Aggregate Innovation

New design mixes are expanding precast concrete's capabilities creating such innovative options as glow-in-the-dark designs, expanded colors, and translucent concrete

— Craig A. Shutt

Precast concrete's aesthetic versatility long has appealed to architects looking for creative, high-quality finishes for their projects. Precast can provide a range of colors, textures, and other appearance treatments. That range is expanding constantly, as precasters find new ways to use this highly engineered product to provide innovative options.

"I love working with concrete," says Jim Isermann, an artist based in Palm Springs, Calif., who designed a mosaic artwork in precast concrete using several colored aggregates at the University of Houston. "The variety of colors available was amazing. There were incredible colors to work with, and the quality control was amazing. Everything was identical and consistent."

This architectural precast concrete panel had glow-in-the-dark aggregates post-applied to the interior of the numerals cast into the panel to serve as the building's address. Photo: Gate Precast

Precast Lights-Up the Night

A standout style just starting to gain attention is glow-in-the-dark aggregates, which can be inset into panels in a pattern or other design. Gate Precast Company recently used the material on a building clad with architectural precast concrete panels by post-applying glow-in-the-dark aggregates to the base of the number in the building's address, which was embossed into one panel. Another design sprinkled some of the aggregates throughout the panel in a random pattern, adding visual interest at night.

The material consists of an angular epoxy aggregate that can be used in sizes from ½ inch to powdered, in a 1-to-1 substitution for traditional aggregates, explains Conrad Filo, quality control manager at Gate Precast Company. "It's a lighter weight than regular aggregates, reducing weight in a panel, but it's extremely dense and hard, so it's not considered a lightweight aggregate," he explains. The material cost about $70 per pound at the time this article was printed, which limits its use to specific focal points.

The material works similar to other glow-in-the-dark materials, radiating greenish light after exposure to sunlight. A 20-minute exposure allows the material to exude light for about eight hours, although it will diminish over time, Filo says. The aggregates Gate has used have a warranty for 20 years.

The material was supplied by Ambient Glow Technology (AGT) in Pickering, Ontario, which has been marketing it since 2004, says Peter Tomé, president. "Our products have been specified in numerous concrete projects around the world," he says. Many of the applications are for bridges and other high-profile exterior uses, and it has launched a higher-intensity material where greater luminosity is required, such as bike and walking paths.

AGT's glow-in-the-dark aggregates have been used in a number of buildings, including the San Antonio Planetarium in San Antonio, Texas, and the El Blok Hotel and Spa in Isle de Vieques, Puerto Rico.

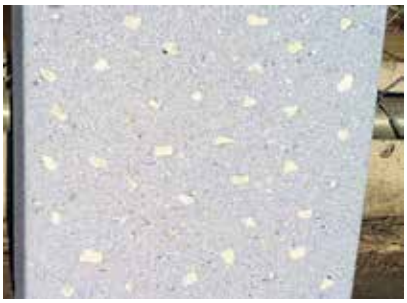
The key to expanding its applications in precast concrete buildings will be spreading the word to architects and showing them that the benefits are worth fitting the material into the budget, says Filo. "Architects need to buy into it as offering an advantage," he explains. "It's an expensive material, but in small amounts it works very well. Architects are always looking for something new, and this fills the bill."

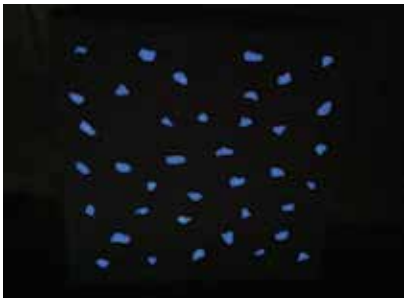
It's not a difficult material to work with, he adds. It is applied similar to a retarder, in which the aggregate is put into the form, and the glow-in-the-dark epoxy is applied "to give it an extra kick."

Lightweight Aggregates

Another type of aggregates gaining popularity on a larger scale is lightweight material that creates lighter components. "The primary benefit of lightweight aggregates is the weight reduction they provide to the component, which begins offering advantages in transportation, as more pieces can be delivered on a truck," explains Ken Harmon, director of engineering resources and territory manager for Stalite, a maker of lightweight aggregates.

The difference can mean transporting two double tees on a truck rather than one, essentially cutting transportation costs in half. It also can reduce the load of a truck to a viable weight to transport





Glow-in-the-dark aggregates can be cast into precast concrete panels, creating dramatic effects that provide illumination or accents after dark. A 20-minute exposure to sunlight provides 8 hours of light. Photos: Gate Precast

the pieces over roads with lower load requirements. Reduced crane capacities and faster erection speed also might be possible, reducing costs further.

Lightweight aggregates provide better hydration for cementitious materials, as more water is absorbed by the aggregates. This ability to provide internal curing enhances the strength of supplementary cementitious materials, such as silica fume, fly ash and metokaolin, which are used more often in design mixes today. Internal curing also minimizes early shrinkage due to rapid drying.

Lightweight aggregates essentially replace other aggregates in the mix and are made of clay, shake, or slate. They weigh about 113 to 115 pounds per cubic foot, compared to traditional aggregates' weight of 145 to 150 pounds per cubic foot. The aggregates typically are used with natural sand, although some versions replace both the aggregates and sand with lightweight aggregates, which reduces the weight to 95 to 100 pounds per cubic foot.

The aggregates are available nationwide, although sources are becoming more scarce, Harmon notes. "Since the 1960s, there's been a steady decline in available plants, as some have merged and others have left the business." Producing the aggregates has become more expensive, especially as environmental regulations have increased for the business, which requires rotary kilns to produce the aggregates. "There is a cost premium for using them due to the additional processing steps, but the savings from transportation alone are significant."

Concrete produced with lightweight aggregates also offers a higher fire rating, allowing a thinner slab to be used to achieve the required rating, he notes. That was put to good use by the 48-story Duke Energy Center in Charlotte, N.C. The project was designed with 12-foot-wide precast, prestressed concrete double tees that served as flooring in the 1.4-million-square-foot building, making it the tallest building in the world to use double tees.

The lightweight double tees, designed by Britt Peters & Associates in Greenville, S.C., span 43 feet from the exterior frame to the core. The tees, with a cast-in-place topping slab, were recommended to reduce concrete volume and efficiently achieve a two-hour fire rating, says Edward Britt, principal. "The greater fire resistance of lightweight concrete allowed us to reduce the floor thickness of the cast-in-place topping by 1 inch. That is a big building, and one inch added up to a lot of concrete and a huge savings."

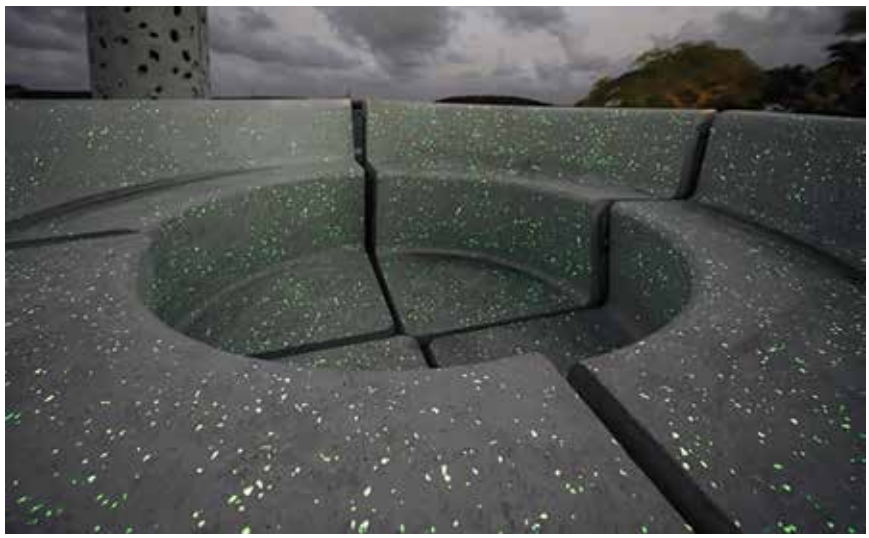
The lighter weight also made handling easier, allowing contractor Batson-Cook to complete a floor every four days. The floors were made with 32-inch-deep tees in the main tower and in the adjacent podium up to the ninth floor, after which the remaining tees were only 19 inches deep.

"We haven't done a good job of promoting lightweight aggregates to suppliers and designers," Harmon says. "They aren't discussed in architecture and engineering schools, so it's up to us to introduce it and educate professionals."

One organization working toward that goal is the Expanded Shale, Clay and Slate Institute (ESCSI), the professional organization representing makers of lightweight aggregates. "Structural lightweight concrete solves weight and durability problems in buildings and exposed structures," the group says. "It has a strength comparable to normal-weight concrete yet is typically 25% to 35% lighter. It offers design flexibility and substantial cost savings by providing less dead load, improved seismic structural response, longer spans, better fire ratings, thinner sections, decreased story height, smaller size structural members, less reinforcing steel and lower foundation costs." For more information on the group, visit www.escsi.org.

Recycled Aggregates

The growth of interest in using recycled materials in buildings, to increase the capability to add LEED rating points to a project's total, has led to interest in recycled aggregates in precast concrete members. Although crushed concrete often is used, other materials are gaining ground, including recycled porcelain



The El Blok Hotel and Spa in Isle de Vieques, Puerto Rico, used glow-in-the-dark aggregates in the precast concrete components around its grounds to provide an added aesthetic touch after dark. Photo: Ambient Glow Technology

The "Cougar Pride" walkway consists of 19 precast concrete panels, comprising four vertical and 15 horizontal panels created with an artistic mosaic of "U" and "H" figures in different color combinations. Photo: Jim Isemann

and smoked glass, which offer unique appearances.

The porcelain comes from bathroom-fixture "seconds" that didn't pass quality inspections, while much of the smoked glass being used is derived from old computer monitors and television screens that are ensured to be nonhazardous, says John Meyer, sales manager at Kafka Granite, which produces the aggregates. "Recycled porcelain is very durable, with low absorption rates, and is available in a cream or bisque neutral color." The smoked glass offers the appearance of smoky quartz at a lower price. Another aggregate growing in popularity is recycled copper slag, which offers a black, glassy appearance similar to black obsidian.

"Architects typically are looking for more aesthetics rather than an additional functional need when they use an untraditional aggregate," he says. "But some are looking at the porcelain options due to its strength, especially when used as a fine dust particulate." All of the specialty aggregates offer high durability, he notes, making them fine substitutes generally.

Colorful Aggregates

Colors are beginning to expand to offer more versatility, including for mosaics and artwork cast into the precast concrete panels. "In recent years, we've seen strong popularity for red, black, white, and buff colors," says Chris Fister, an owner at Fister Quarries. "We're also seeing interest in polished aggregates and softer hues to replicate a terra-cotta appearance. The one we're starting to hear architects are searching for is blue. But the only options to date tend to be price prohibitive."

Another popular trend of late has been colored glass, says Fister. "There are literally hundreds of color options, including recycled Coke and vodka bottles. They offer architects and designers more color options. Glass options typically are used for indoor applications, he notes, as the outdoor elements and weather can fade and darken the color.

Kafka's Meyer also has received more requests for colored options. "In architectural precast concrete applications, 90% of the requests are for black granite in the past year," he says. "But surprisingly enough, aggregates tend to be trendy. In past years, red granite was very popular, but then its popularity faded."

The versatility that can be achieved with colored aggregates can be seen in the elaborate mosaic Cougar Pride walkway and feature wall outside the football stadium at the University of Houston. Initially conceptualized as just a walkway, it expanded to include vertical panels and more presence. Both vertical and horizontal precast concrete panels feature elaborate mosaics intertwining upper- and lower-case "U" and "H" figures created with colored aggregates in the precast concrete panels.

It took 18 months to conceptualize and locate the precise colors desired by Isermann, who worked closely with Gate Precast Company to find the best options. "The precaster helped determine the most efficient approach to creating the design," he says. "I had thought we could do individual letters, but Gate showed that creating 8- by 8-foot monumental panels would be the most cost-efficient way to go. They were amazing to work with."

The most challenging part of the project was finding a red aggregate to match UH's signature red, he says. "Gate suggested recycled red glass for the 'U' letterforms. We tested several sizes and density of glass to get the final mix." A black obsidian was used for the 'H' letterforms." They were cast into 19, 8-foot-square panels in all, comprising four vertical panels and 15 horizontal walkway panels.

As many as seven colors of aggregates were cast into one panel, while the fewest colors in any one panel was four. They were cast using wheelbarrows and mortar mixers to precisely pour the proper amounts into the right portions of the formliner. "We needed to have seven mixes going at once and pour them without anything spilling over as we cast each panel," says Gate's Filo.

Black obsidian, supplied by Fister Quarries, was used rather than a black recycled glass because students would be walking over the panels, sometimes in bare feet, and the black glass could be sharp. "We needed a surface that could handle high heels and bare feet," Isermann explains. Adds Filo, "The black obsidian laid in nicely and provides good traction."

The vertical panels were placed on a concrete footing around the perimeter of the walkway, with a sand bed in the middle to support the horizontal panels. No connections were used on the horizontal portion of the project. Houston-based Metalab was the architectural firm on the project. "I couldn't have done the job without their efforts," Isermann says.

A special lithium admixture was added to the concrete design for the red glass and black obsidian, notes Filo. "The specific mix design isn't important, but designers and precasters must be aware of the

LiTraCon, based in Hungary, has created a translucent concrete consisting of concrete and glass fibers that allows opaque light to pass through, revealing shadows and shapes on the other side behind a strong light.

potential for Alklai Silica Reactivity (ASR)," he warns. It occurs when aggregates containing silica compounds react with Portland cement. "When designers suggest using new or uncommon aggregates, they and their precasters must be aware of the need for additional testing to make projects successful."

The extra efforts paid off with a dramatic, colorful, and functional artwork that serves as a strong introduction to the stadium. "As the work is outdoors, you can imagine how the glass and obsidian glow and sparkle in direct sunlight," says Isermann. "I've done many public projects before but never one with precast concrete. "I'd love to work in that medium again. I couldn't have been happier with the results."

Selecting Choices

Architects often have a specific color or texture in mind when they contact an aggregate supplier or precaster, but in some cases they simply want to know what options are available to reach a certain appearance. "Most often today, architects will review PCI's *Color & Texture Guide*, find a choice they like, and call us to match the plate number," says Fister. "That has become the standard way to approach it."

Some architects also visit aggregate manufacturers' websites to review options. "They often pick a color range they're interested in, and we'll send them four or five samples to show them what choices are readily available," says Tiffany Kafka, marketing coordinator at Kafka. The firm also provides sample rings with about 60 colors of granite, quartz, marble, and recycled materials that architects can retain in their reference library.

"The architects select the colors they want, we send them a sample to make a final decision, and then we send the aggregates to the precaster." In some cases, the precaster works directly with the architect to find the proper aggregate along with the complementary finishing technique to achieve the goal.

Kafka also offers a color-matching service, in which a designer or precasters ships them a sample of an aggregate that is no longer available or an old piece of precast concrete where the aggregate source is unknown. "If one of our 60 colors doesn't match, we'll blend different percentages of our colors to create a match," she says. The firm also meets any size specification required. "We do very thorough testing to match sizes required by different manufacturers."

Future Options

As precasters and aggregate suppliers continue to experiment with the product, and architects keep innovating and pushing the limits of the material's aesthetic properties, more options will open up. One with great potential is translucent concrete, which consists of about 4% glass fibers mixed with fine concrete. It was developed in 2001 by Hungarian architect Áron Losonczi, who worked with scientists at the Budapest University of Technology and Economics.

"The fibers form a matrix and run parallel to each other between the two main surfaces of each block," explains a spokesperson for LiTraCon, short for "Light-Transmitting Concrete," which manufactures the material. Due to the small size of the glass fibers, they blend into the concrete and become a part of its structural integrity but are not visible on the surface, the company says.

"The resulting product looks, feels, and behaves like pure concrete, but shadows and objects show through, similar to the effect of Japanese sliding screens made of rice paper." Panels can be cast up to a few meters thick without any loss of light and can be produced in various sizes and shapes.

The most notable use was in 2004 for Europe Gate, a sculpture consisting of LiTraCon blocks stacked 4 meters high, erected to commemorate Hungary's entrance into the European Union. The panels were considered as a possible sheathing for One World Trade Center in New York City, according to the New York Times.

"Europe often is four to six years ahead of us with concrete advances," says Gate's Filo. "It will take some time to develop materials like that here and interest architects in it, but new ideas always are arising." With precast concrete's capability to adapt and incorporate new ideas, innovations will continue to expand its aesthetic versatility. Architects who remain current with the latest techniques and ask their precasters for the newest ideas will ensure they take full advantage of what precast concrete can achieve.

For more information on these or other projects, visit www.pci.org/ascent.