RECLAMATION
Managing Water in the West

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Bureau of Reclamation

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Bottom Line

This research project evaluated the durability of titanium dioxide (TiO_2)-based coating and bulk cement under the adverse weathering and freeze-thaw conditions at Reclamation structures.

Better, Faster, Cheaper

TiO_2-based cement products could provide Reclamation with a low maintenance option for architectural concrete with air purification properties when used as part of a comprehensive air quality improvement plan at Reclamation. In addition to preserving the aesthetics of a structure with minimum maintenance, these products have been shown to reduce air pollutants such as volatile organic compounds, particulate matter, nitrogen oxides, and sulfur oxides.

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Eco-Friendly Cement for Green Construction

Evaluating titanium dioxide nanoparticle-based cement products with self-cleaning and air-purifying properties

Problem

Environmentally friendly cement is critical to ensuring Reclamation can meet its commitments to sustainable design. In 2008, the U.S. Department of the Interior issued a Sustainable Buildings Implementation Plan (SBIP). Reclamation has committed to SBIP's vision to "reduce the negative economic, social, and environmental impacts of its buildings through sustainable planning, acquisition, siting, design, construction, operation, maintenance, leasing, and decommissioning." The 2011 Green Building Initiative further challenged Reclamation to design new construction with more energy and resource efficiency.

Moreover, Reclamation is often asked to provide architectural concrete to meet the aesthetic needs of new and existing building projects. A new "green cement" using titanium dioxide (TiO_2) may be able to satisfy those needs and even improve air quality in the vicinity of the structure. This cement could help reduce greenhouse gases and contribute to a healthier environment for the community through better building practices.

The Italian manufacturer of two TiO_2 nanoparticle-based photocatalytic green cement products (i.active COAT coating and TX Active® cement) has cited several instances where buildings in both the United States (U.S.) and Europe have used this product as part of a green building plan for Leadership in Energy and Environmental Design (LEED) certification. These products have been shown in the literature to purify air from pollutants such as volatile organic compounds (VOC), particulate matter up to 10 micrometers (PM10), nitrogen oxides (NO_x), and sulfur oxides (SO_x). The manufacturer and others report that these products can reduce NO_x by 45 to 91 percent and PM10 by 20 to 80 percent, depending on test conditions.

In addition, the cement is marketed as a self-cleaning product that helps to reduce maintenance costs and improve cosmetic appearance of structures. It could be used broadly across all Reclamation regions to comply with the SBIP guiding principles. However, while the TX Active® cement product has been employed in several locations in the Eastern U.S., there are little data available on the i.active COAT coating and how it may perform in the wet-dry, freeze-thaw conditions that Reclamation routinely services. Of primary concern, since Reclamation structures are often adjacent to sources of water, is to ensure that there is no release of nanoparticles from the product that could themselves contaminate Reclamation's water systems.

Panels for weathering testing—concrete control (top left), TX Active® concrete (top right), and i.active COAT-coated concrete (bottom).

Solution and Results

This Reclamation Science and Technology Program research project represented a unique opportunity for Reclamation to collaborate on evaluation of these products with Colorado Precast Concrete (CPC).

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CPC used these products on concrete pillar capstones at the Denver International Airport, Colorado. Reclamation's Technical Service Center, Materials Engineering and Research Lab tested the product.

Fiscal year 2014 experiments focused on two key areas:

- Ability of the product to resist nanoparticle leaching under various environmental exposure conditions
- Mechanical durability of the product under freeze-thaw conditions

Laboratory weathering tests were performed with the experimental setup exposing test coupons to cyclic "rain" and light/dark conditions. Samples were taken biweekly for testing of nanoparticle release. These samples were sent to research collaborators at the U.S. Army Corps of Engineers Environmental Laboratory; researchers there specialize in nanoparticle release and environmental toxicity studies. They will help analyze the Reclamation samples and use this as a case study for their ongoing effort to develop guidelines for nanoparticle use in the U.S. Army Corps of Engineers.

Additionally, freeze-thaw exposure tests, following American Society for Testing and Materials (ASTM) standards, were conducted on control concrete, i.active COAT-coated concrete, and TX Active® concrete bars. The i.active COAT coating showed very poor durability under freeze-thaw conditions. However, it is hypothesized that the sample geometry and test conditions were extremely harsh for coated samples; this setup is typically used for testing solid concrete blocks.

Future Plans

It is recommended that freeze-thaw testing be re-evaluated with a test setup specifically for cementious coatings. This would likely yield a more accurate prediction of the performance of i.active COAT coatings under these conditions.

Weathering test setup.

The i.active COAT-coated concrete bar after freeze-thaw testing.

Cross section of TiO_2-based cementitious coating on concrete.

"This research is a great opportunity to assess a so-called "green" construction material for use at Reclamation. The sophisticated technology of TiO_2 photocatalysis is incorporated into a common building material—cement. This cement can be applied to structures such as retaining walls, office buildings, dam crests, and walkways. The white color is preserved with little maintenance, and it provides local air-purification."

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Collaborators

- **Reclamation**
- **Colorado Precast Concrete**
- **U.S. Army Corps of Engineers Environmental Laboratory**

More information

www.usbr.gov/research/projects/detail.cfm?id=7846

For printable version see: www.usbr.gov/research/docs/updates/2015-09-cement.pdf