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About the Cover:
The 19-story headquarters of Spanish banking conglomerate BBVA incorporates self-supporting GFRP fins as a shading device.
Photo courtesy of ©BBVA/Carlos Benitez-Donoso.
Employees Are the Key to Our Success

This issue of Composites Manufacturing magazine has many important articles covering a broad range of topics. In a technology article, Georgia Tech Professor Chuck Zhang shares insight into the up-and-coming nanocomposites market. There’s also an in-depth story on opportunities in architecture, featuring a look at innovative applications from Spain to Japan. In addition, there’s a feature story on workforce development – a topic that’s important to all of us, whether we run a small fabrication shop or a multinational materials corporation.

The most important element to our success is hiring good people to drive our business. Employees are our most valuable asset. Without them we have no opportunity to be successful and make a difference for our customers and our business every day. But attracting, training and retaining good employees is challenging.

Attracting good talent to your organization must be a strategic focus to ensure long-term success. Once you have hired an associate, you must do a thorough job of onboarding the employee in a way that provides the training, information and support to integrate them into your company. After successfully onboarding an employee, the focus turns to retaining that associate through solid communication, continual development and career advancement opportunities. Committing to workforce development will set you apart from your competition. Fortunately, your industry association is here to help you!

ACMA has created a steering committee to study and develop programs that support your efforts to recruit, hire and train the “best-of-the-best” in your markets. ACMA has also teamed with IACMI to boost workforce development opportunities. And, of course, the association continues to offer its Certified Composites Technician (CCT) Program, the industry’s gold standard in composites training.

Thanks to your support of ACMA, our association can commit time and resources to important issues, such as workforce development. That ultimately will help you be successful in your business and build a stronger composites industry.

Jeff Craney
Crane Composites
ACMA Chairman of the Board
jcraney@cranecomposites.com
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A Primer on Glass Fiber Reinforcements

By Kevin Spoo

Glass fiber reinforcements have been a mainstay in the composites industry for decades. Even though textbooks have been devoted to the material, how much do people really know about them? This column will provide a primer on glass fibers, covering the making of glass fiber, nomenclature, product forms and product selection.

The Making of Glass Fiber
Engineered minerals are melted in high-temperature, firebrick lined furnaces. They are refined to allow volatile materials to escape the “melt.” The melt flows out of the furnace through insulated channels and onto platinum-rhodium bushings. The glass melt is pulled and attenuated through the bushings, then cooled rapidly and coated with a water-based sizing. Each single filament is typically 6 to 32 microns in diameter. There can be 1,000 to 4,000 filaments exiting a typical bushing. In comparison, the average human hair is about 70 microns in diameter.

Glass Nomenclature
The basic chemistry of the glass is usually referred to by a letter designation, which indicates the preferred application of the particular composition. Table 1, below, lists some common glass types, their applications and associated properties. Two key pieces of information concerning glass fiber properties are specific gravity (used to calculate glass content) and Young’s modulus (used to calculate part stiffness).

<table>
<thead>
<tr>
<th>Glass</th>
<th>Application</th>
<th>Specific Gravity</th>
<th>Young’s Modulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-glass</td>
<td>Electrical grade</td>
<td>2.56 – 2.62 g/cm³</td>
<td>78 - 79 GPa</td>
</tr>
<tr>
<td>E-CR glass</td>
<td>Electrical &amp; corrosion</td>
<td>~2.62 g/cm³</td>
<td>~82 GPa</td>
</tr>
<tr>
<td>C-glass</td>
<td>Low pH corrosion</td>
<td>~2.39 g/cm³</td>
<td>~68 GPa</td>
</tr>
<tr>
<td>H-glass</td>
<td>High modulus</td>
<td>~2.60 g/cm³</td>
<td>~87.5 GPa</td>
</tr>
<tr>
<td>AR-glass</td>
<td>Alkali resistant</td>
<td>~2.63 g/cm³</td>
<td>~77.5 GPa</td>
</tr>
<tr>
<td>S-glass</td>
<td>High strength</td>
<td>~2.43 g/cm³</td>
<td>~88 GPa</td>
</tr>
<tr>
<td>Carbon fiber</td>
<td>Lightweight/high modulus</td>
<td>1.76 – 1.83 g/cm³</td>
<td>206 - 304 GPa</td>
</tr>
</tbody>
</table>

Product Forms
Glass fiber reinforcements are available in many product forms developed to perform best in a variety of composite molding processes. Most people are only familiar with the processes they use or read about, but Table 2 contains a list of several product forms and processes where they are typically used.

Sizing, tex/yield/denier and filament diameter are differentiators that affect the performance of these products. Many of the product forms listed are offered in a fairly narrow range of these differentiators. For instance, yarns usually have very fine filament diameters, and very low tex (small) strands are used as inputs for yarn-based fabric tapes. Single-end and multi-end rovings – the highest volume products in the composites industry – have the widest selection of differentiators. I will cover these in more detail to illustrate the effects of sizing, tex/yield/denier and filament diameter.

It takes multiple filaments to make up...
Table 2: Product Forms

<table>
<thead>
<tr>
<th>Product Acronym</th>
<th>Product Form</th>
<th>Composite Process</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>MER</td>
<td>Cylindrical package</td>
<td>Pultrusion, filament winding</td>
<td>Structural shapes, pipes</td>
</tr>
<tr>
<td>CSM</td>
<td>Roll goods</td>
<td>Open molding</td>
<td>Open and closed molding</td>
</tr>
<tr>
<td>CFM</td>
<td>Roll goods</td>
<td>Closed molding, vacuum infusion, resin transfer molding, pultrusion</td>
<td>Electrical panels, body panels for sport vehicles</td>
</tr>
<tr>
<td>DUCS</td>
<td>Short dry chopped fibers</td>
<td>Injection molding</td>
<td>Thermoplastics</td>
</tr>
<tr>
<td>WUCS</td>
<td>Long wet chopped fibers</td>
<td>Continuous laminating</td>
<td>Asphalt shingles</td>
</tr>
</tbody>
</table>

Chemistry Applied to Glass Reinforcements

After determining the product form that fits the applicable molding process, the next step is to ensure that the proper chemistry has been applied to the reinforcement so that it will bond with the resin. Two important concepts related to chemistry are sizing and binder. These terms are not interchangeable.

In the glass reinforcements industry, the term sizing is used in a slightly different way than in the traditional textile industry. Sizing is a microscopic layer of chemicals applied to every single glass filament as it exits the furnace. The sizing system is arguably the most important choice after selecting the product form. Sizing applied to the fiber:

- Protects it during the reinforcement manufacturing process
- Protects it during the fabrication process
- Provides the preferred interface with the appropriate organic or inorganic matrix (most often resin)

All glass reinforcements have sizing to prevent the fibers from self-destruction. The sizing is the interface between the glass and the resin. It facilitates bonding of the two so that load can be transferred and shared in the composite structure.

Commonly used resin matrices are unsaturated polyester, vinyl ester, epoxy, polyurethane and phenolic resin.

Let me dispel one myth about sizings. All glass reinforcements have sizing to prevent the fibers from self-destruction. The sizing is the interface between the glass and the resin. It facilitates bonding of the two so that load can be transferred and shared in the composite structure. Commonly used resin matrices are unsaturated polyester, vinyl ester, epoxy, polyurethane and phenolic resin.

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The guest columnist for this issue’s “Best Practices” column is Kevin Spoo, a senior research associate with Owens Corning. Email comments to kevin.spoo@owenscorning.com.
Getting a Charge Out of Roads

The future of electric vehicles could soon come charging down the road—in more ways than one—with composites playing a key role. At a Logan, Utah, test track, researchers from Utah State University are exploiting the strength and wireless transparency of GFRP while experimenting with recharging moving electric vehicles. The goal is to solve a problem that’s kept electric vehicles to a small fraction of total car, truck and bus sales despite some clear advantages.

“An electric vehicle with a city-range battery is quite economical. The total cost of ownership is on the order of half that of an internal combustion engine vehicle,” says Regan Zane, a Utah State University electrical engineering professor and director of the Center for Sustainable Electrified Transportation (SELECT), which manages the quarter-mile test track. “But that vehicle won’t meet your needs unless it can get you from city to city.”

Some batteries in high-end electric vehicles, such as the Tesla Roadster, remain charged for more than 200 miles. But the average electric vehicle can only travel 40 to 100 miles on a single charge. Plus, a complete charge can take several hours.

Studies and modeling show that more than 80 percent of the time, drivers travel less than 40 miles, Zane says. That makes an inexpensive electric vehicle practical—most of the time. Those occasions when drivers need to travel further distances could be better handled if there was some way to recharge the battery periodically while in transit. That’s why researchers at Utah State are looking at in-road, wireless recharging.

There are a variety of ways this could be done. One is to bury the recharger in a trench under the road, which protects people from potential exposure to high voltage electricity. It also enables recharging independent of the weather and results in a roadway that doesn’t look much different than a standard one.

Wireless recharging can be accomplished via electric fields, magnetic fields or a combination of both. Faculty at Utah State are experimenting with a magnetic approach at the test track, while faculty at SELECT partner University of Colorado Boulder are evaluating capacitive coupling with electric fields. According to Zane, the test track needed a material for trench covers that was transparent to any of the wireless recharging options housed below the track. The trench covers also had to be strong, since many tons of metal would routinely roll across them. Finally, trench covers had to be easy to remove so that the recharging systems could be changed out between experiments.

Given these requirements, the Utah State researchers opted for DURAGRID® pultruded GFRP bar gratings from Strongwell Corporation, headquartered in Bristol, Va. The gratings, which won one
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of the Awards for Composites Excellence (ACE) at CAMX 2015, feature a polyester resin reinforced with longitudinal glass roving and multidirectional glass mat. The grating is heat cured, with bearing bars and cross-rods first pultruded and then assembled into the final shape. A standard rectangular shape wouldn’t work because the grating had to cover an oval track. The bearing bars and cross-rods were custom fabricated to fit the contour.

“Additionally, it’s not your standard grating that you or I might walk on,” says Barry Myers, marketing manager for Strongwell. The application uses DURAGRID HD-4000, a heavy duty version of the grating. “It’s a much heavier and thicker bearing bar that’s actually 2½ inches thick to be able to support vehicle traffic without a problem,” Myers says. He adds that the composite grating doesn’t interfere with cellular and radio frequencies, which is important not only in wireless recharging, but also in wireless communication.

In the testing program at the Utah State facility, half of the track will provide wireless recharging. As vehicles travel around the track, researchers will evaluate how well a given recharging approach works. The eventual goal is to deploy a system that pumps in a tiny bit of electricity each time a car passes over a recharging zone. The dwell time over each recharger might only be fractions of a second, and it’s likely that the energy imparted might only be just a bit more than what is consumed moving between one recharger and the next. Over time and hundreds of miles, though, an electrified road could completely top off a battery, Zane says.

As for the future, one thought is to develop recharger modules that can be buried when new roads are poured. This option would be akin to putting in piping and wiring that currently goes in with new road construction. Composites might be used in the structure to hold coils and other parts of the recharging system in the right position while providing protection against asphalt or concrete and offering the necessary electromagnetic transparency, Zane says.

In other situations, the current setup on the Utah State test track might be replicated. Real estate in a city’s downtown is expensive and shutting down traffic costly, so tearing up the road to bury an inexpensive module might not be the most cost-effective approach. A better option would be an installation method that minimizes disruption. “In those areas it might make sense to have something like this GFRP grate that gives you easy access,” Zane says.

It likely will be years before demonstration projects are put into place, he says. Possible initial locations include shipping ports and airports, where vehicle fleets and roadways are closely controlled. This project is just one step on the road to an expansive use of electric vehicles.

Hank Hogan is a freelance writer based in Albuquerque, N.M. Email comments to hank@hankhogan.com.

For more stories like this, visit CompositesManufacturingMagazine.com and check out the Infrastructure articles under the “Market Segments” tab.
American ferries carry approximately 200 million passengers annually, according to the Passenger Vessel Association, and that number is likely to rise significantly as urban areas like New York, Seattle and San Francisco add new ferry lines to help combat congestion. That's good news for Arcadia Alliance, a new partnership between Front Street Shipyard in Belfast, Maine, and Brodrene Aa of Hyen, Norway, which will produce the first-ever CFRP ferries for the U.S. market.

The new catamaran-style, high-speed passenger ferries will travel at speeds of 25 knots or more and carry up to 149 people. Larger ferries are out of the question for now, according to J.B. Turner, president of both Front Street Shipyard and Arcadia Alliance, because Coast Guard regulations only allow composite hulls on these smaller 'T-class' vessels.

Front Street and Brodrene Aa's partnership began last summer, following conversations between Turner; Steve Von Vogt, executive director of the Maine Composites Alliance; and Martin Grimnes, a Norwegian-American composites manufacturer who has long been interested in building CFRP ferries in the U.S.

Last June, Turner and Craig Picard, lead designer at Front Street, visited Brodrene Aa and liked what they saw. "It was pretty clear right away that their philosophy on building and our philosophy on building are very similar. They like using vinyl ester resin systems. They infuse much like we do. The way their company is structured is a lot like ours, and generally, the personalities fit," Turner recalls. In July, the two companies signed an agreement of mutual understanding, followed by Brodrene Aa's first visit to Front Street in October.

Brodrene Aa has been building CFRP ferries for the Norwegian market since 2001 and will deliver its 50th CFRP ferry later this year. Recently, the company has begun looking to other markets and won a contract to build two high-speed CFRP ferries for Hong Kong and China. It has not been able to enter the U.S. market because the Merchant Marine Act of 1920 requires ferries and other U.S. port-to-U.S. port vessels to be constructed in the United States. Arcadia Alliance is located in Belfast, Maine, with 80 percent ownership by Front Street Shipyard and 20 percent by Brodrene Aa.

The ferries will be built at Front Street's 82,000-square-foot indoor shipyard. Brodrene Aa, which translates into 'Brothers O' in English, will provide the design and engineering, as well as the molds for the first few ferries.

The entire outer shell of the ferries will be CFRP, including the hull and the 'superstructure' – everything above the hull, such as decks and the pilot house. Interior areas will have composite and aluminum seats, lightweight aluminum interior panels, carpeting and other traditional components. Turner says that it will take 13 to 14 months and hundreds of CFRP parts to build each ferry. The parts will feature a carbon fiber sandwich fabricated using a lightweight structural foam core and several layers of carbon fiber structural material that are vacuum infused with a vinyl ester resin system.

The hull will be fabricated from a single mold, while superstructure components will be constructed from large, flat panels measuring up to 42 x 12 feet. Once completed, the panels will be cut to create doors, windows and other openings. Turner plans to purchase a CNC waterjet cutting machine to save time and reduce noise. After they are cut to shape, the panels will be fitted into place and taped together with vinyl ester and carbon by hand. Front Street will use vacuum lifters to move the largest panels from the molds to the waterjet cutting machine and then onto the shop floor.

Arcadia Alliance’s CFRP ferries will be a novelty in an industry currently dependent on metal hulls. Turner acknowledges that
Now in its 3rd year, CAMX has established itself as North America’s event that connects and advances the world’s composites and advanced materials communities. CAMX is the go-to marketplace for products, solutions, networking and advanced industry thinking. CAMX is the largest global event in North America for the industry.

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Workers at Brodrene Aa in Norway fabricate a CFRP hull for a passenger ferry.

the transition to CFRP hulled vessels will take time. "It took years for American ferries to go from steel to aluminum, and it's going to take a lot of education to get that next step from aluminum to composites," he says.

That was the case in Norway, according to Andre Ole, sales manager of Brodrene Aa. In the beginning, says Ole, Norwegian operators accustomed to aluminum ferries didn't want to consider composites. He recalls hearing frequently, "Don't come here and sell me any plastic boats!"

Now, attitudes have changed. "It has been a process, but now most of the operators are very satisfied and convinced that carbon fiber is a robust material," says Ole. "They see the pure benefits of reductions in weight, fuel costs and CO2 emissions." Some operators, he adds, have purchased a CFRP ferry each year for the past 10 years.

Arcadia Alliance has begun to reach out to potential customers through trade shows, membership in the Passenger Vessel Association and calls to individual companies to obtain bid packages. A big part of selling in the U.S. will be educating operators about the benefits of carbon fiber hulled ferries – especially the enormous weight and fuel savings. The structural weight of CFRP ferries is 40 to 50 percent less than GFRP or aluminum ones, according to Ole. The CFRP superstructure makes it possible to use smaller engines and fuel tanks. Depending on the configuration, Ole says that CFRP ferries save their operators 20 to 40 percent in annual fuel costs.

Arcadia Alliance also will stress the benefits of reduced maintenance costs. Unlike aluminum ferries, Turner emphasizes, CFRP ferries "don't fracture every time they hit a dock, don't have weld issues, don't crack and don't require painting."

Turner believes that these advantages will initially attract private U.S. ferry operators because the CFRP ferries will cost about 10 percent more than aluminum ones and public operators are generally required to take the lowest bid. "Private companies that want to increase their profits will quickly realize that they can save thousands and thousands of gallons of fuel every year and reduce maintenance costs down the road for years," he emphasizes.

Even while the company looks to sell its first T-class ferry, Arcadia Alliance has begun conversations with the U.S. Coast Guard to work toward acceptance for larger CFRP hulled 'K-class' ferries capable of carrying 150 or more passengers. To help with this process, the company has hired Captain John W. Mauger, a retired Coast Guard commanding officer, as a consultant. With Mauger's help, Arcadia Alliance recently began talks with the Coast Guard's Marine Safety Center. Turner knows it will likely be a long process, but says that the Coast Guard has been very receptive to working toward a positive outcome.

Meanwhile, there is plenty of room in the T-class market. Turner says that New York City alone is adding 30 new ferry routes later this year that will require approximately 20 ferries. "As we familiarize ourselves with the landscape, we learn of more and more potential boats and routes that may become available as larger cities on water realize that water transportation is, in some cases, the only way to relieve the over congestion on the highway, rail and subway systems," explains Turner.

Melissa O'Leary is a freelance writer based in Cleveland, Ohio. Email comments to mxb144@case.edu.

For more stories like this, visit CompositesManufacturingMagazine.com and check out the Marine articles under the "Market Segments" tab.
Ultra-efficiency and portability were the inspiration for the Ecocapsule, an incredibly compact housing unit designed by Nice Architects in Slovakia. As the designers explored materials that would bring these goals to fruition, they decided to use composites to make a lightweight, durable shell.

A 2009 design competition around the theme “Small is Beautiful” led the Nice team to create the Ecocapsule. “We didn’t win the competition, but we got serious interest from the media, and consequently many people started to inquire about Ecocapsule,” says Tomas Zacek, partner in Ecocapsule. “We knew we were on the right path.”

The small, portable pod was conceived as a comfortable way to allow people to live or work off-grid anywhere in the world. For some, “comfortable” may sound like a stretch for a home that measures about 15 x 7 feet, with barely 70 square feet of usable floor area. But for others, the Ecocapsule fits beautifully into today’s growing interest in the Tiny House movement.

TinyLife.com describes “Tiny Living” as a social movement where people choose to significantly downsize the spaces in which they live. American homes average around 2,600 square feet; a typical tiny house might be between 100 and 400 square feet. The reasons for downsizing vary, but include environmental concerns and a desire for more freedom. These factors were key drivers in the design of the Ecocapsule.

To achieve this sense of freedom, the designers knew the housing unit would need to be lightweight for easy towing. While the designers considered many materials for the shell, GFRP ultimately was selected in part because of its lightweight. Durability was another factor, as the designers envision these small homes potentially protecting occupants for year-round use in remote locations.

A composite shell also allowed the designers to achieve the capsule’s complex, egg-like shape. That shape is more than just a striking differentiator from traditional homes, Zacek says. He explains that the oval “is the best energy-saving shape.” Sloped walls, filled with high-performance thermal insulation, are designed to minimize thermal loss. In addition, the rounded shape makes the unit ultra-efficient in collecting rainwater and dew. As rainwater pours down the side, it is collected for later use in one of two tanks at the bottom of the pod. A series of filters, including a reverse osmosis filter, reportedly remove 99.99 percent of dirt to provide clean drinking water.

Portability was a crucial factor in designing the Ecocapsule, so that it could easily be transported by scientists, photographers, rangers, rescue workers or extreme tourists for self-sufficient living anywhere in the world.
A wind turbine mounted on a foldable pole can deliver another 750 watts, day or night. In the absence of sun or wind, a fully-charged battery can provide electric power for at least four days. In other words, hot showers, good lighting and warm meals don’t have to be a distant dream for occupants of the Ecocapsule.

The Ecocapsule remains an evolving concept, with 50 exclusive models based on the original prototype for sale today. The first prototype took 2½ months to produce, Zacek says. In 2014, the production process began with a 3-D model from the designers that was transferred to CNC machines operated by JAG, the Slovakia-based composite fabricator producing the units. Manufacturing shells for these unique mobile homes isn’t a far stretch for a company that specializes in the production of GFRP components for boats, trains and other vehicles.

For the prototype, JAG used a hand layup process to manufacture the fiberglass and polyester resin shell in three main components – the bottom, left top and right top – as well as doors and certain interior components, such as the bathroom unit. (Future versions are expected to use vacuum infusion.) Fabricators place several layers of fiberglass and polyester resin over an aluminum framework to create the lightweight shell.

Once the form is finished, other systems are assembled by hand. This includes electric components, the water management system, floor heating and, of course, interior carpentry and finishes. Furniture, including a desk and various cabinets, is made from lightweight honeycomb panels with a wood veneer finish. And what wilderness retreat would be complete without a smart home system and 4G coverage? The result is an efficient kitchenette, a foldout sleeping area and creative storage solutions.

Empty, the mobile home weighs about 2,600 pounds.

Zacek says the team hopes to complete its small-scale production goal – about 50 units – at a speed of more than five homes a month. Mass production is planned for 100 units per month and doesn’t seem far off. The company has received more than 15,000 emails, with interest primarily from individuals. However, Ecocapsule is now in negotiations with hotels interested in using the comfortable pods as onsite cabins.

For interested parties around the world (and there are many – actress Susan Sarandon shared her desire in a preorder on Twitter in 2015), there’s an added bonus to the pod’s light weight and unique shape: both allow the unit to be easily transported in a standard shipping container. As the designers promise that costs will go down in future iterations from the steep initial price of $88,000, potential Ecocapsule dwellers are exploring their maps for sites that might once have seemed out of reach.

Megan Headley is a freelance writer based in Fredericksburg, Va. Email comments to rmheadley3@gmail.com.

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Pushing the
More architects are turning to composites to create dazzling designs.

By Megan Headley

Highly complex facades featuring dramatic curves are becoming a signature of today’s architects. New technology and materials are helping designers create these increasingly intricate facades that push the boundaries of engineering.

“Younger architects, developers and contractors are hungry for standout unique projects,” says Andy Bridge, vice president of industrial markets and director of research and development for Janicki Industries in Sedro-Woolley, Wash. Composites are poised to help architects in this mission. And as architects push the limits, they are more open to considering the possibilities available from previously unexplored materials.

To date, the biggest obstacle facing the use of composites in architectural applications has been a lack of familiarity with the product. But with new composite-based projects going up around the world, and new guidelines now available governing FRP’s use in architecture, experts predict that composites are likely to become a greater part of the design conversation.

Capitalizing on Today’s Trends

In many ways, composites fit perfectly into many of today’s top architectural trends. “They can produce highly curved shapes for truly innovative designs,” says Robert Steffen, Ph.D., PE, associate professor in the Department of Construction Management for Western Carolina University in Cullowhee, N.C. In addition, Steffen adds, “The texture, color and appearance of composites can be customized far beyond what can be done with metals.”

Composites also dovetail neatly with today’s interest in sustainability. The U.S. Green Building Council predicts that up to 48 percent of new nonresidential construction in 2016 will be green, and that number is expected to grow significantly in coming years. Architects are seeking materials that are environmentally friendly to manufacture and highly durable once installed. Composites fit that bill.

Bill Kreysler, president of Kreysler & Associates in American Canyon, Calif., and chairman of ACMA’s Architectural Division, points out that composite systems are environmentally efficient
Composites & Manufacturing

The CABKOMA™ Strand Rod – known as the CABKOMA™ Strand Rod – are fiber strands that run from rooftop to ground. These thermoplastic carbon fiber strands are surrounded by hundreds of thin strands of reinforced fiber. The result is what the manufacturer calls the lightest seismic reinforcement in the world. A 525-foot-long roll of the fiber weighs about 26 pounds. As the manufacturer points out, metal wire with the same degree of strength is about five times heavier.

What makes the application all the more striking is the seemingly delicate appearance of the rods. Komatsu Seiren explains on its website that the CABKOMA Strand Rod features an inner layer of carbon fiber, an outer layer of synthetic fiber and inorganic fiber, all filled with thermoplastic resin. The result is the lightest seismic reinforcement in the world. A 525-foot-long roll of the fiber weighs about 26 pounds. As the manufacturer points out, metal wire with the same degree of strength is about five times heavier.

Looking beyond today’s design trends, David Riebe, vice president of Windsor Fiberglass Inc. in Burgaw, N.C., sees the shift to composites as a necessity. Riebe cites United Nations’ statistics that suggest a 66 percent increase in population by 2050 will lead to significant demand for new housing stock—enough for 44 new buildings every day for the next 40 years. “With this demand and the emerging technologies and transportation networks that are in place, it isn’t long before we begin to see radical changes in the way buildings and infrastructure are built,” he says. “I really think that given material choices to meet this crazy demand, composites are becoming a necessity.”

While these advantages may seem obvious to composite fabricators, the architectural industry is only just discovering the ways that composites can help them reimagine building facades.

**The Future of Buildings**

For architects interested in experimentation, composites seem to present near limitless potential. “To me, composites are the future of buildings,” says Van Dyck. “They’ve proven to be very effective in conflating multiple needs of structure and skin and envelope, and that idea of solving lots of problems with a single system is compelling and potentially disruptive to our industry.”

Julia Koerner, a lecturer at UCLA’s SUPRASTUDIO, an experimentation-driven research platform for architecture students, agrees. “To have a lightweight, but at the same time strong material with the opportunity to create complex freeform geometries is a fantastic fabrication technique for architecture students and works well in combination with cutting-edge digital design modeling processes,” she says.

A combination of light weight, strength, aesthetics and structural needs drove Japanese architect Kengo Kuma’s recently unveiled use of composites for seismic reinforcement. In renovating the former head office of fabric manufacturer Komatsu Seiren, the design team sought to reflect the “fabric laboratory” the building was set to house.

The concrete block building, known today as “fa-bo,” is surrounded by hundreds of thin strands of reinforced fiber that run from rooftop to ground. These thermoplastic carbon fiber strands – known as the CABKOMA™ Strand Rod – are designed as an exterior reinforcement that essentially anchor the building in place in the event of an earthquake. The exterior reinforcement, working in conjunction with interior bracing walls, reportedly exceeds structural seismic requirements.

What makes the application all the more striking is the seemingly delicate appearance of the rods. Komatsu Seiren explains on its website that the CABKOMA Strand Rod features an inner layer of carbon fiber, an outer layer of synthetic fiber and inorganic fiber, all filled with thermoplastic resin. The result is what the manufacturer calls the lightest seismic reinforcement in the world. A 525-foot-long roll of the fiber weighs about 26 pounds. As the manufacturer points out, metal wire with the same degree of strength is about five times heavier.

It’s an impressive application that demonstrates the possibilities of composites in architecture. But the application stands out, in part, because few other architects are exploring composites’ potential as a structural member.

**Overcoming Hurdles to Adoption**

Industry experts point to factors that may limit the use of composites in structural applications. “Years ago we used to think it was going to take over steel and concrete as a structural element,” Steffen says. “But when you’re an FRP engineer, you realize quickly where it should be used and when it should not be used.”

Steffen recalls working for a bridge builder in Australia. The company aimed to create structures entirely out of composites, but quickly realized the costs were too high. Instead, the company found that composites worked well in certain minimal areas—the cables for suspension bridges, for example—but not for the superstructure itself.

“There are plenty of areas where composites should not be used because they cost more than your typical concrete or steel,” Steffen says. But, he adds, “When you consider its light weight, there are applications where the cost of construction equipment can be decreased and you can save your money there.” For example, in raising composite facades, contractors can use a small scissor lift rather than a more expensive crane needed to lift concrete components.

“That’s a great plus for architectural facades. And there’s nothing wrong with a well-designed precast concrete beam. So why compete with that—unless the cost comes down and the durability can be warranted,” Steffen says.

Riebe agrees that in some cases it is difficult to justify the expense of composites for a structural application—but that’s only in traditional structural applications. “Currently, it is difficult to imagine FRP being used as columns and beams, or as a material replacement for traditional construction assemblies,” he says. “But if you look at monocoque structures, which rely primarily on structural surfaces and not individual members, composites begin to become a preferred material. This is why the aerospace and marine industries have so strongly embraced composite structural skin systems.”

Bridge advises composite fabricators to shift the conversation with architects and owners from upfront costs to big-picture savings. “We need to better explain the total installed cost of composite solutions and steer the focus away from just the uninstalled initial cost,” he says. As Bridge explains, those cost reductions include lower costs for support structure, reductions in crane capacity and location, erection savings and anti-corrosion benefits, just to name a few.

Kreysler adds that it may be some time yet before true
structural applications of composites are allowed by building codes due to the material’s reputation for poor fire resistance. With fire-resistant additives, these products can pass smoke and fire tests for certain applications, but this capability is still being proven. Kreysler & Associates’ recently completed facade for the San Francisco Museum of Modern Art is among the first projects to pass requirements for smoke and fire resistance for buildings over 40 feet tall. Even so, consistent fire-resistance is a challenge that fabricators are still addressing.

But it was FRP’s ability to meet specific fire regulations that helped prompt its use as the foundation of a complex green wall system in the Center for Architecture Science and Ecology in the Bronx, N.Y. Fabricated by Windsor Fiberglass, the wall is a series of molded fiberglass “cassettes” – essentially stacked boxes that resemble a waffle. The cassettes are integrated with an LED lighting system and slots for irrigation, providing everything plants need to grow. Other drivers for the use of GFRP included the ability to control surface finish and the possibility of inexpensively re-tooling visible components, giving future installations a unique appearance.

For Kreysler and ACMA, expanding recognition of composites’ fire-resistant and structural capabilities is a challenge in need of a solution. “We’re working on it, and I think that’s going to be the next focus of the ACMA Architectural Division – to address the codes and at least attempt to get FRP recognized as a [structural] material.”

Scaling Up Applications

As a result of these challenges, many designers are working on experimental ideas and exploring small-scale applications. Ryan Salvas, senior associate and design director for fabrication shop CW Keller in Plaistow, N.H., notes that in the past year his company has had inquiries for several architectural projects looking to use composites. These range from facade panels that serve as sunscreens for a high-rise project to a series of fiberglass “study pods” to provide quiet working environments. “It seems like the market is ready for composites to come around in scale,” Salvas says.

In a 2015 paper prepared for the Council on Tall Buildings and Urban Habitat, Jesus Cerezo Miguel and Miguel Angel Nunez Diaz of Madrid-based facade consultant ENAR aimed to convince designers of the benefits of FRP over conventional materials in certain applications on high-rise buildings. “High-rise buildings can extract the most advantages of the FRP composites,” the paper concludes. “Unlike other building typology, tall buildings must be pioneers with the use of FRP composites to make the case that they can be light, thin and consequently of appropriate use.”

The paper, “Fiber Reinforced Polymer: A New Material Used in Facades of Tall Buildings,” focuses on the recently completed 19-story headquarters of Spanish banking conglomerate BBVA. The building dramatically incorporates self-supporting GFRP fins as a shading device.

Each fin is manufactured in two pieces measuring more...
than 8 feet wide and reaching as tall as 32 feet. These massive fins feature a sandwich structure, which the engineers found could increase their load resistance for less cost than traditional materials. The sandwich consists of an inner structural core of polyethylene terephthalate that provides the panel’s stiffness and two outer layers of polyester resin reinforced with fiberglass. The resin includes alumina loads that allow the fins to meet European fire-resistance standards. Of course, many U.S. architects point out that European designers have been quicker to adopt composites in architecture due to differences in building codes.

Expanding Guidelines

In the U.S., a significant challenge to getting composites specified has been the lack of code recognition for composites. Today, due to the efforts of ACMA’s Architectural Division, the International Building Code (IBC) recognizes FRP for architectural, but not structural, applications. “You can’t use FRP as a load-bearing element in a building without going through a special exception clause in the building codes,” Kreysler says.

The limited allowance by the IBC is cited as one of the most significant barriers to wider use of composites in architecture. “If it’s not in the building codes, it’s considered experimental,” Kreysler says. “You can come up with something new and different and propose it for a project, but you’re required to jump through a bunch of hoops to do it. And if you ever want to do it again on another project, you’ve got to go through the process again.”

Moreover, the recognition FRP now has in the IBC codes doesn’t provide real guidance for architects interested in using this material. “The reality is that the little bit of code that relates to composites is very hard to interpret. [It’s difficult] to make any clear deductions about how you might go about applying this technology,” Van Dyck says.

To provide that translation, ACMA’s Architectural Division has released a new document featuring a comprehensive set of guidelines and recommendations for using FRP in architectural products and designs. “Guidelines and Recommended Practices for Fiber-Reinforced-Polymer (FRP) Architectural Products” is available free for a limited time at svy.mk/1SSF7nX and will be distributed at ACMA’s Composites Pavilion at the AIA Convention May 19-21 in Philadelphia.

“In the past we’ve been able to show some photos and cursory documents, but nothing that has all the information [architects] need,” Steffen says. “Now if a project comes along they can go to the document and know if seismic is handled, how bending loads and attachments are taken care of, etc.”

Gaining Acceptance from Architects

Seeing more composites in architectural applications will take more than code changes; it will require education. For example, although composites fabricators take for granted their product’s durability and strength, these are among the first questions asked by many architects. “They have a misconception that it’s only for light loads or there are no long-term durability studies,” Steffen says. That’s largely due to a lack of familiarity with the product.

“In the educational requirements for accredited schools of architecture, there are entire curriculum blocks dedicated to covering building construction materials and systems,” Riebe says. “However, as a relatively new building material, FRP is not included in most of these curricula. All the time is spent on steel, timber, concrete and glass. There needs to be a concerted effort by the composites industry to help introduce composites into these types of courses and to equip the educators with the most current and relative data.”

To this end, Riebe explains that ACMA’s Architectural Division held the first “Composites Challenge.” It invited five architecture schools to participate in a semester-long composites design exploration. “We held workshops for 75 students earlier this spring and are looking forward to incredible results. These are the types of activities that are crucial to introducing the future leaders of the architectural industry to the possibilities of composites,” Riebe says. The strongest and most imaginative entries in the challenge will be on display at CompositeBuild.com’s booth in the Composites Pavilion at the AIA Convention.

Koerner adds that the costs of materials and fabrication equipment may hold some schools back from adding composites to their curriculum. UCLA’s Architecture and Urban Design Department works with donated materials from local composites suppliers.

Matthew J. Glawatz, associate principal of The Clark Enersen Partners, an architecture firm in Lincoln, Neb., adds that education for practicing architects also is crucial. “Due to our lack of understanding of these products, I would encourage manufacturers to expand their efforts to engage the architectural community,” he says. “We do like to be on the cutting-edge of building technology, but at times it eludes us if we are not presented with the possibilities that exist.” Education could range from a simple
30-minute presentation on the benefits of a specific product to a customized continuing education session, says Glawatz.

Having someone on staff who speaks the architects’ language also could prove helpful for composites manufacturers. Riebe finds that his background as a licensed architect allows him to serve as a guide to architects making decisions on materials during the design process. “One strategy would be to hire a recent grad of an architectural program, as they most likely will know the latest modeling and manufacturing tendencies in the industry,” he suggests.

Riebe’s architectural background also has helped him understand the importance of getting involved early in the process in a design-assist role. “We essentially become consultants and part of the team in the hope of securing the actual fabrication down the road,” he explains.

But Van Dyck points to one more obstacle that still needs to be overcome: convincing owners that composites belong in architecture. “That right now is our hurdle. We’ve proven concepts, we’ve proven the value proposition, and we’ve proven the cost is not insurmountable, but we’re working on getting these clients excited about making the leap to be the first to do something like that,” he says. “It’s a two-sided effort: designers need to overcome this fear factor, but owners do, too.”

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For more information on ACMA’s Composites Pavilion at AIA, visit compositespavilion.com.
Gary Miller of SGS Tool Company recalls interviewing a high school student for an internship several years ago. “When I asked him to tell me about himself, he slouched down in his chair, crossed his arms and said, ‘I’m cool,’” says Miller, director of training and occupational development for SGS, a manufacturer of high-performance cutting tools for composites, aluminum and titanium. “I waited because I hoped he was going to tell me what he was cool at, but he never did.”

Rather than abandon the idea of hiring interns, Miller decided to help prepare students for the workforce. He reached out to local high schools with machining programs and offered tutorials. Now he visits classes, teaching students everything from how to write a resume and prepare for an interview to how to read micrometers and perform simple shop mathematics.

For the past seven years, SGS Tool Company has hired one or two interns each year. But that’s really a side benefit of his community outreach, says Miller. “We’re not in there to push the SGS brand, nor am I going to classes to recruit. I am preparing these kids for any manufacturing career,” he says.

Attracting and training the next generation of workers is a challenge for manufacturers, including those in the composites industry. By 2025, there will be two million jobs available in U.S. manufacturing, according to the U.S. Commerce Department’s Hollings Manufacturing Extension Partnership (MEP). But 84 percent of manufacturers report a moderate to severe shortage of available, qualified workers.

“In the last five to seven years, workforce development has become a really big issue with smaller companies — those under 500 employees,” says Mary Ann Pacelli, manager of workforce development for MEP, which is part of the National Institute of Standards and Technology. “They recognize that not having the right talent is really holding them back.” Since its inception in 1988, the MEP nationwide network has helped create and retain more than 797,000 jobs. (See the sidebar on page 22 for more on MEP.) But individual companies are doing their part, too. Here’s a look at efforts undertaken by four firms in the composites industry to find and train future workers.
There was another issue with the instruction model: It utilized a uniform approach ill-fitted to composites training. “It’s not like a welding course. Anybody can go to a trade school, learn how to weld, then go to a company and weld,” says Chambers. “When you’re dealing with composites, it’s much different. I may do a 6-ounce skin coat and infusion and light RTM, but another company does 12-ounce skin coats using a resin with different characteristics. Each of us have our trade secrets, and you can’t send somebody to school to learn them.”

So Chambers and his peers in the boatbuilding market convinced Florida’s workforce development community to flip the training model on its head. They asked that funding focus on in-house training at the manufacturing companies. “We offered to develop our own programs and train employees, using our suppliers and our expertise,” says Chambers. The state agreed.

Four years ago, JRL Ventures/Marine Concepts began receiving state grants for in-house training through CareerSource Florida, a network of career development professionals that work with employers to find talent. New employees are vetted by CareerSource Suncoast and CareerSource Southwest – the two non-profit organizations the company works with – to ensure they meet requirements of the state and local government. Then the employees participate in training at the manufacturing company on a range of topics, including safety, composite skills and self-responsibility. “It covers everything you need to be an employee in our facility, not a generic employee,” says Chambers.

JRL Ventures/Marine Concepts receives $2,000 per employee for training. The grants cover all of the company’s training costs and about 20 percent of the total cost of hiring a new employee. “It makes it feasible – and financially motivating – to train employees,” says Chambers.

JRL Ventures/Marine Concepts began the workforce development program in 2012 when it opened its second facility, a 300,000-square-foot plant in Sarasota, Fla. The company initially planned to hire 25 to 45 new employees in Sarasota. The program was so successful that the company ended up with approximately 125 employees.

Chambers encourages composites manufacturers to reach out to their local workforce development agencies for guidance. “They will help and mentor you,” he says. “There’s not a more important part of your business than the people portion. If you don’t have time to spend training your people, then your business will not grow.”

### Offering an Apprenticeship Program

**Company:** MPM  
**Headquarters:** Leeds, England  
**Employees:** 22  
**Measure of Success:** Total sales and number of employees have doubled in five years  

Six years ago, MPM recruited Jonny Haley as an apprentice. Today he is a production leader at the manufacturing company and winner of the 2014 Employee of the Year Award from industry trade association Composites UK.
MPM hires two to three apprentices each year, “some with good success, some with not-so-good success,” admits Ben Wilson, managing director of MPM. But the company remains committed to its apprenticeship program, and employees like Haley highlight its potential. “We strongly believe in apprenticeships as a way of building the skills of potential future employees,” says Wilson. “We are always looking for young recruits who have energy, enthusiasm, commitment, a great work ethic and an ability to work in a team.”

MPM recruits its apprentices from various organizations. One was hired through Talent Match, a program of the Leeds-based charity Ahead Partnership that helps find meaningful jobs for people between 18 and 24 years old who have been unemployed for at least a year. MPM’s newest apprentice, Connor Dockerty, was recruited through The Works Charity, which helps line up vocational training for young people. Dockerty began working as a production operator and hand laminator in January. “He has already made fantastic progress with skill levels, flexibility as a team member and his efficiencies,” says Wilson.

Apprentices receive on-the-job training as either a production operator or finishing operator, working side-by-side with an employee on the shop floor. “With composites, there’s only so much you can learn from theory books and in classes,” says Wilson. “Production and hand layup require learning by doing.”

During the one-year program, apprentices can earn levels 2 and 3 of the National Vocational Qualifications (NVQs) – a level system of work-based awards in the United Kingdom ranging from Level 1 (basic work activities) to Level 8 (senior management). “We look forward to the official Composites NVQ, which is currently being put forward by government bodies,” says Wilson.

After a year, MPM hopes apprentices opt to become full-time employees of the company. According to the Skills Funding Agency, a government entity in the United Kingdom, 71 percent of former apprentices stay with the employer. Three of the apprentices MPM has trained since 2010 are now in skilled positions with the company, including 26-year-old Haley in a leadership role. (The United States also has an apprenticeship program – ApprenticeshipUSA, offered through the Department of Labor. For information, visit dol.gov/apprenticeship.)

Wilson credits part of the reason for the success of MPM’s apprenticeship program to the hiring of a full-time, on-site advisor to ensure the participants get the support, training and development they require. “[Workforce development] is not easy. It takes commitment and consistency,” says Wilson. “It’s about creating opportunities.”

Nationwide Network Helps Manufacturers Thrive

Manufacturing has an image problem. According to the Hollings Manufacturing Extension Partnership (MEP), 90 percent of Americans believe manufacturing is important for a strong national economy. Yet only 37 percent of parents encourage their children to enter manufacturing and a mere 18 percent of people view manufacturing as a top career choice. One of MEP’s goals is to change the perception of manufacturing and attract a skilled workforce.

Founded 28 years ago, MEP is a nationwide network of independent centers that provide services ranging from innovation strategies to process improvements and workforce development. MEP centers are located in every state. These centers are a great place to start for help with workforce development. (You can find the one nearest you by visiting nist.gov/mep and clicking on your state on the map.)

“Manufacturing is an important part of our economy,” says Mary Ann Pacelli, manager of workforce development for MEP, which is part of the National Institute of Standards and Technology. “We need the best and the brightest going into the industry!” She offers several suggestions to composites companies on attracting and training employees:

1. Create a “talent plan.” Think about the skills your company will need in the next one to three years, then develop a strategy to obtain those skills. What can you develop in-house? Where can you find those skills on the street? “Recruiting starts with developing better job descriptions and knowing what you’re going to do with people once you bring them in,” says Pacelli.

2. Engage with local high schools and vocational schools. “You can take high school students at the end of their junior year and give them a meaningful internship,” she says. “They may continue on to community college while working for you part-time as a technician.”

3. Reach out to workforce organizations. There are hundreds of state and local organizations that connect companies with job seekers. Ask your MEP center for referrals to such organizations, or check out Career One Stop at careeronestop.org.

4. Train your trainers. “Companies that are looking to upgrade their existing workforce need to get better at structured, competency-based, on-the-job training,” says Pacelli. “It’s more than just putting Sue with Joe. Companies need to be better at training the next person who comes in because 80 percent of most training happens on the shop floor.”

5. Connect with your industry association. “There’s always going to be a disconnect in generic education. Schools can’t train for your company,” says Pacelli. “Companies have to accept that and connect with groups such as ACMA, which offers tremendous education.” Learn about ACMA’s Certified Composites Technician (CCT) program at acmanet.org/cct.

“We can make manufacturing exciting again by talking about lightweight materials like composites and cool technologies like additive manufacturing,” says Pacelli. “We can inspire the next generation.”
Creating a Custom Training Program

Company: Miles Fiberglass and Composites
Headquarters: Clackamas, Ore.
Employees: 62
Measure of Success: All employees will be cross-trained within two months

For years, the standard method of training new employees at Miles Fiberglass and Composites had been to rely on “tribal knowledge,” says Justin Luchak, quality assurance/training facilitator at the company. “If we were training somebody in the finishing department, we would just pair the new employee with an experienced one and say, ‘Teach him everything you know.’” The problem was there were no lists to check off indicating the new employee learned the necessary tasks, no test to indicate he or she mastered those tasks and no guarantee that the trainer was adept at instruction.

Last fall, Miles Fiberglass embarked on creating a new training process and career pathways for employees with the help of the Oregon Manufacturing Extension Partnership (OMEP). The OMEP – the state’s sanctioned MEP center – is a non-profit organization that helps small and mid-sized Oregon manufacturers thrive. Lori Miles-Olund, president of Miles Fiberglass, is a member of OMEP’s Board of Directors. When she heard about the organization’s new training program, she immediately signed up the company. “It’s one of the few training programs I’ve seen that

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“There’s not a more important part of your business than the people portion. If you don’t have time to spend training your people, then your business will not grow.”

– Matt Chambers, JRL Ventures/Marine Concepts

fits us well because it’s customized,” says Miles-Olund.

Since November, Luchak has met two mornings each week for four hours with a consultant from OMEP. They began by reviewing all the processes at Miles Fiberglass, such as hand layup, finishing and mold maintenance. They analyzed all the tasks related to each process, then created job modules that lead employees step-by-step through each task. “The modules provide about 30 minutes of training,” says Luchak. “So if a layup process takes two hours, then there are four training modules.”

For instance, one of the job training modules covers how to set up the chopper gun. The module includes detailed instructions for each of the following steps: getting parts for the gun, setting up the tip, installing the tip onto the gun, setting up the motor, setting up the pressure and opening the valves, and calibrating the chopper gun. In addition, the module includes labeled photos of all the chopper gun parts and the gun set up.

As of March, Luchak had created eight modules for layup and finishing. He had begun work on three other modules – shop orientation, safety procedures and 5S procedures (the company’s quality program). “It’s very time-consuming, but I really think it’s going to pay off in the end,” says Miles-Olund. The training method will ensure everyone is trained consistently and correctly, and it will help with lean manufacturing.

Miles Fiberglass began expedited training in March for current employees. They train in groups of three once a week for 45 minutes. Everyone on the plant will be cross-trained on both layup and finishing. “Cross-training allows us to manage our employees better and move people around when one area is slow,” says Miles-Olund.

When the company rolls the program out to new employees, training will be conducted one-on-one – by trained trainers – in 30-minute increments. New employees will receive laminated copies of each training module as a reference. The trainer will walk through the steps of each task, let the employee perform the task under his or her supervision, then give the employee time to practice it. The new employee will then be evaluated and signed off for that module. Luchak will maintain an Excel spreadsheet that indicates who has been trained on what modules.

Once all the training modules have been developed, Luchak will begin creating career pathways for employees. “The modules are the nuts and bolts of the training program,” he says. “Career pathways provide a big picture for employees, showing them where they can go in the company and giving them a map to their success.”

In addition, Miles Fiberglass and Composites continues to encourage employees to enroll in ACMA’s Certified Composites Technician (CCT) Program. “Our new training method goes hand-in-hand with ACMA’s CCT exam,” says Miles-Olund. “It serves as a knowledge module that complements our technical, hands-on modules.”

Investing in Interns

**Company:** SGS Tool Company
**Headquarters:** Munroe Falls, Ohio
**Employees:** 230
**Measure of Success:** Average employee tenure is 14 years

SGS Tool Company casts a wide net for interns. It recruits young people from local high schools, students enrolled in certificate programs at Stark State College and undergrads from the University of Akron. The company also is flexible in its internship structure, tailoring opportunities to the student rather than pigeonholing students into a rigid program.

A business major from a New Jersey college called the company asking if she could spend a week working at SGS unpaid during her spring break. Gary Miller, director of training and occupational development, agreed and developed a custom 5-day training program for her. “If she’s willing to donate her time, I’m going to support her as much as possible,” he says.

Another came from the Schnee Learning Center, a school in Cuyahoga Falls, Ohio, for at-risk students. Miller met the student while leading a tutorial at the school, which included administration of the pre-employment Bennett Mechanical Comprehension Test for technical and industrial occupations. The young man scored so high on the test that Miller offered him an internship in the company’s prep department. The student quit his part-time job at a fast food restaurant, joined SGS and has since been hired full time in the apprenticeship program.

One incentive that SGS offers interns who stay with the company is financial assistance with college. The intern from the Schnee Learning Center now attends Stark State College, where he is working toward Journeyman Tool Maker Certification. SGS pays for his tuition, books, parking and mileage to and from the college. Once the employee earns his certificate, he can work toward an associate’s degree in applied industrial technology. He will receive
100 percent reimbursement for any class where he earns an A.

SGS invests in its interns, but not all of the expenses come out of the company’s pocket. The tool manufacturer partners with several government agencies and advocacy groups to obtain grants for workforce development. For instance, SGS has an intern in its research and development department who attends the University of Akron. The company pays him $14 an hour. But a grant from Ohio Means Jobs, Medina County, covers most of the wages, leaving SGS to fund a mere $1.53 per hour. “There are so many grants that go unutilized,” says Miller. “This is untapped money — well, others are not tapping into it, but we are!”

Miller encourages companies in the composites industry to get involved with organizations, such as their state MEP or local manufacturing advocacy groups. They can help companies find and train employees. He also recommends reaching out to local high schools and even middle schools to offer plant tours and participate in Career Day events.

“There’s a human capital challenge right now,” says Miller. “With so many people retiring, we’ll lose a lot of our workforce in the next 10 years. By supporting schools and teaching kids about manufacturing, we’re building our employee pipeline. We’re developing our industry’s future.”

And a strong manufacturing industry is auspicious for everyone in composites.

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

ACMA Focuses Efforts on Workforce Development

ACMA has formed a steering committee to address workforce development activities in the industry and devise potential approaches for the association to lead such activities. “The more I talk to our members about finding, training and retaining good workers, the more I realize how much of an issue this is for our industry,” says ACMA President Tom Dobbins. “It’s not just shop floor workers either. It’s at every level, from engineers to technicians in the plant.”

Additionally, at CAMX 2015, ACMA and IACMI officially joined forces to help grow the composites industry. Part of the agreement entailed partnering on workforce development efforts, including the support and promotion of the ACMA Certified Composites Technician (CCT) Program. ACMA and IACMI are encouraging members of the composites industry to provide feedback to determine where specifically they should focus their efforts in workforce development and education. You can fill out a survey at www.surveymonkey.com/r/IACMIWorkforceSurvey.

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Georgia Tech Professor Chuck Zhang shares his expertise on nanocomposites.

By Mary Lou Jay

If there are renowned experts in the up-and-coming nanocomposites industry, one of them is Chuck Zhang, Ph.D., a professor at Georgia Tech’s Stewart School of Industrial & Systems Engineering in Atlanta. His research interests include scalable nanomanufacturing, development of multifunctional composites and nanocomposites materials and their manufacturing processes, and additive manufacturing (3-D printing and printed electronics). His research projects have been sponsored by many organizations and companies, ranging from the Army Research Laboratory and Office of Naval Research to General Dynamics and Lockheed Martin.

Dr. Zhang recently talked with Composites Manufacturing magazine to unravel the mysteries of nanocomposites and shine light on where the materials are headed.

Q: What exactly are nanocomposites?
A: In nanocomposites, you have one phase, primarily the reinforcement or matrix material, which is in the nanoscale. A nanoscale is defined as one dimension of the material that is less than 100 nanometers.

Q: How long have nanomaterials been used in composite products?
A: It goes back to the 1970s and the early 1980s. That was the time of the first commercial success in nanomaterials at Toyota. They developed a nanocomposite by mixing a thermoplastic matrix, like nylon, with nanoclays. It was used for auto parts close to the engine block. They replaced the metal so they could save weight.

The first report that Toyota published was in 1988. In that paper they talked about the mechanical strength; it was stronger than traditional polymer parts. Better yet, the heat distortion that they could achieve was much better than with regular plastic parts. They could actually endure more heat, and they didn’t distort.

Q: What properties do nanocomposites bring to products that other materials don’t offer?
A: Most of the nanocomposite applications are for either special properties or multifunctionalities. In auto manufacturing, when the structures – particularly plastic – are painted, the paint is like a plastic. It’s non-conductive, and there’s a static issue. So they had to put some conductive particles [made with nanomaterials] into the paint so that it would make them anti-static.

Nanocomposites can also be used in high-end products, like sporting goods. High-performance golf clubs have nanotubes that can improve the mechanical properties. The response is better, so when players swing the club they can hit the ball further. Similarly, professional tennis players use nano-enhanced rackets. The stiffness of such rackets is believed to be better, so the players can hit the ball better, at higher speed.

Q: Are most of these carbon nanocomposites?
A: Yes, most of them are either carbon nanotubes or carbon nanomaterials that are put in the matrix. Carbon is the choice for two reasons. One, carbon nanomaterials have very special multifunctional properties – including mechanical properties, electrical conductivity, thermal conductivity and barrier properties. The second reason is that carbon nanomaterial is probably one of the most commonly used nanomaterials in R&D, so there is more of it available than other types.

Q: Why are nanocomposites of interest to the composites industry?
A: In the early years of these applications, nanocomposites were used more for their mechanical properties. But later on [the automotive and aerospace industry] asked what else can you
improve by using nanocomposites? They found out that if you put the nanomaterials into the composites – and if you design, arrange and manufacture them in specific ways – it can improve electric conductivity or thermal conductivity and maybe others like barrier properties, such as fire and smoke retardance.

If we put a thin layer of carbon nanomaterials close to the skin of a plastic or polymer composite structure, it significantly improves the fire retardancy. You’re talking about adding just a very thin layer, maybe 10 to 15 microns, even thinner than a piece of paper, and almost no weight. A 12 x 12-inch carbon nanotube sheet is less than one gram. So if you have an aircraft that has an accident, if the composite materials in the aircraft have this nanomaterial layer on the surfaces that will reduce the smoke and heat generation and also delay the fire. You can give passengers more time to escape.

Q: Are companies beginning to seriously look at nanocomposites?
A: We have been approached by probably more than a dozen companies in the last few years that are interested in different multifunctionalities of nanocomposites – electrical, thermal, barrier and mechanical. For example, one company was interested in putting carbon nanotubes into polymer composite structures for ships to improve their fire and smoke retardancy. Another company was looking at the possibility of replacing steel cables using lighter weight carbon nanotube-based nanocomposites for applications such as elevators.

Q: How does the industry classify nanocomposites?
A: There’s one general way for people to categorize them, by looking at their matrix materials. So you can have polymer nanocomposites, like the Toyota application. In their case the polymer or the matrix material was nylon, a thermoplastic. If you use the nanomaterial in a metal matrix, you have a metal matrix nanocomposite. There are other people working on the ceramic matrix nanocomposites; they put nanomaterials into a ceramic matrix to make ceramics with better properties.

People also categorize nanocomposites by looking at the properties, like mechanical reinforcing nanocomposites, electrical-enhancing nanocomposites or fire-retardant nanocomposites.

Q: Does the use of nanocomposites require any major changes in the composite manufacturing process?
A: For some types of material, you don’t have to change too much. With others, you do. For instance, consider carbon nanomaterials in a composite. There are two ways to use it. One is that you simply mix the nanomaterial with the matrix, like a polymer resin, and then you make a composite. For that, you actually need to change your process, because once you put a nanomaterial into the polymer, you increase the viscosity of the mixture significantly when you put a high loading of nanomaterials, and thus you need to change the manufacturing process. Once the viscosity increases to a certain level, you can no longer use typical liquid composite molding processes. Or, you have to use very high pressure, like a compression molding type of process. Most of the time, you increase the manufacturing cost.

Alternatively, you can use other types of nanomaterial format, like the thin film or membrane of carbon nanotubes that we call “buckypaper.” You can laminate multiple layers of buckypaper to make buckypaper nanocomposites just like when you handle glass fiber/carbon fiber fabrics to make conventional composites. Then you can still infuse the resin as you usually do, because this doesn’t affect the molding process. You can also put just one layer of buckypaper on top of glass/carbon fiber laminate to enhance surface properties. Once the composite is done, the layer will stay on the surface, and it can improve the electrical connectivity, thermal connectivity and the fire retardancy of that composite.

Q: Are there any pitfalls associated with using nanocomposites?
A: The first one is cost. For carbon nanotubes today, we’re talking about $200 to $300 per pound for the lower end. If you look at high-grade nanotubes for aerospace applications, we are talking about $100 to $200 per gram. It’s very, very expensive.

Another problem is the scalability of manufacturing. Currently, very few companies can mass produce nanomaterials and nanocomposites. Compared to fundamental and exploratory research for nanomaterials development, there is less R&D work and efforts in scalable manufacturing of nanomaterials and nanocomposites.

Fortunately, we have seen increasing interest in this area by funding agencies, universities and industry companies. Some research groups – and my own group is one of them – are developing scalable manufacturing techniques with sponsorship from the National Science Foundation Scalable Nanomanufacturing (SNM) Program. Our SNM project is to develop a manufacturing process and its control strategy to make high-performance carbon nanotube buckypaper in a continuous, roll-to-roll fashion, like a paper mill process. There are also some industry companies working on scalable manufacturing of nanomaterials and nanocomposites. (Editor’s note: See the sidebar on page 28.)

Another challenge is the repeatability, reliability and durability of the nanomaterial. If we want to use it, let’s say for multifunctional applications, and you want to put it in an aircraft, then you have to get the material qualified or certified by the FAA.
The market for global polymer nanocomposites should show an annual growth rate of more than 24 percent through 2019, according to a recent report from Research and Markets. But high deployment costs could limit that growth, since the lack of large-scale production capabilities makes nanocomposites expensive to use.

Luxembourg-based OCSiAl says it has found a way to solve these problems for single wall carbon nanotubes. “A few years ago, the cost of single wall carbon nanotubes was $100 a gram,” says Mike Nemeth, OCSiAl’s vice president of sales and marketing. “We are now at $2 a gram.”

The price reduction is due to the company’s development of a large-volume synthesizing process. The Graphetron 1.0, its pilot facility, is currently producing one ton of nanotubes each year. With other reactors coming online, the company will be able to boost annual production to 10 tons.

“We use a continuous production method as opposed to methods used over the last decade, which were often batched. You’d have high costs of manufacturing because you’d fire up the nanotube reactors, make a couple of nanotubes and then turn them off. But we are constantly making kilograms a day of nanotubes,” he adds. The composites industry is a good fit for nanotechnology because it is a space that values both performance and innovation, Nemeth says. Composites made with single wall carbon nanotubes can provide multifunctionality, offering strength, stiffness and conductivity.

According to OCSiAl, single wall carbon nanotubes provide high electrical conductivity with ultralow loading, which ranges from 0.01 to 0.10 percentage of the composite’s weight. Carbon nanotubes can enhance the conductivity of a variety of materials, including CFRP, SMC, BMC and other fiberglass reinforced composites. OCSiAl offers the nanotubes in whatever form the customer requires to make their adoption into the manufacturing process as seamless as possible.

Nemeth expects that the aerospace and automotive industry will become big markets for OCSiAl’s nanotube product, TUBALL™. Nanotubes could provide conductivity in auto parts while maintaining a desired color, something that carbon black additives cannot do. For aerospace, nanotube technology could enable heating applications like the de-icing of aircraft without a complex network of wires.

Although OCSiAl is now able to produce TUBALL in quantities, it will take some time for industries with long design cycles to work the carbon nanotubes into their products. “Another challenge is explaining to people that you can now consider some other opportunities that might need more than one or two grams of nanotubes, because we can give them to you not only at scale, but also at a competitive price point,” Nemeth says. “I can help some customers save money, and that is something that nanotech has rarely been able to say that it can do.”
Q: What notable research is being done in nanocomposites today?
A: There is a lot of work being done in the area of nanocomposites. For instance, my group and colleagues at Georgia Tech are working with collaborators at Florida State University on development and scalable and repeatable manufacturing of multifunctional buckypaper, which is a very unique field of work. There are many other groups, such as those at Rice University who have done a lot of work in synthesis high-performance carbon nanotubes and their nanocomposites. Government research labs like Air Force Research Laboratories, NASA and Oak Ridge National Laboratory have also done some pioneering research in nanocomposites. There are many other groups outside of the U.S. conducting excellent R&D in this area, including the University of Cambridge, UK.

In industry, Toyota is one of the pioneers in nanocomposites, and there are other companies that create new nanomaterials. For example, Applied NanoStructured Solutions, LLC (ANS), a wholly-owned subsidiary of Lockheed Martin Corporation, has created a high-volume continuous process to mass produce carbon nanostructures that can be grown at scale on various substrates, including glass and carbon fiber, and formed into materials with superior structural and conductive properties.

Q: What can industry professionals anticipate in the future?
A: I think you’ll see unique multifunctional materials for high-end applications like space and aircraft in the near future. Auto companies would also like to use some of the nanomaterials in the future; they are thinking more about lightweight, multifunctional materials to help them meet the Corporate Average Fuel Economy (CAFE) standards. Cost has to be low and scalability needs to be good, as we are talking about a large quantity for car production.

Another area of potential applications of nanocomposites is medical and life science. Can we use nanocomposites or nanomaterials with other types of manufacturing, like 3-D printing, to make multifunctional, custom-made devices/structures for implants? We are actually working on something like that in my lab, for printing heart valves that can mimic physiological behavior of human aortic valves using 3-D printing techniques with polymer and carbon nanotubes. Right now it’s for in-vitro [outside the body] applications, but in the future it can be used for something inside the body, like an implant.

Keep an eye open. Many other things are coming!

Mary Lou Jay is a freelance writer based in Timonium, Md. Email comments to mljay@comcast.net.
It’s Membership Renewal Season

ACMA membership renewal season began in April. Don’t forget to budget for ACMA membership dues and programs. If you are not a member, join today! To learn more about the benefits of ACMA membership, contact Paul Hirsh at phirsh@acmanet.org.

ACMA at AIA

ACMA will be present at this year’s American Institute of Architects Convention, May 19-21 in Philadelphia. Stop by the ACMA booth (#2407) for your first opportunity to pick up ACMA’s Guidelines and Recommended Practices for Fiber-Reinforced-Polymer (FRP) Architectural Products. The guidelines address the application of composites in architecture and help architects better understand how, when, where and why to use composites.

The Composites Pavilion (compositespavilion.com) will also feature presentations from esteemed composites experts and the Composites Design Challenge, a student design competition. Toothpick bridges and balsa wood structures are a thing of the past: Students will showcase unique ways to use composite material to develop new architectural components and assemblies. Winners for the challenge will be announced each day at 3 p.m. Come and see how composites are shaping the future of building and construction! For more information, please contact John Busel at jbusel@acmanet.org.

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ACMA gathered composites industry leaders from all over the world for the first international composites recycling meeting. Attendees included representatives from organizations such as Composites UK, Composites Germany, The European Composites Industry Association (EuCIA), Boeing, Airbus and IACMI. ACMA’s website will soon include a link to a full report from the Paris workshop. ACMA will host the next global recycling meeting at the Composites and Advanced Materials Expo (CAMX) – Sept. 26-29, 2016, in Anaheim, Calif. Those interested in attending the meeting should contact Dan Coughlin at dcoughlin@acmanet.org.
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