Ultrafine Pumice Pozzolan for Glass Fiber Reinforced Concrete Products

EXECUTIVE SUMMARY

Glass Fiber Reinforced Concrete (GFRC) panels and products are well established in the materials vocabulary of building design professionals. Although methods of GFRC manufacture vary, spraying a glass-fiber reinforced, cement-based composite onto a form of a desired shape and size and installing a light-gauge metal stud frame to support the GFRC skin is the most common. A typical GFRC panel consists of 5% (by weight of total mix) of alkali resistant glass fibers combined with a Portland cement/silica sand slurry and acrylic latex curing compound

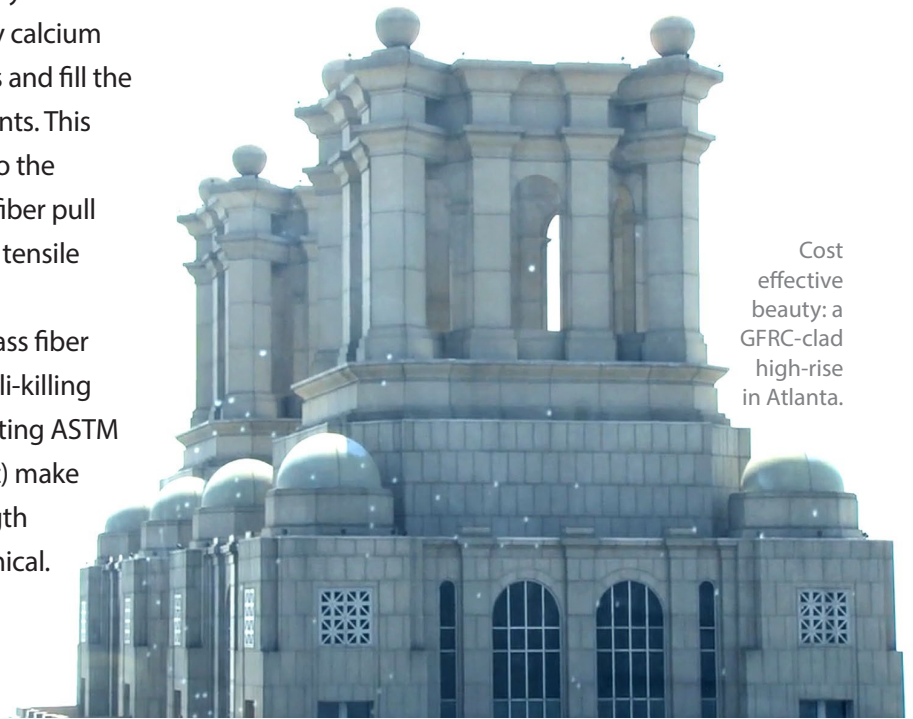
IMPROVED PERFORMANCE WITH HESS PUMICE POZZOLAN

If moisture is present, the GFRC composite—even with special alkali resistant glass—will lose some strength and ductility with time. The leading theory to explain this phenomenon is that ongoing cement hydration results in deleterious compounds, primarily calcium hydroxide, that penetrate the fiber bundles and fill the interstitial spaces between the glass filaments. This then increases the bond of the glass fiber to the cement matrix and leads to a reduction in fiber pull out with a reduction in strain to failure and tensile strength.

Working in concert, an alkali-resistant glass fiber (Nippon Electric Glass AR fiber) and an alkali-killing supplementary cementitious material meeting ASTM C-618 type N specifications (Hess UltraPozz) make the versatile beauty and lightweight strength of the GFRC product enduring and economical.

Like any construct or product that uses Portland cement, a congenital performance vulnerability in the cement and water hydration reaction must be accounted for in the mix design.

WHEN AN INTERNATIONAL and widely respected corporation initiates an agreement to become an exclusive supplier of a product to a highly specialized and exacting industry, it signals a level of trust and comfort with both the product and the company producing that product. Such is the case with the 2013 agreement between Nippon Electric Glass America (NEGA) and Hess Pumice Products for their pumice pozzolan product, Hess UltraPozz.



Cost effective beauty: a GFRC-clad high-rise in Atlanta.

Founded in 1949, Nippon Electric Glass (NEG) now operates 11 subsidiaries in various countries and manufactures a wide spectrum of technical glasses, including architectural glass, electronic glass, glass ceramics, LCD glass, E fiber, and Alkali Resistant (AR) glass fiber.

They successfully developed a high zirconia (ZrO2) alkali-resistant glass fiber in 1975 that is used widely to strengthen cement and concrete building products, and in particular, those classified as Glass Fiber Reinforced Concrete (GFRC). NEG not only provides alkali resistant glass fiber to the industry, they are also a supplier of Polyplex acrylic curing compound, Riteks SP7000 SCC admixture and Power-Sprays mixing, pumping and spraying equipment. In addition, NEGA provides training and technical support to GFRC manufacturers.

Glass Fiber Reinforced Concrete products are well known to the construction industry, as they provide a cost effective way to add architectural interest and enduring performance to the most notable part of a building: the exterior cladding.

The utility of GFRC is not limited to buildings…the sculpted strength of GFRC is also beautifully practical in creating durable faux-natural features such as rock formations and other landscaping elements. Statuary and other works of art are well served with GFRC, as is the need to recreate intricate ornamental features for historic renovation projects.

GFRC is a portland cement-based composite reinforced with randomly dispersed, alkali-resistant glass fibers. As the name implies, these fibers add strength—impact, tensile, and flexural—to the concrete, and that strength can be leveraged into making thin, lightweight architectural cladding panels for all types of buildings, both inside and out. Imagination finds rare limitation in the design possibilities made practical by GFRC panels.

The Need For Pozz

Like any construct or product that uses portland cement, a congenital performance vulnerability in the cement and water hydration reaction must be accounted for in the mix design. And of concern for the GFRC industry is the loss of strength and ductility from the interaction of alkalinity in the hydrated cement paste with the very glass fibers used to provide the concrete composition with its multi-faceted strength.

This deleterious effect is overcome by using a pozzolan in the mix design to reduce the overall alkali content and alter the pH of the concrete pore solution.

But not just any pozzolan will do. NEGA selected Hess UltraPozz as a product it endorses and distributes. This ultrafine natural pumice pozzolan meets these important criteria—

Color. A light-colored pozzolan means panel designers are not limited on color options and can tightly control color consistency. Hess UltraPozz is refined from the whitest pumice commercially available. (GE Brightness of 84).

Consistency. Because GFRC panels and products are meant to be seen, look and performance is critical. Achieving such undeviating consistency is only possible with predictably performing component materials. Hess UltraPozz is carefully refined to perform as expected, application after application.

Economy. The utility of pumice as a high-performance pozzolan is the result of its being formed and calcined by volcanic action. After such a spectacular genesis, all that remains in the product-development process is to grind it to an ultrafine particle size, increasing the surface area and hence, its effectiveness in mitigating the alkali byproducts formed in the hydration of Portland cement. As Hess UltraPozz enjoys at-source benefits of natural calcination, purity, and whiteness, the use-costs are quite attractive.

The other side of the economy coin is that Hess UltraPozz can be added at a 25% replacement of Portland cement—the cost of pozzolan is offset by the savings from using less Portland cement. As an added benefit, the net carbon footprint (greenhouse gas emissions) for the finished concrete product drops.

The utility of GFRC is not limited to buildings…the sculpted strength of GFRC is also beautifully practical in creating durable faux-natural features such as rock formations, fountains, and other landscaping elements.

Improved Durability

Natural pumice pozzolan also deals decisively with another issue that arises when using portland cement: porosity. Byproducts (calcium hydroxide) from the cement hydration process migrate out of the concrete composite as it cures, creating a maze of microscopic wormholes that not only affect cured strength, but increase permeability—and that permeability is an invitation to all kinds of unwanted problems…. chloride and sulfate attacks, efflorescent surface staining, and freeze-thaw damage. In short, the presence of calcium hydroxide subverts the tight impermeability concrete needs for longevity and performance.

The Pozzolanic Reaction

The pozzolanic reaction ignited by Hess UltraPozz consumes and repurposes the calcium hydroxide byproduct into beneficial compounds (primarily Calcium Silicate Hydrate) that help to tightly bind the aggregates and densely weld the concrete composite matrix. Permeability is significantly decreased, strength is amplified, and the life-span of the GFRC product goes way up. Research shows that density and strength continue to improve for months, even years, as the beneficial pozzolanic reaction will continue until the pozzolan is used up.

It is important to note that the pozzolanic reaction with the alkali byproducts does not occur immediately, so it is necessary to use alkali-resistant, glass fibers with a zirconia content greater than or equal to 16% and meeting the specifications outlined in ASTM C-1666.

Borosilicate or E glass fibers that are used to reinforce plastics should never be used in GFRC.

Research Supported

NEGA commissioned Washington University in St. Louis to conduct research using Hess UltraPozz in GFRC composite mix designs. This vetting process primarily involved the ASTM C-1560 accelerated age test to determine durability. Petrographic analysis was also performed to quantify the effect of the ultrapozz on cement paste content, cement hydration and cement aggregate reactions.

Extensive research has also been performed by the University of Utah on Hess Pozz and Hess UltraPozz to determine performance a various percentages of replacement for portland cement to determine strength, ASR, resistance to sulfate attacks and more. The findings of this research—especially the flat-lining effect pumice pozz has on ASR—was a factor in NEGA's decision to specifically look at using Hess UltraPozz in their composite mix designs…and ultimately to become the exclusive distributor of Hess UltraPozz to the GFRC industry.

The adoption of Hess UltraPozz as cost-effective, high-performance supplementary cementitious material in GFRC products by a major player like NEGA has piqued the interest of others in the precast industry, all of whom have similar demands for economy, performance, brightness, and cement replacement.

—*by* Brian Jeppsen *and* Michael Driver

Contact Brian Jeppsen at Hess Pozz or Michael Driver at NEGA for information on utilizing, testing, or sourcing natural pumice pozzolan in your precast concrete products.

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