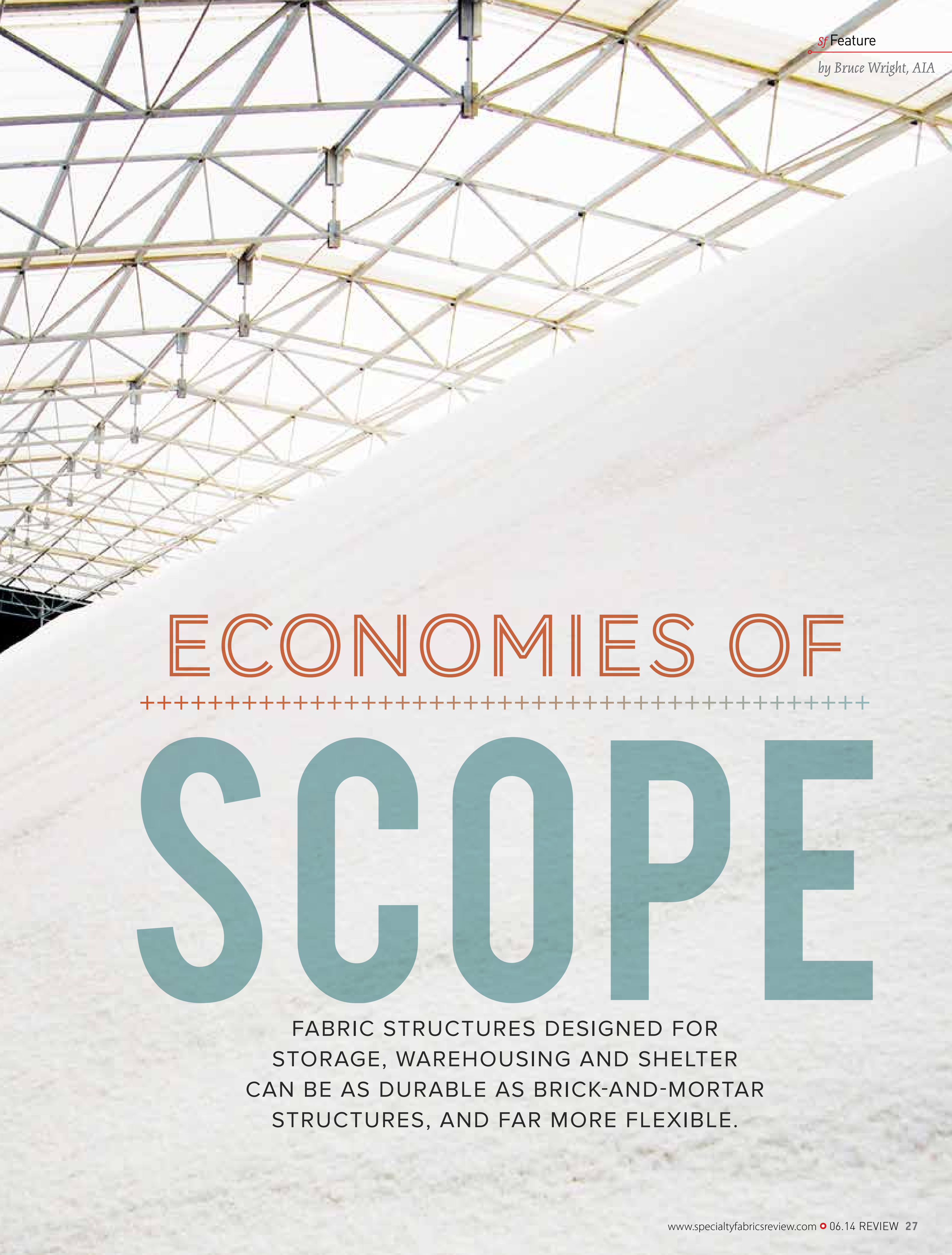
Hissong Development Corp. of Kennebunk, Maine, recently erected a Rubb structure at their bulk storage facility in South Portland, Maine, as part of a commercial salt bagging operation. The Rubb BVE structure measures 100 feet wide and 283 feet long with a sidewall height of 10 feet; it sits atop an 8-foot poured-in-place concrete wall. Vehicle movement is streamlined along one side of the building, allowing loaders to move the salt to the bagging operation. Photo: Rubb Inc.

by Bruce Wright, AIA



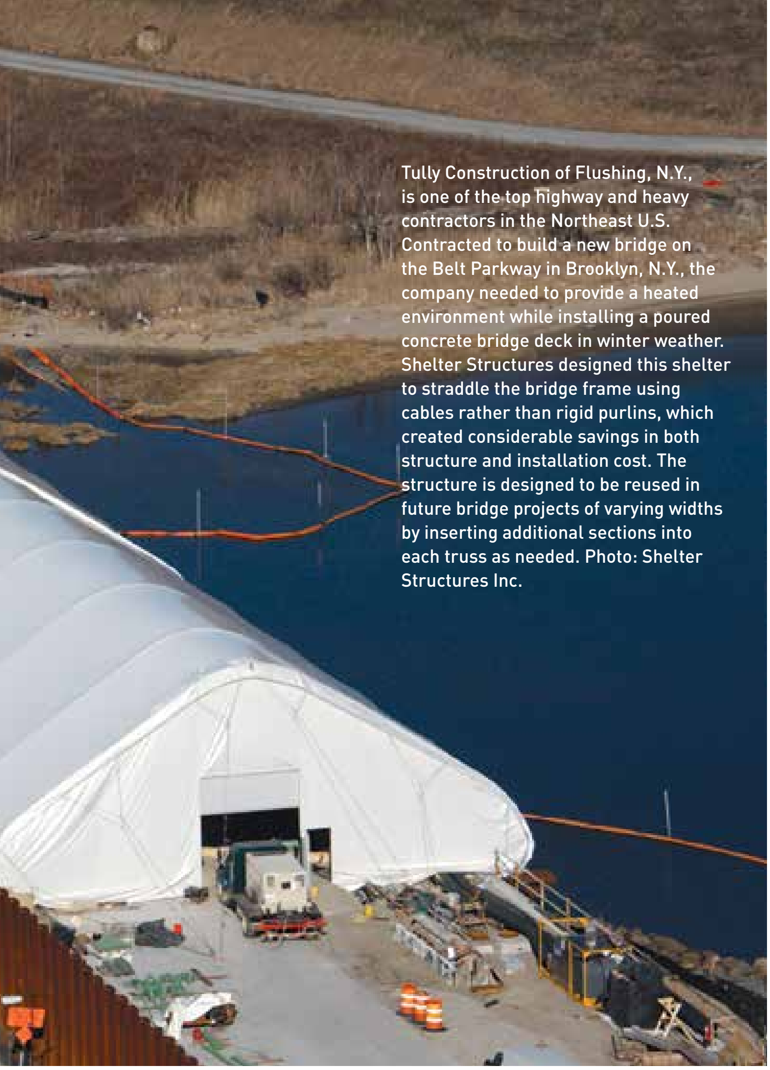
ECONOMIES OF SCOPE

FABRIC STRUCTURES DESIGNED FOR STORAGE, WAREHOUSING AND SHELTER CAN BE AS DURABLE AS BRICK-AND-MORTAR STRUCTURES, AND FAR MORE FLEXIBLE.

With the construction of fabric structures consistently meeting (and often exceeding) stringent building codes, you'd think that more clients would opt for one of these highly engineered and efficient fabric-clad buildings. With clearspan or air-supported fabric buildings being used to shelter aircraft, for heavy equipment storage or construction warehousing, to more temporary uses such as remediation enclosures, relocatable military structures or emergency shelters, choosing fabric buildings remains a complex situation.

The crux of the matter may depend on two factors: a slow recovery of the construction economy and a lack of understanding of the structural concepts that are the foundation of these adaptable and mutable forms. In an October 2013 fabric structures survey by IFAI (reported in the January issue of *Specialty Fabrics Review*), IFAI market research manager Jeff Rasmussen reported: "The fabric structures industry, like many other specialty fabrics market segments, has suffered from some difficult economic times since 2009. But it has been a resilient market as well—achieving slow but steady 2 percent per year growth since 2012." Along with the market sectors reported in the economic snapshot was the expectation of increased sales of commercial buildings and storage facilities, and increased demand for temporary structures.

When challenged with locating structures on unpredictable surfaces, Shelter Structures uses its ballast system that enables a shelter to be securely anchored without the use of foundations or earth anchors. The heavy-weight system shortens the time needed to install and allows rapid redeployment when moved. Photo: Shelter Structures Inc.



Tully Construction of Flushing, N.Y., is one of the top highway and heavy contractors in the Northeast U.S. Contracted to build a new bridge on the Belt Parkway in Brooklyn, N.Y., the company needed to provide a heated environment while installing a poured concrete bridge deck in winter weather. Shelter Structures designed this shelter to straddle the bridge frame using cables rather than rigid purlins, which created considerable savings in both structure and installation cost. The structure is designed to be reused in future bridge projects of varying widths by inserting additional sections into each truss as needed. Photo: Shelter Structures Inc.

Most fabric-clad buildings fall into two basic structural types: steel- or aluminum-framed structures with taut fabric skins (called "clearspan") or fabric air beams with fabric skins. Both types have been refined over the past 40 years to address every code and fabrication concern put forth by clients, code officials, engineers or architects, such as durability, flammability or cost effectiveness and if the building is permanent or temporary. Fabricators have responded with good designs and convincing arguments for the use of these structures. With the increase in the production of fabric structures noted above, clients are catching on to the advantages—such as reusability, adaptability and relocatability, not to mention sustainability. Given all of the advantages of this technology, however (see sidebar on this page), more fabric structures should have been built and in use than actually have been. A perception remains that because they are made with fabric and often designed to be moved, these types of buildings are somehow less durable than more traditional storage structures.

Speaking in codes

"Our shelters are manufactured to the same building codes as brick and mortar buildings," says Patricia Smail, president of Shelter Structures Inc., Philadelphia, Pa. "[The] buildings

ADVANTAGES
OF THE FABRIC FOOTPRINT

WHY CHOSE A FABRIC STRUCTURE OVER MORE TRADITIONAL CONSTRUCTION?

- Manufacturing and erection time is considerably less than with conventional construction.
- Many fabric structures do not require local planning agency consent if the structures are temporary in use.
- Structures can be packed and stored in a small space when not required.
- Many fabric structures do not require permanent foundations and need minimal site preparation.
- Many fabric structures can be relocated after first use, reducing cost to the client.
- The modular nature of the structures makes them easy to re-purpose at the end of first life.
- Frames can be made from recycled steel, and fabric covers can be recycled after first use.
- Translucent fabric cladding means that natural light can reduce the need for electric lighting inside, reducing the carbon footprint (in tandem with recycled materials).
- Transportation requirements to get structural parts to site are considerably lower than normal construction because of the components' lower initial weight. Structures can be shipped on a typical flatbed truck and transported to many types of flat surfaces.
- The manufacture of fabric and employment of lightweight framing metals uses significantly less raw material than brick-and-mortar construction, and produces a significantly lower carbon footprint.

carry the fabric manufacturer's warranty of at least 10 years." In general, to be constructed or installed on a site, all fabric buildings must pass local building and fire codes and meet the industry standards by the National Fire Protection Association (NFPA) and the California Fire Marshal tests, the two most commonly cited in North America. "Our fabric meets all requirements for NFPA 701 and California Fire Marshal regulations, as well as the ASTM E84 tests," says Chuck Auger, marketing and facilities manager with Rubb Inc., Sandford, Maine. (ASTM E84 is entitled "Standard Test Method for Surface Burning Characteristics of Building Materials.")

"Rubb knows that there is a direct correlation between the thickness of the material and its service life. The fabric we use has a greater than 20-year life expectancy. We have [constructed] buildings that have hit 30 years [old] with the original fabric," says Auger. Rubb manufactures tensioned fabric steel buildings for use when requirements call for large covered spaces with a lot of height and no structural columns in the middle. Company markets include aviation hangers, bulk storage, sports facilities, military shelters and environmentally challenging climates where a building might need to be relocated after its first use.

Strength to weight

Some fabric buildings can be found in the most severe climates and conditions. For example, one of Rubb's fabric structures, actively used for truck maintenance and assembly by a mining company in Labrador City, Newfoundland and Labrador, Canada, is located only 37 degrees south of the North Pole. With an average yearly snowfall of 12 feet in that area, the structure experiences some of the harshest weather in North America.

"Textiles have exceptional strength-to-weight characteristics," says David Kelsall, technical director and co-founder of Tectoniks Ltd., Shropshire, England. "They also have UV resistance and life spans of 10 to 20 years outdoors, and are suitable for use in temperatures ranging from -30˚C (22˚F) to 70 C (158˚F)." Tectoniks manufactures inflatable fabric structures for warehousing, storage and maintenance purposes, as well as custom designs for various events and public uses.

One of Shelter Structures' buildings has been fitted to a new bridge overpass in Brooklyn, N.Y., to provide a heated environment while crews poured concrete bridge deck in winter weather. The shelter was designed

IT MAKES SENSE IN TERMS OF EFFICIENCY AND COST CONTROL TO DEVELOP A REPEATABLE STRUCTURAL CONCEPT THAT CANNOT BE COPIED BY COMPETITORS.

This portable hanger, designed and manufactured by Tectoniks Ltd., utilizes an air-inflated fabric structure technology of air tube beams, typically with spans up to 65 feet (20 meters); because it has a modular construction, it can be made any length. A variety of end terminations—fully inflated walls to membrane ends—can be used to create closure, as well as functioning door ends that can be opened for full-width access. Photo: Tectoniks Ltd.

The Idaho National Laboratory, near Idaho Falls, Idaho, required two conjoined Rubb structures for its Idaho Cleanup Project. Rubb fabricated two AVS structures each 250 feet long, one 200 feet wide and the other 290 feet wide. The 290-foot span required a custom spaceframe central girder supported by three columns with articulating joints. The recovery structure complex covers nearly three acres of land. Photo: Rubb Inc.

so that it could be reused on future bridge projects of varying widths with a variable truss cross-section to keep costs down.

Allsite Structure Rentals, a brand line of Kingscliff, Australia-based Alexander Pacific Group and a manufacturer of fabric clearspan structures, has a box beam series of structures (TFS series) that can be insulated with either R25 or R30 glass fiber batt insulation integrated with HVAC equipment.

Fabric matters

Fabrics typically used for these types of applications tend to fall into two main varieties: polyester base fabrics with PVC or PVDF coatings or glass fiber fabrics with PTFE or silicone coatings. Other options are available, such as HDPE or similar commodity polymer fabrics, but most industry representatives agree that these lighter-weight fabrics must be kept for temporary structures that do not have a long life expectancy. "We use only PVC-coated fabrics with PVDF (Tedlar®) topcoat," says Smail. "Coated PVC is used rather than HDPE or polyolefin because it provides a substantially longer service life. PVC has a much higher adhesion factor than HDPE, which results in more secure welds [of the fabric]."

Rubb uses a 28-ounce PVC-coated fabric; Shelter Structures uses 20-ounce for standard structures and a 32-ounce version for use in locations with extremely heavy snow loads. Allsite uses 22- to-24-ounce PVC-coated polyester fabrics for its temporary and permanent TFS Series of structures. As Kelsall notes, the functioning temperature range of these technical fabrics is substantial. Clearly, the fabrics of fabric-clad structures meet most requirements for building durability.

Matching buildings to climate

Is there an ideal building type for each climate? Perhaps. Some manufacturers might tell you that their buildings can go anywhere, but on closer examination, certain details that make sense in one climate don't suit in another. "We manufacture for the industrial and military markets," says Smail. "They are perfectly suited for hard use as warehouses, manufacturing plants, aircraft hangars, bridge protection and any situation requiring weather protection; and are ideally suited for a warm climate as they can be on site quickly and provide much needed shade.

"One of our military customers told us that our fabric canopies reduced the cockpit temperature of the aircraft by 80 degrees. That's hard to believe until you see a pilot all suited up [under our shelter] in a hot southern sun," Smail adds.

Air-inflated structures seem fairly adaptable to warm climates, says Kelsall. "For hot climates the structures can be constructed using textiles which contain a blackout layer. These prevent the transmission of light through the fabric and dramatically reduce solar gain, helping to keep the interior cool."

"Rubb structures can be fit with doors that are insulated," says Auger, "and a patented insulation design by a company within the Rubb Group helps provide clients with buildings that meet a very wide range of climate control while still being relocatable."

Buildings destined for cold climates have their own requirements in addition to the expected heavy insulation and double walls, such as internal structures that are reinforced to withstand snow and wind loads. "In cold climates, our structures keep the snow off of expensive equipment and allow precast concrete manufacturers to pour even in cold weather," says Smail. "The buildings still provide portability, allowing the shelters to be moved when needed."

Kelsall echoes the need for adequate insulation for cold climates, but adds, "The additional level of insulation provided by the air in the walls of an inflatable structure helps reduce the requirement for heating." Tectoniks recently completed research on a method that allows them to manufacture inflatable structures with flexible insulation inside the walls sufficient to meet International Energy Conservation Codes, such as the IECC 2012.

Any shape you want?

Each manufacturer has developed a stable of standard structure configurations, most often based on a unique, patented method of construction details, such as truss frames and joints for clearspan structures and air tube and welded beam arches for air-supported structures. It makes sense in terms of efficiency and cost control to develop a repeatable structural concept that cannot be copied by competitors.

Allsite's TFS series of aluminum-framed structures are portable and easily crane-lifted or relocated. According to Kirk Klever, sales and marketing manager, "While any Allsite structure that we build for a permanent application will require bolt connections for all arch splices, purlins, baseplates, etc., our TFS series structure, when used for temporary applications, can be built with quick-release pin connections." The system dramatically reduces installation and dismantle times, a cost savings passed along to clients.

Rubb manufactures steel-framed buildings in three main configurations, as well as custom designed structures

on demand. "Some requirements demand large space coverage without a lot of height," says Auger, "while others may need a higher peak to account for a bulk storage pile that has a high angle of repose." Rubb's three types are the BVE (a gabled truss frame with side walls and a span up to 70 feet [21 meters]); the NV (high arched segmented truss roof with spans up to 100 feet [30 meters]); and the BVR (box section walls and low-sloped peak roof with spans up to 60 feet [18meters]).

Shelter Structures has a rounded-hip truss system that can be adapted to a wide variety of sizes. "Truss spacing is 20 feet on center," says Smail. "Our shelters have fewer components, which means they are installed more quickly at a lower cost. Design is infinitely adjustable in width and height." Fabric panels are tensioned in all directions to give a better appearance and increase the service life span of the covers, Smail adds.

The majority of fabric structures produced by Tectoniks are for warehousing and shelters, such as aircraft hangars. "They typically have spans of up to 20 meters [66 feet]," says Kelsall, "and of modular construction so they can be any length. They can be configured with a variety of end terminations, from fully inflated walls to membrane ends that can be opened for full-width access."

Because they don't need a metal framework, the main concern for inflated structures, says Kelsall, is how they are anchored. For hard surface locations like concrete,

The Naval Air Station in Meridian, Miss., had 54 T-45 aircraft that needed to be covered on a tarmac with limited space. Instead of 54 individual canopies, each requiring 10 feet of space between them, Shelter Structures designed 18 triple-wide canopies covering three aircraft per structure, reducing the overall footprint of the project and saving money with fewer structures. Photo: Shelter Structures Inc.

expanding eye bolts can be installed with adjustable straps connecting the inflated structure to the ground. For grass or earth locations, spiral anchors can be screwed into the ground. If either the hard or soft surface cannot be penetrated, then ballast blocks or water-filled containers are used.

While the number of fabric structures being constructed yearly continues to increase at a steady pace, the potential for application of this technology also grows as improvements in material durability and a track record of successful, highly functional structures proves the viability of the product. As these examples demonstrate, fabric structures can perform in extremely varied climates and conditions at a level equal to any brick and mortar building.

Bruce N. Wright, AIA, a frequent contributor, is an architect, design journalist and the former editor of *Fabric Architecture* magazine. For contact information on the sources used in this article, turn to page 78.

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