Bridge Preservation Program: Maintaining Best Practices

by Rex L. Pearce, Virginia Department of Transportation

Bridge maintenance, preservation, and service-life extensions represent primary challenges for departments of transportation across the United States. These agencies must ensure that they have effective, sustainable programs to manage their aging bridge inventories, and when available resources—such as funding, materials, and industry response—are subject to a complex system of variables, it can be especially difficult to develop and maintain a bridge management program guided by best practices.

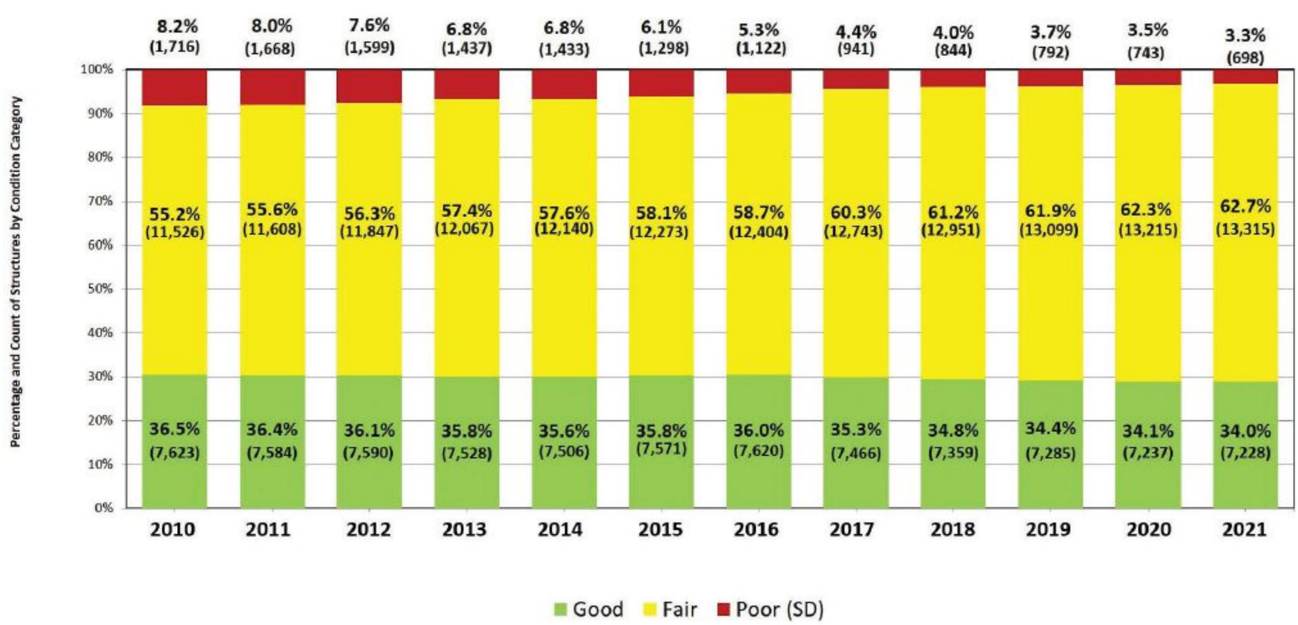
Adam Matteo's article, "Virginia's Strategic Approach to Bridge Management," in the Winter 2023 issue of *ASPIRE®*, aptly described the Virginia Department of Transportation's (VDOT's) bridge inventory conditions, projections, and asset management strategies. My Fall 2016 *ASPIRE* article, "Introducing New Ideas to an Aging Bridge Inventory," outlined VDOT's district-level means and methods that have evolved into best preservation practices in recent years. This article provides an update of the latter article for one VDOT district, the Staunton District. In particular, the article focuses on the district's recent asset management challenges and preservation projections and reflects on the effectiveness of ongoing methods.

Staunton's Place in the Virginia Bridge Inventory

VDOT maintains 21,000 bridges and large culverts across nine regional districts. Among all VDOT districts, the Staunton District Bridge Section is responsible for the greatest percentage of the statewide bridge inventory: the district is home to 2200 bridges (45% of which are concrete) and 1300 culverts (85% concrete). Given the size of the Staunton District inventory, the performance and condition of the district's bridges greatly influence statewide performance and condition trends. Building on a history of innovation and preservation, 97% of Staunton District's bridge inventory is currently classified as being in fair or better condition. **Figure 1** shows the VDOT statewide general condition rating (GCR) trends, which resemble the Staunton District trends.

Interstate corridors are crucial to travel, commerce, and defense, and those corridors that rely on bridges that have reached the ends of their design service life are therefore of paramount concern. Absent the fiscal resources to support a large-scale bridge replacement program, bridge maintenance, preservation, and service-life extension are critical. Staunton District's attention to the

Figure 1. General condition ratings for bridges and large culverts maintained by the Virginia Department of Transportation. All Photos and Figures: Virginia Department of Transportation Staunton District Bridge Section.



importance of bridge preservation has resulted in no poor-condition interstate bridges in this district.

Bridge Inventory Assessment

The Staunton District bridge maintenance program is founded on a current, comprehensive inventory assessment. In our data-rich era, using this valuable asset to the utmost is sound logic. Trends for structure aging, conditions, materials, techniques, and successes found through the inventory assessment help ensure the best program maintenance and preservation responses and can be used to guide decisions about future construction. Asset-query software affords extensive programmatic evaluation through condition and element-level screening.

It is crucial to remain current with deterioration trends and evaluations. Although ever-changing conditions can lead agencies to continually reprioritize target goals, annual trend updates have proven to be sufficient for Staunton District. Alignment with funding, staffing, and industry resources is integral to assessments and projections.

Deck Evaluation and Response

A good example of the district's ongoing prioritization efforts is its complex deck-aging assessment. This assesment takes into account both the bridge's GCR and the structure's element-level condition states (CSs). GCRs are ranked on a scale from 0 (failed condition) to 9 (excellent condition). CSs are ranked as 1 (good condition), 2 (fair condition), 3 (poor condition), and 4 (failed condition).

The Staunton District's interstate corridors represent a primary focus for hydromilling and overlay deck-preservation prioritization. The target structures are initially culled from the interstate bridge inventory by capturing structures with decks classified as GCR 5 (fair condition). No interstate bridges in this district have GCRs lower than 5, which is a testimony to successful preservation practices. These fair-condition bridges are then further classified by CSs. Higher priority is given to decks that have more CSs of 3 to 4. This prioritization is then refined by determining the significance of areas where CSs of 3 to 4 are coincident within both the top- and bottom-of-deck assessments. Such a condition may correspond to the highest of all deck preservation priorities, as a greater potential exists for a full-depth deck void due to deteriorated conditions.

The tabular nature of the element CS data does not lend itself to determining coincident top- and bottom-of-deck defective areas. A graphic mapping approach was recently initiated for interstate decks with GCR 5 to supplement the tabular CS data collection, enhance condition interpretation, and improve prioritization.

The deck assessment can be more complicated when a bridge has an overlay. According to National Bridge Inspection Standards, when a bridge deck is overlaid, the top of deck is then described only as a wearing surface and the deck itself is considered to be hidden beneath the overlay. This qualification may be accurate for a bituminous overlay, but interstate bridges in Virginia typically have a concrete wearing surface.

A milled or hydromilled rigid overlay is quite different from a bituminous overlay. When deteriorated deck concrete is removed to a specified depth through the milling process, that material is then replaced with new concrete to the elevation of the original traveled surface. This restoration is integral to the existing deck and most accurately described as a new top of deck. The complication is that this type of restoration may also be described as an "overlay," a term that should be further clarified.

Furthermore, while the restored top of deck would likely be classified as GCR 6 (satisfactory condition), deterioration of the bottom of deck may still govern. For efficient program management, it is best to include bottom-of-deck restoration at the same time so that classification as GCR 6 fully describes both deck surfaces upon completion of the preservation effort.

Deck Service Life: Preservation and Limitations

Staunton District interstate bridges were constructed primarily during the 1960s. By the 1980s, interstate bridge decks began to exhibit deterioration due to chloride contamination. At that point, the district set out to overlay all interstate corridor decks, which was accomplished through the 1990s.

To offset the permeable concretes used in earlier eras that allowed greater chloride penetration, epoxy overlays were initially applied to the sounder decks. Milling followed by placement of silica fume or latex-modified concrete rigid overlays restored the more deteriorated traveling surfaces (**Fig. 2**). In the 2000s, Virginia bridge decks began to be constructed with low-permeability concretes, which are considered substantially more chloride resistant than the types of concrete used previously.

Today, more than 25 years have passed since the earliest Staunton District interstate bridge deck overlays. The next generation of deck preservation must

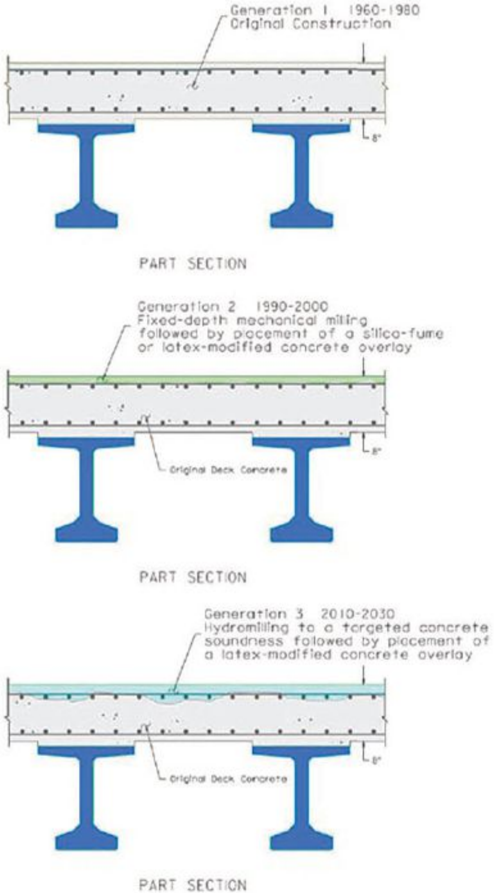


Figure 2. Three generations of concrete bridge decks on interstate bridges illustrate the evolution to the Virginia Department of Transportation's current bridge preservation practices.

Figure 3. For new construction, continuity and jointless bridge solutions are good options. This bridge has a 1915-ft-long, 100-ft-wide continuous reinforced concrete deck.

address deterioration related to ongoing chloride contamination, aging, cracking, and subsequent patching.

Hydromilling is becoming a standard practice in this arena. Unlike standard mechanical milling operations, which proceed with a fixed depth of removal and must remain above reinforcement, hydromilling dials in a targeted soundness, reaching below reinforcement where necessary to remove chloride-laden concretes. The result is a stable, deeply roughened concrete matrix that is extremely well suited to overlay.

The nature of this more in-depth restoration approach will considerably extend the program-delivery time frame for restoring the targeted structures in the district interstate system. It will likely take more than 20 years to hydromill and overlay all the bridges, whereas the earlier milling and overlay initiative was accomplished within a decade.

The true service life of a structure or its components can only be determined upon its demolition. If the third-generation deck restoration program is accomplished as described herein by the year 2030 and the program yields up to a 30-year life extension, structures will achieve nearly 100 years of service life. Considering the original service-life projection was 50 years, this is a notable accomplishment. It is fair to suggest that not all decks will reach the 100-year target and that the next effort will likely be replacement.

Preservation Methods and New Construction

Best methods and materials used in preservation retrofits will likely replicate new construction standards and solutions. All preservation practices—deck hydromilling and overlays, joint elimination, deck extensions, beam repairs, and superstructure and substructure restoration using shotcrete and self-consolidating concrete—will eventually yield to new construction. A necessary part of a bridge infrastructure maintenance program will inevitably be full replacement.

For new construction, where possible, an integral-abutment bridge type is best. The Route 340 bridge over the Shenandoah River South Fork pushes the limits of continuity and jointless bridge solutions with its 1915-ft-long, 100-ft-wide continuous reinforced concrete deck (**Fig. 3**). With deck extensions and jointless Virginia abutment types, it is exemplary of a truly jointless bridge environment and will likely achieve a century of service life. (For details of the Virginia abutment, see the "Atkinson Boulevard Over CSXT Railroad and Interstate 64" Project article in the Fall 2021 issue of *ASPIRE*.)

In other cases, the routine "workhorse" bridges that make up the majority of the bridge inventory can be preserved instead of replaced. Preservation of Interstate 64 bridge (**Fig. 4**) involved bearing reconfiguration to accommodate joint closures, deck extensions, hydromilling, and overlay replacement for a comprehensive jointless solution.

Conclusion

Virginia's bridge infrastructure is sustained only through the tireless efforts and dedication of VDOT district bridge engineers, state bridge engineers, designers, builders, and inspectors. Supported by the Virginia Transportation Research Council and Virginia's engineering universities, VDOT represents an enviable standard of agency ownership and well-met responsibilities. The common goal is to determine the best preservation approach for the previous 100 years of bridge inventory while applying the knowledge and experience gained to construct the next century's transportation system.

Rex L. Pearce is the Staunton District bridge engineer for the Virginia Department of Transportation.

Figure 4. Preservation strategies for this Interstate 64 bridge included bearing reconfiguration to accommodate joint closures, deck extensions, hydromilling, and overlay replacement for a comprehensive jointless solution.