Add and decarbonise

Net-zero performance-enhancing additives for cement grinding and concrete can not only improve energy efficiency but also offer a practical and scalable path to decarbonisation.

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In the ever-evolving landscape of cement production, innovation and sustainability are no longer optional goals but have become essential pillars of the cement producer's strategy. As the industry faces mounting pressure to reduce its carbon footprint, cement producers are turning to advanced technologies and materials to meet environmental targets without compromising performance. Among these innovations, performance-enhancing cement additives have emerged as powerful tools in the decarbonisation journey.

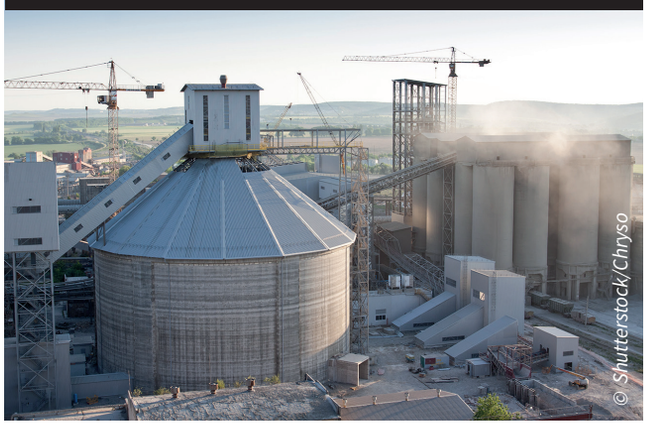
Two North American case studies highlight how performance-enhancing additives are addressing key operational challenges, elevating cement quality and significantly reducing CO_2 emissions. These success stories underline the importance of collaboration, customisation and continuous improvement in building a more sustainable cement industry.

Why cement additives matter in decarbonisation

Cement production is one of the most carbon-intensive industrial processes. A significant share of these carbon emissions arise from the calcination of limestone, driving the need for clinker factor reductions. Astute selection of performance-enhancing cement grinding additives offers a strategic pathway to reduce emissions through several mechanisms:

- **enhanced strength development** – By improving early and late-age strength, performance-enhancing additives enable higher levels of clinker substitution with supplementary cementitious materials (SCMs) such as limestone, fly ash, or slag – each of which has a lower carbon footprint than the primary clinker ingredient. Alternatively, these strength gains can be leveraged toward coarser grinding, leading to further production gains and energy reduction.
- **increased grinding efficiency** – Grinding additives reduce agglomeration and improve the flow properties of materials in the mill. This reduces the specific energy consumption and improves material handling and flowability.
- **operational flexibility** – Customised formulations allow producers to find a product best suited to their materials, market demands and regulatory requirements – all while maintaining or improving sustainability metrics.
- **lower production costs** – By enabling clinker reduction, improving grinding efficiency and enhancing overall mill throughput, additives help reduce energy usage, raw material costs and maintenance demands, delivering measurable cost savings alongside emissions reduction.

Modern cement plants are at the forefront of decarbonisation efforts, leveraging advanced additives to reduce emissions and improve efficiency



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These benefits are being realised today, as shown in the following case studies that highlight two significant projects undertaken by North American cement producers to address specific challenges and enhance their operations.

Case study 1: overcoming staining and boosting output

A North American cement producer encountered persistent issues with staining and discolouration in flatwork. Initial testing revealed that their cement was highly susceptible to the iron-chelating effects of alkanolamines found in traditional activators, which led to a high degree of soluble iron in the pore solution, resulting in the discolouration issue.

While switching to a conventional glycol-based additive eliminated the staining as a temporary action, it came at a cost: a significant drop in cement strength, forcing the plant to grind finer, resulting in a 13 per cent reduction in output.

To resolve this, a comprehensive factorial study was launched to develop a non-amine-based activator that could leverage a strength gain to a Blaine specific surface area reduction and corresponding increase in mill throughput. The result was EnviroAdd™ WR, which delivered over 15 per cent strength improvement compared to the conventional product without causing iron solubilisation or discolouration.

Key project outcomes:

- 13 per cent increase in mill output and energy efficiency
- six per cent higher 28-day compressive strength at the higher production levels
- two per cent increase in limestone replacement
- estimated 2.2 per cent reduction in embodied CO_2
- positive feedback from ready-mix customers on batching "wet-out" times, discharge from the truck and finishability in the field.

This project not only resolved a technical issue but also aligned

with broader market demands and sustainability goals. By enabling coarser grinding and higher limestone content, the additive helped reduce the carbon intensity of the cement while improving its performance in the field.

Case study 2: elevating sustainability

At a flagship facility producing 2Mta of cement, another North American producer sought to transition from a basic grinding aid to a more advanced solution that would support higher limestone content and lower CO_2 emissions. The objective was to increase the limestone content from 10 to 12-13 per cent, translating to CO_2 savings of 40,000-60,000tpa.

The challenge was to meet the producers' aggressive CO_2 reduction targets while maintaining the high performance of their cement in the market. As with the adoption of any new material, care must be taken to address the nuances of its performance characteristics in the field. A rigorous screening process involving numerous combinations of high-performance cement additives was initiated to develop a customised EnviroAdd™ EL formulation.

Key project outcomes:

- 12-13 per cent higher 28-day compressive strength
- 2-3 per cent increase in limestone replacement
- Meeting the embodied CO_2 reduction target of 40,000-60,000tpa.

Concrete performance studies showed that the bleeding rates were primarily related to the overall fineness of the cementitious powder system, rather than the amount of limestone. This finding enabled the plant to achieve the project targets while avoiding any negative impacts on bleeding rates and associated impacts to field performance.

The project also leveraged Chryso's proprietary Mill Value Model to evaluate market scenarios and quantify the financial and environmental benefits. The result was a solution that not only met but exceeded sustainability targets while remaining economically attractive and flexible.

Lessons learned and industry implications

These case studies highlight seven critical insights for cement producers navigating the path to decarbonisation:

1. Customisation is key – Off-the-shelf solutions rarely address the unique challenges of each plant. Tailored additive formulations can economically unlock performance gains and sustainability improvements simultaneously.

2. Collaboration drives innovation – Close coordination between producers, additive suppliers, and field users ensures that solutions are practical, scalable and aligned with market needs.

3. Data-driven decision making – Tools such as the Chryso Mill Value Model help quantify the trade-offs between performance, cost and sustainability, enabling smarter investment.

4. Additives as enablers – Rather than being seen as ancillary, performance-enhancing grinding aids and activators should be viewed as strategic enablers of low-carbon cement production.

5. Integration across the value chain – Performance-enhancing cement additives and concrete admixtures are most effective when considered together. Holistic mix design optimisation, which entails coordinating cement additives with water reducers, strength enhancers and other admixtures, can unlock greater SCM usage and cost savings while enhancing both sustainability and real-world performance.

6. Field validation matters – Cement optimisation must extend to how concrete behaves in the field. Admixtures that support workability, set control, pumpability and finishability help ensure high-performance results, even with increased limestone or SCM content. This alignment is essential to building market confidence in lower-carbon solutions.

7. Admixtures as strategic partners – Just as cement additives have evolved from commodity products to performance tools, concrete admixtures should be viewed as essential allies in sustainable construction. Used in tandem, these technologies help mitigate field-level concerns such as shrinkage, slump loss, or curing behaviour which can be common barriers to broader adoption of low-carbon cements.

Field performance is a critical measure of success. Enhanced cement and concrete additive formulations enhance workability, finishability, and long-term durability

Innovative research and development in the laboratory drive real-world sustainability gains in construction

Cementing a low-carbon future

As the cement industry moves toward net-zero, performance-enhancing additives, at both the grinding and concrete stages, will be key enablers of progress. From boosting energy efficiency and enabling higher SCM replacement to ensuring reliable jobsite performance, these solutions offer a practical, scalable path to decarbonisation.

The success of EnviroAdd cement additive range projects shows that sustainability and performance can go hand in hand. It also reinforces the importance of thinking beyond the plant. By aligning grinding additives with the right combination of concrete admixtures (such as water reducers, set modifiers and strength enhancers) producers can address performance challenges across the full value chain.

With the right partnerships, customisation, and data-driven tools, producers can meet evolving customer expectations, achieve aggressive CO_2 reduction targets, and deliver high-quality cement and concrete that performs in the real world. These strategies offer not only incremental improvement, but are foundational to a more resilient, sustainable future for the industry. ■