South Carolina
Department of Transportation

UNIVERSITY OF SOUTH CAROLINA

U.S. Department of
Transportation
Federal Highway
Administration

SUMMARY REPORT

Report Number FHWA-SC-99-02
April 1999

South Carolina
Department of Transportation
955 Park Street
P.O. Box 191
Columbia, SC 29202

Bridge Rehabilitation Using Fiber Reinforced (FRP) Composites

STATEMENT OF THE PROBLEM AND SCOPE OF REPORT

The FHWA estimates that 21.7% of bridges in South Carolina are structurally deficient or functionally obsolete. It is necessary to identify practical and cost efficient technologies to rehabilitate these structures. The South Carolina Department of Transportation (SCDOT) has determined that the use of FRP materials for highway bridge rehabilitation shows considerable promise in addressing many of the issues incumbent with the state's deteriorating infrastructure.

This report is an extensive summary of the state-of-the-art for infrastructure repair using FRP materials. The report summarizes international research and development efforts in this area as well as demonstration projects and field applications of FRP rehabilitation technology. The report also identifies the particular nature of transportation infrastructure deficiencies in the State of South Carolina.

The authors present conclusions, based on their review, as to how and where the State of South Carolina and the South Carolina Department of Transportation may best address the issues of infrastructure rehabilitation of local concern.

SUMMARY OF CONCLUSIONS

Although a considerable body of research investigating the use of FRP composite materials for infrastructure rehabilitation does exist, this work is incomplete in all senses. Most existing research has focussed on the structural retrofit of bridge structures, primarily for seismic loads. The structural enhancement, using FRP materials, of bridge columns, piers and beam elements has been well documented, however few formal guidelines or recommendations exist to aid the practitioner.

Although the structural enhancement provided by FRP materials has been studied extensively, little emphasis has been placed on long-term performance characteristics such as: 1) fatigue performance of FRP rehabilitation measures; 2) creep behavior of FRP rehabilitation measures; and, 3) the effects of exposure to severe environments. All of these issues have particular significance pertaining to bridge structures. Indeed, it is also noted that the general enhancement of structural characteristics is often unclear and conclusions are often disputed. The majority of studies have focussed on the structural capacity of the exposed portions of bridge piers. Rehabilitation of superstructure elements has not received considerable attention. Substructure rehabilitation studies are virtually nonexistent.

With few exceptions, research programs comprise laboratory studies often on smaller than full-scale specimens. Such studies are

carried out under optimal conditions for structural behavior and quality control. An important parameter that has traditionally been neglected is the quality of FRP application and how this affects both the structural and long term response of the system.

Continued research is necessary to provide reliable characterization of both existing and emerging FRP rehabilitation technologies. Particular attention needs to be paid to issues of long-term performance of FRP rehabilitation techniques. Additionally, research is necessary to investigate quality control methods and the influence of application quality on the final product.

There is a paucity of field applications of FRP materials for the rehabilitation of infrastructure systems. Additionally, it is the authors' opinion that there are surprisingly few demonstration projects having a sound methodology which would allow the characterization and evaluation of various materials and processes. Assuming that the goal of demonstration projects is to evaluate FRP rehabilitation systems, it is necessary to pursue a methodology which will allow evaluation and comparison under realistic conditions.

The impetus behind many of studies and projects included in this report is seismic retrofit in regions of high seismicity. Certainly, South Carolina has many seismic related rehabilitation issues, however the nature of seismicity and expected ground motion in South Carolina is considerably different from that of the Western United States, where the majority of existing research has taken place.

What few durability studies exist, focus on durability issues relevant to Northern climates, such as extreme cold temperatures and attack from deicing salts. Other climate related issues have remained largely unstudied. These include: 1) exposure to a marine environment; 2) exposure to a large number of freeze-thaw cycles as may be expected in Western South Carolina; and, 3) exposure to extreme warm temperatures and ultraviolet radiation.

Significantly, few studies or field applications have addressed the acknowledged infrastructure rehabilitation requirements of South Carolina (and presumably other South Eastern states). Focussed research efforts that would address these issues include: 1) the use of FRP materials to rehabilitate deteriorated and deficient conventionally reinforced concrete beams and slabs; 2) the use of FRP materials to rehabilitate timber piles; and, 3) the use of FRP materials to rehabilitate prestressed concrete piles, particularly those subject to a marine environment.

Research efforts aimed at the evaluation of FRP rehabilitation systems must include characterization of the following. It is noted that few extant studies approach multiple aspects of FRP behavior.

1. structural enhancement, including strength, stiffness and toughness, afforded by FRP rehabilitation techniques;
2. long-term durability of FRP systems subject to representative severe environments;
3. long-term performance of FRP systems including the effects of creep and fatigue loading;
4. durability and performance of the FRP-substrate interface, in particular the mechanisms of bond;
5. the effect that product and application quality have on all performance parameters; and,
6. the economics and ease of use of FRP rehabilitation systems.

Appropriate characterization of all aspects of FRP system performance will aid in determining appropriate uses for and the limitations of each type of rehabilitation system.

An integrated research and field application effort is necessary to address these issues. An integrated approach will allow more efficient allocation of the limited resources to the already under-allocated area of infrastructure rehabilitation.

This research project was conducted at the University of South Carolina by Michael F. Petrou, Ph.D., Kent A. Harries, Ph.D. and Christos Papakonstantinou.
for further information, contact Terry Swygert at SCDOT: (803) 737 6652; swygerttl@dot.state.sc.us