition to energy savings and resilience, there are many additional advantages within the lifecycle of concrete structures that benefit society.

"Championing sustainable solutions adds excitement as the industry searches for and implements new solutions so world-class structures can be built to new, lower-than-ever carbon footprints."

Reduce vehicle emissions
Concrete pavements actually enhance the fuel efficiency of the vehicles driving on them, thus lowering emissions.

Decreased maintenance
Due to their durability and resilience, concrete structures (buildings, pavements, bridges, dams, etc.) last longer and require less frequent maintenance.

Recycled concrete
Concrete in place can be 100 per cent recycled, limiting the use of raw materials and production emissions.

Carbonation
Every exposed concrete surface absorbs CO_2 over the course of its service life. The rate of CO_2 absorption by concrete can vary depending on a number of factors, such as the type of concrete, the age of the concrete, and the exposure of the concrete to the air. However, overall, exposed concrete surfaces can reabsorb as much as 10 per cent or more of cement and concrete production's CO_2 emissions over their service life. This may make concrete the most sustainable building material that can help to mitigate climate change.

Clean energy
Even clean energy solutions require concrete. Windmills, solar, and hydroelectric are a few examples of clean power solutions that use concrete in their infrastructure. Today, some of the largest and most advanced companies want to be seen using solutions that reduce carbon emissions.

Construction workforce
With a large portion of the industry's workforce nearing retirement age, there are valid concerns that as more industry veterans retire, there will be a gap in the technical, mid-skills and trades workforce. Concentrating on issues concerning lowering the carbon footprint has an added benefit of attracting more younger people to the industry. Fortunately, incoming generations consider sustainability and environmental concerns a high priority.

Championing sustainable solutions adds excitement as the industry searches for and implements new solutions so world-class structures can be built to new, lower-than-ever carbon footprints. More and more, talent will be attracted to our industry by construction companies, organisations and associations working together toward a common goal of reducing carbon emissions.

St Marys Cement – supporting sustainability in North America

As part of international building materials and sustainability solutions provider, Votorantim Cimentos, St Marys Cement is a major producer of cementitious materials in North America. Its plants, grinding facilities and distribution points are strategically located to serve Canadian and US customers with a capacity of more than 8.1Mta.

St Marys Cement first produced PLC in 2010 in Canada and in 2020 in the US. Because of the vast number of research studies and required background specification adoption requirements, the product was initially slow to gain acceptance. In North America, Departments of Transportation were among the last to change their specifications to adopt PLC for general use. Today, 100 per cent of general-use cements produced by St Marys Cement are PLC, with the exception of the recently added McInnis plant in Quebec, which is running at approximately 85 per cent PLC, as the customers it serves in the eastern Canadian and US provinces and states transition to full adoption. Looking ahead, suppliers, like St Marys, will face similar challenges as it introduces new lower-carbon blended cements to the marketplace, with performance-based specifications being of critical importance.

Resources

The following organisations provide information and insights that can help the industry deliver on its climate and environmental ambitions:
- Cement Association of Canada
- CSC
- GCCA
- GCCA 2050 Net Zero Roadmap
- GRI
- National Ready Mixed Concrete Association (NRMCA)
- PCA Roadmap to Carbon Neutrality
- Portland-Limestone Cement NEU: An ACI Center of Excellence for Carbon Neutral Concrete
- Carbon Leadership Forum

The future

The decarbonisation of the cement industry is a complex challenge that requires ongoing collaboration between the industry, governments, specifiers and researchers. Considering the cement industry is a major employer around the world, decarbonisation should be implemented in a way that minimises job losses and attracts more young people to our industry to drive continued innovation. Overall, decarbonisation of the cement industry is a challenging but achievable goal with the right combination of technologies, policies and investment, for the industry to reach ambitious low-carbon emissions goals. ■

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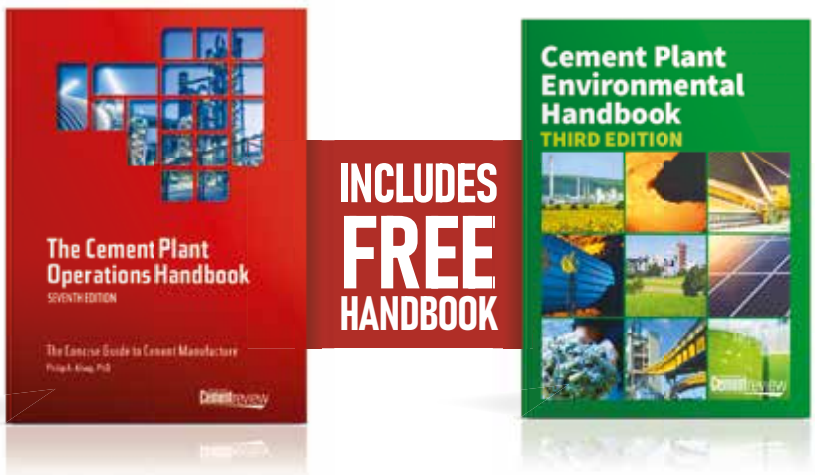

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