

TAKING SOMETHING BACK

If environmental targets are going to be met, construction companies will need to find new ways to reduce carbon emissions in building, and increase sustainability. One way this might be achieved is by embracing new cement technology. A number of firms around the world are busy developing solutions that claim to reduce, or entirely negate, cement's carbon footprint. Eric Payne reports.

Roughly two billion tonnes of Portland cement is produced every year; accounting for approximately five per cent of man-made CO₂ emissions. Pressure to reduce carbon emissions therefore places a significant burden of responsibility on the shoulders of construction firms and those that supply them, with governments, in turn, imposing strict targets forcing companies to adapt and respond to an increasingly ecology-conscious market place.

The traditional cement industry is pursuing a number of different strategies: blending pozzolans with Portland cement, adding mineraliser additives to reduce process temperatures, and CO₂ sequestration or storage. Much of this work is still in the early development stages, however a few companies have already emerged as obvious leaders, preparing themselves so that they are ready to meet any challenge the future might bring.

Massive carbon stores

One such company is Australian-based TecEco (Pty) Ltd, headed by Tasmanian technologist John Harrison. The company's

website explains how Mr Harrison drew much of his inspiration from nature: "During earth's geological history, large tonnages of carbon were put away as limestone and coal by the activity of plants and animals... John concluded that the answer to the problems of greenhouse gas and waste was to use them both in building materials."

One of the initiatives that resulted from this was a new type of cement, subsequently branded 'Eco-Cement'. Eco-Cement, based on magnesium carbonate as opposed to calcium carbonate (used in Portland), is used to make permeable concretes. It was one of the first products of its kind on the market, absorbing CO₂ and water from the atmosphere during the natural setting process.

Eco-Cement is made by heating magnesite in a kiln to produce reactive magnesium oxide (magnesia). That magnesia powder is then added to a conventional Portland cement mix which, in turn, can be mixed with aggregates, in the usual fashion, to make Eco-Cement. In the longer term the company plans to use the magnesium in sea water and brines, making it readily available for bulk processes.

Eco-Cement hydrates in permeable substrates, using mix water, then carbonates. The more magnesia added and the more permeable it is, the more CO₂ the Eco-Cement absorbs. An Eco-Cement concrete block typically takes up to one year to carbonate fully, occurring quickly at first and then slowing as the process continues. Furthermore, should an Eco-Cement structure reach its end-of-life or become obsolete, it can be almost fully recycled back into cement.

The material's major environmental benefit comes from the fact that Eco-Cement can effectively incorporate large amounts of waste matter into its mixture – including carbon-based wastes that would otherwise rot or be burned, releasing further CO₂ into the air. As has already been mentioned, incorporating pozzolans into cement mixtures is common practice, but because Portland is alkaline there are strict limits. Magnesium-based cements, however, are significantly less alkaline, leaving room for much larger amounts of bulking material without compromising structural integrity. "We can probably get three of four times

more waste into our cement than Portland cement," Mr Harrison has said. Buildings could become massive 'carbon stores'.

Carbon negative cement

Manufacturing Portland cement is one of the most energy intensive industry manufacturing processes. Ordinary Portland cement is made by heating limestone or clay to around 1,500°C – the extreme heat required to operate kilns creates a significant demand for energy. Approximately six million BTUs are required to produce one tonne of Portland cement. The process itself releases 0.8 tonnes of CO₂ per tonne of cement.

When this is mixed with water to make concrete, however, each tonne can absorb up to 0.4 tonnes of CO₂. Which still leaves you with an overall carbon footprint of 0.4 tonnes of CO₂ per tonne of cement.

Producing TecEco's Eco-Cement, the kilns do not need to be run so hot. Magnesium carbonate converts to magnesium oxide at around 650°C. Like Portland, Eco-Cement absorbs around 0.4 tonnes of carbon per tonne, but carbon absorbed in Portland cement reacts with calcium to deposit calcium carbonate crystals, which weaken the strength of the concrete. Eco-Cement, which is magnesium-based, actually gains strength from the magnesium carbonate crystals that are the result of the equivalent reaction. Prime sources of magnesium carbonate currently cost significantly more to mine than sources of calcium carbonate, although the makers claim this cost should fall with economies of scale.

Offering what is arguably the most compelling argument to date for the potential in this newly emerging market, is a company called NovaCem – a spin-out from Imperial College, London, which claims to have invented an eco-friendly cement with the potential to achieve cost and performance parity with Portland cement. Headed by Chairman Stuart Evans, NovaCem leads a £1.5 million Technology Strategy Board (TSB) project, along with major industry partners Rio Tinto Materials, Laing O'Rourke and WSP, and investors including the Carbon Trust.

NovaCem cement, which is awaiting a patent, uses magnesium silicates which do not emit CO₂ when heated. The production process also runs at much lower temperatures – around 650°C – the total CO₂ emissions from which are around 0.5 tonnes per

tonne of cement. Furthermore, the NovaCem cement formula absorbs about 1.1 tonnes of CO₂ as it hardens, making the overall carbon footprint negative – i.e. the cement removes 0.6 tonnes of CO₂ per tonne used.

NovaCem's next goal is to demonstrate the commercial viability of its product, at a pilot plant prior to scaleable volume production. Figuring out the size and location of this facility will be the next, crucially important goal for the TSB team.

An important opportunity

NovaCem is confident in its ability to fill the gap in the market, created by its own innovation. What follows is a quote from the company's own literature: "The cement industry is globally fragmented – the top four companies only control 14 per cent of industry revenues. NovaCem is playing a global game." However, "this is a big job and we can't do it on our own. We aim to build an eco-system of investors and partners that can make a real difference. And governments have an important contribution to make as well. We don't plan to have our own cement plants, but will make our technology available to others on competitive and compelling terms."

Given the ubiquity of cement use, this is bound to be an attractive answer to the needs of construction companies, especially in Middle Eastern countries where an ongoing steam of very large, hugely ambitious infrastructure and construction projects appears to be underway and where there are very few practical alternatives to cement.

Of course, it remains to be seen whether NovaCem can generate enough investment and interest to "build an eco-system of investors and partners that can make a real difference," then develop and prove the technology at a pilot plant. Likewise, a number of important questions remain unanswered – what happens to carbon stores when these buildings are destroyed? Are there any drawbacks to having a negative carbon footprint?

More research is needed, but the fact that people are working on solutions of this kind is certainly a hopeful one. The environmental benefits that might result from commercialising the concept are huge. If, at some point in the future, NovaCem completely replaced Portland cement, cement would absorb about five per cent of man-made CO₂ emissions rather than generating five per cent of CO₂ emissions. □