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About the Cover:
The Sarah Mildred Long Bridge, which connects New Hampshire and Maine, uses L-shaped FRP wind fairings to make it more aerodynamic. 

Photo Courtesy of Composite Advantage
From the ACMA Chair

Be the Change

For the past few years, CAMX has showcased disruptive innovation and shown businesses across the industry how they can be an active part of the FRP revolution happening in markets everywhere. And much like the industry itself, CAMX has evolved in each of its previous four years as composites and advanced materials companies find new ways to innovate and stay competitive. Year 5 in Dallas will be no exception. (Check out page 32 to learn more about what you can expect at CAMX 2018).

One market that will be heavily discussed at the event, and that is on the precipice of major change, is infrastructure. ACMA is inching closer to a federally-funded standards initiative that will empower the National Institute of Standards and Technology to develop the tools engineers need to build more confidently with composites. The ways we incorporate composites in infrastructure are rapidly changing, too. (Turn to page 16 to see the latest advancements).

But while our industry’s focus is often centered on how composite technologies can change the outside world, this year I would challenge you to see how you can change the status quo by looking inward at your own business, starting with how you recruit, foster and retain talent. We all know that having the right people with the right skills in the right places drives our companies’ successes.

With manufacturing becoming increasingly digital and automated, companies everywhere are at a crossroads with how to adapt their businesses and workforce strategies. As manufacturers implement more new-age shop floor technology, the level of technical savvy and training needed to maintain operations is undoubtedly going to increase. In this issue of Composites Manufacturing, we take a fresh look at the topic and the ways composites businesses are staying ahead of the curve (page 22).

You can take a great step toward staying ahead of the curve by attending CAMX, Oct. 15-18. See you in Dallas!

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Designing Composites for Fire-retardant Applications

By Benito Rodriguez and Michael Stevens

There are a wide variety of composite applications being developed that require good fire-retardant performance. Many of these applications mandate the use of their own unique fire tests. An Ashland study published in 2012 demonstrated that there is little correlation between the various flame spread and smoke tests employed by code officials for approving FRP composites. It also showed that a resin system’s performance in one test may not guarantee that it will perform similarly in another test. The appropriate choice of fire-retardant (FR) resin technology will depend largely on what fire tests will be utilized and how the composites are fabricated.

Recently, ACMA published its “Guidelines and Recommended Practices for Fiber-Reinforced-Polymer (FRP) Architectural Products” to assist composite designers on selection of materials (resin, FR additives, reinforcements, etc.) and proper fabrication techniques (hand lay-up, infusion, pultrusion, etc.), as well as explain how these choices affect fire retardance. The guidelines also provide a helpful overview of important FR tests (such as NFPA 285, NFPA 286 and ASTM E84) and factors that contribute to successful test results. There is also a useful reference to adoption of the NFPA 285 test for the evaluation of floor-to-floor fire spread by the 2009 International Building Code, which was critical to the adoption of composite materials in building rain screens above four stories.

There are many FR resin systems available to construct fire-resistant FRP building panels. In horizontal fire tests like the ASTM E84 surface burning test, halogenated systems tend to be more efficient than aluminum trihydrate (ATH) filled resins in obtaining a low flame spread index. Some intumescent systems also work well in this test. Halogenated resin systems, however, are unlikely to meet the desired smoke index value (450 or less) unless the composite panel has a high glass content and a thickness less than 0.1 inches.

Non-halogenated FR epoxy options have been developed that produce less smoke in this test. There are broad offerings of flame-retardant epoxy systems, including non-halogenated options, for the reliability, protection and performance required for electrical laminates and other challenging composite applications. All U.S. epoxy producers have FR resin systems.

Phenolic resins are well known for meeting stringent flame/smoke/toxicity specifications and do not require specialty fillers. Benzoxazine thermoset resins combine good flammability resistance with outstanding thermal and mechanical properties.

In a 2003 study, composites fabricated with halogenated resins performed quite differently from those employing ATH fillers in the NFPA 286 room corner burn test. ATH-filled systems with an ASTM E84 flame spread index of 20 easily passed the NFPA 286 test, whereas halogenated resin systems with the same ASTM E84 performance failed the NFPA 286 test. In vertical tests, such as the NFPA 286 room corner test, ATH-filled FR systems are thus more effective.

In the Single Burning Item (SBI) test, which is now being used to classify materials for buildings in the European Union and in China, there was no correlation between the results of the ASTM E84 test and the SBI test. The rating system used in both Europe and China has a letter rating for the flame spread of the system and an S number rating for the smoke index. A rating of

The ASTM E84 is the standard test method for surface burning characteristics of building materials.
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Class B is the best rating that an FRP panel can obtain. A Class A rating is for noncombustible materials. The rating system utilized for smoke is S1 (low smoke), S2 (medium smoke) and S3 (high smoke).

Once again, halogenated resins do not perform as well in the SBI test as they do in ASTM E84. ATH-filled systems, however, easily deliver a Class B, S1 rating. Halogenated resin systems that achieve an ASTM E84 flame spread index of less than 25, however, only earned a Class D, S3 rating in the SBI test. The addition of ATH to brominated resin systems meets the Class B, S3 rating requirements.

The proper choice of fire-retardant technology depends not only on what fire tests must be passed, but also on the manufacturing process used to fabricate the FRP panels. The particle size and amount of ATH filler used will be limited if the fabrication process is RTM light or vacuum infusion. Suppliers have developed special resins with low enough viscosities to accept 100 phr (parts per hundred parts of resin) of 3-micron particle size ATH for vacuum infusion processes. These highly-filled systems still deliver the low viscosities required for vacuum infusion. In addition, the type of flow media and the pitch configuration have a significant effect on the infusion process, particularly with larger, more complex parts.

Yet another factor to consider is FRP laminate construction. Glass content and panel thickness can easily affect the flame spread and smoke values obtained in FR tests. Lastly, it is critically important to test the FRP panel in the configuration it will be used. Otherwise the results will not be representative of actual performance in the application.

Fire retardancy is a critical consideration in many composite applications, so be sure to work hand-in-hand with material suppliers during the design process. This will help ensure the best performance in fire tests, and, ultimately, final use of the product.

Benito Rodriguez is a technical service representative at Ashland Composites.
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Tomorrow's Architects Take on Composites

Lightweight, strong, malleable, exciting. These were some of the words that architectural students used to describe composites after competing in ACMA’s third annual Composites Design Challenge at the 2018 American Institute of Architects annual conference.

The contest, which is the brainchild of ACMA’s Architectural Division, was created to inspire the next generation of architects, says David Riebe, vice president of Windsor Fiberglass and challenge coordinator. Twenty-seven teams of students from six universities took part in this year’s challenge, beginning the semester with a technical workshop presented by ACMA and then breaking into teams to design and fabricate a composite architectural component. All materials were provided by ACMA members Ashland Chemical, Composites One, Gougeon Brothers, Owens Corning, Polynt Group and Vectorply.

Riebe says that this kind of grassroots outreach is crucial because architectural schools remain focused on traditional building materials like steel, glass, concrete, wood and masonry. For students like Karolina Piorko from Cornell University, the experience was an eye opener. “This was my first time working with a composite material,” she says. “Composites seem to have unlimited potential. We experienced firsthand how strong fiberglass is when cured, how light it remains, and how many forms can be developed.”

This is music to Riebe’s ears. “Students often describe the experience as empowering,” he notes. “This friendly competition offers the students a chance to experiment with materials that can help to realize their designs in ways other material systems can’t. Many times, they realize that they can build things they never dreamed of.”

The award-winning entries are profiled here.

1st Place: Tubular Knitting

First prize went to “Tubular Knitting” by Cornell University students Jingjing Liu, William Qian, Xiaohang “Gloria” Yan, Jinxin Yang and Yuheng “Amber” Zhu, who created a porous, lightweight structural column out of knitted fiberglass.

The team chose to knit the fiberglass after experimenting with other techniques. “With knitting, you can control the mesh size and be more precise in fabrication,” explains Sasa Zivkovic, one of the team’s advisors, assistant professor in Cornell’s Department of Architecture and director of the Robotic Construction Laboratory. “They started with something very simple, for example wrapping the fiberglass around an object, and then graduated to knitting, which opened up amazing possibilities.”

The team used hand-cranked knitting ring “machines” to knit multiple roving strands into two large, stretchable, sock-like tubes, which were stitched together into two branches. The structure was then hung from a frame, inflated with different-sized balloons and hand-coated with non-styrenated resin and cured for a day. The result is a porous, transparent structural column that is lightweight and highly portable. The team believes the technique has the potential to fabricate lightweight, customized components that can be flat-packed, transported and quickly assembled on-site to create permanent structural supports.

“What’s so exciting,” Zivkovic says, “is that different knit patterns could potentially correlate with different structural requirements throughout the structure, creating an intelligent structure.”

Cornell University student Vela Wang stands amid the final prototype of structural columns made from knitted fiberglass.
2nd Place: A Tough Tuft

Rachel Ghindea, a recent graduate of the Knowlton School of Architecture at The Ohio State University, and teammates Chris Block and Jon Decipeda began with one goal: to cast aside the usual flat, hard, linear properties of structural insulated panels (SIPs) and instead create something that appears light, approachable and soft. Drawing on the overinflated sculptures of Austrian artist Erwin Wurm and the bulbous plaster accent walls by American designer Andrew Kudless, the students used the buoyant properties of expanding foam to create an SIP that resembles a giant couch cushion.

To make the cushion, the students filled a wooden mold with several pounds of polyethylene teraphalate (PET) foam in its liquid state. This was covered with a highly elastic sheet of fabric, compressed with a second open mold and depressed with dowel rods to create low points. Once the foam expanded, the team layered chopped strand fiberglass mat and a polyester resin and allowed it to cure for a day. To finish, they smoothed it with joint compound and applied multiple coats of exterior enamel paint. Ghindea says that making the final 3 x 4 x 18-foot prototype was highly satisfying – and adventurous, in part, because they had only five minutes to
stir and pour the foam before it began to expand and harden. Nonetheless, she is hooked. “I’m already thinking,” she admits, “what else can I do [with composites] to inject character and personality into these elements so that they are a source of surprise as well as structure?”

3rd Place: Don’t Leave Me Hangin’

Third place was awarded to Cornell students Karolina Piorko, Veronika

Cornell University students created this dome from braided fiberglass roving.

Varga and Song Ren, who created a lightweight fiberglass dome using braided rovings. After investigating the hanging chain models of the Spanish architect Antoni Guadi and the suspended string installations of artist Janet Echelman, the team set out to form a dome using gravity.

To increase the dome’s strength, the students braided fiberglass roving into a three-part braid. The braid was split and merged into a catenary pattern inspired by spider webs and plant leaves. This continuous network was then suspended from a frame until it reached an ideal state of tension. The braids were then brushed with a non-styrenated resin and cured for a day before being inverted to create the dome.

Team Advisor Sasa Zivkovic says that fiberglass rovings, unlike other materials, easily supports this kind of construction. “It’s an ideal material to freeze something in space while it’s hanging relaxed in tension, and, when it is flipped around, it becomes an ideal compression structure.” With further research, he believes this method could be used for multiple applications, such as stadium roofs and other large span structures.

Melissa O’Leary is a freelance writer in Cleveland. Email comments to mxb144@case.edu.

For more stories on innovative composite applications in architecture, visit CompositesManufacturingMagazine.com and check out the Architecture Articles under the “Market Segments” tab.
A boat made in Germany, a pedestrian bridge in the Netherlands and wooden nails from Austria might appear to have little in common, but they do share one important trait: They are all made with biocomposite materials. A look at the three winners of the 2017 Innovation Award at the European Conference on Wood and Natural Fiber Composites shows the advantages of combining the strength, durability and light weight of traditional composites with the environmental benefits of natural, renewable resources.

**Green Sailing**

Friedrich Johann Deimann started GreenBoats to develop alternatives to the fiberglass and styrene-based polyester resins typically used to build boats. He found eco-friendly, viable replacements with similar properties in flax fiber, cork and bio-based (linseed oil) epoxy resins.

The GreenBente24 sailboat is made from 80 percent renewable materials and is vacuum infused. Flax fibers provide stiffness, vibration damping, and impact and abrasion resistance, while the lightweight cork adds water repellency. The result is a boat that doesn’t splinter if damaged, doesn’t release toxic substances into the water and doesn’t allow water to enter the hull’s composite sandwich core. “The products have a really nice haptic in the end,” Deimann adds.

The strength and stiffness of the flax-based composite is slightly less than glass fiber laminates. But the flax fibers have half the density of glass fibers, so the green boats weigh about 100 pounds less. The renewable biomaterials are also easier on the environment, since they can be harvested and processed with very little CO2 emissions.

Although the GreenBente24 is about 15 to 20 percent more expensive than similar high-end boats made with epoxy resin, GreenBoats is seeing steady customer demand. “The first customers are already sailing happily on German seas and lakes,” says Deimann. The biocomposite material he developed for the boats is also being used to produce travel trailers in Europe.

**Footbridge to the Future**

Eindhoven University of Technology in the Netherlands is home to the world’s first footbridge built completely with biocomposite materials. The 46-foot-long bridge was a collaborative effort by a consortium that included several regional universities and composite manufacturer NPSP.

The bridge weighs approximately 3,300 pounds and is designed to carry loads of 102 pounds per square foot. Its biocomposite material includes hemp and flax fibers. “We had the idea that flax fibers would be able to fulfill the mechanical requirements for a bridge like this,” says Patrick Teuffel, professor of innovative structural design at Eindhoven University. The fibers were also readily available from the project’s industrial partners.

To manufacture the bridge, workers attached the fibers to a biological polylactic acid (PLA) foam core, then introduced a bio-resin using a vacuum injection process. The bridge, installed over a stream in October 2016, includes 28 sensors that continue to measure its strength, stiffness and deformation (creep behavior) over time.
time. The university staff is also testing the behavior of the bridge materials in the lab.

“There is still not a lot of experience about how [the bio-material] will behave long term,” Teuffel says. “If you really intend to have these kinds of projects for 10, 20 or even 60 years, you have to define a certain stress level that should not be exceeded to avoid creep problems.”

The team has acquired a grant to build a small biocomposite pavilion and hopes to construct another bridge in Eindhoven this year. “I’m sure there will be more applications in the future,” Teuffel says.
Nailing It

Wooden pegs are one of the oldest known fasteners in the world, but the Beck Fastener Group in Austria put a modern spin on the product with its LignoLoc® collated wooden nails. The headless nails are made from straight, high-density, indigenous beech wood, compressed with a phenolic resin to yield a fastener with a tensile strength similar to aluminum nails. A specially designed nail gun shoots the nails into wood.

One advantage to LignoLoc nails is that there is no thermal transfer, according to Chad M. Giese, national sales and product manager for FASCO American, which distributes Beck’s products in North America. “They are only as conductive as the material they’re fastening,” he says. “Metal nails transmit hot and cold from the inside of the building to the outside – or vice versa – and that creates condensation, which can lead to rot around the nail.”

In addition, LignoLoc nails can be sanded or cut without damaging any bits or saws used during construction. Plus, driving the nails into wood creates “lignin welding,” a bond formed when the heat of the friction of the driven nail melts the lignin, an organic polymer found in the cell walls of wood.

LignoLoc nails have been used for fastening cross-laminated timber and in the production of ecological furniture and high-end green buildings. Wooden pallet manufacturers are another potential market, since they can shred their products after they’re used without having to remove metals in advance.

Mary Lou Jay is a freelance writer based in Timonium, Md. Email comments to mljay@comcast.net.

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Biocomposites at CAMX

Biocomposites are a hot topic within the industry. To learn more about bio-based solutions and green composites, consider attending these two educational sessions:

Development of Multifunctional and Green Composites for Aerospace and Beyond
Tuesday, Oct. 16, 1 p.m.
During his presentation, Xiaosu Yi of AVIC Composites Corp. and the University of Nottingham Ningbo China will discuss the latest development of bio-sourced materials for secondary and interior structures for green aviation applications.

Micro-Cellulose Fiber Reinforced Biocomposites for Additive Manufacturing
Tuesday, Oct. 16, 3:30 p.m.
Halil Tekinalp, a research assistant professor at the University of Tennessee/Oak Ridge National Laboratory, will share his technical paper on bio-based renewable alternatives for additive manufacturing.

In addition, be sure to look for biocomposites and other green solutions on the CAMX Exhibit Hall.
Founded in 1856, Uljanik Group in Pula, Croatia, is one of the oldest shipyards in the world. Yet when the company set out to reduce fuel consumption for Siem Car Carrier’s Cicero vessel, it turned to modern materials.

Uljanik had been exploring the use of composites in shipbuilding applications since 2006, when it became a partner in a European Union-funded research project. The DE-LIGHT Transport project was launched to demonstrate innovative integrated lightweight modules for commercial ships. Siem Cicero would become the first real-world application of this research, using composite sandwich materials for the pure car/truck carrier (PCTC).

Only the top three decks of the 13-deck ship were made of composite sandwich panels. “The idea was to reduce the weight in the upper zone of the vessel to improve the stability properties and reduce the required counterweight in the lower zone,” says Vito Radolovic, senior designer for Uljanik.

PCTCs like the Cicero typically need a ballast (a compartment at the ship’s bottom, often filled with seawater) to counteract the ship’s high center of gravity and meet stability requirements. By reducing the structural weight higher in the ship, the designers were able to lower the vertical center of gravity. The result was an ultimate reduction in the ballast requirement by 575 tons.

Radolovic explains that the design team behind the Cicero analyzed a variety of core types – including polyvinyl chloride (PVC), polyethylene terephthalate (PET), polyurethane (PUR) and balsa – and different glass fiber layouts before selecting the final design of its panel. Ultimately, they chose a GFRP sandwich structure, with Diab’s Divinycell H PVC at the core. PVC’s strength-to-weight ratio and known properties in a fire scenario made it the best choice for this application.

“They wanted to use a structural core material for the decks,” explains Ferdinando Ollino, sales and marketing director for Diab Group. “Diab was quick in suggesting the right core with the requested performances.”

The sandwich panels feature a balance of both Divinycell H80 and Divinycell H100 PVC. More than 10,000 square feet of the higher density Divinycell H100 was used along panel edges to meet stringent strength requirements. Nearly 27,000 square feet of lower-density H80 was used throughout panel interiors to bring down the overall weight of the vessel.
weight and cost of each panel. Each resulting structure was vacuum infused with epoxy vinyl ester resin. For this first foray into composite decks, Uljanik deemed it best to keep all panels the same, designed to meet the worst-case load.

Croatia-based Brzoglas fabricated 1,043 lightweight composite panels to be installed across 135,625 square feet of the ship. The switch from steel to GFRP panels reduced the ship’s weight by 200 tons, or 25 percent – equivalent to the weight of an entire traditional steel deck.

While the benefits of this design were clear, achieving them presented some challenges. Chief among these issues was determining how to connect the composite panels to the supporting steel structure. International Convention of Safety of Life at Sea (SOLAS) regulations require structural steel supports be used to ensure a deck is structurally sound. While the strength and stiffness of the panels helped minimize the amount of support steel needed, the design team was still left with the challenge of how to connect each panel to its steel framework. Radolovic explains that the panel geometry had to be modified at connection points. The team also had to develop a connection layout that could be adjusted to best fit steel shipbuilding’s tight tolerances of +/-5 mm. The connection points ultimately were designed as a flexible bolted joint.

Because fire resistance was also a concern for the ship owner, the project team went above and beyond in meeting SOLAS requirements. While not required by SOLAS, Uljanik performed a fire safety assessment in accordance with SOLAS at the request of the ship owner to prove the composite design met the same safety standards as a conventional steel design.

Third-party inspector RISE performed two hazard identification studies, large-scale fire tests of the steel and composite deck structure, and 12 fire dynamics simulations (six for steel and six for composites). Fire test results showed that the lash holes in the composite panel for securing cargo – a total of 23,000 openings on three decks – were critical in achieving crew safety. The combination of closed lash holes and the insulating ability of the panels were proven to delay deck-to-deck fire spread, a huge boost to crew safety. “At the end, with some simple improvements implemented, equivalent safety was obtained,” Radolovic says.

Siem Cicero set sail in July 2017. For a 656-foot-long ship that is able to carry 6,900 vehicles, cutting fuel consumption by 4.5 percent is a big deal. In fact, it means an increased payload of up to 800 tons. But the design team is not ready to rest on this success. New research projects will explore pultruded FRP structures as a replacement for the sandwich panel and possibly for the steel support structure as well.

According to the shipbuilder, the Siem Cicero has the lowest fuel consumption of any car and truck carrier in its class – so far. The success of that ship has led to the use of composite materials in the SIEM Ashanti, which hit the water in early 2018.

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For more stories like this, visit CompositesManufacturingMagazine.com and check out the Marine articles under the “Market Segments” tab.
Hurricanes, wildfires, floods and tornadoes battered the U.S. in 2017, inflicting millions of dollars in damage on roads, bridges, power grids and other infrastructure. While that repair bill is high, it’s only part of the story. To get the infrastructure in good shape, the American Society of Civil Engineers (ASCE) estimates that the U.S. would have to spend $4.6 trillion by 2025 to make the necessary repairs and replacements.

The use of composite materials can help the country get the best value for its investment—and it’s not just industry insiders who are saying that. In testimony to Congress in April 2018, Joannie W. Chin, deputy director of the engineering laboratory at the National Institute of Standards and Technology (NIST), enumerated composites’ advantages. “Advanced composites are often stronger, lighter and longer lasting than traditional building materials, thereby offering many cost savings,” she said. “The longer lifespans for infrastructure components that include advanced composites mean fewer service days lost to maintenance of the bridges, roads, dams, levees, highways, railroads, utility poles and other elements that support movement of the goods and services that underpin our economy.”

Protecting Power

Hurricanes, ice storms and high winds frequently bring down wooden telephone poles, cutting power to thousands of homes and businesses. Resilient FRP poles help utilities keep the lights on. There are many examples. When Hurricane Odile hit Mexico’s Baja Peninsula in 2014, only the electric lines that had been hardened by replacing every fifth wood pole with an FRP pole remained standing. In the Grand Bahamas, hurricanes in 2011 and 2015 took out 2,700 wooden poles, but all 450 composite poles the utility had installed remained intact.

Composite poles are more environmentally friendly, don’t require the use of chemical preservatives like creosote and are easier to install in difficult-to-access locations. Highland Composites, for example, makes FRP poles in 13-foot sections that can be joined together on site, eliminating the need for cranes to lift heavy wooden poles into tight places.

Composite poles cost two to four times more than wooden poles, and that has discouraged many utilities from installing them. But FRP poles have a lifespan of 60 to 80 years, twice that of a wood pole. In the long run, power companies that use FRP poles save money because they’re paying installation costs only once in 60 years instead of twice.

But utilities tend to use much shorter time frames when
figuring costs, so they usually overlook that equation, according to Scott Holmes, director of business development, Highland Composites. "Utilities are more receptive to looking at some of the other benefits, like the environmental ones or hardening the grid against future storms," he says. "They may also look at a case where using a composite pole will make installation safer and easier because the location is difficult to access."

Direct comparison of fiberglass and wood poles is difficult because they are measured or rated by different standards. FRP pole manufacturers use ASCE 111, Reliability Based Design of Utility Structures, which rates a material’s strength based on its variability. It’s the same standard used for rating composite materials for bridges and other building applications. Wood poles, however, are measured on their average mean strength, which is expressed as a class rating. To make comparisons easier, ACMA’s Utility and Communication Structures Council has developed a wood equivalent class rating system for composite poles.

The FRP pole market could get a big boost from a recent decision by the Federal Emergency Management Agency (FEMA) in the U.S. Virgin Islands. FEMA has previously allowed recovery funds to be spent only for a like-for-like replacement – a wood utility pole for another wood pole. But after reviewing the performance of FRP utility poles in recent hurricanes, FEMA agreed that federal funds could be used to replace several thousand wood utility poles with composite poles. "That really is unprecedented," Holmes adds.

News about the superior performance of FRP poles is spreading. After a 2017 windstorm cut power to more than 170,000 customers in Rochester, New York, the utility companies there signed an agreement with the New York State Public Service Commission to improve their infrastructure. They will be spending $1.25 million to replace many wooden utility poles with the stronger, more resilient fiberglass poles.

**Hardening the Infrastructure**

It’s not only severe weather that causes infrastructure damage. Over time, environmental elements like moisture, salt and chemicals can cause the concrete in bridges and similar structures to spall or crack. Water seeps in, rusting the steel rebar and the bridge structure eventually weakens.

State departments of transportation (DOTs) began testing carbon fiber reinforcement plates in the 1990s to strengthen and extend the life of these bridges. Caltrans, the California Department of Transportation, started using glass fiber wraps (wet layups) to harden bridge piers and H-piles against potential earthquake damage. Now, with two decades of data supporting...
Contractors generally use carbon-based composites for preserving and strengthening bridges because they are stronger and offer better resistance to the continuing dynamic loads generated by traffic. “Glass fibers are better for a one-time event like an earthquake,” says White. “You are not trying to strengthen the bridge for heavy truck loading; you’re trying to get it so it will stand up to the one time when an earthquake hits.”

To help engineers find the right composite material, the American Concrete Institute (ACI) Committee 440 has developed numerous documents on the use of composites with concrete in infrastructure applications. These documents provide technical equations and design examples for using composites.

In addition, the International Code Council (ICC) has an evaluation service program that tests composite materials for tensile strength, tensile modulus, elongation and other mechanical properties. “They will also require full-scale testing at times, where you have to put your products on concrete beams and columns to have it tested,” White says. Composite materials that meet all the test criteria receive an ES report number from the ICC. Agencies working on infrastructure projects may require a composite product to meet this ICC acceptance criteria.

FRP utility poles can be constructed in sections and joined in the field, making them easier to transport and install in tight spaces.

Providing Longevity

Sika installed its first composite bridge reinforcements in 1991. “We have gone back and looked at a lot of these early projects, and they don’t show any signs of degradation,” White says.

In 2007, Sika worked on the Sunshine Skyway Bridge in Tampa, Fla., which had opened in 1987 but showed some concrete cracking after just 20 years. “They decided to repair the cracks and wrap them with a carbon fiber material to provide a barrier and to keep the moisture and chlorides out of the inside of the bridge,” White says. The composite wrap, installed in 2007, has performed well and looks almost new.

The demonstrated durability and resiliency of composite materials in these applications has encouraged bridge builders to find other uses for the material.

White notes that composite rebar is currently being installed in new bridge decks. Contractors are also cutting grooves into existing decks and adding composite rebar to provide extra reinforcement before they are repaved. On some smaller bridges, designers are replacing pre-cast concrete deck slabs with pre-cast FRP panels. “They are just as strong as pre-cast concrete and much lighter in weight,” Scott says.

Designers are also employing composite components to prevent the collapse of suspension bridges. The vibrations caused by high winds can cause these bridges to ripple, bounce and eventually fall apart. (The best-known example is the Tacoma Narrows Suspension Bridge in Washington State – Galloping Gertie – which buckled and fell in 1940.)

To avert a similar disaster, bridge owners began adding weight to their structures, using concrete and steel to stabilize them. They also installed triangular wind fairings to deflect the wind from the bridge. While bridge fairings are usually made with steel, composite fairings are a better choice in some instances.

Composite Advantage built 50 FRP wind fairing panels for the Bronx Whitestone Bridge in 2003. “They had added mass to the bridge back in the 1940s and 1950s, but as traffic loads got heavier the bridge was beginning to show fatigue. They decided they needed to get all the extra weight off and come up with a new solution, which was fiberglass fairings,” says Scott Reeve, the company’s president.

The designers of the new Sarah Mildred Long Bridge, which connects New Hampshire and Maine, also chose FRP fairings for their structure’s lift span. “If it wasn’t a lift bridge, they might have added concrete and steel if they were concerned about wind loads causing vibrations,” Reeve adds. “But when you’re talking about a lift bridge, that weight has a huge effect on the structure and on the mechanisms that are lifting that bridge up. If you make that bridge heavier, you have to make mechanisms more robust and more costly.”

Lighter weight fairings are not needed for many bridges. “But when you do have the need, it’s a place where fiberglass is pretty much the only solution. That’s where we provide the value,” Reeve says.

Springing Back

Nature isn’t always the culprit when infrastructure suffers damage. Sometimes the harm comes from human error. Composites are just as resilient in these situations.

Operators of barges and other boats on the U.S. waterways occasionally collide with electrical transmission towers or with
unprotected bridge supports. “Ten years ago, a large ship hit a bridge in Florida, and it had to be shut down,” Reeve says.

The owners of these structures surround them with fenders (fences) for protection. But the steel and wood structures that are typically used aren’t ideal in this environment; the steel corrodes, and preservative-soaked wood may contaminate the water.

Composite Advantage has installed FRP fenders in the James River and along the New Jersey coast. Composite poles, some 100 feet long, anchor these fences, with FRP cross braces filling the span between the poles. If a boat collides with them, the FRP fenders bend and return to their original shape, unlike those made of wood and steel. They also cause less damage to the ships that hit them.

Ferry terminals also benefit from fenders produced by Composite Advantage. “When the ferries come in the wind is blowing, the currents are moving and a lot of times the ferries are coming in fast. In bad weather, a ferry can hit hard enough that people and motorcycles fall over,” Reeve explains. “When the ferry hits fiberglass fenders, it’s a much gentler impact because there’s more give. We bend, but we don’t break.”

Although the FRP piles cost more than wood or steel, the flexibility of the composite material allows the installation of fewer piles overall. That means less costly pile driving. “Even though the product price of the materials delivered to the site is higher, when they get done with the actual installation the whole project cost is lower,” Reeve says.

Emergency Response

Composite materials can also deliver speed and flexibility for infrastructure repairs. QuakeWrap’s PileMedic® is made with multiple layers of carbon (or glass) FRP to form an extremely thin (1/1000 to 25/1000 of an inch), solid but flexible laminate. The material is coiled into 4-foot-wide rolls that can be 200 to 300 feet long and easily shipped anywhere.

Building crews shape PileMedic into the desired diameter for a pipe, pier or other application right at the site. Infused with additional epoxy, it forms a continuous wrapped column or jacket that can be filled with concrete.

“The laminate has a lot of strength in both the longitudinal and the transverse directions,” says Mo Ehsani, president and CEO, QuakeWrap Inc., and centennial emeritus professor of civil engineering at the University of Arizona. The thin laminate offers another advantage for submerged pile repair. Work crews can form the wrapped columns in sections above water and then push them down into position around the pier underwater. This reduces costs by limiting the number of divers required for installation work.

The U.S. Army Corps of Engineers has designated PileMedic the material of choice for emergency pier repairs at U.S. ports since all the components of the system can be stored on site, enabling a quick response.

QuakeWrap has used PileMedic to repair 500 badly-deteriorated timber piles at a private port in Virginia, as well as 100 piles in a demonstration project at the Port of Seattle. Another potential market is New York Harbor, where hundreds of thousands of timber piles support docks and major structures. Because the water is getting cleaner, marine borers – mollusks or crustaceans that live in warm seas and destroy wood – are moving in and attacking the piles at alarming rates. This threatens the structures these piles support, Ehsani says. A composite laminate wrapped around the piles would strengthen them and repel the borers’ incursions.

The company is using another new product – a sheet pile repair system (SPIRe®) – to contain potential runoff from a riverside steel bulkhead owned by a chemical product company in Virginia. The rigid 4 x 15-foot FRP panels are installed in front of the bulkhead in a continuous wall. A small gap left between the original wall and the impervious FRP panels is filled with concrete and reinforcing bars. Runoff can’t get through the FRP to the water, and oxygen doesn’t get through to the bulkhead.

“We prolong the life of the old steel wall, so it’s not only strengthening the wall but preventing corrosion as well,” Ehsani adds.

Sharing Knowledge

Communities throughout the U.S. have successfully used composite materials to improve the resiliency of their infrastructure. But many builders, designers, engineers and other decision-makers need more information and more guidance before they feel comfortable using the material for this purpose.

NIST is trying to accelerate the acceptance of composite materials for infrastructure applications by developing a roadmap for its adoption. One key component will be the development of
FRP fenders prevent boats from damaging electrical transmission towers. Made from resilient composites, these fenders will return to their original shape after a collision.

Climatologists are predicting an increase in both the severity and frequency of dangerous weather. So it's essential that communities get the data and the tools they need to take advantage of the materials that can best help them protect and maintain their infrastructures. In more and more cases that means composite materials.

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Beyond the Boomers

As baby boomers retire, manufacturers are turning to innovative workforce programs to find the next generation of composites professionals.

By Evan Milberg

On shop floors across America, composites industry workers are aging. According to a 2015 report from IACMI – The Composites Institute, 22.9 percent of workers in the IACMI region (Michigan, Colorado, Ohio, Indiana, Tennessee and Kentucky) are over the age of 55 and set to retire in the next decade. And as they retire, they are leaving with years of experience and essential knowledge necessary to maintain best practices on the shop floor.

“There’s a bit of fear there,” says Joannie Harmon Heath, workforce development manager at IACMI. “How are we going to keep what’s in Bob’s head here so that no one repeats mistakes or continues to do business as usual and there’s no downtime? Retaining tacit knowledge is a big concern … because the number of available workers is a significant mismatch to those that are leaving.”

IACMI projects that more than half a million workers will need to be replaced in the next 10 years. Currently, there are more workers over 45 than under 45, which means the pipeline is getting weaker. However, organizations like IACMI, ACMA, Abaris, the National Institute of Standards and Technology (NIST) and SME (formerly the Society of Manufacturing Engineers) are all working with composites manufacturers to
make sure they have the tools to thrive after the baby-boom generation retires.

Getting Lean

One way companies can help ease the transition to new talent is by reaching out to NIST’s Manufacturing Extension Partnership (NIST MEP), which works side by side with manufacturers to reduce costs, improve efficiency, develop next-generation workforces, create new products and find new markets.

“Some small companies know what they need to do, but they don’t know where to look,” says Mary Ann Pacelli, NIST MEP’s workforce development manager. “So we can connect them with a Manufacturing USA institute, colleges doing research, a lab that is doing research or another company that has the materials and help those companies adopt all these new techniques so that they can grow their business.” She notes that over the past three years, the program has achieved more than 950 success stories.

One of those successes came in 2016, when Smithfield, R.I.-based manufacturer Fiberglass Fabricators Inc. (FFI) connected with Polaris MEP, Rhode Island’s NIST MEP affiliate, to help the company cut waste from its processes. Tim Streuli, an estimator at FFI, says the company recognized the composites industry was becoming increasingly competitive and that many of its competitors had drastically lowered overhead. To keep up with its competition, FFI needed to operate more efficiently. The company had begun a lean manufacturing initiative in the 1990s, but the effort subsided due to personnel changes and a lack of process standardization.

“We had gone through kind of a generational turnover,” says Streuli. “The older generation had left and the younger generation has come in and … the transition was not as smooth and as forthcoming as possible. That had created some issues as far as the way things are done in the shop, so it was a matter of straightening everything back out.”

Polaris conducted Lean 101 training for FFI, which introduced the company to tools that leadership can use to make continuous improvements to logistics and operations. FFI leaders selected staff members to form an improvement management team, which had the opportunity to be trained on Polaris’s lean manufacturing tools and concepts, including one-piece flow production to reduce unnecessary batches, workplace organization, project management and planning through visual tools, such as “value stream” flowcharts that help leaders make better strategic decisions. Polaris also helped FFI’s management team easily communicate the results of the program to stakeholders.

Streuli says that because of the improvements FFI made, the company was able to invest $300,000 in a new, quicker CNC machine that automated its glass-cutting processes and produced more consistent parts.

Student Programs

While some companies prefer to invest in workforce development programs for existing talent, others, such as Shape Corp., a Grand Haven, Mich.-based manufacturer of FRP, plastic and metal components for the automotive market, also approach the issue through K-12 engagement.

In the spring of 2017, Shape began working with the SME Education Foundation’s Partnership Response in Manufacturing (PRIME®) initiative, which helps manufacturers conduct analyses to identify their skills gaps and then develop a talent pool that can help them address their needs. Julie Davidson, director of talent acquisition at Shape Corp., says the company was drawn to PRIME because it incorporates a deep understanding of the needs of the industry and of educational systems. “It is not a cookie-cutter curriculum, but rather custom built to meet the needs of the business and ultimately the community,” she says.

SME PRIME developed a pre-apprenticeship program at Grand Haven High School, where students can learn different aspects of manufacturing over a three-year period. Throughout the program, students learn about quality, precision measurement, instrumentation and inspection directly from Shape Corp. employees. Year one, which started in 2017, focused specifically on quality. Year two will focus on industrial robotics, and year three will focus on Shape’s unique Radius-Pultrusion™ process for curved composite automotive parts.

Josh Cramer, the interim executive director at the SME Education Foundation, says that at the end of the program in spring 2019, the students will spend two days with Shape, where they will have the opportunity to receive industry-recognized certification in seven areas of precision, instrumentation and quality. Students will go through the entire process of making a component; Shape’s destructive testing technology will then be used to analyze and evaluate the students’ work.

According to SME’s Education Foundation website, 84 percent of last year’s graduating seniors in PRIME programs intended to pursue careers in manufacturing, and 60 percent of those students intended to pursue post-secondary education in a field directly related to manufacturing. A big reason for that, says Cramer, is that the curricula go beyond just principles of manufacturing; they also help students understand how the company they’re learning from got to where they are today. At Grand Haven, Cramer wants to make sure the students can make the connection between Shape’s history and the impact it has on the quality of the parts it makes.

At the university level, IACMI pairs university students with composites manufacturers through its internship program. As Harmon Heath explains, before their internships, the students are trained in basic FRP manufacturing processes. That way, by the time they begin their internship, they already have background knowledge and training on each company’s specific equipment.

“It’s really a win-win for everyone,” Harmon Heath says. “The industry partner is getting an intern … that has already received some training and background knowledge, so they’re hitting the ground running. And for the interns, it benefits them because they feel like they can add value.”

That was the case for Alix Ambrose, a mechanical engineering major at the University of Tennessee, Knoxville, who interned with RMX Technologies for 10 weeks in 2017. During the internship, he provided engineering support for the modification and operation of research while developing equipment focused on commercializing a new plasma technology for carbon fiber. He also assisted in the execution and analysis of data gathered from a test matrix to finalize several engineering details that are critical to the design of the new technology.

“Alix brought a unique and valuable perspective to our organization,” said Jonathan Ford, a project manager and design engineer for RMX Technologies in an IACMI press release.
“With a little training, he quickly became an integral part of our team working alongside our researchers and scientists to develop and test new technologies.”

Harmon Heath says the internship program has become increasingly diverse. She points to the fact that 38 percent of the 2018 IACMI internship class is female, which is more than double the national average of women in engineering in 2015 (15 percent). She says that by increasing the diversity of internships and candidates to fill these internship positions, IACMI is better able to support a well-rounded workforce and reach students who are likely to enter an immediate workforce market.

**The Image Issue**

As Cramer tours the country to help manufacturers and schools develop PRIME programs, he’s learned that not only are manufacturers having trouble getting quality talent; they’re having trouble getting talent, period. During ACMA’s Composites Executive Forum in 2017, Cramer said that even if 100 percent of the graduating high schoolers in the Pittsburgh metro area got jobs in manufacturing, employers in the area would still be short 20,000 employees.

A big part of the issue stems from a familiar foe – the negative perception of manufacturing among students and their parents. Harmon Heath believes many parents’ fears come from personal experiences in the 1970s and 1980s, when many American manufacturing jobs were offshore and either they or their parents were left unemployed. In addition to job security, many high school and college-aged students still view manufacturing jobs as inherently dirty. But ironically, according to Harmon Heath, the positions manufacturers are having the hardest time filling aren’t dirty at all.

“It isn’t like that anymore,” says Harmon Heath. “That’s not to say that there aren’t some jobs that are hot or you might get dirty doing them, but many of the manufacturing jobs today are in a very clean environment. These jobs require a high level of skill.” Those skills, she says, can only be obtained through education in a community college technical program or on-the-job-training.
To help reshape the conversation around composites manufacturing, IACMI participates in the National Association of Manufacturers’ (NAM) annual Manufacturing Day, during which manufacturers from all over the country open their facilities to the public to give hundreds of thousands of students and their parents an idea of what a career in manufacturing actually looks like. During Manufacturing Day 2017 in Detroit’s Corktown neighborhood, IACMI and LIFT – Lightweight Innovations for Tomorrow inaugurated the IACMI Scale-Up Research Facility (SURF), which is used for innovative automotive research and development projects. Harmon Heath says exposing middle and high schoolers to the facility helped create awareness of what it means to work on a 21st century shop floor. She believes parents get to see that automotive manufacturing can be a real career and not just a temporary job for early career professionals waiting for a “real” opportunity. And for students, activities at SURF show how cool manufacturing can be.

“We increase [students’] awareness on what these types of jobs are, but we do it in a way that’s engaging and fun,” says Harmon Heath. “They get to see technology being used in fun and cool ways, and they don’t realize that what they’re doing is really science and learning. It just feels like it’s a lot of fun.” One example of an activity that always captivates students, she says, is playing the game Connect Four with industrial robots.

Cramer believes that another great way to get young people interested in manufacturing careers is to create programs that appeal to their inner sense of purpose. He believes that Generation Z is driven by how it can impact others, as opposed to some of its millennial predecessors who are driven more by self-importance. That doesn’t mean, he adds, that one generation is “better” than another, but that engagement strategies need to change as manufacturers look toward the future.

“I think this generation of students, more so than any, always looks to ‘How is this bigger than me? How do I make an impact?’” he says, noting that by showing a young person a simple composite manufacturing process, a company can put its own work into perspective and help inspire future professionals.

Cramer says that type of engagement must start early, though. For example, SME PRIME outreach also includes elementary and middle school students, their parents and community members to build excitement and awareness of manufacturing, similarly to how kids get excited about first responders during a school’s career day. That early exposure, he says, can ease recruitment once the kids get older.

**Future Opportunities**

With high-performance composites markets like aerospace and defense primed for major growth over the next few years, the need for skilled composite technicians in those markets will undoubtedly increase. To help manufacturers prepare for this trend, earlier this year ACMA expanded its Certified Composites Technician (CCT) program to include a new course that allows professionals to become certified in “Advanced Composites.” Because the learning curve for advanced manufacturing processes, such as vacuum bagging and autoclave, is steeper than it is for traditional FRP processes, for the first time in the nearly 20-year history of CCT, ACMA is requiring enrollees in the program to gain prerequisite knowledge prior to certification in the new program.
That’s no surprise to Lou Dorworth, direct services manager at Abaris Training Resources Inc., which became an ACMA Affinity Program partner a few years ago to bridge the training gap between GFRP- and CFRP-intensive processes. Dorworth, an industry veteran since 1978, says with the aerospace industry transitioning to more thermoplastic composites, the skill sets employers need are becoming increasingly complex.

“What I’m seeing now is a real interest in being able to manufacture more quickly and with techniques that are more aligned with fabrication rather than with deep processing, which thermosets require,” says Dorworth. “But I think we’re going to see more and more demand for training [in thermoplastics] starting with … basic classes like we did with thermosets back in the ‘80s and ramping up to full-scale fabrication training events.”

But for that to happen, companies like Abaris need to be fully equipped with the resources to train high-performance composite technicians properly. That’s why the company decided this summer to move its east coast operations from its facility at Atlanta Aerospace Composites to the Composite Prototyping Center (CPC) in Plainview, N.Y. The CPC, Dorworth says, gives Abaris access to advanced technology it did not have available for trainees in Georgia, such as automated fiber placement robots for thermoset and thermoplastic designs, large autoclaves, RTM and VARTM systems, and CNC routers with five-axis alignment verification systems for cutting, milling and machining. In return, Abaris brings expertise in prepreg manufacturing, wet layup, tooling, adhesive bonding and composite repair to CPC.

Abaris and CPC believe the Long Island region’s workforce development efforts will benefit from Abaris’ presence at CPC, as the area’s manufacturers will gain easy access to more advanced materials training programs, which will enable them to build a more proficient, skilled workforce able to work with composite materials. They believe that, in turn, will help position those manufacturers for greater subcontractor opportunities awarded by larger manufacturers.

Evan Milberg is a former communications coordinator for ACMA. Email comments to evanmilberg@gmail.com.

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**Strengthen Your Skills Through the CCT Program**

ACMA’s Certified Composites Technician (CCT) program has been the gold standard for certification in the composites industry. The program allows composite manufacturers to elevate their standards, enhance production performance, recognize professional expertise and improve their employees’ knowledge of composites. Recently, ACMA expanded CCT to include a new program that allows professionals to become certified in “Advanced Composites” (AC). For more information, contact Andrew Pokelwaldt, ACMA’s director of certification, at apkelwaldt@acmanet.org.
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There isn't a single solution to increase the use of CFRP. The high price of carbon fiber, limited availability in large quantities, lack of options for high-volume/high-speed production, recycling implications and changing OEM mindsets to accept CFRP and associated production requirements are all challenges. However, composites companies are tackling these issues, and industry advances are fast-paced. Here are a handful of new solutions that could potentially impact the entire CFRP supply chain.

**CFRP Innovations Gaining Speed**

New technologies to process carbon fiber and convert it into parts are turning ideas into innovations.

By Patrice Aylward

Successful trials of 4M’s innovative oxidation technique to form carbon fiber tow in higher volumes were conducted with this full-scale plasma oxidation cell.

**Carbon Fiber Oxidation**

A simplistic description of carbon fiber production includes three phases: oxidation, carbonization and surface treatment. Oxidation, also known as stabilization, causes the polymer chains to cross link, enabling the microstructure and shape of the fibers to be retained during the carbonization phase. It is a critical step because it takes the most time, energy and expense. 4M Carbon Fiber Corp. in Knoxville, Tenn., is commercializing the world’s first plasma oxidation oven for the oxidation phase of its
carbon fiber tow production. The anticipated results are higher production volumes, shorter production schedules and improved energy efficiency.

The new oxidation technology takes less than half the time of conventional oxidation methods, according to the company. 4M is developing its plasma oxidation ovens in partnership with C.A. Litzler, a global manufacturer of process equipment. The ovens will be smaller and use less energy, yet result in greater throughput than conventional ovens, according to 4M. The plasma chemistry, developed by 4M’s affiliate RMX Technologies, generates a highly reactive process that accelerates the oxidative stabilization process utilizing electrohydrodynamics.

Rob Klawonn, CEO of 4M, explained the difference between traditional oxidation and plasma oxidation. “In a conventional oven, filaments are exposed to warm air to chemically change the fiber. But oxygen molecules are quite stable and don’t jump at the chance to react with the precursor,” he says. “Introducing plasma helps excite the atmosphere inside our ovens, making it more reactive than conventional warm air so that more oxidation occurs in a shorter time. Not only is the oxidation time shortened, but the need to recycle the supply air is reduced, further saving energy.”

While 4M won’t reveal too many details about its proprietary plasma oxidation process, Klawonn says it converts precursor material faster, which significantly reduces fiber handling and enables the production of three times as much product in the same operational footprint as traditional carbon fiber production methods. He adds that a wide range of precursors can be processed with the plasma oxidation technology.

In addition, the process can produce 50 percent larger diameter filaments than conventional methods, says Klawonn. “Compression strength tends to be the weakness of carbon fiber compared to glass,” he notes. “The result is carbon fiber tow with high compression performance and buckling resistance. By targeting larger carbon filaments, this weakness can be mitigated while at the same time lowering fixed costs through higher volumes.”

4M anticipates its first product line will be available at the end of 2019, with full commercial production slated for 2021. “By targeting high-volume production, we are resolving a significant barrier to meeting market demand,” Klawonn notes.

New Preform Process

A consortium formed by IACMI – The Composites Institute has developed a new CFRP manufacturing process that improves fabric formability compared to traditional woven materials. The first phase of the project shows promise for easier and safer production of carbon fiber composites.

Led by DuPont in partnership with Fibrtec Inc. and Purdue University, the process has the potential to increase design flexibility and decrease the cost of production for carbon fiber composite structures. This could allow for “net near shape” preforms, where initial production of the preforms is close to the final shape, reducing the need for finishing. That would be a compelling option for automotive and other high-volume industries requiring complex shapes.

The process uses Fibrtec’s flexible coated carbon fiber tow, Fibrflex™, which is partially impregnated with DuPont’s polyamide thermoplastic resin and then processed with DuPont’s Rapid Fabric Formation (RFF) technology. The research was facilitated by Purdue University’s modeling and characteristics capabilities software for the development of the net near shape preforms.

The new process begins when Fibrtec partially impregnates the outer layers of carbon fiber, leaving the inner material uncoated to maximize the flexibility of the ribbon-like tow.

“Fibrflex preforms rapidly consolidate to a void-free composite under heat and pressure,” says Bob Davies, CEO of Fibrtec, Midland, Texas. “Using a 12K carbon fiber, the resulting 5-millimeter wide, 0.3-millimeter thick tape is easily manipulated and draped, ready to produce near net shapes through RFF.”

Davies adds that the tapes can be woven or braided and “drape without wrinkling or buckling as compared to fully consolidated rigid unidirectional tapes or organo sheets made from films and fabric, which are stiff and board-like.”

The process eliminates another potential issue with woven fabric: Weaving dry fiber tows often causes fiber breakage, releasing short, conductive carbon fiber strands into the environment. Because of this issue, looms and equipment must be electrically isolated. The Fibrflex product fully encapsulates the fiber with a thermoplastic sheath, preventing fiber breakage.

DuPont’s RFF process quickly manufactures fabrics in varying orientations using robotic tow placement, eliminating the need to lift the tow during processing. Experiments, modeling and simulations conducted by Purdue University have reportedly shown that this combination of materials and process has the potential for producing lower cost continuous FRP materials with a thermoplastic matrix that conforms well during molding.

An Automated Conversion Process

Many industries still hand cut, stack and assemble layers of carbon fiber, making them subject to misalignment, wrinkles, missing layers and fiber crimping. Start-up company Seriforge is automating the process of converting unidirectional carbon fibers into advanced composite preforms that can be mass produced, a dream for the high-volume automotive industry and others.
San Francisco-based Seriforge uses CAD technology to design a composite laminate based on customer requirements and then proprietary software to fully automate how the dry carbon fiber layers are cut, stacked, assembled and stitched together to form a 3D preform that is ready for insertion into a tool for infusion. The result is high-volume production capability – from 10,000 to 20,000 near net shape preforms per line/per month depending on the part complexity.

Automating the process simplifies future part revisions. Once a design change is entered into the part’s CAD file, the downstream processes are also updated. “Our CAD system and production equipment are integrated from start to finish,” says Marco Zvanik, vice president of business development for Seriforge. “A change made at the starting point of the design automatically alters the entire process.” Automating production also enables documentation of the manufacturing process, creating a record for historical analysis.

Seriforge offers Z-axis reinforcement of unidirectional and woven continuous carbon fiber preforms. For parts requiring a high fiber-to-resin ratio and designed for maximum performance, Seriforge stitches the stack with a continuous fiber tow with no tension on the fiber stitch and no chain or lock stitch, which can cause distortion of the X and Y layers of the unidirectional fibers, reducing the performance of the finished laminate.

The Z stitching is only used where needed, such as areas with a significant load pattern or a cutout in the part that poses the risk for delamination. “Our same design software develops the laminate schedule for the part based on what the loading requirements are and where the load paths are,” says Zvanik.

The resulting near net shape preforms are cost neutral or lower in cost than those made by hand lay-up or other standard prepreg fabrication methods, says Zvanik. Seriforge’s current customers are primarily in the oil and gas and recreational markets, although the company has several automotive projects underway. The company moved into a new manufacturing facility in 2017, and its first production line kicked into gear in June 2018. Seriforge is currently building a second production line and plans to add a third by the end of this year.

### 3D Printing

Material supplier Hexcel Corporation views 3D printing as the next frontier in composites manufacturing. While it is not applicable to all composite applications, it provides a quick-to-market alternative for many smaller parts with intricate geometries. The company manufactures carbon fibers that are suitable for 3D printing and utilizes 3D printing primarily for aerospace parts production.

The carbon fibers Hexcel uses for 3D printing are not treated with sizing agents, which can interfere in the bonding of thermoplastics and carbon fiber. “Our unsized carbon fibers, HexTow™, ensure there are no adverse effects between the fiber and resin chemistry and provide excellent interfacial bonding properties with thermoplastic matrices for 3D printed parts,” says LaRhea McBee, carbon fiber technical support engineer with Hexcel.

In addition to supplying materials, Hexcel manufactures CFRP parts for customers, so moving into additive manufacturing was a logical step. Earlier this year, Hexcel entered
An Expert Weighs in on CFRP Growth

Uday Vaidya, an expert on the manufacturing and use of thermoplastic composites, shared his thoughts on future innovations in CFRP. Vaidya is IACMI chief technology officer and University of Tennessee/Oak Ridge National Laboratory Governor’s Chair for Advanced Composites Manufacturing.

CM: What important developments will impact the quest for high-volume CFRP production?

Vaidya: The adoption of high-rate processes, such as high-speed resin transfer molding, high-speed injection and compression molding, will contribute to the growth of CFRP applications. I believe the automation of fabric preforming and overmolding will also help optimize high-performance part production at rapid cycle times. Additive manufacturing will be one way to lower the cost of making tools used in the production of CFRP parts.

CM: There’s a lot of talk about smart manufacturing and Industry 4.0. Have you seen valuable developments for users of CFRP in this area?

Vaidya: I think one of the most important developments for smart manufacturing is the use of nondestructive evaluation (NDE). Modeling and simulation to identify the amount of carbon fiber material required for a part leads to the removal of excess weight from the part while still achieving desired performance. This allows us to use the most expensive material as little as possible. Modeling also enables us to test part designs without damaging the product. NDE, sensors integration and in-process monitoring will contribute to quality control and cost reduction through the quick correction of processes and more efficient operation.

In addition, there will be a growth in database knowledge. New projects will benefit from databases for the estimation of the process flow of carbon fiber or prediction of the costs of equipment, material, energy usage and labor, as well as recommendations regarding which process would be best suited for a part. We may also see database knowledge that can compare the costs of making an assembly from several smaller subassemblies or manufacturing it as a consolidated part.

CM: Are there material developments that interest you?

Vaidya: I am watching for innovative thermoset resins that are curable at room temperatures in shorter cycle times with less manufacturing effort. Thermoplastic resins will continue to expand as they are attractive in terms of rapid consolidation and their ability to be more easily recycled at end of life. Of course, we’re watching for carbon fiber to come down in price, especially for non-aerospace applications. We’ll need a lot more industrial grade carbon fiber for those high-volume applications that are converted at a high rate of speed. That’s when the magic of carbon fiber and cost savings will come together.

Materials development has gone through a lot of innovation to bring costs down, but that won’t be enough for CFRP without processing and production changes. They are very much integrated with each other. You can deliver material innovation, but efficiencies in heating, cooling, automation and other production technologies must be in sync. One happening without the other won’t capture the benefits we are seeking.
In 2014, when ACMA and the Society for the Advancement of Material and Process Engineering (SAMPE) joined forces to produce a new industry trade show, the two organizations ambitiously aimed to create the largest, most comprehensive event in North America for the composites industry. Since its inception, the Composites and Advanced Materials Expo (CAMX) has grown in size and scope.

Now in its 5th year, CAMX has more than 8,000 attendees from 64 countries and over 550 exhibitors featuring the latest industry innovations and cutting-edge materials, supplies and resources for all markets. CAMX, which will be held Oct. 15 - 18 at the Kay Bailey Hutchison Convention Center in Dallas, also offers a robust conference program with 200 education sessions, tutorials, technical papers and poster sessions.
Industry Leaders to Gather for CAMX in the Lone Star State
Composites Manufacturing

Co-Locating with IFAI Expo

This year, CAMX is co-locating with the Industrial Fabrics Association International’s IFAI Expo, the industrial fabric industry’s flagship show. CAMX attendees will have access to the 550+ exhibitors in the CAMX Exhibit Hall and more than 300 exhibitors on the IFAI exhibit hall floor. IFAI exhibitors will showcase specialty fabrics, advanced textiles, smart fabrics, shade and weather protection, geosynthetics and fabric structures.

Exhibitors that have products and solutions for both the composites and fabrics industries will be conveniently located in the center of the two halls in the IFAI & CAMX SharedZone. With approximately 20 leading companies on display, this unique area will showcase the best of both worlds.

Collaboration at CAMX

“We’ve always believed in CAMX’s potential to unite composites professionals from all over the world and provide them with the resources they need,” says ACMA President Tom Dobbins. “It’s rewarding to see how the industry has rallied around CAMX and formed a community that continues to drive the innovation that’s necessary for our success.”

CAMX is a catalyst for collaboration and innovation, and networking remains a major benefit for attendees. The conference is placing a greater emphasis on networking this year with new and expanded networking opportunities designed to help attendees build lasting professional relationships.

If you’re a working professional 35 and under, the new Young Professionals Meet-Up on Wednesday, October 17 is a great opportunity to connect with industry peers. The next generation of industry professionals can start building their professional network with colleagues who can share challenges and opportunities within the industry.

Innovation Park, introduced last year, will be in the rear of the CAMX Exhibit Hall. The park comprises four “zones” – The Connection Zone, Presentation Theater, Ask the Experts Station and New Exhibitors Pavilion – tailored to specific needs of CAMX attendees. Each day, the Connection

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Zone will hold specialized meet-ups for young professionals, educators, chemists, sports enthusiasts and other geographic and demographic niches within the composites and advanced materials industry. Innovation Park will also host “campfire sessions” on trending topics, including workforce development, knowledge transfer, emerging technologies and global trends.

With so much to see and do, CAMX has expanded the exhibit hall to 19 hours – longer than any previous year. Exhibitors will showcase their creativity and ingenuity in new, creative applications and methods. “CAMX has become the venue in North America to witness the latest and greatest from the critical players in the composite industry,” says SAMPE CEO Gregg Balko. “This is where business gets done and ingenuity is celebrated in our industry.” Whether attendees are looking for new techniques, want to view the latest equipment in action or scope out the latest materials, they will find inspiration on the CAMX Exhibit Hall floor.

Many exhibitors will hold live demonstrations to showcase their innovations first hand. This year’s demos include 3M’s Hi-Tack Composites Spray Adhesive Spray Demo and The Lean Mean Process Machine, a CAMX favorite. Composites One and the Closed Mold Alliance will present practical demonstrations of key process techniques to help attendees work smarter, faster and more efficiently. Attendees will be able to watch demonstrations featuring advanced materials like prepreg, carbon fiber and epoxy, along with processes such as light RTM, vacuum infusion and 3D printing.

Additionally, all the 2018 Awards for Composites Excellence (ACE) entries will be located in the CAMX Exhibit Hall near the ACMA Booth. The ACE award winners will be announced at 2 p.m., Tuesday, October 16, near the ACE Pavilion in the Exhibit Hall. Award entrants will be available to talk with attendees about their entries.

North American Composites (NAC) has stocking locations across the United States and Canada providing local, personalized service to composites manufacturers. We deliver high-quality composite materials, accessories and equipment from the top suppliers. For nearly 40 years, our knowledgeable sales representatives have served manufacturers in aerospace, ballistic, construction, corrosion, energy, marine, transportation and other industrial and consumer applications.

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Dive Deep with Conference Programming

The CAMX Conference Program is designed for industry professionals at all levels and backgrounds. Featured sessions cover trending hot topics in the industry, including sustainability, market growth, workforce training and consumer markets. During the session “Adhesive Bonding of Hybrid Structures,” facilitator Mick Maher of Maher and Associates and a panel of leading experts representing design, manufacturing, materials, testing and the end user will discuss new capabilities – and challenges – in designing multifunctional structures that can provide lower cost and weight platforms for automotive, aerospace and other markets.

Looking for a deep dive into key topics? CAMX’s Tutorials on Monday, October 15 and Tuesday, October 16 provide new knowledge from expert instructors in a more intimate classroom setting. The tutorials will focus on hot industry topics, including fabrication, design, bonding and joining composites, artificial intelligence in composites, epoxy resin, composite recycling and thermoplastics.

The full conference program, MyCAMXPlanner and registration information is available at www.thecamx.org.

Barry Black II is senior manager of marketing for ACMA. Email comments to bblack@acmanet.org.
ACMA has a long history as an effective advocate for the composites industry in Washington. For many years the focus was primarily regulatory in nature, assuring that federal requirements for composites manufacturing are sufficiently protective but not overly burdensome. We maintain this focus to this day, but about five years ago we agreed we can do more. We decided to leverage federal legislation and policy to open and grow markets for composite products. In other words, rather than play defense we chose to play offense. Of the many sectors where composites compete, infrastructure was a natural target for our efforts since the government owns or finances many of the assets and the performance upside of composites compared to the traditional competition is substantial.

Since we began down this path, our success has been noticeable. Of the past six major infrastructure bills approved by Congress, all have included innovation provisions in large part driven by ACMA efforts. We have launched and continuously grown our annual Infrastructure Day fly-in, and ACMA members have testified before Congress twice in as many years on composite infrastructure solutions.

In the last few months, however, ACMA’s advocacy efforts have reached new heights with two major accomplishments. The comparative lack of standards and design and durability data relative to traditional construction methods is a major barrier to broader adoption of composite solutions. Recognizing this, ACMA began a relationship with the National Institute of Standards and Technology (NIST) to specifically identify these barriers in the standards space and develop a pathway to clear these hurdles. To this end, leaders from both NIST and the composites industry collaborated on the development of a roadmap to overcome these barriers, which called for an expanded role for NIST to do research and education that will help grow the standards database. This was important by itself, but we’ve taken it one step farther.

After aggressive advocacy by ACMA members, the House Science, Space, and Technology Committee, which oversees NIST, has designated $11 million for composites research and standards at NIST. ACMA is continuing to aggressively work with Congress to see this provision signed into law this year, and we are optimistic about success. This infusion of resources will generate an important body of knowledge that will allow composites to be specified and used in major infrastructure projects to a degree as yet unseen.

Our crowning achievement to date, however, came in early August 2018 with the introduction of the Innovative Materials for America’s Growth and Infrastructure Newly Expanded Act – or IMAGINE Act. The premise of the IMAGINE Act is simple – whether you use composites or another material, when it comes to infrastructure investment in America we can do better by building better.

The IMAGINE Act would create new grant programs – one at the Federal Highway Administration for bridge construction and repair and one at the Environmental Protection Agency for water treatment and distribution – that provide funding to municipalities to use innovative materials like composites and others in projects designed to reduce lifecycle and maintenance costs and extend the service life beyond traditional performance. It would also promote research on the next generation of infrastructure solutions by authorizing Innovative Material Innovation Hubs and creating an interagency taskforce on standards development for innovative infrastructure.
The bill has been introduced in the Senate (S. 3341) by Sens. Whitehouse (D-RI), Alexander (R-TN), Rounds (R-SD) and Booker (D-NJ) and in the House (H.R. 6653) by Reps. Esty (D-CT), Comstock (R-VA), and Cicilline (D-RI). ACMA worked with these offices for close to two years to develop the IMAGINE Act from infancy. Along the way, we’ve secured support from companies and associations across the infrastructure value chain and started a coalition committed to the effort. This coalition will be essential in seeing the tenets of the IMAGINE Act signed into law.

For ACMA as an advocacy force, this is a historic moment. We are no longer just along for the ride on legislation, we are now in the driver’s seat. And we are not pushing one composite solution, we are advocating for a paradigm shift in how this country handles infrastructure investment.

But the journey is far from over. To see the IMAGINE Act signed into law, or its major tenets integrated into a broader infrastructure package, we need to significantly increase support on Capitol Hill for these ideas. Composites companies all around America can make a difference by securing their members of Congress as sponsors of the IMAGINE Act. ACMA has developed an online toolkit (http://bit.ly/2Mz4f2A) to help our members reach their elected leaders, and we hope you’ll join us in action.

Together we can change the way America thinks about our built environment. It’s going to be a long hard journey, but I hope you’ll join us for the ride.

MJ Carrabba is the head of government affairs at ACMA. Email comments to mcarrabba@acmanet.org.
In June, ACMA members formed the California Composites Council to address California’s Prop 65 toxicity warning program and other public policy issues in the state. David Ring, corporate manager of governmental affairs and strategic projects for Strongwell Corp. and chair of ACMA’s Regulatory Steering Committee, talked to Composites Manufacturing magazine about the role of the committee and broader regulatory issues.

CM: Why did ACMA members in California decide to form a group to address Prop 65 issues?

Ring: Cal-EPA proposed to list styrene under the Prop 65 toxicity warning program in 2014. At that time ACMA’s Regulatory Steering Committee launched a research program designed to provide data that would allow composites manufacturers to know whether or not use of their products could be associated with styrene exposure levels above California’s no significant risk level for styrene. The committee made extensive guidance available for ACMA members before the warning requirement took effect in early 2017.

The Regulatory Steering Committee’s efforts were directed at warnings that may need to be issued to product end users. Prop 65 is widely viewed as a consumer-warning regulation. So, we were very surprised earlier this year when a public health advocacy group filed Prop 65 violation notices against two composites manufacturers in California claiming the companies failed to provide warnings before emitting styrene into the air from their facilities, causing exposures to plant community members.

ACMA was immediately concerned, not just with the possible impact to the two companies, but that this kind of legal action could be brought against other styrene-emitting facilities in California. The Regulatory Steering Committee recommended the development of a sub-committee of companies with operations in that state to review the situation, evaluate potential actions to minimize adverse impacts on the industry and manage a collective response.

To gauge interest and raise awareness, we produced a webinar on this topic and hosted conference calls for industry members, and in late June we hosted an organizational meeting in Los Angeles. At the standing-room-only meeting, a group of composites manufacturers and suppliers with operations in California agreed to form a committee, called the California Composites Council. Attendees also approved a program to seek a successful resolution of this issue.

CM: How will the California Composites Council function?

Ring: The council meets every month to review reports from experts and staff and set strategies for continued legal action and advocacy. Other ACMA groups, including the ACMA Technical Committee, are providing information and guidance to help the council. The council established a dues schedule to collect funds from its members to support legal and technical programs. Any interested companies are encouraged to join the council to provide leadership and guidance as the industry works to address the issue.

CM: What is the goal of the council?

Ring: Consistent with ACMA’s other regulatory and advocacy programs, the council wants to achieve an outcome that fairly balances public health benefits with cost and other impacts. On its surface, Prop 65 only requires warnings, but in practice meeting the safe-harbor established for community warnings may have a significant impact on the viability of many composites manufacturing operations in California. That’s why this is such an important and complicated issue, and why the industry needs ACMA’s legal, advocacy and administrative resources, along with the participation, support and leadership of the impacted companies.

CM: What is the state of the regulatory landscape regarding organic peroxides?

Ring: Two unconnected developments resulted in fire code requirements that may pose problems for composites manufacturers and distributors. First, the organic peroxide suppliers developed a new hazard classification scheme based on a recent series of laboratory tests. This placed MEKP, which accounts for more than 90 percent of the organic peroxide formulations used in the industry, in a higher hazard classification. In turn, this meant code compliance would require measures such as increased sprinkler density and reduced storage quantities.
The Regulatory Steering Committee did not believe these more expensive and burdensome code requirements reflected the industry’s long-term experience safely storing this material and asked the organic peroxide suppliers to confirm the validity of the new small-scale tests. In response, the suppliers are conducting a number of investigations and tests to make the most accurate determination possible of the correct hazard classification of storage of MEKP. Results from this research are expected to be available later this year.

The second development was a requirement established by the National Fire Protection Association’s Technical Committee for Hazardous Materials to employ a consistent approach to code requirements for all materials covered under the NFPA 400 standard, including organic peroxides. The organic peroxide industry was aware of the new code, but delayed incorporating the approach into the 2019 edition of the code. However, it expects to bring a proposal consistent with the approach to NFPA later this year.

The net effect of all of this is that the 2019 edition of NFPA 400 will not permit storage of organic peroxides in more than minimal quantities except in single-purpose buildings separated by 25 feet or more from other structures and a plant’s property line.

**CM**: What is ACMA doing to keep members informed about compliance strategies for organic peroxide storage?

**Ring**: In general, ACMA promotes compliance with NFPA codes as a responsible measure to protect both property and employees. The Regulatory Steering Committee has sponsored language in the flammable liquids and spray-application codes establishing safe practice for handling and using resins and other flammable liquids in composites manufacturing operations.

In the case of the 2019 edition of NFPA 400, we are working with organic peroxide suppliers and NFPA to clarify the appropriate storage and usage practices for MEKP and other formulations used in the industry. As this effort progresses, ACMA will work with the organic peroxide suppliers to make this information available to the industry and to enforcement agencies and insurance companies.

Again, this demonstrates the ability of ACMA to solve important and complex problems for the industry. Collectively, ACMA staff members have more than 40 years of experience working successfully with fire and building code authorities.
Reach the Transportation and Defense Markets

Join your fellow industry peers at ACMA’s upcoming Transportation and Defense Policy Fly-In Sept. 25–26, 2018, in Washington, D.C. The event provides key opportunities to advocate for robust funding on R&D on composites applications, educate members of Congress about the valuable capabilities of composite products and advocate for broader use of composites in military and federally-owned assets. To attend the most important forum for advancing composites in transportation and defense markets this year, register at acmanet.org/policyflyin.

New ACMA Members

From left: Joe Fox, director of emerging and external technologies at Ashland LLC; Leon Garoufalis, president and COO of Composites One; Keith Bihary, corporate sales director at Molded Fiber Glass Companies; and Michael Annis, vice president of Michelman Inc. meet with Sen. Rob Portman (R-Ohio).

For more information on becoming a member of ACMA, email membership@acmanet.org or call 703-525-0511.
Survey on Global Recycled Composites Supply Chain

In 2017, ACMA and IACMI – The Composites Institute kicked off an exciting project to identify and test a pyrolysis process for recycling scrap composite materials. As part of this project, the team designed an industry survey to map the sources of composite scrap materials and waste in order to align an efficient composites recycling supply chain. We call upon your participation in this global effort to help identify the current state of scrap production, both process scrap and end-of-life resources. The survey caters to manufacturers, material suppliers, academic institutions and others and accommodates both domestic and international businesses. You may access the survey at www.surveymonkey.com/r/2BSGFZV from Sept. 1 – 30, 2018. The results will be aggregated by country to preserve business anonymity in the final report. For more information, contact Madeline Wehrle at mwehrle@acmanet.org.

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