THE IMPORTANCE OF PARTNERSHIPS IN THE IMPLEMENTATION OF BRIDGE PRESERVATION PRACTICES

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Abstract

This paper discusses the advantages of multi-discipline partnerships for instituting bridge preservation programs from the perspective of the bridge maintenance engineer. FHWA, AASHTO, and other stakeholders, including the bridge maintenance community, are working collaboratively to increase communications in developing a more holistic approach to managing highway structures. This paper will briefly review a few of the communication initiatives implemented, describe several "best practices", and identify topics for further development within three areas pertinent to bridge maintenance; 1) bridge management; 2) bridge design; and 3) "maintenance friendly" materials.

Introduction

FHWA and AASHTO have been instrumental in providing avenues for bridge maintenance practitioners to meet and discuss issues through peer exchanges and web-based formats. Though bridge maintenance was discussed in such circles as TRB Committees and the AASHTO Subcommittee on Bridges and Structures, most often bridge maintenance engineers were in the minority or not in attendance. The Bridge Technical Working Group (BTWG) to the AASHTO Subcommittee on Maintenance was one of the only conferences specifically focusing on bridge maintenance. A few regional groups, such as the Midwest Working Group and the Pacific Northwest Maintenance Conference, invited bridge maintenance practitioners to meet and discuss the issues specific to bridge maintenance. On the whole, however practicing maintenance engineers had limited opportunities to participate in peer to peer discussions.

In 2007 the BTWG to the AASHTO Sub Committee on Maintenance developed a Bridge Preservation and Maintenance (BPAM) Strategic Plan. The document was created to provide a comprehensive strategic plan for highway bridge preservation and maintenance. The plan listed objectives of identifying good practices and strategies, succession planning strategies, communication needs, identified suggested research topics, promoted management systems, materials innovations, and requested the creation of regional partnerships consisting of bridge preservation and maintenance stakeholders. The BPAM was included in a resolution entitled AASHTO Bridge Preservation Strategic Plan Recommended Strategy Focus Areas 2008 - 2013 adopted by the AASHTO Standing Committee on Highways in 2008. The document continues to serve as a roadmap for bridge preservation stakeholders.

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In 2009, AASHTO contracted with the National Center for Pavement Preservation (NCPP) to include bridge preservation in their Transportation System Preservation Technical Services Program (TSP^2), which was formed only a few years earlier to focus on pavement preservation. The TSP^2 now provides administrative services, a website, FAQs web board, and on-line library assisted in the creation and continues to support regional partnerships on bridge preservation. All stakeholders involved with bridge preservation were invited to become members. Owners, consultants, suppliers, academics, and contractors were invited to join one of four regional partnerships covering all AASHTO members.

During the same period, FHWA held a national meeting to develop a research roadmap for bridge preservation. Stakeholders representing a variety of disciplines gathered to develop and prioritize research needs statements. The process has been successful as topics related to bridge preservation continue to receive funding through the NCHRP.

The multi-disciplined approached was also used by FHWA in 2010 to define the term "Bridge Preservation", Again, owners, product manufacturers, consultants, FHWA officials, and academics were brought together to work toward a definition. The definition is currently under consideration for adoption by AASHTO.

The draft definition states: "Bridge Preservation: Actions or strategies that prevent, delay or reduce deterioration of bridges or bridge elements, restore the function of existing bridges, keep bridges in good condition and extend their useful life. Preservation actions may be preventive or condition-driven." (Ahmad, 2011)

Bridge preservation is more than bridge maintenance. AASHTO, FHWA, and others advocate for owners to adopt preservation strategies that "employ long term strategies", include "sustained and adequate funding sources", and ensure the "appropriate treatments are applied at the appropriate time". The concept of preservation necessitates that treatments are available for various condition states, that management systems are based on element level condition assessment, and have the capability of identifying, prioritizing, and estimating bridge needs. Bridge maintenance engineers support the implementation of these concepts.

Bridge Management

Bridge management until recently was essentially a "worst-first" program. Federal funding was primarily focused on structurally deficient and functionally obsolete bridges. Much has changed. Perhaps the precursor to a review of all bridges began with the implementation of Pontis, offered by AASHTO as a national bridge management system.

Pontis provides for element level bridge condition ratings, perhaps the singularly most significant enhancement in managing a network of bridges. Bridge conditions could now be described on an element level basis as opposed to the three components used in the National Bridge Inspection program (deck, superstructure and substructure). Element level conditions are critical in identifying and addressing early failures thereby avoiding more costly repairs. Recording the "condition state" goes even further as it provides the maintenance engineer with a comprehensive review of the condition of the element.

Pontis Task Force members are primarily state bridge management engineers with input from other groups, including bridge maintenance engineers. Pontis enhancements currently under development include condition rating information for steel coatings and wearing surfaces. These protective systems are currently rated in a review of the primary member and the structural deck, respectively. Maintenance engineers will thereby be informed when protection systems have been compromised. Pontis will also be able to group bridge needs. It currently lists response options for individual needs. Grouping bridge needs is expected to improve system derived options for treatment selection and improve repair estimates.

The requirements instituted to obtain high quality condition data are not matched for inventory data. Uncertainty in data quality, missing data, and incorrect inventory data hamper reviews on the performance of new materials, investment strategy outcomes, feedback on changes in design details, compliance with technical memorandum on assessments, or improvement in element level deterioration modeling. It is not unusual for a maintenance crew to remove an armored angle expansion joint and replace it with a polymer-based system without the inventory being updated. Most agencies do not currently have a link between their maintenance management system and their bridge management system.

Needs lists, derived from data from the bridge inspection program, do not capture all the needs of the network structures. U.S. Domestic Scan 07-05 entitled <u>Best Practices in Bridge Management Decision-Making</u> identified the need for management systems to be flexible and work to include the experiences of the regional or district personnel. Host states mentioned the needs list developed by the agency's bridge management system contained, at best, 50 to 55% of the needs identified by field reviews. Management systems using safety-based inspection criteria are not capturing the same information collected by regional staff. Regional or District bridge maintenance engineers and crews may have 20 plus years of experience with a set of bridges. Agencies recognize the value of this experience and allow regional management to edit the needs lists.

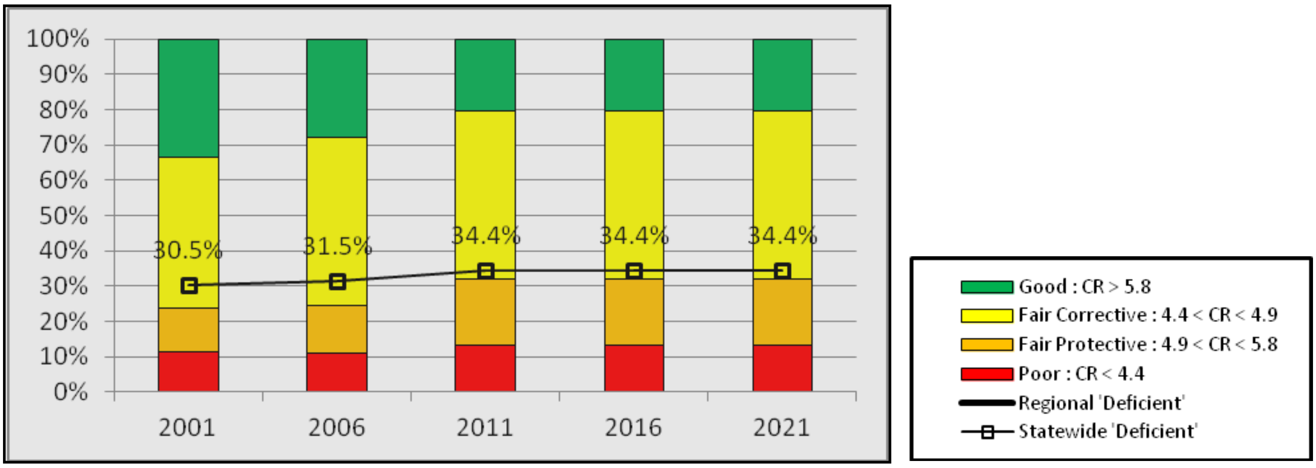
Durability is not captured in current inspection systems and as a result management systems are not able to differentiate between a good performing bridge with a low condition rating, health index, or sufficiency rating or a poor performing bridges with good ratings. Bridge maintenance engineers determine durability through experience, either by bridge design type or knowledge of the performance of an individual bridge. To illustrate: a jack arch structure with a low condition rating does not concern the maintenance engineer. Ratings for those structures do change significantly and the structure still has ample service life even in poor condition. On the other hand, even a slight change in the condition rating of adjacent pre-stressed box beams causes alarms. These structures do not age well and can fail catastrophically.

BIN 3346310 Built 1925

BIN 1011510 Built 1983

An international scan tour on Bridge Evaluation Quality Assurance in Europe outlined the German SIB-Bauwerke system of rating bridges. German inspectors rate structures for 1) structural stability, 2) traffic safety, and 3) durability. The study found that "in Europe, the emphasis is greater on determining the cause of a particular defect in the bridge." "This is in contrast to the U.S. approach of characterizing the element or component, which essentially characterizes the effect of the defect". (Everett, 2008)

Many agencies are moving to include alternative indicators to measure network conditions. Bridge programming now looks to minimize the percentage of structurally deficient structures by including a review of the conditions of the entire network. Agencies have increased efforts to keep bridges from becoming deficient. The most common approach divides the network into categories of Good–Fair-Poor based on condition. Historic data and forecasting methods can be used to track the movement of bridges over time.



System Bridge Conditions by Deck Area *courtesy of NYSDOT*

Municipalities, counties, cities, and towns own slightly more than 50% of the bridges in the U.S. In most cases, they do not have the resources to adequately maintain their structures. Consultants are typically held on retainer to provide designs for emergency repairs and design services for bridge rehabilitation or replacement projects. Some consultants, however, have found a niche by providing municipalities network management services. The City of Rochester, New York has secured consultant services for the inspection, needs assessment, maintenance program development & design, and construction inspection services for the city's 70 bridges. The consultant essentially acts as the manager of the inventory, determines bridge needs, and develops the bridge preservation plan for the network.

Designing for Access

A vast amount of effort has gone into research of new materials and design parameters expected to improved bridge performance. Epoxy coated bars, joint-less bridges, and high performance concrete are some examples of common enhancements aimed at improving the service life of highway structures. Comparably, however, little attention has been paid to designing for the maintenance of the bridge. Bridge maintenance engineers generally adhere to the realization that "all concrete cracks, all joints leak, and rust never sleeps" (Welch 2005). Some of the following suggestions would facilitate maintenance and inspection efforts throughout the life of the structure.

Increasing the size of the pedestals and/or diaphragms would facilitate bridge jacking operations. Steel sliding bearings need to be lubricated approximately every six years. To properly lubricate the bearing, the bridge has to be raised. Bearing manufactures do not supply a parts list or maintenance requirements for their bearings. It would be helpful if the expansion bearings included a means to indicate if they were still capable of movement. If "frozen", a maintenance action could be programmed to avoid deterioration of the anchor bolts and pedestals.

Access to the substructure is not easy. Traversing 1 on 2 slopes, even without tools and ladders, is difficult. When 10" (254 mm) sized loose stones (rip–rap) are used for slope protection footing becomes hazardous. Setting up ladders and scaffolding on narrow or non-existing berms is difficult. A level six foot (1 meter) wide concrete berm for tall abutments would facilitate inspection and maintenance operations.

Designers should consider the possibility that typical maintenance activities may not be possible to perform for standard bridges carrying high volumes or high speed traffic. It is difficult to obtain approval for multi-lane closures on interstate roadways for maintenance actions. Joint repair, deck sealing, and deck repairs may not be performed until serious conditions exist. Alternative means of access, stainless rebar, and durable waterproofing membranes could be included in the design for these service conditions.

Materials

Most materials adopted by an agency come through the maintenance organization first. To be able to "apply the right treatment at the right time", maintenance managers need a tool box of products for assorted conditions. Typical activities performed by maintenance crews focus on deck waterproofing systems, correcting leaking joints, protecting steel elements, and concrete repairs. Perhaps the primary factor, after safety considerations, in selecting repair materials is speed. Not only is it hazardous to be working next to high speed traffic, but traffic delays are unacceptable. Overnight lane closures or concrete barrier protection for bridge maintenance activities are seldom employed.   Field crews need to "get in and get out".

The most common deck waterproofing system, bituminous sheet membranes, were developed for the roofing industry. These peel and stick sheet membranes are labor intensive and time consuming. Spray applied applications with automated equipment increase productivity but are more costly. Manufacturers have responded to failures attributed to bond by introducing hot applied membrane systems. Some agencies now specify only hot or torch applied systems.

Polymer manufactures attentive to deck maintenance needs have developed materials and application techniques. Thin Polymer Overlays (TPOs) are easily applied by maintenance crew using a "broom and seed" or a slurry method and have provided satisfactory performance for a number of years. These materials offer minimal dead load, require no adjustments to bridge rails or existing expansion joints, but are more costly than sheet membranes.

The use of second generation polymer modified binders, developed for pavement preservation applications, has promising potential for use as a deck waterproofing system. These materials require minimal surface preparation, are comparatively cost-effective and placement rate are similar to those of HMA applications. They have minimal dead load (typical thickness of 3/8' (9.5 mm), and may provide a long term waterproofing barrier. The material and application technique, commonly called Nova-chip, can be formulated with a high percentage of rubber and a low modulus of elasticity. Representatives from the pavement preservation industry now attend bridge preservation conferences.

The New York Department of Transportation is working with a local inventor who has developed a moisture sensor using the concept of a "beneath the surface" wireless technology. These sensors measure moisture of the concrete through wires on the side of the units. Resistivity readings are taken through the membrane by a computer surface unit that excites the sensor. The low cost sensors are being placed in shallow cavities in existing bridge decks. Wiring or batteries are not required. A variety of waterproofing systems are being reviewed to determine if they are effective as a waterproofing barrier.

Bridge maintenance engineers probably spend more time attempting to correct leaking expansion joints and avoid the subsequent deterioration of elements under the joint, then any other bridge activity. Manufacturers have responded. Innovations in design and materials, especially for small movements allow for rapid replacement using “maintenance friendly” materials and techniques. Polymers with low modulus of elasticity provide a resilient anchoring material, an important characteristic for protection against the impact of snow plows. These two part materials, most commonly epoxies, are easy to use, and are traffic ready in 3 hours depending on ambient temperature.

Various seals are available. Pourable silicones are useful for non-parallel, and irregular surfaces, but surface preparation is critical. Pre-formed closed cell foams are more tolerant of contaminated surfaces, are inexpensive, but must be sized accurately and can be difficult to install. Manufactures have responded by developing W and V-shaped pre-formed seals of neoprene or silicone which provide for a wider range of movement. These seals are very easy to install but are considerably more expensive.

When these joints fail, it can most often be attributed to improperly sizing of the seal. All too common a measurement of the opening is taken on the day of installation without consideration of the movement range of the structure. A common misconception is to measure the opening on the day of installation and size the seal (typically foam) ¼” (6.35 mm) wider than the opening. Despite manufactures claims to the contrary, a good practice is to size the seal so it does not go into tension. Manufactures are working to make the installation of the seal as foolproof as possible.

A notable innovation is the used of urethane-based repair materials. A small company in Washington has developed an application where the ultra-low viscosity resin is pumped from barrels, mixed in the nozzle and gravity-fed onto gap graded 3/8” (9.5 mm) angular aggregate. This application has been well received by maintenance crews. Modified urethanes are traffic ready in 30 minutes, can be placed in below freezing temperatures and significantly increase productivity. Mixing in 5 gallon (3.78 liter) containers and placing with hand trowels is eliminated. Several other manufactures are developing similar applications.

Silane sealers provide an inexpensive barrier to the ingress of chlorides for reinforced concrete. They perform well in the laboratory testing. However, the effectiveness of silane sealers on in-place structures is not well documented. Effectiveness studies for in-place applications are difficult to conduct and require a lengthy assessment period. A comparative review of deck condition data of agencies known to have a generally consistent sealing program to that of those known that do not seal bridge decks could prove informative. Sealers do not prevent contaminates from entering through cracks in the concrete. Manufactures are working to enhance sealers with corrosion protection properties. Studies on the effectiveness of a penetrating sealer on vertical surfaces, such as columns and abutments would also be helpful.

Coatings of paints are the primary means of protecting steel superstructures. Blasting the surface is necessary because the paint systems specified require a white metal or near-white metal surface profile. Most agencies have dropped their in-house painting programs because of prohibitions against open blasting. The efforts of the manufactures and the coatings industry have been on extending the service life of the paint system, whereas the bridge maintenance engineer is focusing on extending the life of the superstructure. Coatings that could be applied on surfaces requiring much less preparation and capable of providing some years of protection are being sought by maintenance engineers. Manufacturers of older technologies such as high content calcium sulfonate, long chain non-polar hydrocarbons, such as marine grease are working with bridge maintenance engineers to assist in providing some protection against section loss between painting projects.

Summary

The multi-disciplined approach of including all stakeholders in the discussion of needs to address bridge preservation concerns has yielded immeasurable benefits. The ability to respond to the needs of an aging infrastructure with limited funding will require input from many sources. Peer exchanges, such as the Regional Bridge Preservation Partnerships, now only in it's second year of existence, has already proven beneficial for bridge designers, maintenance managers, industry, and the consultant community.

Coordinating the energies and interests of the various stakeholders becomes a much more realistic endeavor when done through partnerships. Through the communication of needs, sharing good practices, and developing a unified statement of objectives, partnerships are assisting in developing a more holistic approach toward bridge management.

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