

FRP Composite Bridge Decks: Barriers to Market Development

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ABSTRACT

This paper reviews the progress and lessons learned during the first two years of 'Project 100', the state of Ohio's initiative to accelerate commercial development of FRP composite bridge decks. Project 100 was funded by a grant from the Ohio Department of Development and is managed by the National Composite Center in Kettering, Ohio. Technical and institutional barriers facing FRP bridge deck manufacturers as they try to penetrate the public sector infrastructure market are discussed. These barriers include price, standard specifications, competition, preferred material acceptance, and engineering infrastructure.

1.0 FRP BRIDGE DECK PROJECTS AT NCC

1.1 Review of Project 100

Project 100 was a state-backed initiative to capitalize on the anticipated growth of FRP composites in bridge decks and other infrastructure applications. Under this program, counties and municipalities in Ohio were subsidized for the initially higher cost FRP bridge decks through a grant from the Ohio Department of Development (ODOD) and administered by the National Composite Center (NCC) in Kettering, Ohio. In addition to assisting owners in project selection and engineering, NCC worked with FRP deck manufacturers, the Ohio Department of Transportation (ODOT), and other state DOTs and specifying agencies to develop standards for designing, fabricating, installing, and inspecting FRP deck panels. NCC concluded the second year of the proposed 6-year program which aims to speed acceptance of FRP bridge decks while reducing costs and demonstrating the performance advantages of composite materials.

In Phase I of the program, NCC selected Hardcore Composites of New Castle, Delaware to supply the deck panels. In return, Hardcore agreed to invest in local facilities to manufacture the panels, thereby creating a new industry in Ohio that will stimulate significant job growth as the demand for FRP products in infrastructure markets increases in coming years. By the end of Phase I in September 2001, Project 100 sponsored nine FRP bridge deck installations in Ohio. Details on the decks are shown in Table 1.

Bridge Name	Owner	Dimensions	Total Sq. Ft.	Manufacturer	Completion Date
Shaffer Road	Ashtabula Co.	175' x 17'	2,975	Hardcore	Oct. '01
Sintz Road over Rock Run	Clark Co.	62' x 30'	1,860	Hardcore	Nov. '00
Five Mile Road Bridge # 0171	Hamilton Co.	44' X 28'	1,232	Hardcore	Nov '00
Five Mile Road Bridge # 0087	Hamilton Co.	47' X 30'	1,410	Hardcore	May '01
Five Mile Road Bridge # 0071	Hamilton Co.	43' X 30'	1,290	Hardcore	Aug. '01
Elliot Run	Knox Co.	38'-10" x 25'-6"	975	Hardcore	July '00
Spaulding Road	Montgomery Co.	83'-1" x 56'	4,653	Hardcore	May '01
Westbrook Road	Montgomery Co.	34'-3" x 32'-8"	1,119	Hardcore	April '00
Hebble Creek	Wright Patterson AFB	32' x 17'2"	544	Comptek / Webcore	July '01

- Notes:
1. Sandwich constructions molded using the VARTM process.
 2. All wearing surfaces were asphalt.

Table 1. FRP Composite Decks Installed in Project 100

To support the program objective of establishing an FRP bridge deck industry in Ohio, the original goal of Project 100 was to design, manufacture, and install 100 composite bridge decks in Ohio during the period CY2000 through CY2005. The volume of product required to accomplish this goal would have been sufficient to stimulate creation of a manufacturing base in Ohio. Two conditions were required for this to happen: a single supplier would have to be “guaranteed” a significant share of the market to justify investment in an Ohio plant, and state funding would be required to subsidize bridge owners for more costly FRP decks in the near term until costs were reduced to a point at which FRP decks became competitive with conventional materials.

Unfortunately, while these conditions were satisfied for the first 18 months of the project, neither condition will be satisfied for the full planned duration of the program. In particular, procurement regulations make it impossible to direct a sufficiently high enough volume of business to a specific supplier (Hardcore Composites) to set up an adequate economic presence in Ohio. Therefore, NCC was compelled to consider other ways to achieve the economic development objective of the program.

The second major factor forcing a redefinition of the program was lack of state funding for Phase II of Project 100. The Ohio biennial budget for FY02-03

did not include funds for Phase II of Project 100. These realities forced a change in the of the program.

1.1 Current ‘Composites For Infrastructure’ (C4I) Initiative

A major effort at NCC is now focused on facilitating FRP bridge deck installations without state subsidy. An additional effort considers other infrastructure related applications that can make effective use of composites. These efforts fall under a new initiative at NCC called ‘Composites For Infrastructure’ (C4I).

The change in focus of the FRP bridge deck program is based on discussions with the Ohio Department of Development (ODOD), the Ohio Department of Transportation (ODOT), and the County Engineers Association of Ohio (CEAO). After installation of the last Hardcore bridge deck in Fall 2001, NCC will not primarily subsidize future bridge deck procurements. Merely subsidizing deck projects will not alone solve the issues that need to be addressed to enable FRP decks to be competitive. Future emphasis will be on more comprehensive system approach to enable the FRP deck business to grow: specifications development, industry liaison, providing a technical resource for counties interested in procuring FRP decks, performance monitoring of decks and possible selective subsidies.

NCC will facilitate the installation of six FRP decks in CY2002. NCC will act as technical resource for the counties and monitor the decks for two years after installation. The decks will be supplied by Martin Marietta Composites who can leverage the relatively small volume of FRP deck fabrication with its other non-infrastructure FRP product lines to create a business sufficiently large to justify a facility investment in Ohio. Martin Marietta will establish an assembly operation for its pultruded decks panels in the Dayton area.

2.0 BENEFITS OF FRP BRIDGE DECKS

Before addressing the barriers to more usage of FRP bridge decks, it is helpful to remember the many benefits of FRP decks. These well-recognized advantages are important motivations for overcoming the barriers to FRP deck market development.

Light Weight. FRP bridge decks weigh about 10 to 20 percent as much as a structurally equivalent reinforced concrete deck. Using an FRP deck to replace a concrete deck reduces dead load significantly, meaning that load-rated structures may be re-rated to their original design capacity or aging structures may be kept in service longer before they are replaced. In new construction, lighter dead load can translate into savings throughout the structure, as the size of structural members and foundations is reduced accordingly.

Corrosion Resistance. Corrosion of reinforcing steel is the leading cause of premature deterioration of concrete bridge decks. Use of road de-icing salts, combined with higher-than-anticipated traffic loads, accelerates this corrosion.

Because FRPs are not susceptible to the corrosion, FRP bridge decks offer a promising alternative to conventional materials in this highly demanding application.

Quick Installation Time. Fabricating deck panels in a factory and shipping them to the bridge site offers several advantages over cast-in-place concrete. Quality can be closely monitored in a controlled environment; the potential for weather delays is greatly reduced; and most significantly, bridge down-time can be substantially reduced. Once the superstructure is prepared, prefabricated FRP deck panels can be installed quickly, compared to the labor intensive process of erecting formwork, placing rebar, pouring and curing concrete, and removing the formwork needed to construct a cast-in-place deck.

High Strength. Since stiffness drives the design on FRP decks, the decks have high safety factors. Static tests of FRP decks greatly exceed the strengths of traditional material decks. The decks also have high ductility.

Lower Life Cycle Costs. Because of the projected durability of bridge decks made of FRP, savings in deck replacement and maintenance costs over a 100-year bridge service life could be much greater than the initial cost of the entire structure. The life cycle cost savings can be shown to more than offset the relatively high initial cost of the FRP materials compared to conventional material. However, as discussed below, long-range durability claims are viewed by the construction industry with some skepticism. Furthermore, few public agencies select materials based on projected life cycle costs. Instead, materials are chosen based on the engineer's experience and judgment, agency preferences, and industry standard practice, usually with a strong bias toward minimizing initial construction cost.

3.0 MAJOR BARRIERS TO FRP DECK MARKET DEVELOPMENT

The bridge deck industry represents a huge and largely untapped potential market for lightweight, corrosion resistant FRP composite materials. However, there are barriers to realizing this potential. The major barrier is PRICE, PRICE, PRICE. The other barriers of standard specifications, competition, preferred material acceptance, and engineering infrastructure are important, but can and will only be resolved when the price of FRP decks makes decks a viable option for bridge owners.

Price. Public agencies responsible for construction and maintenance of the nation's bridges are under tremendous pressure to do more with less. Every year, these agencies typically have a significant backlog of substandard bridges, all competing for limited maintenance dollars. Under these conditions, officials are compelled to maximize the number of bridges in serviceable condition at any given time, and rarely have the latitude to consider the life-cycle costs advantages of initially-more-expensive materials. Therefore, any decision to use more expensive materials must

be justified based on superior performance or specific project requirements. Project requirements that support using FRPs include reduced dead-load, speed of construction, proven performance in highly corrosive environments. However, engineers have difficulty using lower life cycle costs as a reason to use FRP decks for more common applications because data do not yet exist to support this decision.

FRP deck prices must become more competitive with traditional materials. Project 100 tried to use subsidies to build the volume needed to gain economy of scale. The factors mentioned previously prevented this from being fully realized. The FRP deck industry must now address ways to reduce the deck costs including type of materials, fabrication and standard deck designs. Costs of traditional deck materials range from as little as \$8-to-\$10 per square foot for timber to typical reinforced concrete decks in the range of \$25 to \$35 per square foot. Cost of FRP decks have been generally been twice the cost of these reinforced concrete decks. This factor needs to be reduced to at most 1.25 times the cost of the reinforced concrete decks to be a viable alternative.

FRP decks have been installed on an experimental basis on many different types of bridges. This has provided valuable experience. It may now be time for the FRP deck industry to concentrate on a single segment of the bridge market where it can provide standard deck solutions. One promising market segment is low profile decks. These thinner decks require less quantities of 'expensive' composite material. The bridges have fewer design issues than other decks. The specialized design support which must now be provided by the deck supplier is carried in the deck price or a separate engineering cost. Development of standard deck panels for this market segment could provide the bridge owners with a more cost-competitive 'bridge in a box'.

Standard Specifications. Specifications for the procurement and construction of FRP decks must be quickly developed so that bridge owners can obtain the decks within their procurement processes. The composite industry cannot expect a market to operate outside their established methods for too long. Experimental designations allow the FRP decks to go on a few bridges, but this will not build the necessary volume needed to sustain FRP decks as a viable business. Virtually all materials used in a civil engineering project are supplied in accordance with established standards that are widely recognized by the construction industry. In most states, suppliers' construction materials must be listed on the DOT's "approved" list before they can be offered by a contractor for use in a particular project. Such standards do not exist for FRPs in construction, and this is a barrier to widespread acceptance and use of composites. Many states also require that products be tested to their specific requirements before they are placed on the DOT's "qualified products list". As a new product enters the market, the cost of testing adds to the price of the decks.

Competition. As in all industries and products, the price of FRP decks is dependent on competition. There must be competing suppliers to push each other

to deliver lower cost solutions. Competition also provides bridge owners with choices to fit their needs and delivery schedules.

Acceptance as a Preferred Material. FRP decks need to be accepted as a preferred material for bridge construction in the same way that galvanized steel beams are accepted as a preferred material. Bridge owners can justify cost premiums for galvanized beams and this approach needs to be recognized for FRP decks.

Lack of Engineering Infrastructure. There are two areas where the lack of engineering infrastructure affects the market growth. The first is personnel. Most of the engineers familiar with composites are not from the construction market and are still learning the technical aspects and procedures of the bridge industry. On the other side, practicing civil engineers have only limited exposure to FRP materials and are not familiar with how to select, specify, or install composites. The second area is data and tools. Composite data related to bridge applications needs to be provided to bridge engineers in a format consistent with their procedures. Publishing articles in composites-related journals and trade magazines, or speaking at composites-related conferences, does little to remedy the situation since civil engineers are not in the composites industry and generally do not read these journals or attend these conferences. Civil engineers are in the construction industry. Composites manufacturers and trade groups need to recognize this fact and concentrate on “getting the word out” to their target market through appropriate channels.

For these reasons it will be some time before owners and consulting engineers are comfortable taking responsibility for design and installation of an FRP deck system. Suppliers must currently provide engineering support before and during construction. This will require panel manufacturers to work closely with consulting engineers, owners, and contractors to clarify limits of liability for design and installation. Standard products and installation methods will make FRP decks more acceptable to owners.

4.0 SUMMARY

The composite infrastructure development program sponsored by the Ohio Department of Development at the National Composite Center is working toward development of the FRP composite bridge deck market. The bridge deck industry represents a huge and largely untapped potential market for lightweight, corrosion resistant FRP composite materials. However, there are barriers to realizing this potential. The barriers are price, standard specifications, competition, preferred material acceptance, and engineering infrastructure and the greatest of these is PRICE. Project 100 attempted to use price subsidies to generate enough volume to reduce the price. Budget and procurement constraints have delayed attainment of this goal. NCC is working through its Composites For Infrastructure (C4I) initiative to assist the industry in overcoming these barriers. Efforts include assisting in the installation of six more ‘experimental’ bridge decks; facilitating the

development of a low-profile deck market segment where composite decks can be a cost-competitive preferred material; participating in development of standard specifications and providing technical resources to the bridge owners. Following this next installation of six FRP decks, the CEAO plans to pursue installation of six more FRP decks, but these will be done on a competitive basis.

BIBLIOGRAPHY

Scott R. Reeve is Vice President of Engineering at the National Composite Center. He has nineteen years of experience working with composite structures in the aerospace and commercial industries. He teaches multiple courses on composite technology and stress analysis. Mr. Reeve received a Masters degree in Engineering Management from Washington University and Masters and Bachelor degrees in Aeronautical Engineering from Purdue University.