Meeting Extreme Demands

Activated fly ash cement concrete—resistant to extreme environments, yet environmentally friendly

by Michael H. Weber

Concrete surfaces at industrial facilities may be exposed to a wide range of extreme environments, including strong acids or high temperatures. Owners need long and trouble-free service, and most strive to minimize environmental impacts. Activated fly ash cement concrete can help provide the needed service life to withstand a variety of harsh conditions.

Extreme Service Environments

When portland cement concrete is directly exposed to acidic chemicals, the calcium hydroxide and calcium silicate hydrates within the concrete break down rapidly, weakening and eroding the matrix. To ensure adequate service lives, designers may specify expensive concrete mixture designs and epoxy coatings. Although epoxies have been available for decades and can be extremely durable, they must still be properly applied by knowledgeable installers and can be problematic if chipped or damaged once in service. Alternatively, extremely acidic environments can be effectively resisted by using concretes produced with activated fly ash cement systems.

The dense crystalline structure in activated fly ash cement concrete is the result of both crystal growth and a low liquid content. The activators are hydroxy-carboxylic acid salts. These salts initially retard the dominant hydration reactions that typically occur when Class C fly ash is mixed with water alone (these hydration reactions result in rapid set but also poor strength development). The activator components allow for the formation of a solution equilibrium and solubilize fractions of the fly ash that do not normally react. Finally, when hydrates nucleate and grow in the activated system, they produce predictable set and normal but accelerated strength development.

Activated fly ash cement concrete is comprised of a dense crystalline structure that is much less permeable than the continuous capillary network typically found in portland cement concrete. Also, activated fly ash cement concrete has neither calcium hydroxide nor calcium silicate hydrates in its matrix. One such product, KEMROK™ by CeraTech Inc., shows remarkable durability when exposed to acids (Fig. 1 and 2).

TOPCOR Services, a company that specializes in maintenance and restoration, routinely completes projects in production facilities for the forest products, pharmaceutical, chemical, and food processing industries. When the completed project will be exposed to acids, they choose KEMROK cement as their green solution to corrosion (Fig. 3). As Stephen Harrell, TOPCOR's Project Manager/Development, explains, "When the situation arises where highly corrosive materials are prevalent, we're using KEMROK cement concrete more and more."

Maintenance managers at industrial facilities have reported much greater durability and higher corrosion resistance with KEMROK. Many are also projecting a significant reduction in maintenance shutdowns, as the material's corrosion resistance results in a life cycle that is two to three times greater than conventional portland cement products.

In high-temperature environments, portland cement concrete can rapidly deteriorate as calcium silicate hydrates decompose. The decomposition of the matrix results in increased porosity and significant loss of strength.

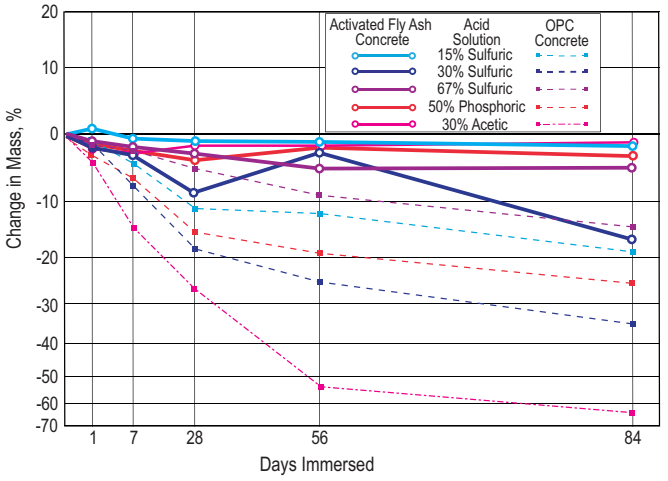

Fig. 1: Testing per ASTM C267, "Standard Test Methods for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacings and Polymer Concretes," shows that activated fly ash cement concrete provides excellent resistance to most acid solutions. In contrast, ordinary portland cement (OPC) concrete rapidly loses mass when exposed to acidic solutions

Fig. 2: These 4 x 8 in. (100 x 200 mm) concrete cylinders were partially submerged in a 15% sulfuric acid solution for 28 days per ASTM C267. The cylinder produced using OPC (left) exhibited significant corrosion, exposing the coarse aggregate. The cylinder produced using activated fly ash cement concrete (right) exhibited only minor damage

Fig. 3: TOPCOR Services workers construct a containment slab near a sulfuric acid storage tank: (a) damaged concrete on the existing slab was removed, and reinforcing bars were placed for the new containment slab; (b) the activated fly ash cement concrete was mixed and delivered using conventional equipment; and (c) it was finished using conventional methods

An activated fly ash cement concrete, however, is comprised of a dense interlocking network of crystalline calcium alumino-silicate hydrates. This network is capable of withstanding intermittent temperatures as high as 1000°C (1850°F) and sustained temperatures of up to 300°C (570°F) without significant loss of strength. That's why FIREROK™, an activated fly ash cement concrete system by CeraTech, has become an accepted solution for the construction of landing pads for vertical take-off and landing aircraft.

Environmentally Friendly

As the first commercialized zero-carbon cement, CeraTech's brands of acid- and heat-resistant products comprise 95% fly ash and 5% liquid activators derived from rapidly renewable resources. This combination provides significant environmental benefits, including:

- Substantial reduction in landfill demand for coal ash;
- Elimination of the resource extraction, energy consumption, and CO_2 generation associated with portland cement production; and
- Reduction (about 50%) in the mixing water requirements for concrete production.

Note: Additional information on the ASTM standards discussed in this article can be found at www.astm.org.

Selected for reader interest by the editors.

—CeraTech, Inc., **www.ceratechinc.com**

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