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### **Photocatalysts, Self-Cleaning Concrete** ***Photocatalysts can keep concrete clean and reduce air pollution.***

by Michael Chusid, FCSI

Europe is the home of the reigning showplace of photocatalytic technology, the Jubilee Church (also known as the Dives in Misericordia) in Rome, completed in 2003. The soaring structure was designed by the award-winning international architectural firm of Richard Meier & Partners Architects LLP. It is an awe-inspiring composition of 256 precast, post-tensioned concrete elements assembled into curved white “sails” that rise 85 feet into the sky.

The project was constructed with TX Millennium, a white portland cement with a photocatalytic additive that is manufactured by Italcementi Group. Crushed white marble aggregate was also used to make the concrete a brilliant white. As the project’s “technical sponsor,” Italcementi Group estimates 12,000 man-hours went into developing and testing the new cement to make sure the photocatalytic material is compatible with the concrete and would, indeed, keep the building clean for the thousand-year service life used as the project’s design criteria.



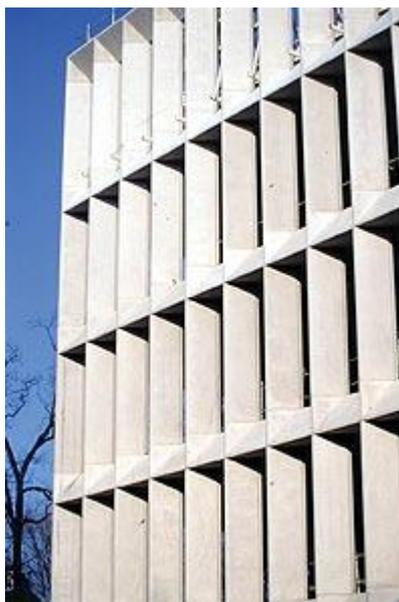
Italcementi Group’s subsidiary, Essroc, is presently introducing the technology to the North American market with a primary focus on the precast concrete industry. The company’s director of marketing, Paul Batt, also sees great opportunities for the technology in cast-in-place and other types of concrete construction. However, the wide range of conditions and materials affecting concrete

requires a “case-by-case approach to ensure all the factors that impact the success of photocatalytic concrete are considered,” he says.

Green Millennium, on the other hand, is already selling water-based photocatalytic materials in the U.S. Finding a way to put photocatalytic

material into a water base was an important breakthrough because organic binders used for other types of coatings decompose in contact with photocatalysts.

In a recent demonstration project, they treated a guest room in a major Las Vegas hotel and measured a greater than 30 percent reduction in odors from tobacco and other olfactory nuisance; performance would have been better, the manufacturer claims, if the hotel kept draperies open during the day.



While Green Millennium's solution has been used on concrete in Japan, the firm has not yet formally introduced the technology to the concrete industry in North America. Still, the material is available. Marketing director George Tseng says the product can be applied with an HPLV sprayer and 0.3 to 0.8 mm diameter spray tip to produce a fine mist pattern for a thin and even coating on the surface. In addition to new construction, he sees a huge potential demand for treating existing buildings and says the company plans to offer training programs for distributors and applicators.

#### Nanotechnology

The catalytic ingredient in all of these products is titanium dioxide (TiO<sub>2</sub>). Titanium dioxide is widely used as a white pigment in paint, plastics, cosmetics, and a host of other products. Making it photocatalytic requires manipulating the material to create extremely fine nanotechnology-sized particles with a different atomic structure. At the nano-scale, this new type of titanium undergoes a quantum transformation and becomes a semiconductor. Activated by the energy in light, the TiO<sub>2</sub> creates a charge separation of electrons and electron holes. The electrons disperse on the surface of the photocatalyst and react with external substances, causing chemical reductions and oxidations and forming hydroxyl radicals that act as powerful oxidants to decompose organic compounds.

Extensive research into photocatalysts is being conducted worldwide, and they may one day prove to be an invaluable part of the concrete construction palette. Meanwhile, David Shepherd, Director of Sustainable Development at the Portland Cement Association, characterizes the technology as “an interesting laboratory experiment. There is too much to learn about them before we declare the technology a breakthrough for concrete construction.”

Before the materials can be widely used with confidence, industry standards must be developed and long-term exposure tests — in a variety of environments and concrete mixtures — must be conducted to determine the best dosage rates and application techniques, compatibility with admixtures, the longevity of treatments, and the treatment's effect, if any, on the durability of structures. For example, will the hydrophilic effect of the photocatalysts draw moisture into concrete in a way that could promote corrosion or freeze-thaw deterioration? And even if the photocatalyst manufacturer says its product is compatible with joint sealants and coatings, who will warrant that these materials will adhere to a treated concrete substrate?

Conventional pigment-grade TiO<sub>2</sub> is an inert substance with acceptable toxicological and environmental risks. Initial indications are that the nanotechnology forms of TiO<sub>2</sub> will also be acceptable, but prudence is justified pending further investigations. Researchers are discovering new photocatalysts that operate under visible light and that promise even more effective photocatalysis. Increasing production capacity should result in lower material costs. In addition, new applications are being found for photocatalysts in fabrics and clothing, personal care products, and other everyday products: for example, you can buy photocatalytic antibacterial deodorant pantyhose in Japan. What will happen when widespread use of photocatalysts results in a build-up of the chemicals in the environment?

Photocatalytic materials that are buried are not exposed to light and do not decompose organic materials. What will happen when the compounds are drawn out of the earth into the foods and water supply and then ingested by humans and other species? What might happen when they wash into shallow seas and decompose the microorganisms upon which the ocean's ecosystem feeds? These concerns must be addressed because catalysts are not depleted by the reactions they trigger; they continue to affect the environment long after



the reason for their initial application has past. Pending further research and field long-term field trials, the readily identifiable environmental benefits of the new technology have to be weighed against possible and unknown risks.

#### **On the beach**

If you are reading this at the beach, you may be experiencing the power of the sun to decompose organic material — known in this case as “sunburn.” The tube of sunscreen you brought with you may include titanium dioxide in its list of ingredients; if so, it is the old-fashioned non-photocatalytic type. As you apply it to yourself, however, take time to daydream about how and where you might use the new type of TiO<sub>2</sub> in your concrete projects.

While photocatalysts may not be ready for major projects, I suspect many readers of this article will return from their vacation eager to test photocatalytic materials in their workshops and sample yards. Entrepreneurially spirited and willing to get their hands dirty with experiments, decorative concrete contractors have always been an innovative force in the construction industry, and are certain to find exiting new ways to use photocatalysts to offer their clients a better product.

Michael Chusid, FCSI is an architect and marketing consultant specializing in the evaluation and promotion of innovative building materials. He is a consultant to many manufacturers and trade associations in the concrete industry. Based in Los Angeles, he can be reached at [www.chusid.com](http://www.chusid.com).