

Green cement may set CO₂ fate in concrete

Carrie Sturrock, Chronicle Staff Writer

Back when Stanford Professor Brent Constantz was 27 he created a high-tech cement that revolutionized bone fracture repair in hospitals worldwide. People who might have died from the complications of breaking their hips lived. Fractured wrists became good as new. Now, 22 years later, he wants to repair the world.

Constantz says he has invented a green cement that could eliminate the huge amounts of carbon dioxide spewed into the atmosphere by the manufacturers of the everyday cement used in concrete for buildings, roadways and bridges.

“It changes the nature of the fight against global warming”

– Carl Pope
Executive Director, Sierra Club

His vision of eliminating a large source of the world's greenhouse CO₂ has gained traction with both investors and environmentalists.

Already, venture capitalist Vinod Khosla is backing Constantz's company, the Calera Corp., which has a pilot factory in Moss Landing (Monterey County) churning out cement in small batches.

And Carl Pope, executive director of the Sierra Club, says it could be "a game changer" if Constantz can do it quickly, on a big scale and at a decent price.

"It changes the nature of the fight against global warming," said Pope, who has talked with Constantz about his work.

That might sound like hyperbole, but the reality is that for every ton of ordinary cement, known as Portland cement, a ton of air-polluting carbon dioxide is released during production. Worldwide, 2.5 billion tons of cement are manufactured each year, creating about 5 percent of the Earth's CO₂ emissions.

When Constantz learned about the high CO₂ levels, he thought he could do better. After all, the majority of his 60 patents have to do with medical cement.

He claims his new approach not only generates zero CO₂, but has an added benefit of reducing the amount of CO₂ power plants emit by sequestering it inside the cement.

To make traditional cement, limestone is heated to more than 1,000 degrees Celsius, which turns it into lime - the principal ingredient in Portland cement - and CO₂, which is released into the air.

Constantz uses a different approach, the details of which remains secret pending publication of his patent.



Brent Constantz, at his pilot factory in Moss Landing (Monterey County), has created a way to trap CO₂ in cement.

Paul Chinn / The Chronicle

At his pilot factory, a former magnesium hydroxide facility that made metal for World War II bombs, magnesium crunches underfoot as Constantz, wearing a pressed, blue button-down shirt with rumpled shorts and sandals, outlines how the process works.

He pointed to two enormous smokestacks billowing flue gases full of carbon dioxide next door at Dynegy, one of the West's biggest and cleanest power plants.

Constantz takes that exhaust gas and bubbles it through seawater pumped from across the highway. The chemical process creates the key ingredient for his green cement and allows him to sequester a half ton of carbon dioxide from the smokestacks in every ton of cement he makes.

Constantz believes his cement would tackle global warming on two fronts. It would eliminate the need to heat limestone, which releases CO₂. And harmful emissions can be siphoned away from power plants and locked into the cement.

The same process can also be used to make an alternative to aggregate - the sand and gravel - that makes up concrete and asphalt, which would sequester even more carbon dioxide from power plants.

"The beauty here is we're taking this old industrial polluting infrastructure and turning it into something that will save the environment," Constantz said.

On a per-person basis, the United States is the world's worst CO₂ polluter from all sources. But according to the Netherlands Environmental Assessment Agency, China just surpassed the U.S. for total carbon dioxide emissions.

China is expected to produce 47 percent of the world's 2.5 billion tons of cement this year, Constantz said.

To power its new buildings and sustain its building boom, China constructs at least one coal-fired power plant a week. Each one belches out enough CO₂ to cancel the benefits of every hybrid on U.S. roadways, said Constantz. A CO₂ molecule can travel from Beijing to San Francisco in less than a day through atmospheric circulation, he said. So even with California mandating that CO₂ emissions fall to 1990 levels by 2020, a crisis remains.

"Carbon dioxide is a global problem, not a regional problem," he said.

As far as cost, Constantz estimates his cement would retail for \$100 a ton versus roughly \$110 for Portland.

The reason no one invented it before now, he said, is that people didn't truly understand the dangers of CO₂ until less than a decade ago.

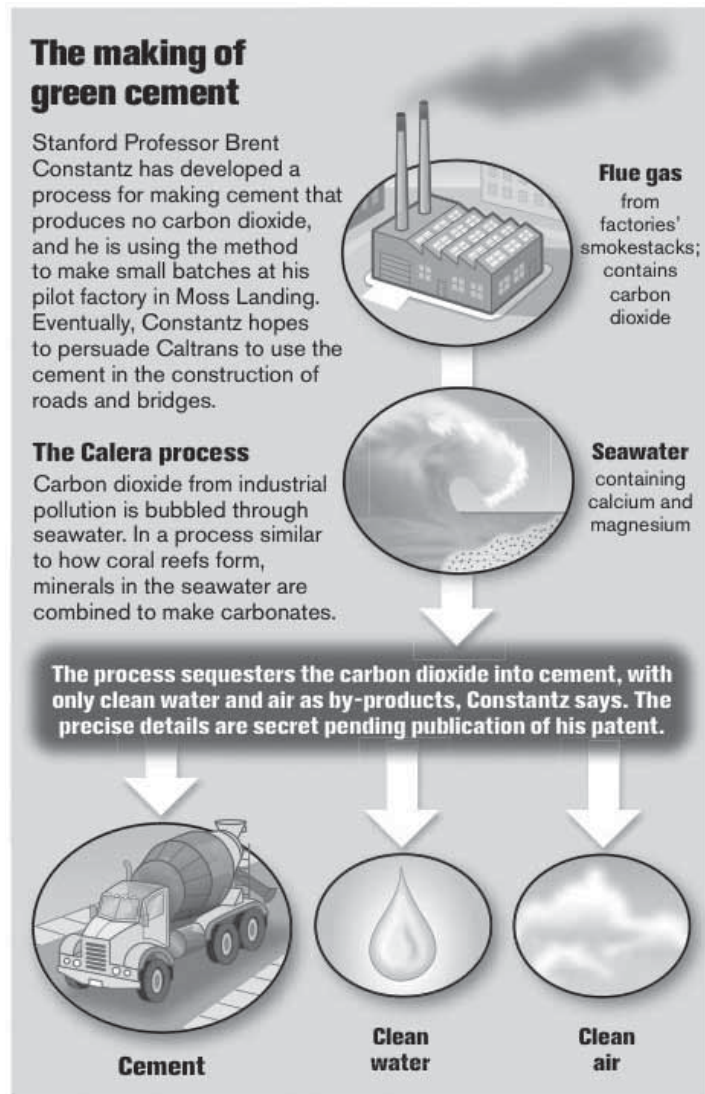
Skeptics question product.

He has skeptics. Portland cement has a track record of more than 100 years, and any new material would have to get incorporated into building codes, noted Rick Bohan, director of construction and manufacturing technology for the Portland Cement Association in Skokie, Ill.

And Tom Pyle, a Caltrans engineer who serves on the cement subgroup of Gov. Arnold Schwarzenegger's Climate Action Team, acknowledged that the technology is possible, but he still wants to examine Constantz's cement.

"We hope they have a carbon-reducing viable construction material," he said. "They need to show up with a bag of this so we can test it."

Constantz is confident he will prove himself. Initially, he proposes mixing his new invention with Portland cement to ease a conservative industry into a new product. Concrete bigwigs have invited him to speak about Calera cement at their annual World of Concrete in Las Vegas next February.



Source: Chronicle reporting

TODD TRUMBULL / The Chronicle

Power plant partnerships

Constantz envisions building cement factories next to power plants the world over. A team is scouting out U.S. locations. While Dynegy has supplied Constantz with some flue gas, it hasn't entered into a formal agreement.

"As we're looking into the future, we're very interested in technology that would help capture CO₂ from the flue gases and turn it into a product that offers a benefit," said Dynegy spokesman David Byford.

"Climate change is the largest challenge of our generation"

– Brent R. Constantz, Ph.D.
CEO, Calera Corporation

It could be good for business. California has mandated emissions reductions. And Congress is working on legislation that would allow high polluters to buy credits from those with low emissions. Power plants would have a huge incentive to sequester their CO₂ in cement. But even if Constantz succeeds, the world would still need to do much more to fight CO₂ emissions, said Chris Field, director of the department of global ecology at the Carnegie Institution for Science at Stanford. "It's a big, long complicated game," he said. "As we develop each new segment of the solution we need to embrace it and deploy it and work hard to develop the next segment of the solution."

Coral basis of idea

Big ideas can form in haphazard ways. The one for bone cement began during a televised football game, when Constantz read an osteoporosis article in the New England Journal of Medicine. Three weeks later, as he studied a coral reef, it occurred to him he could maybe synthesize coral skeletons in human bones.

His new cement mimics how coral reefs form, too. Coral uses the magnesium and calcium present in seawater to create carbonates much as he's using CO₂ and seawater to make carbonate.

This latest invention took 18 months to conceive and execute. He feels it's one of the most important things he's ever done. "Climate change is the largest challenge of our generation," he said.



One of the tanks that will be used to make green cement at Brent Constantz's Calera pilot plant in Moss Landing.

Paul Chinn / The Chronicle

Who is Brent Constantz?

Profession: An associate consulting professor in Stanford's department of geological and environmental sciences and founder of the Calera Corp. Created and sold three other companies - Norian Corp., Corazon Technologies Inc. and Skeletal Kinetics.

Education: UC Santa Barbara, bachelor's of science (1981); UC Santa Cruz, doctorate (1986)

Family: Married and father of four.

Pastime: Surfing and rock climbing.

Concrete facts about cement

2.5 billion tons of hydraulic cement is produced worldwide annually. Add sand and gravel and that makes more than **9,000 million cubic yards** of concrete. That's more than enough concrete to pave an **eight-lane highway** from the Earth to the moon and back again - twice.

If you stayed on the planet, that same eight-lane highway would circle the Earth almost 40 times.

Source: Portland Cement Association