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To: All State Directors
Attention: State Engineers

From: Director, National Applied Resource Sciences Center

Subject: Fiber-Reinforced Polymer Composites in Bridge Construction and Repair

Modern technologies discussed at the 1997 Western Bridge Engineers’ Seminar in Coeur d’Alene, Idaho, in October 1997 and at the 1998 Annual Meeting of the American Association of State Highway and Transportation Official’s (AASHTO) Subcommittee on Bridges and Structures in Nashville, Tennessee, in May 1998 included the use of fiber-reinforced polymer (FRP) composites in bridge construction and repair. A FRP composite is a combination of a polymer matrix and fiber reinforcement materials. FRP composite materials have been used in bridge engineering throughout the world for the past 25 years.

The polymer matrix is typically a thermoset resin which is a plastic that changes into a substantially infusible and insoluble material when cured by the application of heat or chemical means. Polyester, isopolyester, vinyl ester, epoxy, and phenolic resins are polymer matrices. Fiber reinforcement materials include aramid, glass, and carbon. Aramid is a high-strength, high-modulus fiber used in the production of Kevlar and Nomex. The constituent elements of FRP composite materials including the resin, reinforcement, filler, and additives do not dissolve or merge into each other but rather retain their individual identities to provide highly beneficial properties such as corrosion resistance, high strength-to-weight ratios, freeze-thaw and weathering resistance, and design flexibility.

FRP composite materials are manufactured by several processes including pultrusion, hand lay-up, continuous braiding, and vacuum-assisted resin transfer molding. Pultrusion is a continuous process for manufacturing composites that have a cross-sectional shape where fiber-reinforcing material is pulled through a resin impregnation bath and through a shaping die in which the resin is cured. Hand lay-up is the process of placing successive plies of reinforcing material or resin-impregnated reinforcement in position on a mold by hand. Continuous braiding is the process of weaving reinforcing fibers into a tubular shape instead of flat fabric to produce fiber reinforced tendons. Vacuum-assisted resin transfer molding is the process whereby resin is transferred or injected into a mold in which fiberglass reinforcement has been placed. The resin is then infused into the dry fiber preform by vacuum. FRP products include beams, columns, channels, angles, tubes, sheets, bars and rods, tendons, decking, grating, guardrails and barriers, concrete reinforcement, formwork, composite dowel bars, and fender, bearing, friction, and sheet piles and bulkheads.

The overall performance of a structure consisting of FRP composite materials is largely dependent upon the selection of the constituent materials such as the resin used, the type of fiber reinforcement, volume fractions, and fiber orientation. FRP composites are orthotropic materials in nature which means that the physical properties of the material can vary along different axes. Since FRP composites are a relatively new-engineered material, codes and standards for the design and construction of FRP structures have not been fully developed. However, empirical formulas and design procedures have been developed and tested over the years. Therefore at the present time, the services of a FRP product manufacturer or FRP engineering consultant should be engaged if FRP composites are specified for a particular project.

FRP composites are somewhat more expensive, initially, than conventional materials such as concrete and steel. However, savings can be realized during design, construction, and maintenance activities. Faster installations because of pre-fabricated modular construction, reduced use of heavy equipment during construction because of reduced weight, and long service life because the material won’t crack, spall, or rust all contribute to savings during design, construction, and maintenance activities. The ease of handling and application, minimal disruption to the structure’s function, and the versatility of the materials have contributed to the increased use of FRP composites in bridge construction and repair. The extent to which FRP composites will be used in the future will be dependent upon the resolution of technical issues such as fire performance and durability, the extent to which automation in the manufacturing process can reduce cost, and the availability of validated codes, standards, and guidelines which can be used as design references and tools by the engineering profession.

Please direct any questions or comments to Keith Christiansen, NARSC Architecture and Engineering Group, at (303) 987-6853.

Signed by:
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