FRP ROOF DECK:

A Solution for Challenging Conditions

By Tom Toler

A SPECIALIZED NEED

A roof deck serves as the structural substrate for roofing materials while providing protection for equipment, products, and personnel located below. These basic functions require materials that provide long-term, reliable performance.

However, many facilities have chemical exposures or continuous moist conditions that can result in a short service life for metal or wood roof decks and produce costly maintenance and premature replacement of the entire system.

Corrosive elements can attack uncoated edges of a steel deck and its fastening points. Moisture will eventually cause wood planking to rot and deteriorate. Concrete plank decking is sometimes used for harsh conditions; however, chemical vapors can penetrate the porous material, attack its reinforcing bars, and cause the decking to flake or spall. This can be a concern for personnel safety and can damage equipment or contaminate finished goods located below. In addition, aged concrete deck planks can sag and, in extreme cases, experience catastrophic failure and collapse.

Facilities that can have these conditions include natatoriums, food and chemical processors, pulp and paper mills, power plants, mining and metal treatment facilities, and others.

A PROVEN SOLUTION

Offering long and reliable service life, a properly fiberglass-reinforced plastic (FRP) roof deck can provide performance exceeding that of metal, wood, or concrete decking for these types of applications.

For corrosive conditions, an FRP roof deck is a lower-cost alternative than stainless steel. In addition, when compared to concrete planks, an FRP roof deck can provide an 11-pound-per-square-foot reduction in dead load on the building structure. As support for either single-ply or built-up roofing, structural FRP decks have delivered significant life cycle cost savings and outstanding performance for many end users. To achieve this level of performance and acceptance, an FRP deck must effectively address all of these issues:

- Chemical and moisture resistance
- Long-term support for dead and wind-uplift loads
- Installation
- FM and UL requirements

CHEMICAL AND MOISTURE RESISTANCE

To ensure appropriate selection of materials, the potential effects of chemical or high-moisture exposure should be considered in the design and specification stage. Many factors must be evaluated, including chemical type, concentration, duration of exposure, and operating temperature.

FRP materials made with an appropriate polymer resin system can easily resist chemical exposures that are deleterious to metal components. A well-designed FRP roof deck does not rust, rot, peel, or flake, thus eliminating the threat of falling particles that can damage equipment or contam-

CHEMICAL RESISTANCE: PREMIUM-GRADE VINYL ESTER

Chemical	Concentration	Operating Temp (˚F)
Chlorine dioxide	Fumes	210
Chlorine wet gas	All	210
Copper sulfate	All	210
Hydrochloric acid	15%	210
Hydrogen sulfide	All	210
Magnesium chloride	100%	210
Phosphoric acid	85%	210
Sodium chloride	All	210
Sodium hydroxide	Vapor	180
Sodium hypochlorite	5%	180
Sulfuric acid	50%	210

Table 1

inate product. FRP roof decks have an extensive history of successful use in continuous wet conditions such as those found in papermaking operations.

The type of resin used in the FRP material will affect its long-term capability to resist chemical attack. Both vinyl ester and isophthalic polyester resin systems offer outstanding corrosion resistance. Vinyl ester materials have better strength retention at elevated temperatures and capacity for support of long-term dead loads. In consideration of these factors, premium-grade vinyl ester resin should be the required resin system for an FRP roof deck. The chemical resistance table (*Table 1*) provides guidelines for vinyl ester materials in a sampling of chemical exposures. See *Photo 1*.

Photo 1 – A corrosion-resistant FRP roof deck can deliver long, maintenance-free service life in chemical or high-moisture exposures.

STRUCTURAL PERFORMANCE

In an FRP material, the primary source of strength and stiffness is its glass fiber reinforcement. As structural properties are controlled by the content and alignment of the fibers, glass-reinforcing content must be maximized.

For a roof deck, it is recommended that FRP material contain a minimum reinforcing content of 50% of its weight, which should be a minimum of 1 lb. per sq. ft. (psf). This is virtually twice the amount of glass-fiber reinforcing that is found in light-duty, chopped strand FRP panels and results in much higher strength and stiffness properties. As translucent roofing and siding, chopped-strand-reinforced FRP panels may be suitable for some applications with low structural requirements but not as a structural roof deck.

For effective reaction and transfer of loads within a structural FRP panel, the glass fiber reinforcements should be straight and continuous and aligned in both longitudinal and transverse directions. The reinforcing alignment and glass content provide the structural capability necessary to support the dead load of roofing materials and wind uplift loads with minimal deflection.

The reinforcing content of 50% by weight in straight, continuous, bidirectional alignment is the basis of design for Tuff Span, the first FRP building panel used as a structural roof deck. This is also a typical requirement for other FRP materials used for demanding structural applications such as pultruded FRP beams and grating.

As a key part in developing the first FRP material used as a roof deck, engineers conducted repetitive, large-scale tests to accurately determine material capacity to support long-term, dead, and uplift loads at deflection levels typical for structural roof decks. The large-scale tests are the basis for load/span data developed for the FRP decks in *Figures 1* and *2* and their accompanying tables (*Tables 2* and *3*).

For metal deck panels, moment capacity is typically the limiting factor for determining maximum spans. However, for an FRP profile such as the 6.5 deck, deflection and stiffness (EI) can be the controlling design limits. These can result in longer allowable spans for a two-span condition when compared with a multiple span. To increase stiffness and maximum spans, these FRP decks are designed with greater panel depth than metal deck units. The 6.5 x 2 deck is 2 in. deep versus the 1.5-in. depth of conventional steel B Deck. The 8.0 deck is manufactured in 3.5-in. depth as compared to 3-in.-deep, steel N Deck.

6.5 x 2 VFR 500

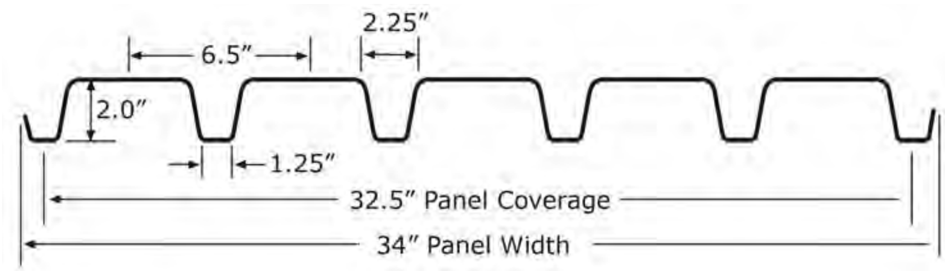

Figure 1

DEAD + LIVE / UPLIFT LOADING: L/D=180, FOS=2.5							
Uniform load, psf	**20**	**30**	**40**	**50**	**60**	**70**	**80**
Single span	7'0"	6'1"	5'6"	5'1"	4'10"	4'7"	4'4"
Two span	9'4"	8'2"	7'5"	6'11"	6'6"	6'2"	5'10"
Three or more spans	8'7"	7'6"	6'10"	6'4"	6'0"	5'8"	5'5"

Table 2

8.0 x 3.5 VFR 700

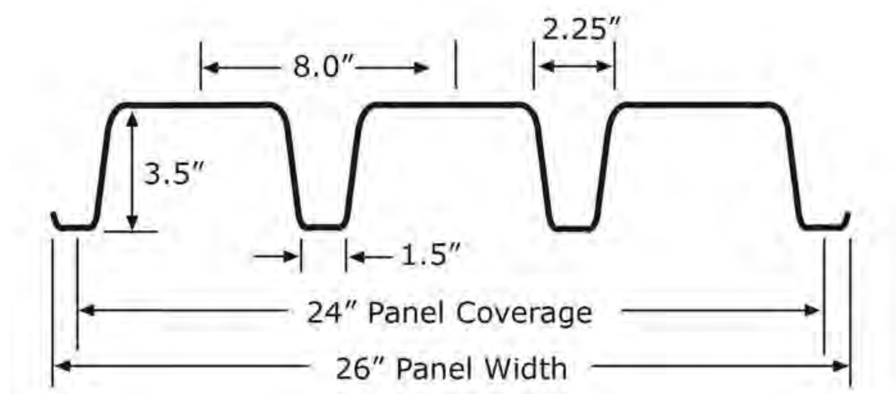

Figure 2

DEAD + LIVE / UPLIFT LOADING: L/D=180, FOS=2.5							
Uniform load, psf	**20**	**30**	**40**	**50**	**60**	**70**	**80**
Single span	9'6"	8'3"	7'6"	7'0"	6'7"	6'3"	6'0"
Two span	12'9"	10'6"	9'1"	8'1"	7'5"	6'10"	6'5"
Three or more spans	11'9"	10'3"	9'4"	8'8"	8'2"	7'8"	7'2"

Table 3

Photo 2 – Fastening of FRP roof deck to supports is similar to a metal deck. Layout of the lighter FRP sheets is faster.

Photo 3 – Mechanical fasteners or cold adhesives are commonly used to attach roofing membrane and insulation to FRP deck.

FM GLOBAL LISTINGS		
Roof Deck Section	**6.5 x 2 VFR 500**	**8.0 x 3.5 VFR 700**
Maximum span	6 ft. 3 in.	8 ft.
Fastener - washer diameter	1-60 = .729 in. 1-90 = 1.125 in.	1.125 in.
Side-lap fastener spacing	18" o.c.	24" o.c.
NC insulation fasteners	16 / 4 x 8 board	16 / 4 x 8 board
Polyiso insulation board	1.3 in.-thick minimum	1.3 in.-thick minimum
BUR glass felt	3 ply minimum	3 ply minimum
Wind uplift rating	1-90	1-90
Deflection limit	L/240	L/240

Table 4

Photo 4 – A corrosion-resistant, FRP roof deck can deliver long, maintenance-free service life in chemical or high-moisture exposures.

INSTALLATION

Offered in rib profiles similar to conventional steel deck, installation time and procedures for fastening FRP roof deck to supports are similar to those for a metal deck. With lighter weights, the layout of FRP deck panels is typically quicker and costs less than metal units. Compared to concrete decking, installation cost for a much lighter FRP roof deck is significantly lower.

Attachment of roofing insulation or membrane to FRP roof deck can be achieved by the following:

- Mechanical (positive lock) fasteners such as Enduro NC plastic, SFS-TPR peel rivet, or Rawl speed-lock toggle
- Cold adhesives such as Olybond 500, Duro-Grip, or an equal. Uplift data are available for Olybond 500 and Duro-Grip materials used with FRP roof deck.
- Hot bituminous adhesive (if allowed) with temperature not exceeding maximum value set by the *NRCA Handbook of Accepted Roofing Knowledge*

See *Photos 2* and *3*.

FM AND UL LISTINGS

FRP roof decks with vinyl ester and a fire-retardant resin system have a UL Class 1 flame spread rating of 25 or less in accordance with ASTM E84 testing. FRP roof deck sections are also UL listed for Class 90 uplift, including construction #NM523 for 6.5 x 2 VFR 500 and construction #NM524 for 8.0 x 3.5 VFR 700.

A roofing assembly with FRP 6.5 x 2 roof deck has FM Global approval for Class 1 fire and Class 1-90 windstorm classification. Other assemblies with FRP roof decks are listed as Class 2 per *FM Report J.I. OTOA9* (*Table 4*).

SUMMARY

Conventional metal, wood, or concrete roof decks may not be the best materials for chemical or continuous wet conditions. Structural FRP roof decks constructed with 50% reinforcing content, premium-grade vinyl ester, and fire-retardant resin have proven that they can provide longer service life and significant life cycle cost savings for these challenging structural and environmental conditions. The following two case histories are provided as examples.

CASE HISTORY: WEYERHAEUSER PAPER

Prior to June 1987, Weyerhaeuser Paper had tongue-and-groove wood roof deck installed on its Longview, Washington, paper mill. According to roof consultant Gus Siegrist of A.N.G. Consulting Services, Inc., the roof was leaking, and the deck was rotting and deteriorating.

Expecting that an FRP roof deck would stand up to the demanding conditions, Siegrist and Weyerhaeuser selected Tuff Span 6.5 VFR 500 roof deck to replace the 44,000-sq.-ft. wood roof deck. The FRP roof deck is still in service after 24 years and has delivered huge life cycle cost savings for Weyerhaeuser. See *Photo 4*.

CASE HISTORY: UNIVERSITY OF WEST FLORIDA NATATORIUM

As the result of exposure to moist, chlorinated conditions, the coated steel roof deck at the University of West Florida natatorium had been weakened by corrosion and seriously damaged during Hurricane Ivan. In its search for a replacement material, STOA Architects included the following requirements for the new roof:

- Resistance to chlorine vapors
- Resistance to hurricane-force, wind uplift loading due to its coastal location
- Compatibility with cold adhesives for attachment of roofing materials

STOA identified an FRP roof deck as the material that would provide performance superior to metal for the environmental conditions in the natatorium. Installed in 2005, the FRP roof deck has met expectations and provided outstanding service. See *Photo 5*.

Photo 5 – FRP roof decks are a suitable substrate for either single-ply or built-up roofing.

Tom Toler

Tom Toler has held senior management positions for both steel and FRP building panel manufacturers. During his career, Toler has contributed to the development of several FRP products, including FRP roof and form deck, FRP roofing panels supporting foot traffic, the first FRP exterior cladding to achieve FM approval, long-span FRP structural shapes, and FRP louvers and ridge vents. He served on the committee for the Society of Plastics Institute that developed ASTM 3841, the standard for fiberglass-reinforced plastic building panels. Tom is currently product manager for building and environmental products for Enduro Composites, Inc., located in Houston, Texas.