TRANSPORTATION RESEARCH BOARD

A3C06 Structures Maintenance

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Recording of Bridge Condition in Virtual Reality Format

David V. Jáuregui

Recent studies conducted by the Federal Highway Administration (FHWA) have raised several issues in need of further action to improve routine bridge inspections. The research conducted at New Mexico State University (NMSU) has focused on the implementation of QTVR (QuickTime Virtual Reality) and panoramic creation utilities to better document the field observations and measurements made during a routine inspection of a bridge. A virtual reality approach provides the capability to document a bridge's physical condition in digital format at a significantly higher level of detail compared to a written bridge inspection report. The development of a QTVR bridge record consists of four major steps: 1) planning of site visit and selection of camera stations, 2) acquisition of

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Bolt Loosening Retrofit in Iowa's Multiple Steel Girder Bridges

Brent M. Phares, Terry J. Wipf, Lowell F. Greimann, & Douglas L. Wood

The Iowa Department of Transportation (DOT) has encountered a recurring fatigue problem in some of the multiple steel girder bridges constructed in the 1960's and 1970's. Through routine visual inspections of these bridges, cracks in the area commonly referred to as the web gap, which is between the top of the web stiffener fillet weld and the top flange, have been identified. Although not exclusively, cracks have been most commonly found in the negative moment regions of these bridges. It has been determined that these fatigue cracks result from differential deflection

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AASHTO/FHWA International Scan:

Bridge System Preservation and Maintenance

Ian Friedland

Background and Panel Scope: Automation of inspection and management systems is becoming an integral part of managing the nation's transportation infrastructure. This is particularly true with processes associated with the design, inspection, maintenance, and operation of highway bridges and other highway structures many of which are aging and deteriorating in the United States. Although progress has been made in several areas of automation, more can be learned from bridge inspection and management processes, and the associated systems and technologies which are employed abroad. During the period March 28 through April 13, 2003, the U.S. AASHTO/FHWA Panel on Bridge System Preservation and Maintenance, which was comprised of ten members representing AASHTO, FHWA, State DOTs, the National Association of County Engineers, and academia,

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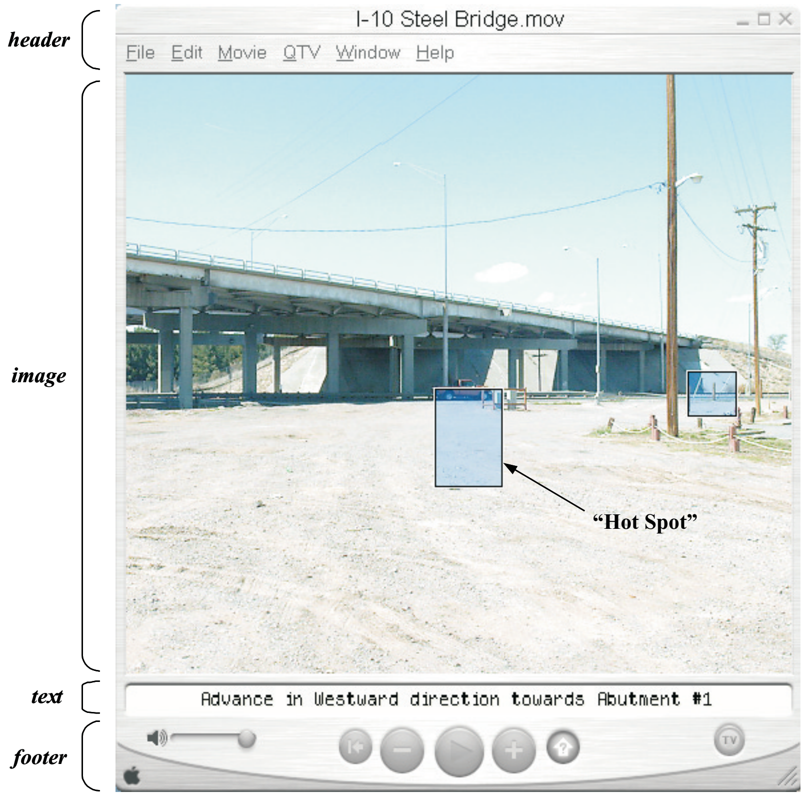
Figure 1: QTVR record of steel bridge showing header, image, text, and footer areas of screen.



… Jáuregui on Virtual Reality Format

digital images, 3) creation of panoramic images, and 4) rendering of QTVR file incorporating "hot spots".

Figure 1 shows the opening scene from a QTVR record of a steel bridge. The *header* or top portion of the screen contains the bridge designation and the menu items for the QuickTime player. The middle or *image* portion of the record contains the area where panoramas are displayed. The inspector may scroll within this viewable image area with the use of the computer mouse. The rectangular boxes within the viewable image area represent "hot spots" which link the panorama in existing view to other panoramas. As the inspector brings the cursor into the area of a "hot spot", a text description towards the bottom of the screen (i.e., the *text* area) describes the link. A simple click of the computer mouse with the cursor positioned in the "hot spot" will display the linked panorama in the image area. In addition to other panoramas, "hot spots" may also link the active panorama to individual pictures of noted problem areas. On the bottom portion of the QTVR screen or *footer* are buttons that allow the inspector to zoom in and out within the viewable screen area, to toggle the display of the "hot spots" on and off, and to return to the previous panorama and/or individual picture.

This technique has been used in various bridge inspection projects in the state of New Mexico including: 1) bridges and culverts on US 550, 2) the Omega Bridge in Los Alamos and 3) several Bureau of Reclamation bridges including the Elephant Butte and Caballo spillways. Experience from these projects has shown that the QTVR technology has the potential to advance the state-of-the-practice for recording bridge inspection data for purposes such as enhancing the training of inspectors, facilitating the review of previous bridge inspection records, and overall improving bridge management systems.

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IMPLEMENTATION OF VIRTUAL REALITY IN ROUTINE BRIDGE INSPECTION
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Photo 1: Drilling to Arrest Fatigue Cracks

... Phares on Bolt Loosening Retrofit

of adjacent girders. Specifically, differential deflection causes the secondary transverse members (i.e., diaphragms) to induce out-of-plane forces into the web because they are rigidly connected to the girder webs. These forces, combined with a lack of connection between the stiffener plate and the girder top flange and the fact that the top flange is restrained from movement by the deck slab, cause the web to distort out-of-plane. Repeated loading of this type has caused fatigue cracks to develop and grow in the web gap.

In the 1980's the DOT began drilling holes at the terminus of the cracks in an attempt to stop, or slow, the crack propagation. However, this technique has not always proven successful either because of difficulties identifying the crack terminus or because the stress levels were simply too high.

Realizing that a better solution was needed, the Iowa DOT in coordination with the Bridge Engineering Center at Iowa State University developed an alternate retrofit scheme. This retrofit, quite simply, involves loosening of bolts in the girder-to-transverse member connections. By loosening these bolts, the existing rotational restraint in the connection is reduced. This results in the transverse members being allowed some rotation without inducing out-of-plane displacements in the web gap.

Several bridges across Iowa have been tested before and after installation of the bolt-loosening retrofit including bridges with X-type bracing, K-type bracing, channel-shape diaphragms, and I-shape diaphragms. Monitoring of these bridges has typically included recording strain levels in the web gap region, out-of-plane displacement of the web gap, and behavior of the transverse members during both short-term and long-term tests under controlled and ambient loading.

In all but the K-type bracing bridge, a reduction of over 75 percent in web gap strain and out-of-plane displacement that may contribute to web gap fatigue cracking was found by installing the bolt-loosening retrofit. Long-term testing has revealed that these reductions basically remain stable over time.

Before implementing this retrofit, good practice suggests that a bridge owner must consider the impact on the overall structure behavior. First, girder stability must be checked in light of the removal of the transverse members. However, it is more than likely that even if girder stability was found to be lacking, that the retrofit would not jeopardize structural integrity because the diaphragms might still provide lateral support under extreme situations as the loose bolts could "engage" with sufficient displacement. Second, the impact on lateral load distribution should be considered. However, research conducted on the impact of transverse members on lateral load distribution has consistently indicated that even complete removal has minimal impact on structural behavior.

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BOLT LOOSENING RETROFIT TO INHIBIT FATIGUE CRACKING IN STEEL GIRDER BRIDGES

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NewsLetter

Have an item for STRUCTURES MAINTENANCE NEWS?
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traveled to the African and European continents and met with highway agency representatives, and bridge management and inspection technology practitioners and researchers, from the following countries: South Africa, Switzerland, Germany, France, Denmark, Sweden, Finland, Norway, England, and Wales.

Specific topics of interest to the U.S. Panel addressed during the International Scanning Tour included:

- Organizational, policy and administrative issues including: relationship among agencies (national, local); organization of their bridge activities (design, construction, operation, inspection); inventory ownership and management; inventory characteristics (number, type, materials, span lengths); and inspection type, frequency, and rigor.

- Status of their Bridge Management Systems (BMS) including: economic modeling and forecasting; deterioration modeling; and information technology (databases, architecture, input, data transfer, updating)

- Inspection issues and practices including: typical practices; innovative methods; use of non-destructive evaluation (NDE) technologies; use of load testing; design for inspection (e.g., accessibility) and "smart" bridges.

- Operations issues and practices including: permit vehicles; load rating and load posting; indicators of performance and their relationship to design and other activities; maintenance; repair; and enforcement.

A number of important policy and operational issues that could have a significant impact on U.S. bridge management practices were identified during the scanning tour, and will be further evaluated and discussed with appropriate U.S. bridge owning and operating agencies. Included in these are:

- Bridge inspection frequency based on bridge type and consequence risk;
- Bridge inspector qualifications and training;
- Development of integrated highway structure management approaches which include bridges, tunnels, freestanding retaining walls, sign and light structures, etc.;
- Application and use of appropriate waterproofing systems for bridge deck protection;

The AASHTO/FHWA Panel is currently preparing a draft report documenting the findings of the Scanning Tour, which should be ready for dissemination and technology implementation by AASHTO and the FHWA near the end of 2003.

Call for Papers

TRB Committee A3C06 Structures Maintenance

Annual Transportation Research Board Meeting
Washington, D.C., January 2004

Preventive Maintenance Procedures
Performed on Bridges

Papers that provide case studies of bridge preventive maintenance are being solicited for presentation at the Annual TRB meeting and for subsequent publication in the TRB Research Record following peer review. Papers must be submitted to TRB by August 1, 2003. Guidelines for preparing a paper can be obtained from TRB at http://www4.trb.org/trb/annual.nsf. Authors are requested to reference the Committee designation "A3C06" when completing the paper submission process. For additional information see the A3C06 website http://gulliver.trb.org/webboard/A3C00 or contact A3C06 Chair Ron Purvis, 730 378 3021, ronpurvis@erols.com