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DETECTING GROUT DEFECTS IN CABLE STAYS: NONDESTRUCTIVE EVALUATION TECHNIQUES

DEPARTMENTAL INFORMATION EXCHANGE

TEXAS TRANSPORTATION INSTITUTE

In cooperation with
Texas Department of Transportation
and the FHWA

Summary Report

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PROBLEM STATEMENT

The Neches River cable-stayed bridge, the first of its kind in Texas, was recently opened to traffic. A second cable-stayed bridge, to pass over the Houston Ship Channel near Baytown, is presently under construction. The cable-stayed bridge is a superstructure of steel or reinforced concrete members supported by a system of inclined cables attached to towers located at the main abutments or piers. This concept supports several benefits: versatility that allows a wide variety of geometrical configurations to suite various purposes and site requirements; economy in material, weight, and cost; and pleasing aesthetics.

As worldwide experience with these bridges accumulates, one problem continues to present itself as yet unsolved—how to identify and prevent corrosion of the cable stays and thus preserve the fatigue life of the structure.

The cable itself usually consists of multiple steel strands with one or more parallel or twisted individual wires. The usual corrosion protection practice in the U.S. is to encase the cable in a steel or polyethylene (PE) pipe and fill the region between the cable and the pipe with a portland cement or epoxy grout. A four-inch wide, weather-resistant tape is then wrapped around the outer surface of the PE pipe to protect it from harsh environmental elements, mainly from solar heating. In principle, the grouting procedure should result in complete filling of the pipe, but in practice, voids or bubbles may become trapped in the grout and then act as storage points for the accumulation of bleed water which, if adjacent to steel strands, often results in localized corrosion.

Since the removal and replacement of deteriorated cables is so costly, the department needs an efficient and accurate means of nondestructively inspecting the cables for defects in the protective grout layer, so that corrective measures may be taken to prevent the onset of corrosion.

OBJECTIVES

The Texas Transportation Institute (TTI) conducted study 0-1268, *NDE Techniques for Detecting Grout Defects in Cable Stays*, in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA) to evaluate promising nondestructive evaluation (NDE) technologies and to develop inspection techniques for detecting voids and other defects in the protective grout layer surrounding the steel strands of a cable stay.

Researchers conducted a thorough literature review to identify the most promising NDE methods. Various radiographic and ultrasonic technologies then underwent experimental laboratory analysis with such tasks as establishing relevant material properties, determining optimum values for the parameters required, and then further evaluating the effectiveness of each technique using representative samples of actual cable stays. From these results, researchers were able to target the most promising NDE techniques, develop performance specifications, and construct and test prototype hardware in a laboratory environment.

FINDINGS

Of the radiographic techniques investigated, computed tomography (CT) was selected over neutron radiography and film radiography. Computed tomography devices use a beam of x-ray or gamma-ray sources synchronized with a radiation detector. Scatter data from scans of the object are digitized, stored, and analyzed with the final results appearing as a cross-sectional image or a picture of a sliced object (tomograph).

The CT devices tested in this study detected air-filled and water-filled voids, some as small as 0.04 in. (1mm) in diameter, in both the annular region of the grout and inside the steel cable bundle. In fact, radiographic techniques appear to be the only feasible choice for inspecting the lower regions of the cable stays where anchorage details and fire and crash protection measures significantly complicate the geometry.

The ultrasonic experimental results confirmed the potential for using ultrasonic techniques to inspect cable stays, particularly in the annular region of grout between the PE pipe and the cables. Although the method developed is limited to detecting voids in the outer annular region of grout and is not useful for inspection between the steel strands, the potential advantages of a high-speed ultrasonic inspection unit outweighed this limitation. Therefore, researchers constructed a prototype ultrasonic inspection unit to conduct a more in-depth investigation and determine the feasibility of transferring this technology to the field.

The prototype inspection unit (figure 1) employs two ultrasonic wheels (rolling contact transducers) mounted to an aluminum support frame which consists of two end rings and several cross beams. Hard rubber wheels are placed on either side of the ultrasonic wheels for positioning and guidance. The prototype was designed to operate in a through-transmission mode with the wheels inspecting along a chord through the grout as the device travels longitudinally along the axis of the cable. A fully operational field unit would require 5 ultrasonic wheels spaced at 72 dg increments to provide full coverage of the cable's grout layer.

Finally, researchers conducted a laboratory investigation using the prototype ultrasonic inspection unit on cable stays with manufactured defects. Several methods of signal analysis were used to evaluate the signals, resulting in a high degree of consistency. The prototype did locate the manufactured defects, but information regarding the size and content of the defects was inconclusive.

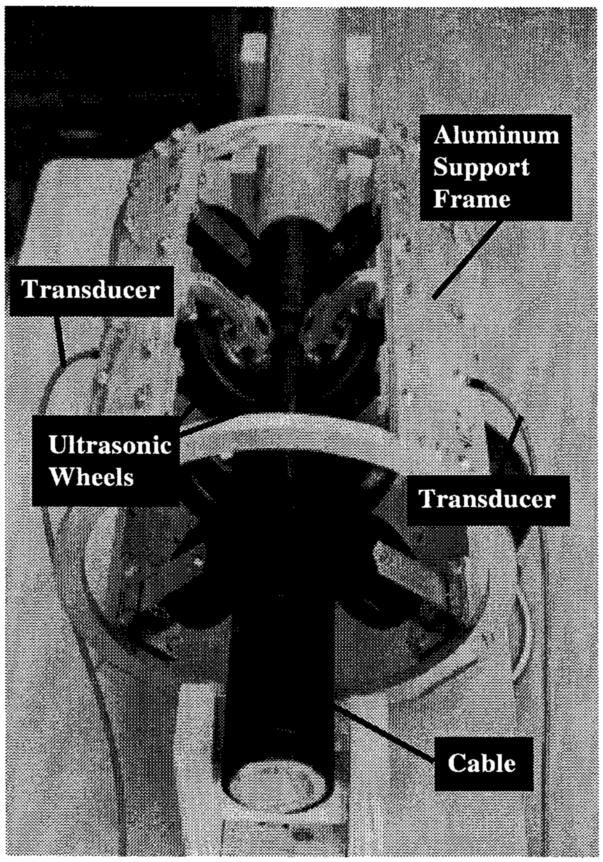

Figure 1: Prototype Ultrasonic Inspection Unit

CONCLUSIONS

The ultrasonic approach is limited in its ability to inspect the lower regions of the cable (in the fire and crash protection zones) and in detecting voids between individual strands. However, the initial cost of such a system is relatively low and researchers believe that the potential usefulness of the device as a quick means of inspecting the annular region of grout outweighs these limitations.

Since the CT techniques show high potential for effective inspection of the lower regions of the cable and in the steel bundles, areas where ultrasonics are not ideal, researchers recommend full development of a CT field inspection unit as well. The technology for developing a portable CT inspection device currently exists and is strictly a matter of cost. Due to the potential nationwide application of a CT inspection device and the high initial development cost, researchers recommend that its development be funded at a national level. Recommended specifications concerning the device are detailed in the report.

Additional work with the ultrasonic inspection unit is recommended to more fully analyze and interpret the content of the received signals. This would allow inspectors to determine flaw size and content of the voids. The culmination of this work would be the development of a fully operational inspection unit suitable for field implementation. This research shows that a combination of the two devices (ultrasonic and CT inspection units), if fully operational, would form a successful system for detecting defects in the grout of cable stays.

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The information described in this summary is reported in detail in TTI Research Report 1268-1F, "NDE Techniques for Detecting Grout Defects in Cable Stays," by Roger P. Bligh, Ray W. James, Don E. Bray, and Sreenivas Nakirekanti, August 1993. The contents of the summary do not necessarily reflect the official views or policies of TxDOT or the FHWA.