Virginia's Strategic Approach to Bridge Management

by Adam Matteo, Virginia Department of Transportation

Virginia, like most states, is managing an aging network of bridges and roadways that must continue to provide acceptable levels of service to motorists for decades to come. The average age of a bridge in Virginia is 53 years, yet the anticipated service life of 90% of Virginia's bridges (those bridges built before 2007) is 50 years. The remaining 10% of bridges are newer bridges that are expected to have a service life of 75 years or more.

To meet the challenge of our aging infrastructure, the Virginia Department of Transportation (VDOT) is using a strategic approach that incorporates dedicated funding, asset management, new materials, and timely interventions. The aim is to maximize the life-cycle value of every dollar spent to achieve our goal of providing a sustainable inventory at an acceptable level of service for the next 50 years.

Meeting the Challenge

In 2010, when the average age of a bridge in Virginia was approximately 42 years, stakeholders acknowledged that our bridge inventory required significant improvement. There were over 1700 structurally deficient (poor) bridges, and the system was in need of recovery. This assessment led to a renewed focus on funding, asset management, technology, and materials that have put the state on a path to long-term sustainability.

That year, VDOT moved its 36 bridge crews from the Maintenance Division to the Structure and Bridge Division. These crews are highly capable, performing a wide range of activities from preventive maintenance to complete bridge replacement. Workers are replacing between 70 and 90 bridges per year, and removing these bridges from the list of poor structures has constituted one of the most significant elements of our recent improvements.

To support this work, funding streams were established to specifically address the large number of poor bridges, with particular emphasis on the many smaller, rural bridges that were structurally deficient. Virginia's State of Good Repair[1] program, enacted in 2015, legislatively mandates that a fixed portion of highway construction funding be provided for deficient pavements and structurally deficient bridges, along with a Special Structures Fund to provide dedicated funding streams to improve the condition of bridges in the VDOT inventory.[2]

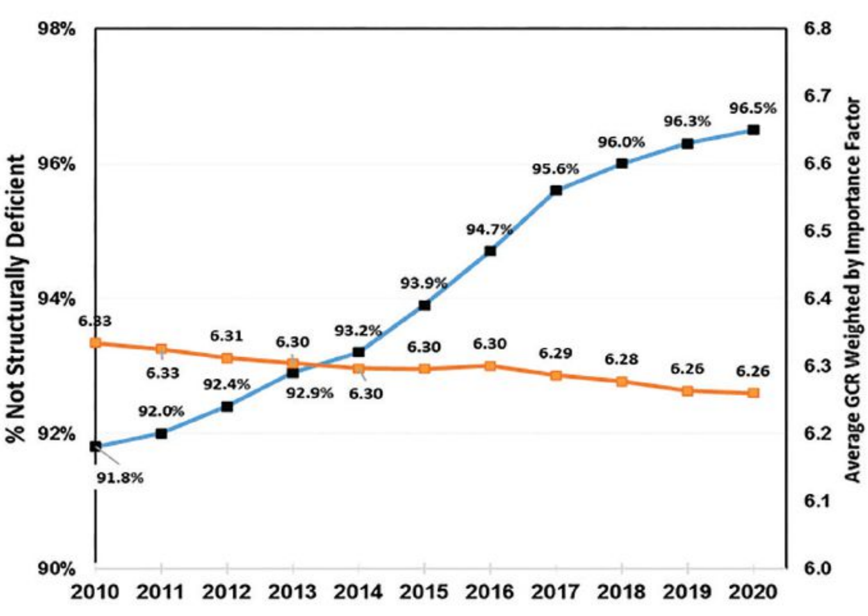

Figure 1. Percentage of bridges not structurally deficient (blue line) and average general condition rating (GCR; orange line) weighted by importance factor since 2010. All Photos and Figures: Virginia Department of Transportation.

Results Since 2010

The steps taken since the program began in 2010 have led to a remarkable reduction in the number of structurally deficient bridges. **Figure 1** shows that since 2010, the percentage of bridges that are not structurally deficient has steadily improved from less than 92% to more than 96%. However, the graph also shows that this improvement has been accompanied by a slow, steady decline in the average general condition rating (GCR). The GCR is a numerical rating from 0 (failure) to 9 (excellence) that is given at every biennial bridge inspection for each of the major components of a bridge. So, while the number of poor bridges has been decreasing to a manageable level, the average condition of the overall bridge inventory has still deteriorated.

Asset Management

Virginia has employed asset management tools and deterioration modeling for over 20 years. Realizing that the inventory was reaching a potential inflection point, VDOT performed a comprehensive review in 2019.[3] This was a statewide, long-term review of its investment strategy, with particular focus on bridges and pavements. The effort sought to determine whether VDOT was investing its funds and measuring its performance in the most appropriate manner. It also sought to establish meaningful performance measures and performance targets based on acceptable levels of service.

The study found that Virginia's total funding could provide an acceptable level of service for the next 50 years if the investment strategy were changed. Currently, Virginia spends about 75% of its available bridge funding on structurally deficient bridges and 25% on preservation. However, the cost of preservation, which we defined to include rehabilitation and repair along with treatments to slow deterioration, is usually about five to six times more cost effective than replacement. The study found that allocations needed to be reversed: 75% should be used for preservation and 25% should be applied to structurally deficient bridges. If the "worst first" approach were continued, long-term projections indicated that overall bridge condition would suffer—that is, the percentage not structurally deficient would be 91% in 2070 for the "worst first" approach instead of 95% if the allocations were reversed using the "preservation" approach.

Analysis of GCR rating data led to similar conclusions. The "preservation" approach would keep the average weighted rating above the acceptable level of service of 5.6 for the entire period, whereas the average weighted rating for the "worst first" approach would fall below the acceptable level of service of 5.6 after about 10 years.

These conclusions are illustrated in **Fig. 2**, which projects bridge conditions for the next 50 years under each approach. As shown in the figure, funding was assumed to remain equal and level for both investment strategies for the period after 2020. Data presented in the figure also indicate that the average weighted GCR for the system cannot be improved without additional funding because the trend in the data is flat or still descending at the end of the study period.

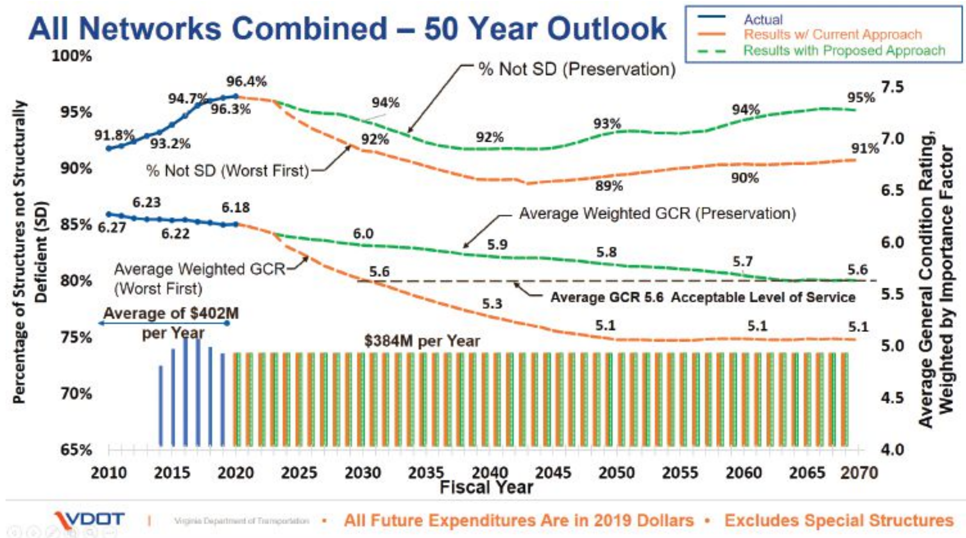

Figure 2. Fifty-year outlook for Virginia's bridges comparing two investment strategies: "worst first" (orange) and "preservation" (green). The current, "worst first" strategy allocates 75% of funds to structurally deficient bridges and 25% to bridge preservation. The proposed "preservation" strategy would reverse the allocations, dedicating 25% to structurally deficient bridges and 75% to preservation. Data are presented for the percentage not structurally deficient (upper set of lines) and average weighted general condition rating (GCR) (lower set of lines).

The investigation also determined that bridge conditions should be measured primarily through average GCR, as opposed to the percentage of structurally deficient bridges. An average GCR of 5.6 (weighted by an importance factor for each bridge) was established as an acceptable level of service. However, bridges must be preserved to significantly slow future rates of deterioration.

Preservation Methods and Durable Materials

Given that the primary cause of bridge deterioration in Virginia is corrosion, the following requirements and expectations have been widely adopted for new construction and preservation work:

- **High-performance, low-permeability concrete** is required in all bridge applications.
- **Corrosion-resistant reinforcement** is required for new and existing structures.
- **Corrosion-resistant** (stainless steel or carbon fiber) **prestressing strands** are required in critical locations.
- **Self-consolidating concrete** is required for substructure surface repair.
- **Jointless construction** is required for new bridges.
- **Installations of metal culverts are limited** because they have generally provided a significantly shorter service life than concrete.

Additionally, the following strategies are mainstays of the preservation program:

- **Concrete overlays** are placed over **hydromilled surfaces**. The use of latex-modified and silica fume concrete, in conjunction with hydromilling, is expected to extend the service life of a bridge by three to four decades.
- **Joint elimination** using link slabs and deck extensions is required for rehabilitation work.[4]
- **Beam end repair and replacement** for steel bridges is preferred, wherever practical, over superstructure replacement.
- **Concrete culvert liners** are used to restore deteriorated metal culverts.
- **Localized hydromilling** is used for substructure surface repair. This is a new strategy for substructure preservation that is more efficient than manual chipping. Hydromilling has been shown to provide an effective and rapid means for removing deteriorated concrete before replacement with patching materials.

Treatment Examples

This section presents examples of the main types of interventions that Virginia uses in its bridge preservation program. Historical data and parametric life-cycle studies have demonstrated that these treatments provide decades of additional service life at a fraction of the cost of replacement.

- **Rigid overlays (Fig. 3)**. When applied over a hydromilled surface, this intervention provides 35 to 40 years of additional service life to the bridge. (see the Concrete Bridge Preservation article on hydrodemolition in the Summer 2018 issue of *ASPIRE*®).

Figure 3. The use of latex-modified and silica fume concrete for overlays, in conjunction with hydromilling, extends the service life of a bridge by three to four decades. It is a mainstay of Virginia's bridge preservation program.

- **Joint elimination on existing bridges (Fig. 4)**. The elimination of joints with link slabs and deck extensions[4] eliminates leaking deck joints, which are the primary source of superstructure and substructure deterioration (see also the Creative Concrete Construction article on Scan 19-01 in the Fall 2022 issue of *ASPIRE*).

Figure 4. Before, during, and after photos of eliminating a joint on an existing bridge. This intervention is commonly used in the bridge preservation program in Virginia. Jointless construction is required for new bridges in Virginia.

- **Beam end repair**. This intervention can provide decades of additional service life for steel superstructures without the need for component replacement, particularly when it is performed in conjunction with joint elimination.
- **Substructure surface repair (Fig. 5)**. Substructures can be brought to a sustainable condition using self-consolidating concrete for repairs. VDOT is now beginning to employ localized hydromilling to prepare these patches.

Figure 5. Examples of substructure deterioration (top) and a substructure repaired by localized hydromilling and repair with self-consolidating concrete followed by the application of a coating (bottom).

Figure 6. A spray-on liner using fiber-reinforced concrete is installed to extend the service life of a steel culvert structure.

- **Relining steel culverts with fiber-reinforced concrete (Fig. 6)**. Steel culverts have a limited service life. However, spray-on fiber-reinforced concrete liners are extending the service life of these structures without the need for replacement.

Conclusion

By using a systematic, data-driven approach to bridge management, along with a sustainable level of funding and timely applications of preventive treatments using appropriate materials, procedures, and details, Virginia is putting its bridge inventory on a path to long-term sustainability.

References

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