Guidelines for Selection of Bridge Deck Overlays, Sealers, and Treatments

CONCRETE BRIDGE PRESERVATION

CBP

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The selection and use of bridge deck rehabilitation methods varies widely throughout the United States. Some agencies have developed guidelines but they are limited in scope and detail. While each state likely views the need for deck repairs differently, a set of guidelines based on a general consensus of Department of Transportation (DOT) engineers throughout the country, backed by research and experience, is useful in promoting more consistent and universal procedures for decision making. A recent National Cooperative Highway Research Program (NCHRP)[1] study conducted a survey of transportation agencies and developed just such a methodology for selecting bridge deck treatments for different bridge deck conditions and deck materials.

Survey of Transportation Agencies

The guidelines were developed based on a survey sent to all U.S. DOTs and Canadian highway agencies to obtain information on what criteria are used to make repair decisions about deteriorating bridge decks. A primary goal of the survey was to identify methodologies and procedures used by agencies to guide decisions regarding bridge deck maintenance and repair. These processes vary widely in complexity and many are unwritten or take the form of simple tables or flowcharts. Some procedures reference bridge inspection methods such as the National Bridge Inventory (NBI) condition ratings[2] or Pontis element condition ratings.[3]

The survey showed that repair methods vary between highway agencies and often are based on a few limited techniques with which the agency is familiar. Further, the extent of tolerable damage varies widely between states with the decision to consider full deck replacement triggered when surface distress exceeds from 20% to over 50% of the total deck area. Therefore, the NCHRP Guidelines[1] proposes decision levels and repair techniques that are a general composite of those reported by the agencies. The guidelines were also developed to be flexible to allow individual states to easily modify the decision levels and repair options. While a particular repair option may work well in one part of the country, since the agency has had success specifying the repair and local contractors have the proper equipment and experience to install it successfully, the same technique may not be well suited for another agency because the local experience is not available and would have to be developed.

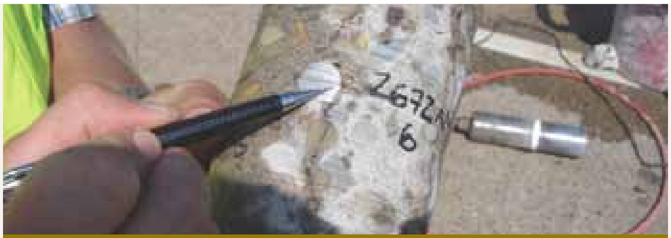
Selection of Repair Options

The selection of the various deck repair options is performed in two steps. First, the general category of repair that is needed is determined based on the current deck condition. The deck characterization process is driven by assessing the following factors:

1. ***Percent Deck Deterioration and NBI Condition Ratings*** – determined by the percent of non-overlapping area of patches, spalls, delaminations, and copper-sulfate half-cell potentials more negative than -0.35V and the National Bridge Inventory condition rating based on examination of the top and bottom deck surfaces.

Bridge with lane closed to perform a deck condition survey.
All Photos: Wiss, Janney, Elstner Associates Inc.

Deck spalls, delaminations, and patches due to corrosion of reinforcement.



Core sample showing transverse deck crack intersecting an embedded reinforcing steel bar.

2. ***Estimated Time-to-Corrosion*** – expressed as the estimated time until sufficient chloride penetration occurs to initiate corrosion over a given percentage of the deck area.

3. ***Deck Surface Condition*** – consideration of the deck surface condition related to drainage, surface scaling, abrasion loss, or skid resistance problems.

4. ***Concrete Quality*** – related to evidence of alkali-silica reaction (ASR), delayed ettringite formation (DEF), freeze-thaw damage, and concrete strength issues.

The guidelines provide a table that considers these deck characterization factors to facilitate a decision on one of the following four repair categories:

1. ***Do Nothing*** makes sense for a deck in satisfactory condition with little corrosion risk in the next 10 years or for a deck that is programmed for replacement in the near future.

2. ***Maintenance*** may include patching, crack repairs, or use of a concrete sealer. This option is best for decks showing little or no serious distress and with little risk of deterioration in the near future.

3. ***Protective Overlay*** is appropriate if the deck has moderate deterioration or is likely to have deterioration in the near future, and the deck is not in need of immediate replacement. Bonded overlays provide a new wearing surface so deck surface conditions, such as cross-slope and grade, joint transitions, drainage problems, abrasion resistance, skid resistance, or surface scaling problems, can be improved. Deep milling can be used to remove deteriorated wearing surfaces and chloride contaminated deck concrete.

4. ***Structural Rehabilitation*** may include partial-depth or full-depth deck replacement. Deck Replacement is selected when the deck has serious deterioration, concrete durability problems, needs strengthening, or a combination of factors that indicate other rehabilitation methods are not suitable.

Decks that are exposed to deicers but have accumulated little chloride are good candidates for sealers or membranes. Decks that have high chloride concentrations in the near surface but little chloride at the reinforcement level are good candidates for surface milling to remove the chlorides and then application of an overlay. The service life of decks with high levels of chloride close to the level of the reinforcement can be extended with overlays, but long-term performance may be reduced since corrosion will likely continue at a slow rate. Decks with very high chloride contents, on-going corrosion, and damage are good candidates for partial- or full-depth deck replacement. Further, in addition to knowing the level of chloride contamination, it is important to understand if the concrete has serious durability or strength concerns before selecting a repair option.

Second, the best repair material option within a category is selected based on various site conditions, such as traffic constraints, dead load or overhead clearance limitations, remaining service life, general exposure conditions, construction constraints, skid resistance, concrete cover, contractor experience, planned future work, cost, or other conditions. In addition, the guidelines provide methods and information useful to help evaluate the deck condition; prepare the deck for sealing, crack repair, or other rehabilitation methods; and estimate relative costs and durability of the various deck rehabilitation methods.

References

1. Krauss, P. D., Lawler, J. S., and Steiner, K. A.,"Guidelines for Selection of Bridge Deck Overlays, Sealers and Treatments," NCHRP Project 20-07, Task 234, Transportation Research Board, Washington DC, May 2009. Available at http://maintenance.transportation.org.

2. *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges*, FHWA-PD-96-001, Federal Highway Administration, Washington, DC. U.S. Department of Transportation, Washington, DC, 1995.

3. *Guide for Commonly Recognized (CoRe) Structural Elements*, American Association of State Highway and Transportation Officials, Washington, DC, 2002.

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Louisiana's Bridge Preventive Maintenance Program

by Danny Tullier, Louisiana Department of Transportation and Development

The Louisiana Department of Transportation and Development (LADOTD) believes that an aggressive and strong preventive maintenance program is needed to slow the deterioration processes at work on our bridge structures. As a result, LADOTD initiated the Bridge Preventive Maintenance Program in early 2006 to help extend bridge service lives.

In July 2007, the Federal Highway Administration (FHWA) approved this program, which focuses on bridges in good structural condition, but are deteriorated, damaged, or exhibiting deficient elements.

LADOTD's goal is to apply systematic, cost-effective treatments to existing bridge elements to preserve their current condition and delay deterioration. A portion of the Highway Bridge Program (HBP) funds is used to perform various approved bridge preventive maintenance activities such as:

- joint repair and replacement
- bearing repair and replacement
- localized deck repairs
- spot painting
- deck sealing
- grid deck section repair or localized section replacement
- concrete spall repair on pedestals, bents, caps, piling, piers, and columns
- bridge deck drainage repair

Specific work is selected based on a systematic process approved by the FHWA. The bridge inventory and inspection data are utilized as a source of information for making selections.

Since the program began, LADOTD has let a total of 14 bridge preventative maintenance projects at a cost of $5.7 million. The majority of these maintenance contracts have been deck joint rehabilitation on interstate bridges. Other projects have included a thin deck overlay on U.S. 90 just outside the New Orleans area and deck spall repairs on I-10 between Baton Rouge and Lafayette. The state is currently involved with other maintenance projects to spot paint a bridge over a large river crossing and to replace failing elastomeric bearing pads.

A 3-in.-thick concrete overlay was applied to this six-span bridge under the LADOTD preventative maintenance program.
All Photos: Louisiana Department of Transportation and Development.

Louisiana is currently implementing a Bridge Management System using the AASHTOWare computer program Pontis. The state is nearing completion of the 2-year cycle of bridge inspections, at which time all bridges will have element-level data in the program. The 2-year cycle is expected to be complete by July 2010.

The LADOTD recognizes the importance of a well-maintained transportation system and is striving to utilize a portion of the HBP funds to extend the service life of the bridge infrastructure.

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This is a failed steel armored expansion joint that was eligible for repair, and the joint following rehabilitation with polymer concrete.

Advances in Nondestructive Evaluation and Structural Health Monitoring of Bridges

by Larry D. Olson and Yajai Tinkey, Olson Engineering Inc.

New sonic-based nondestructive evaluation (NDE) technologies, developed from impact echo (IE) scanning research, are now available to bridge engineers. These technologies address corrosion concerns in post-tensioning (PT) tendons due to voids in ducts and delaminations in concrete bridge decks. Radar-based structural health monitoring technology has developed from interferometric phase radar research for noncontact monitoring of displacements and vibrations of bridges and other structures and even landslide movements.

Sonic Impact Echo Scanning for Structural Concrete Integrity

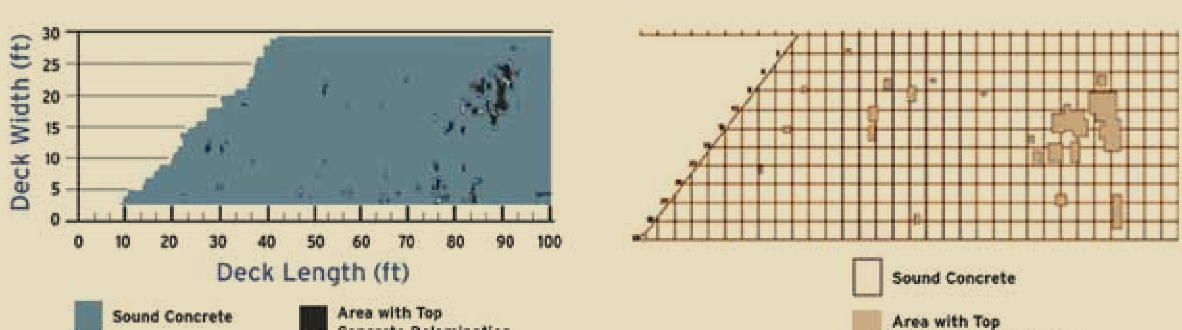
Point-by-point IE tests have been used to detect voids in PT tendon ducts and tconcrete deck delaminations due to corrosion of reinforcement. However, the use of IE testing has been limited due to the comparatively slow rate of the point-by-point testing. Research by the authors has resulted in the advancement of IE scanning tests for faster evaluation of structural concrete conditions. IE scanning tests can now be conducted using either a handheld rolling impact echo scanner (IES) or a Bridge Deck Scanner (BDS) attached behind a vehicle for testing larger surface areas with rougher surface conditions. Research was conducted with both the IES and BDS systems under funding from the National Cooperative Highway Research Program—Innovations Deserving Exploratory Analysis (NCHRP-IDEAS).

Bridge deck scanner (BDS) towed behind a vehicle.

With the IES and the BDS systems, readings may be taken as close as 1 in. and 6 in. respectively along a scan line. Recent test results showed good correlation between a shallow delamination map obtained from the BDS system and acoustic sounding using a chain drag. The typical time required for testing a 36-ft-wide and 300-ft-long bridge deck with points on a grid of 1 ft by 0.5 ft is approximately 3 to 4 hours.

Interferometric Phase Radar for Structural Monitoring

Non-contact interferometric phase radar is available to measure the displacement and vibration of bridges. The use of the interferometric phase radar with the Imaging By Interferometric Survey System for Structures (IBIS-S) allows for rapid monitoring during load testing of bridges. IBIS-S is a system using innovative microwave radar that was developed

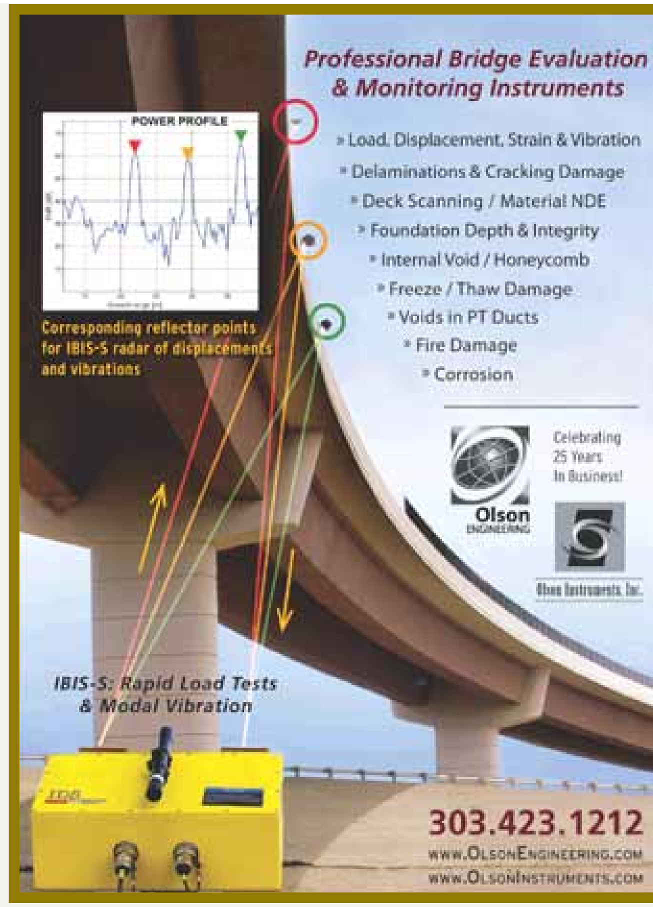


A top surface delamination map from the BDS system (left plot) and the traditional chain drag acoustic sounding results comparison (right plot).

by IDS of Pisa, Italy, in collaboration with the Department of Electronics and Telecommunication of Florence University. The IBIS-S system precisely measures structural displacement with a precision of up to 0.0004 in. and vibration frequencies from 0 to 100 Hz. The system can simultaneously measure the displacement response of several points on bridges and other structures with high accuracy as long as clear reflecting surfaces can be identified (or installed) at least 1.6 ft apart. In addition to its non-contact feature, the new displacement and vibration measuring system provides other advantages including quick set-up time, a wide frequency range of response, and portability. A case history from a demonstration test of the IBIS-S system performed on a post-tensioned, curved, precast concrete box girder bridge in Golden, Colo., is included in the referenced paper. The primary objective of the demonstration was to measure the deflection time-histories and maximum deflections of the bridge under normal automobile and truck traffic loading. Due to the noncontacting nature of the system and operational range, all testing was performed with no traffic disruption and minimal field support requirements.

Summary

IES has been found to provide accurate detection of voids in ducts of post-tensioned bridges and can be readily applied in hand-scanning large areas of bridge walls and decks. Recent research and consulting has built on the IES method to provide a BDS that is capable of providing high-quality data on concrete bridge decks for accurate location of distress. The IBIS-S system can be rapidly deployed for short-term displacement and vibration monitoring. This facilitates the use of short-notice, economical static and dynamic load tests as well as measurement of operating displacements and ambient vibration measurements.



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A detailed paper on this topic by Larry Olson was presented at the 2010 Federal Highway Administration Bridge Engineering Conference: Highways for LIFE and Accelerated Bridge Construction, April 8 and 9 in Orlando, Fla. By permission of FHWA, it is available at the ***ASPIRE***™ website, www.aspirebridge.org, click on "Resources" and select "Referenced Papers."

Handheld impact echo scanner device, traditional point-by-point" impact echo unit.