**TECHNICAL SUMMARY**

**Nondestructive Evaluation of Fiber Reinforced Polymer Bridges and Decks**

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## INTRODUCTION

During the last several decades it has become apparent that bridges constructed with conventional materials have inherent drawbacks for certain applications. Fiber reinforced polymers (FRP) are being used increasingly both for new construction and for the rehabilitation of existing structures. Some advantages offered by fiber-reinforced polymers include: high strength-to-weight ratio, resistance to corrosion, and the ability to be mass produced in virtually any shape. Several fabrication processes are currently in use including resin infusion, contact molding, and pultrusion. Each of these processes has inherent limitations and advantages.

As fiber reinforced polymers find their way into the civil infrastructure, it will be imperative that a means of assessing the quality of the original product and monitoring the product during its service life be established. In the pressure vessel and piping industries, FRP materials have been used in structural applications for over 40 years. During the 1970, a series of FRP vessel failures occurred with sometimes-catastrophic results. These failures necessitated the development and implementation of a nondestructive evaluation method. The most suitable method was acoustic emission monitoring. Evaluation procedures and codes were subsequently developed that incorporated the method.

Acoustic emission monitoring is a sensitive global test technique that can be used to detect significant damage as it occurs in a structure. Due to the advent of affordable, high speed computing and advances in interpretation techniques, acoustic emission monitoring continues to develop at a rapid pace. It is likely that acoustic emission monitoring will be an integral part of the design process and the structural health monitoring of FRP components for use in civil applications.

This report presents the findings from an experimental study conducted on a full-scale specimen that is representative of an FRP honeycomb bridge that has recently been constructed and successfully load tested. The specimen had been cyclically loaded to two million cycles at its design load level prior to the testing described in this report. A detailed and simplified finite element model of the specimen was constructed and the results were compared to experimentally gathered values.

## OBJECTIVES

The objective of this study was to assess the feasibility of the acoustic emission method for the assessment of damage in a full-scale honeycomb FRP specimen. A secondary objective was to assess the feasibility of using a simplified finite element modeling approach to predict load versus deflection behavior of the same specimen.

## SCOPE

The experimental testing of the full-scale FRP honeycomb specimen and the presentation of relevant data are given. The experimentally gathered data includes strain, displacement, load, and acoustic emission. The modeling procedures used for both the detailed and simplified finite element models are described.

## RESEARCH APPROACH

The full-scale FRP honeycomb specimen was evaluated through the monitoring of acoustic emission, load, displacement, and strain. Eight acoustic emission sensors were used and these were equally spaced along the top of the specimen. The specimen was loaded to increasing percentages of the ultimate load and allowed to recover on several different occasions. On the final occasion, the hydraulic rams were extended to their full stroke of 6 inches and held until failure of the specimen occurred.

## CONCLUSIONS

The following conclusions were drawn based on the limited experimental testing and numerical modeling:

1. Interpretation of the acoustic emission data indicated that little or no significant damage occurred in the specimen as a result of the fatigue loading to two million cycles.

2. The first indication of significant damage as determined by interpretation of the acoustic emission data occurred at approximately 40 percent of the ultimate load.

3. Acoustic emission monitoring provided insight into the progression of damage in the specimen. Damage appeared to begin inside the two loading points and then progressed to the ends of the specimen.

4. The results of the finite element model corresponded well with the experimentally measured results. The simplified finite element approach agreed well with both the detailed finite element approach and the experimentally gathered data. The modeling of the support conditions proved to be an important consideration.