VIRGINIA'S PREVENTIVE MAINTENANCE CHALLENGES AND INNOVATION

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Abstract

The Virginia Department of Transportation (VDOT) has a bridge inventory that includes over 21,000 structures that need immediate action to prolong their service life. To address the challenges associated with the aging bridge inventory, VDOT intends to develop a long-term plan to improve the general condition of the bridge decks, superstructures and substructures. The plan will safeguard mobility throughout Virginia by managing preventive maintenance and restorative activities processes. In addition, VDOT plans to continue its use of high performance materials, improve detailing practices, and use innovation to minimize future maintenance activities in all bridge structures.

Virginia's Bridge Inventory, Age and Condition

The Virginia Department of Transportation (VDOT) structures inventory includes over 13,000 structures (bridges and culverts) that are part of the National Bridge Inventory (NBI) and approximately 8,000 non-NBI structures. NBI structures are defined in federal regulations (23 CFR 650, Subpart C) and include bridges and culverts that have a length greater than 6.1 meters, while VDOT defines non-NBI structures as those that are less than 6.1 meters in length and have an opening greater than 3.34 m^2. VDOT proactively treats their entire structure inventory (NBI and non-NBI) in a similar manner and the processes discussed apply to all 21,000 structures. VDOT owns over 92% of the structures within the state (only 8% owned by cities and localities) and therefore they have the fifth largest state-owned bridge inventory is the United States.

As shown in Figure 1, over 55% of VDOT's structures are over 40 years old. This is an important fact, as these structures were designed with a service life of 50 years and this means that over 10,000 structures in Virginia have exceeded or are within 10 years of the end of their anticipated design life.

VDOT determines the condition of its structures from regular inspections and the assigned General Condition Rating (GCR) for the deck, superstructure and substructure (GCR is defined in the National Bridge Inspection Standards (NBIS), ranges from 0-9, and represents an overall accessment of the element). In addition to GCR information, VDOT collects element level inspection data for all of the bridges. Using the GCR and the element level data, VDOT analyzes the information using a customized bridge

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management system (BMS). Using a customized Pontis bridge management system enables VDOT to forecast the deterioration patterns of its bridge inventory in Virginia, to determine the magnitude of the preventive and restorative maintenance needed, and to develop strategies to address them.

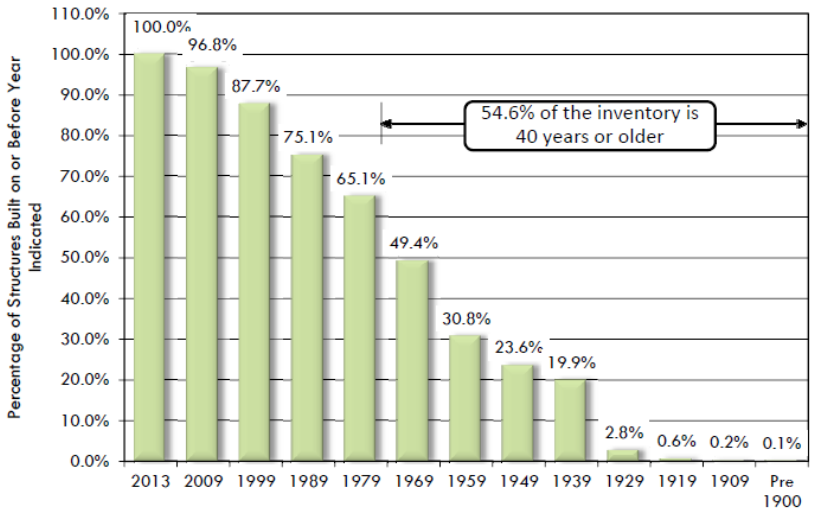

Figure 1. Cumulative Age Distribution of Structures (Bridges and Culverts)

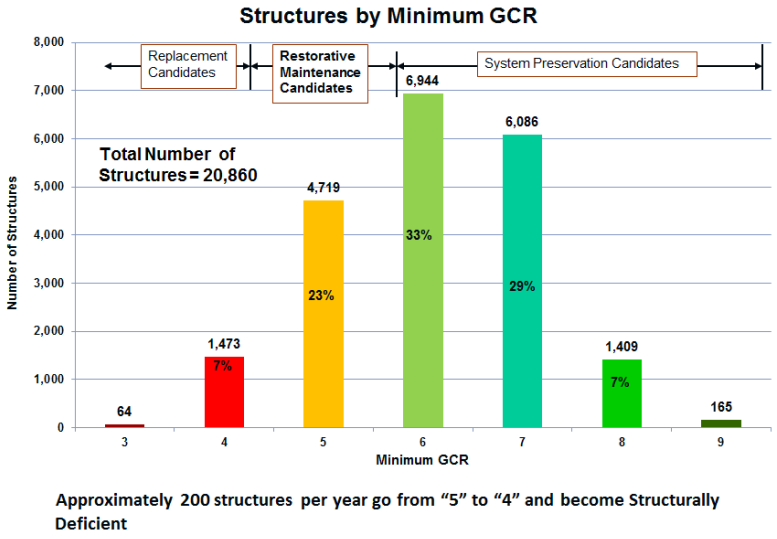

Figure 2. Number of Structures by Minimum GCR.

Preventive Maintenance Activities

Over the years, VDOT along with Virginia Center for Transportation Innovation and Research (VCTIR) and Federal Highway Administration (FHWA) have worked together to utilize proven preventive maintenance activities to minimize deterioration and to extend the service life of these structures. The typical and most commonly used

preventive maintenance activities in Virginia include, but are not limited to, the replacement of leaking joints, use of thin overlays on bridge decks, zone painting and/or spot painting of structural steel, and washing of bridge decks and substructure units on a regular basis. Preventive maintenance activities, when planned and done systematically, have proven to be the most cost-effective for maintaining and extending the service life of structures.

Continuation of current preventive maintenance practices, taking into account the age, design life, and deterioration trends of the structures inventory will lead to a steady increase in structurally deficient structures. Based on the forecast wave of structures that may become structurally deficient, VDOT is proactively pursuing changes to their long-term plan (approach) for maintenance of their aging structure inventory.

New Innovative Approach

The revised approach incorporates the restorative maintenance of structures with general condition rating of five (5), and continues to emphasize the need for systematic preservation activities for the rest of the structures (Figure 2). Examples of restorative activities proposed and used by VDOT include the repainting (over-coating and/or recoating) of existing steel structures, rigid deck overlays, reconstruction (eliminating) of joints, retrofitting of fatigue prone details, and the use of cathodic protection systems in substructures units.

VDOT's revised approach incorporates the elimination (or replacement) of joints in a timely manner, rigid deck overlays, use of data driven decisions, evaluation of new materials and methods, and an acknowledgement not to pursue a "worst-first" approach. Moreover, the proposed plan takes into account the importance of the structure within the transportation network and commerce.

Critical to the success of reducing the number of structurally deficient bridges is the need to codify "best practices" and work to improve the message about the importance of maintenance of the structures within the transportation network. If the public understands the importance of the work, then prioritization (and funding) of the activities may be more readily available.

One of VDOT's priorities and/or emphasis areas is promoting the message to '*keep the roof dry and clean*'. This message is something that the general public can relate to but perhaps never equated with a bridge deck. As with a house, if the roof leaks, the supporting members (superstructure) deteriorate. Similarly, if the joints leak, then the substructure will eventually deteriorate. If you get wet when it rains, you get sick!

Keeping the '*roof dry and clean*' can be accomplished by eliminating joints whenever possible, timely installation of thin/rigid overlays, maintaining the drains in a functional condition and sweep and wash of bridge decks and substructure seats. Whereas

in the past we kept trying different joint systems and replacing them every 10-20 years, now we eliminate the joint and do not have to worry about it for the remaining service life of the structure. Furthermore, using high performance materials, including engineered-cementitious composite (aka, "bendable" concrete developed at VCTIR), Ultra High Performance Concrete (UHPC), corrosion resistant reinforcement, etc., VDOT has seen an increase in the durability and performance of these closures and a reduction in their cost. Virginia has utilized the detail shown in Figure 3 over the past 20 years with excellent success. Based on their experience, VDOT plans to increase the use of the detail, establishing ways to track its use, and develop corresponding performance measures.

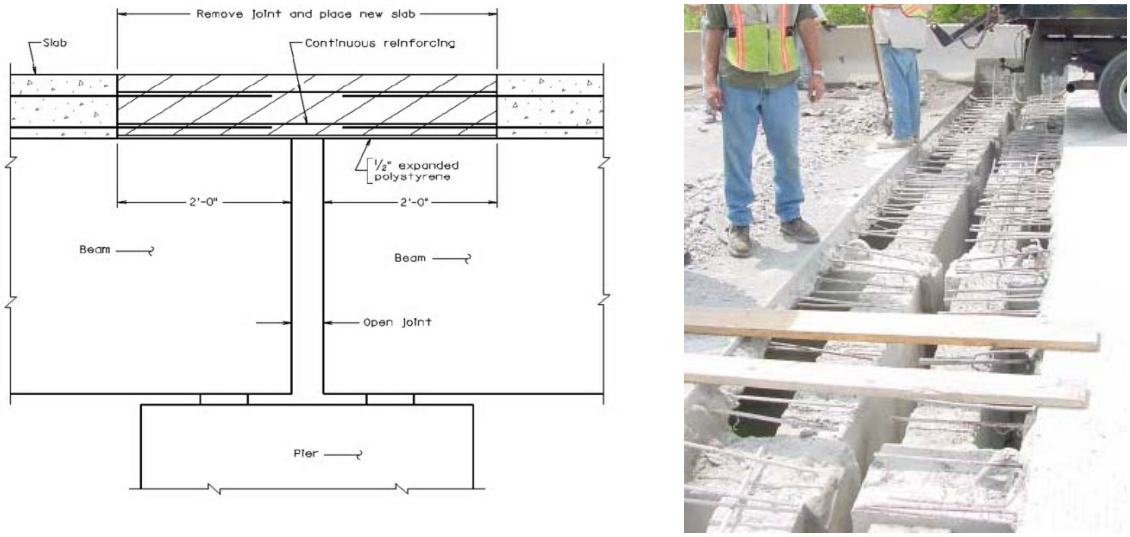

Figure 3. Typical Detail (and picture) used for Elimination of Joints in Virginia

VDOT will continue to emphasize the use of bridge management system and the element level inspection data (collected since 1997) to make data driven decisions. This is not new, and it is a proven way to manage bridge inventories. Experience with its customized bridge management system has helped to forecast and budget for a systematic approach to maintenance that identifies the most cost-effective activities and preservation bridge candidates (Figure 2).

Detailed review and analysis of the bridge inventory data shows the need for improving (and funding) existing maintenance activities and the need for a more aggressive long-term plan to extend the service life of the current inventory. The data shows that there is a small window of opportunity to extend the service life of these structures through restorative and/or preventive maintenance. If we do not act soon, the structures will deteriorate to the point that it is more cost effective to replace the structure rather than repair it.

Again, the challenge for VDOT is how to address the wave of structures that could become structurally deficient unless some intervention (maintenance) occurs (Figure 2)

and how to prioritize maintenance versus replacement. In the past VDOT, similar to other State Transportation Agencies, have tended to concentrate on fixing the "worst" bridges first, and then perform maintenance as funding allowed. This meant that maintenance activities were typically delayed and/or not performed in a systematic way. The data driven analysis from BMS, along with established best practices, indicates that this policy (tendency) is shortsighted and does not incorporate the facts regarding the age of the structures in Virginia. Another challenge associated with this practice is the cost to repair and/or replace as they deteriorate (Figure 4). Therefore, an innovation (which is actually a known fact in the bridge community) is the change in mindset associated with replacing versus maintaining of existing structures. The BMS data clearly shows the need to change! However, the challenge for all of us is how we balance the mobility and safety of these deteriorated bridges and prioritize the maintenance of the majority of structures.

VDOT is modifying their maintenance and construction spending to ensure that preventive maintenance is done in a timely manner, and that restorative maintenance is performed before the structure deteriorates to the point that it needs to be replaced. The success of the change in the mindset of many to fix the "worst-first" is closely associated with the use of a customized bridge management system.

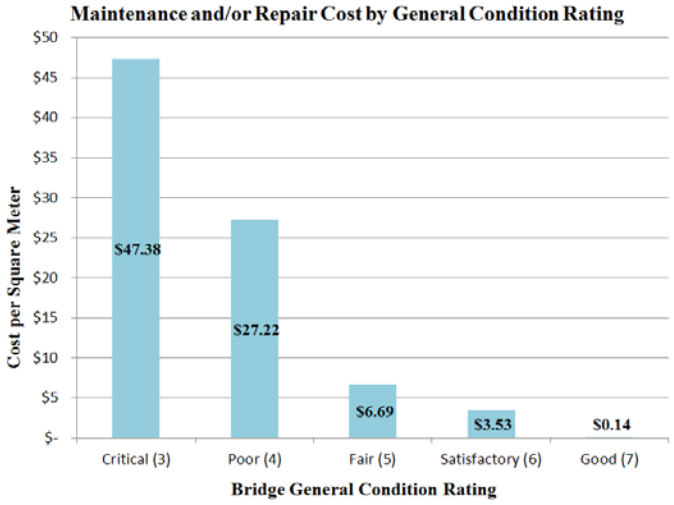

Figure 4. VDOT's Maintenance Cost versus the GCR

Managing existing structures inventory should incorporate managing the construction of future bridges. Since new bridges will eventually be added to the inventory, it is imperative that we utilize best practices during their design and construction. Therefore, VDOT is proactively requiring the use of best practice/processes for all new bridges. This includes the requirement for jointless bridges, use of corrosion resistant reinforcement, high performance concrete for the entire structure, and high performance steel (weathering, if possible). The use of these 'best-practices' and innovation will ensure minimal maintenance of the structure along with a 75-100 year service life.

Conclusions

VDOT is using proven preventive and restorative activities to continue to improve the overall condition of their transportation network. The incorporation of restorative maintenance activities allows for "restoring" and/or improving the general condition rating of the structure component from a five (5) GCR (FAIR) to a higher GCR. The continued use of preventive maintenance activities ensures that structures stay in a satisfactory condition state (equivalent to GCR => 6). The combination of preventive and restorative maintenance activities for existing structures (Figure 5) will enable VDOT to continue to reduce the number of structurally deficient structures in their inventory even as the age of the structure surpasses its design service life. The use of their customized BMS system will help with management of maintenance activities and will ensure that the cost of maintaining the existing inventory will remain at manageable levels instead or rising exponentially. Virginia like other states has a challenging (aging) inventory of structures, but VDOT is implementing an "old and proven" innovative approach to manage their inventory of structures and ensure the longevity of the structure inventory.

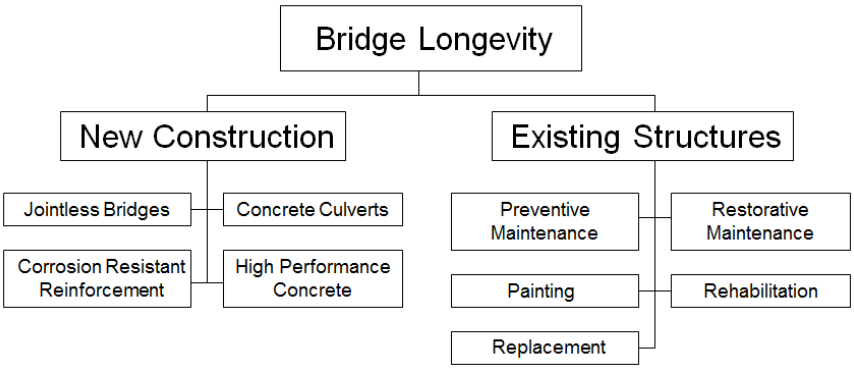

Figure 5. VDOT approach to maintenance to extend their service life.

Acknowledgments

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