March/April 2017

Composites Manufacturing

The Official Magazine of the American Composites Manufacturers Association

Composites Team Up with Traditional Materials

Making an Impact in Architecture

An Update on Out-of-Autoclave

ACMA

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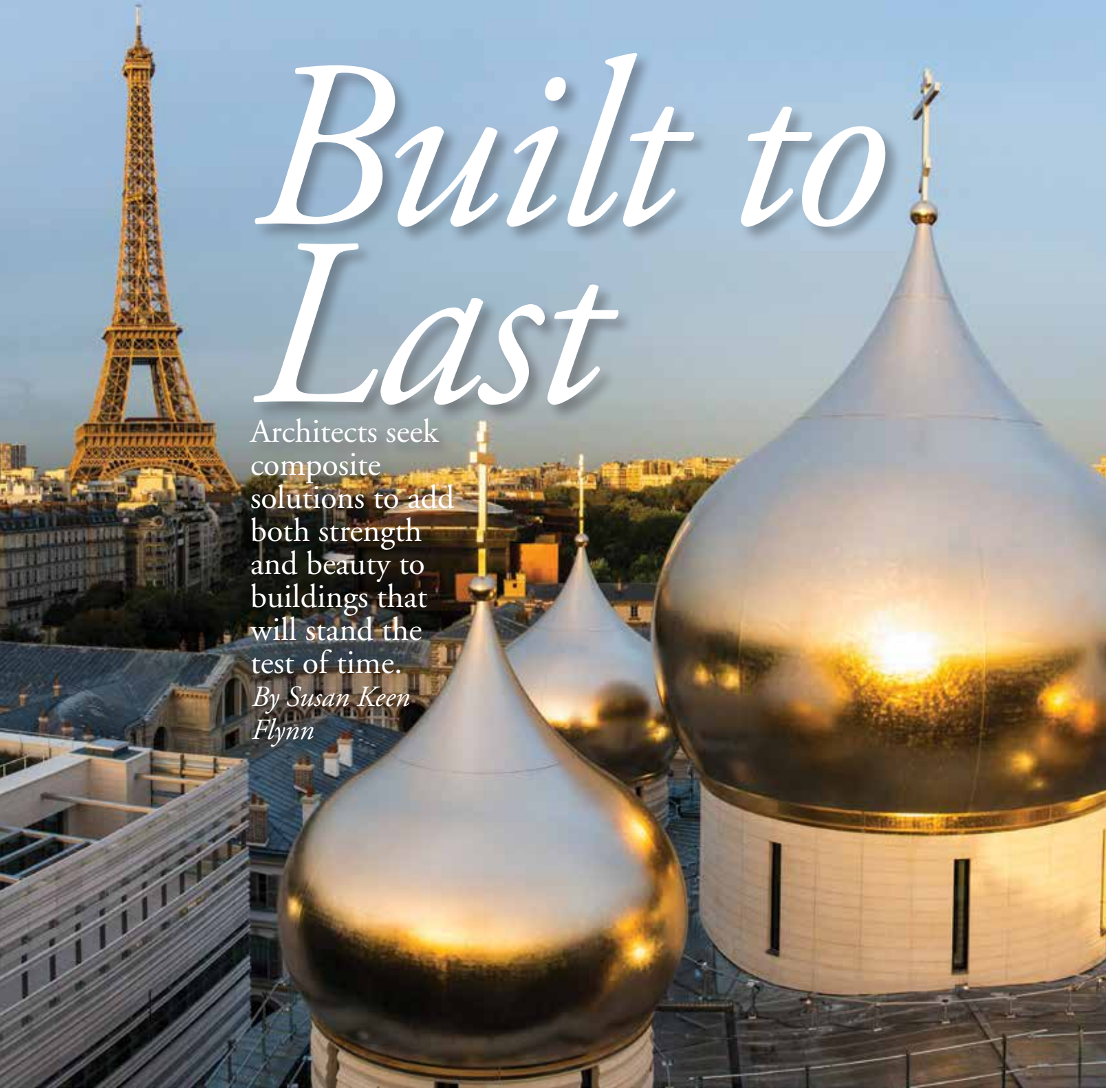

Built to Last

Architects seek composite solutions to add both strength and beauty to buildings that will stand the test of time.

By Susan Keen Flynn

When "A Gathering Place for Tulsa" opens in the Oklahoma city later this year, the nearly 100-acre park along the Arkansas River will feature sports courts, bike and skate parks, nature trails, large lawns for concerts and more. At the heart of the park will be the three-level ONEOK Boathouse, including boat storage on the lower level, educational programming space on the second floor and a restaurant and outdoor patio on the top. The ONEOK Boathouse will not only be functional, but also attention-grabbing thanks to an 8,000-square-foot composite canopy that will cover the patio.

"The boathouse was designed to be the focal point for the park, and the white, modernistic, composite roof will become a very iconic image for the park," says Jeff Stava, executive director and trustee of Tulsa's Gathering

The newly-consecrated 4,800-square-foot Russian Orthodox Cathedral and Spiritual Center in Paris features five GFRP domes covered in gold.

Photo Credit: Sicomin

Place LLC. "There is no other building roof like it." (The architectural rendering of the boathouse is depicted on the cover of this issue.)

Composite materials are increasingly finding their way into architectural projects – ranging from new construction to building restorations and traditional ornamental elements – because of their design flexibility, durability, corrosion-resistance and strength.

New Construction

The patio roof for the ONEOK boathouse comprises 130 sail-shaped, curved panels, which are being fabricated by Kreysler & Associates in American Canyon, Calif. When the company saw the design from Mack Scogin Merrill Elam Architects (MSME) more than two years ago, it thought it was a perfect project for GFRP, says Josh Zabel, vice president of business development at Kreysler. The company, which has been fabricating composites for the construction market since 1982, submitted a proposal. However, it didn't originally win the bid.

Initially, the project team opted to make the roof from polytetrafluoroethylene (PTFE) panels. "They went down that route, but found out it was going to cost just as much or possibly more. And they also discovered they would have to change the design to make it out of [PTFE]," says Zabel. "So, they came back around, dredged up our original proposal, and that's how we got on board."

Kreysler & Associates is using hand lay-up to fabricate the panels, all of which are different sizes and shapes. Each panel includes a top and bottom skin, made from polyester resin and fiberglass, and a balsa core. The molds are created on a 65-foot-long, 5-axis CNC machine. "One of the tricks we're using is rather than creating separate molds for the top and the bottom, we're making a mold for the bottom, fabricating the bottom panel, then using that panel as a mold for the top," says Zabel. That reduces mold-making time – and just as importantly, cost – in half.

The finished panels will be attached to steel columns on site that hold up the completed canopy. In early 2017, Kreysler was creating small mock-ups of the panels to ensure they fit together properly prior to shipping. All the panels will be complete by the end of the summer.

More than 4,700 miles away in Paris, another new building was recently topped by composites, too. Sicomin supplied materials to produce both molds and parts for five gilded domes on the recently opened Russian Orthodox Cathedral and Spiritual Center. The French company Multiplast SAS, part of Groupe Carboman SAS, produced the domes using Sicomin's SR8100/SD4772 epoxy infusion system and a specially-developed fiberglass reinforcement lay-up that includes a heavyweight quadaxial fabric with a woven fabric. After fabrication, craftsmen applied 86,000 leaves made from real gold to nearly 7,000 square feet of the domes.

Building Restorations

Composites were an ideal solution for the restoration of the Harris County Administration Building in Houston, built in 1978 to house government agencies and employees. From the beginning, the 10-story building suffered from poor construction practices. Reinforcing steel throughout the building was placed too close to the concrete façade, which contributed to premature corrosion and distress. Combined with shoddy workmanship, this led to spalling, cracking and honeycombing throughout most of the concrete. Conditions were so poor that the county erected scaffolding around the building to protect people from possible falling pieces of concrete.

Sika Corporation in Lyndhurst, N.J., was brought in by Norex Engineering and Johnston LLC Architects during the early

Photo Credit: Scott Axel

EDON Corporation provided the GFRP cornice at the top of Penn Avenue Place in Pittsburgh during renovations of the building, which was originally built in 1907.

design phase to offer recommendations. It then provided both concrete and CFRP repairs during the restoration, which began in 2015 and took more than a year.

A low viscosity epoxy resin was injected into the concrete to stabilize cracks, then a variety of CFRP solutions were used for additional reinforcement. Sika utilized a unidirectional fabric, which was installed along the top and bottom flanges on sunshade beams and interior corners between the sunshade and outrigger beams where cracking was widespread. It also used a ± 45 degree, double bias CFRP fabric on the middle section of I-shaped concrete beams for shear reinforcement. In addition, CFRP repairs were made in areas with post-tensioned concrete beams to strengthen overstressed and cracked sections.

CFRP is well-suited to repairs because buildings have varying degrees of stresses and strains in different areas, and composite materials can be customized as needed. "It's not like using a steel plate or jacket, which is extremely heavy and prone to corrosion," says David White, P.E., vice president of technical services at Sika. "With FRP, you can custom design the weight of the fabric and the orientation of the fibers so it's truly an engineered solution."

Nearly all of the 180,000-square-foot façade of the Harris County Administration Building was covered with CFRP, which was installed by Structural Concrete Systems LLC using scaffolds while the building was still occupied. "That's where the FRP materials showed their true worth," says White. "I couldn't imagine trying to affix a steel plate on the outside of this building. The lightweight, non-corrosive nature and ease of installation made CFRP a perfect product for the situation."

Ornamental Elements

One of the most common uses of composites in architecture, crossing over both new construction and restorations, is

"The inherent fluidity of the composite product, fabrication process and installation technique allows for an architecture expressive of today's dynamic world."

Bridgette Mont
Mack Scogin Merrill Elam Architects, Atlanta

ornamentation. EDON Corporation in Horsham, Pa., has supplied FRP architectural ornamentation since the early 1980s. It recently completed phase one of a cornice project for Penn Avenue Place in Pittsburgh. The three-piece cornice had to be done just right – and under a tight deadline – because hundreds of thousands of people would be gazing at it during the 2016 Christmas season.

The GFRP cornice runs along the sides of the building's sixth story, meeting at the corner where Pittsburgh's iconic Unity Tree is displayed each Christmas. The 100-foot artificial tree, which wraps around Penn Avenue Place, is decorated with 2,500 lights and 2,000 ornaments. The new cornice provided by EDON provides a beautiful backdrop.

When the original metal cornice on the 110-year-old building began deteriorating, netting was added to the building to protect pedestrians from potential falling debris. EDON was hired for the restoration. "It was a historic cornice and had to be reproduced to match the original," says Matt Axel, president of EDON.

The contractor provided original pieces of the cornice to EDON, which sent them to its pattern maker in Boston. Once the fabricator received the patterns back, it created fiberglass molds and then manufactured the cornice sections using a spray-up process. The cornice pieces are made from OptiSpray™ chopped GFRP from Owens Corning and Hetron™ fire-resistant polyester resins from Ashland. The cornices, which are approximately 8 feet, 9 inches high and project more than 4 feet out from the building, include an upper acroteria band, a cornice with molded coffers and a lower cornice with molded brackets and decorative elements nicknamed "elephant toes."

Aside from working under a time crunch, another challenge of the project was ensuring the new cornice fit into the original framing on the building, which was being retained. "The framing has metal brackets that stick out from the building, so based on the configuration we had to make sure the brackets lined up with a gap in our molded dentils," says Axel.

Glassline in Plymouth, Mich., also understands the challenges of restoration projects on old city buildings. The company is in the midst of a three-year renovation on Detroit's Book Tower, a 38-story Renaissance-style skyscraper in the city's Washington Boulevard Historic District that opened in 1926. The 13th floor of the building is adorned with 12 caryatids – sculpted maiden figures that provide architectural support. One of Glassline's tasks was to replace the original 2,500-pound terra cotta caryatids with much lighter GFRP ones. The first challenge was to accurately reconstruct the detailed figures from one of the originals, which was broken into many pieces upon removal from the building. Glassline, which had previously taken field measurements of the figures, received the pieces in four large boxes. The only fully intact piece was the 250-pound head.

"We dug through those boxes and reassembled the components, which were fairly identifiable body parts," says Guy Kenny, president of Glassline. "Then we pinned them altogether, applied a plaster coat, sanded it, prepped it and used it to make a silicone mold." It took about a month to make two sets of molds – one for six maiden figures facing right and the other for six facing the left.

Next, Glassline fabricated one 13-foot-tall caryatid for approval from the building owner. Once the company received the green light, it manufactured the remaining figures using a U.V.-resistant gel coat and a fire-retardant polyester resin reinforced with fiberglass chopped strand and hand laid mat. While most of the fabrication utilized hand lay-up, some of the detailed parts – such as toes and fingers – required cast polymer molding. Each figure took about five days to make. The finished maidens weighed only 600 pounds each.

Another challenge was making sure the finished caryatids attached correctly under an eave on the Book Tower. A steel frame runs from the building wall on a 45-degree angle through

Photo Credit: Glassline

Construction workers install one of 12 GFRP maiden figurines on the Book Tower in Detroit.

Advice for Penetrating the Architecture Market

"There's tremendous opportunity for future growth in the architecture market, but I think it's longer term," says Andy Bridge, vice president of industrial markets and director of research and development for Janicki Industries. If you plan to stick around, try the following:

Understand everyone's role.

"Working in the architecture industry is different from making boats or wind turbine blades," says Josh Zabel, vice president of business development at Kreysler & Associates. "The people who work on a project – and how they interact – tends to evolve as the project moves from schematic design to construction. The influence in decision-making often shifts." That's why it's important to get familiar with what architects, contractors and building owners are responsible for at various stages of the project.

Get involved in projects early on.

"The most successful projects we've had are the ones where we've been involved early enough to offer our expertise about fabrication and influence decisions on materials and design," says Zabel.

Expect changes.

"You have to be prepared for a lot of field changes," says Guy Kenny, president of Glassline. "You can't get too far ahead of the game until you've installed one or two components because there are always changes – even in the same walls or areas."

Lobby to change building codes.

To be broadly utilized across the architecture market, composites must be included in building codes. Several years ago, ACMA's Architectural Division spearheaded activity that led to the creation of section 2612 of the International Building Code for non-structural applications for interior and exterior cladding. Now the group is planning a strategy to develop sections on FRP composites for structural applications. The initiative requires involvement from composites professionals in the areas of testing, standards development and education of building officials. For more information, contact John Busel, vice president of ACMA's Composites Growth Initiative, at *jbusel@acmanet.org.*

Think locally.

"The best thing to do is focus in your geographic area," says Bridge. "Get to know contractors, developers and architects, find out what their challenges are and see if you can offer solutions." New construction in Seattle must adhere to recently-enacted strict energy building codes, so Bridge is selling prospective clients on the thermal energy management benefits of composites.

Educate architects.

"You have to make architects aware that composites are a viable material good for applications other than restoration," says Kenny. "We have some new buildings in Detroit that are considering fiberglass skins, but it's a challenge to get someone building a new $400 million building to go out on a limb with a new material." Sika Corporation's project sales representatives frequently hold box lunch educational seminars for engineers and architects.

Photo Credit: Quickstep

the body of each caryatid into a slot underneath the eave. The maidens and steel frame needed to line up with the eave to support it. "When the maidens came off the truck and were raised into position, everybody wanted them to fit like a glove," says Kenny. "And they did. The contractors installed the maidens in record time."

The Future Outlook

While opportunities abound in architecture, composites companies admit they've only just begun to dip their toes into the market. "The construction market is enormous," says Andy Bridge, vice president industrial markets and director of research and development for Janicki Industries in Sedro-Woolley, Wash. "Composites only need to penetrate one quarter of one percent and that would dwarf all the other markets we work in."

Bridge sees future opportunities in combining 3-D printing technology with structural elements. "I compare it to what they're doing in automotive – a multimaterial approach," he says. "They are not wedded to any one material." He cites the BMW 7 Series with its mix of CFRP, high-strength steel, aluminum and other materials as an example. "Combining materials and using them where they make the most sense – that's an exciting area where we're going to see more growth in the architectural and construction space," says Bridge.

Zabel at Kreysler & Associates is thinking big, too. "We're very focused on getting past decorative applications," he says. "We've certainly done structural applications with FRP, but they have been small projects – a house with a structural monocoque FRP shell. But a tall building where the structural façade or some part of it is made from composites, that's part of the future in my mind."

Susan Keen Flynn is managing editor of *Composites Manufacturing* magazine. Email comments to *sflynn@keenconcepts.net.*

Visit the Composites Pavilion at the AIA Show

ACMA will hold its fourth annual Composites Pavilion at the American Institute of Architects Convention April 27 – 29 in Orlando, Fla. The pavilion will feature Composites Central, a forum for presentations on composites technology in architecture, as well as the second annual Composites in Architecture Design Challenge. To register, visit *conferenceonarchitecture.com.* For more information, contact Sarah Boyer at *sboyer@acmanet.org.*