

Vermont Agency of Transportation

Program Development – Structures Section

2010 Annual Report

**Interstate Bridge Program
State Highway Bridge Program
Town Highway Bridge Program**



*Berlin I-89, bridge 40S over VT 12

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*East Montpelier US 2, bridge 74 (Carpet Barn Bridge)

Executive Summary

Bridges, including those on local roads, are integral elements of our highway systems. Despite their importance, the past several decades have produced a pattern of neglect. Demands on limited resources too often result in deferred maintenance for bridges. Without adequate attention, many bridges will require replacement, restriction, or closure long before their desired lifespan is complete. This will only further stress Vermont's limited transportation resources, restrict Vermonters mobility and negatively affect the state's overall economy.

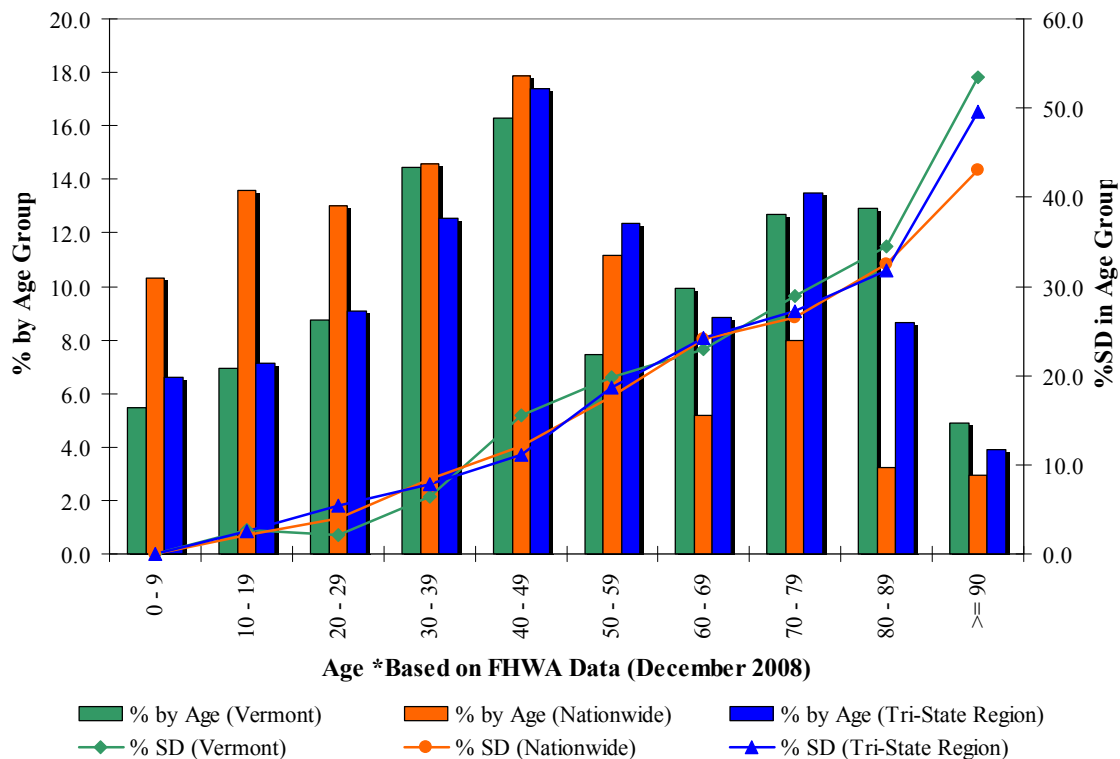
This became crystal clear with the closure of the Lake Champlain Bridge connecting New York with Vermont. Other recent examples include the load restriction of the US 4 bridge connecting Hartford, VT with Lebanon, NH, the closure of the Vilas Bridge between Bellows Falls, VT and Walpole, NH, and the load restriction of the international bridge between Richford, VT and Sutton, QC. Though these bridges are inspected and maintained by others, their restriction impacts have had a profound effect on Vermont's economy, businesses, farmers, and commuters. Similar effects have been felt with restrictions within our borders in locations such as US 2 Moretown-Middlesex, Richmond Bridge Street Bridge, and several others.

We cannot forget the importance of our bridge network and how it is integral to the wellbeing of our State's economy. Fortunately Vermont has an excellent bridge inspection program that keeps our public safe and identifies bridge condition issues well before restrictions are required. However, addressing those issues in a timely manner with our limited resources continues to be a challenge.

Establishment of National Bridge Inspection Standards (NBIS), which requires all structures with a clear span of more than 20 feet to be inspected at least once every 24 months, has reduced the likelihood of catastrophic failure. Routine and timely inspections identify flaws and deterioration and allow for timely remedial action.

Inspection cannot slow down deterioration, only merely identify it. Only properly scheduled periodic maintenance can retard deterioration. Studies have shown that preventive maintenance is a cost-effective investment and that deferment only adds to the bridge's life-cycle cost.

Vermont has one of the oldest bridge inventories in the nation and, as a result, the state is recognized as having one of the nation's highest percentages of structurally deficient bridges. But what does this really mean? Vermont's age-versus-deficiency trend is on par when compared both regionally and nationally, meaning that when age is taken into account, Vermont's rate of structurally deficient bridges is no worse or better than that of most other states. But these numbers also show that significant investments to improve conditions across Vermont's bridge network are needed.



With thousands of statewide structures (bridges, culverts, rail structures, overhead signs and large retaining walls) VTrans’ Structures Section serves three primary functions: design, inspection and asset management.

The Design Unit – consisting of project managers, engineers and technicians – strives to deliver projects which are not only functional but cost effective. Despite all efforts, the process from initial scoping to construction can take anywhere from a few months to several years. Bringing a project to fruition takes more than design. Several external forces including environmental permits, right-of-way acquisition, utility relocation, archeological issues, and historic clearances can, at a moment’s notice, delay or stop project development.

VTrans’ Bridge Inspection Teams carry out the NBIS inspections, as well as provide visual field assessments, maintain the bridge inventory, and provide notification of critical deficiencies or advanced deterioration to bridge owners along with recommended actions.

Bridge Management supports all bridge inspection functions as well as complies with federal report submittal and requests, conducts bridge load ratings, and provides oversize/overweight movement recommendations on state routes to the Department of Motor Vehicles (DMV). Bridge Management also prioritizes and identifies would-be repair, rehabilitation and replacement projects.

Decades of deferred maintenance has pushed structure needs above annual funding levels. Consistent and predictable funding levels are needed to predict, plan, and achieve programs targeted towards maintaining and improving the overall condition of Vermont's structures.

Through performing routine safety inspections, utilizing asset-management techniques, and establishing effective goals and strategies, the Agency can identify cost-effective treatments for improving and extending the life of its assets, and thus assure the continued safe and unrestricted use of the state's highway network.

To this end, the Agency has developed a priority system to determine which rehabilitation and replacement projects should move forward and receive dedicated construction funding. The priority system, applied to structures exceeding 20 feet in length, utilizes data from inspection condition ratings, Regional Planning Commission priority reports, bridge use and functionality, and cost benefits. These priority rankings guide our decisions in developing the Capital Program and advancing the design of rehabilitation and replacement projects.

To aid the selection of candidates for preventive and routine maintenance as well as the prediction of future needs related to budgetary changes, the Agency utilizes a Bridge Management System (BMS). The Agency is committed to both advancing and enhancing the use of this system.



*Craftsbury TH 59, bridge 2 – before



*Craftsbury TH 59, bridge 2 – after

Vermont's Bridge Population

In conformance with the National Bridge Inventory (NBI), Vermont maintains an historical record of all bridges subject to the National Bridge Inspection Standards (NBIS). These standards establish requirements for inspection procedures, frequency of inspections, qualifications of personnel, inspection reports, and both the preparation and maintenance of a state bridge inventory. The NBIS apply to all structures defined as bridges that are longer than 20 feet in length and located on public roads. These assets are commonly referred to as “long” structures. “Short” structures are those not classified as a “long” structure and have a span length equal to or greater than six feet.

Vermont's “Highway” Structure Population

(as reported to FHWA in April 2009)

Structure Type	Interstate	State Highway	Town Highway	Other	Total
Long Structures (span length > 20 feet)	313 (48 buried structures)**	764 (57 buried structures)	1,606 (73 buried structures)	6 (2 buried structures)	2,689 (180 buried structures)
Short Structures (span length ≥ 6 feet and ≤ 20 feet)	222 (222 buried structures)	1,070 (889 buried structures)	*** (see note)	*** (see note)	1,292 (1,111 buried structures)
Totals	535	1,834	1,606	6	3,981

**Buried structures include metal culverts, concrete box culverts, frames, masonry arches, and concrete arches.

***Note: VTrans does not maintain an inventory of town highway or other short structures.

Vermont's “Off-Highway” Structure Population

(as of December 2009)

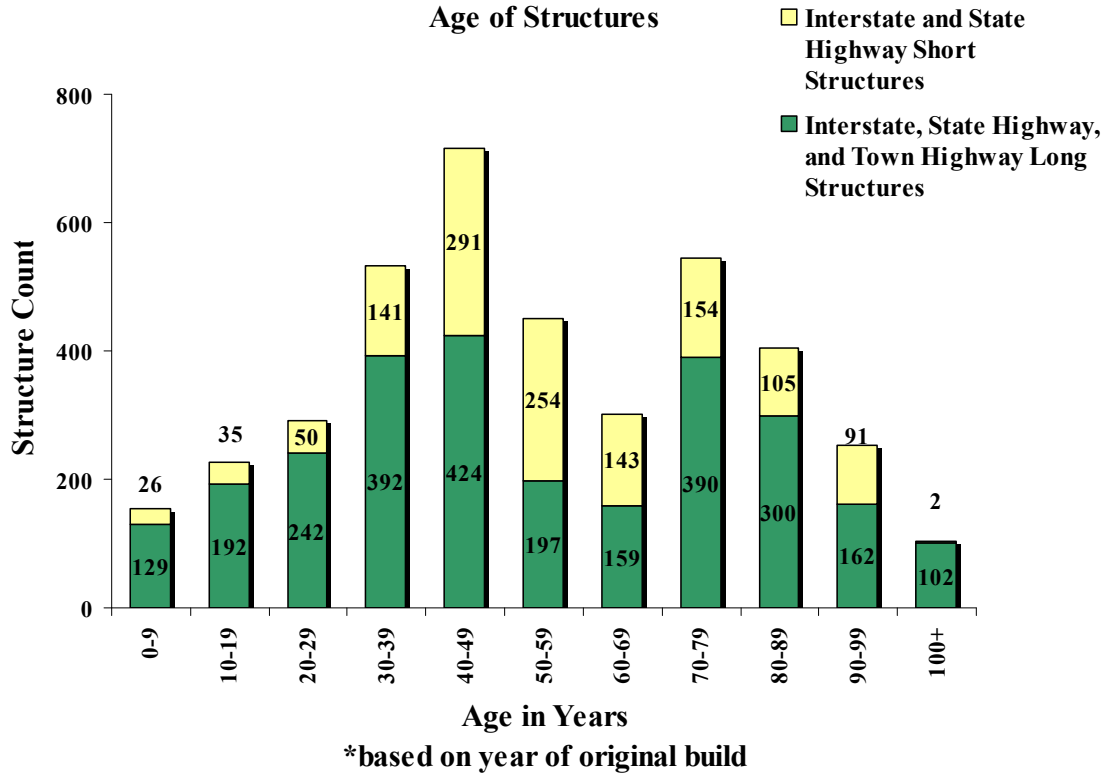
Structure Type	State Highway	Town Highway	Total
Railroad Bridges (state-owned railroads)	214	**** (see note)	214
Retaining Walls (height greater than 3 feet)	261	**** (see note)	261
Recreational Path Structures (span length greater than 6 feet)	0	110	110
Overhead Sign Support Structures	136^Δ	**** (see note)	136^Δ
Totals	611	110	721

****Note: VTrans does not maintain an inventory of municipally-owned retaining walls or overhead sign support structures or privately-owned railroad bridges.

^ΔNote: This number is expected to change as inspection criteria is refined (i.e., minimum sign size, attachment, etc.).

Aging Bridge and Culvert Inventory

With 1927 flood-era bridges now over 80 years old and nearing the end of their useful design life, as well as the 1958-to-1978 Interstate-era bridges around the 40-year mark and in need of repairs, a wave of structures in need of major investment is quickly approaching.



Vermont's bridges are similar to the other northern New England states but are considerably older than the national average. Covered bridges, steel truss bridges, and other historic structures contribute to our village centers and scenic character. These older bridges require regular maintenance and are a challenge to keep serviceable.



*Springfield TH 66, bridge 81

Bridge Inspection and Condition Ratings

The nation's current bridge inspection practice was established largely as a response to disasters involving bridge failures. With each failure, new facts were learned and new standards implemented. Here is a short list of some events that have dramatically influenced national inspection and maintenance practice.

On December 15, 1967, the 2,235-foot Silver Bridge at Point Pleasant, West Virginia collapsed into the Ohio River killing 46 drivers and passengers. This tragic accident aroused national concern about bridge safety inspection and maintenance, and motivated Congress to enact improvements to the Federal Highway Act of 1968. Three years later in 1971, National Bridge Inspection Standards (NBIS) were created, setting national policy for inspection frequency, inspector training and qualifications, reporting formats, and procedures for inspection and rating.

During the 1970s, similar attention was also directed to culverts after several collapses claimed more lives.

In 1983, the Mianus River Bridge in Connecticut collapsed after one of its pin-and-hanger assemblies failed, leading to an emerging national emphasis on fatigue and fracture-critical elements.

In April 1987 with the fall of the Schoharie Creek Bridge on the New York Thruway, new attention also was focused on underwater inspection of bridge foundations.

And most recently, in August of 2007 the I-35W highway bridge over the Mississippi River in Minneapolis collapsed. Undersized steel plates and the stress of 287 tons of stockpiled construction material were singled out in the National Transportation Board (NTSB) Accident Report as reasons for the failure. Federal safety investigators said the collapse was unavoidable once gusset plates in the bridge's center span failed, dragging other sections and rush-hour commuters into the Mississippi River. The collapse killed 13 people and injured 145 others.



*Johnson TH 3, bridge 4 (Power House Covered Bridge) – before and after

Guided by federal requirements, all bridges in excess of a 20-foot span and located on public roads receive regular, biennial inspections by qualified personnel to ensure safety of the traveling public. “Short” structures (those between 6 feet and 20 feet in span length) located on either the Interstate or state highway systems are inspected once every 60 months. Bridge safety is taken very seriously. If deemed necessary because of deteriorating conditions, bridges are inspected more frequently.

Through periodic safety inspections, data is collected on the condition of each structure’s primary components. Condition ratings are collected for the following bridge components:

- **Deck:** The portion of a bridge that provides a surface for vehicular or pedestrian traffic.
- **Superstructure:** The portion of a bridge above the substructure that supports the deck, including beams, girders, trusses, and bearing devices which support traffic and transfers the loads to the substructure.
- **Substructure:** The portion of a bridge below the bearing device, built to support the superstructure and transmit loads to the foundation.

The **culvert** condition rating describes all structural elements of culvert designs which do not have a distinct deck, superstructure or substructure, and are buried under fill. The **channel and the channel protective system** is also rated, describing the physical conditions of slopes, as well as the channel or water flow through the bridge.

Bridge inspectors utilize a point system from zero to nine, where nine indicates an excellent condition and zero indicates a failed condition. Inspectors visually assess the ratings based on engineering expertise, training and experience. These ratings form the basis for assessing the structural condition of the bridge.

Recommendations for maintenance needs, load restrictions or closure originate with, and are based on, inspection findings. Inspection provides a visual record of structural health – including deterioration – and the consequent determination of a structure’s ability to continue to perform in a safe manner.

The challenges faced in the northeast – having an older and aging infrastructure, seasonal limitations on performing inspections, extensive use of deicing salts, and accelerated corrosion rates – are among the more demanding, and the importance of routine inspections cannot and should not be underestimated.

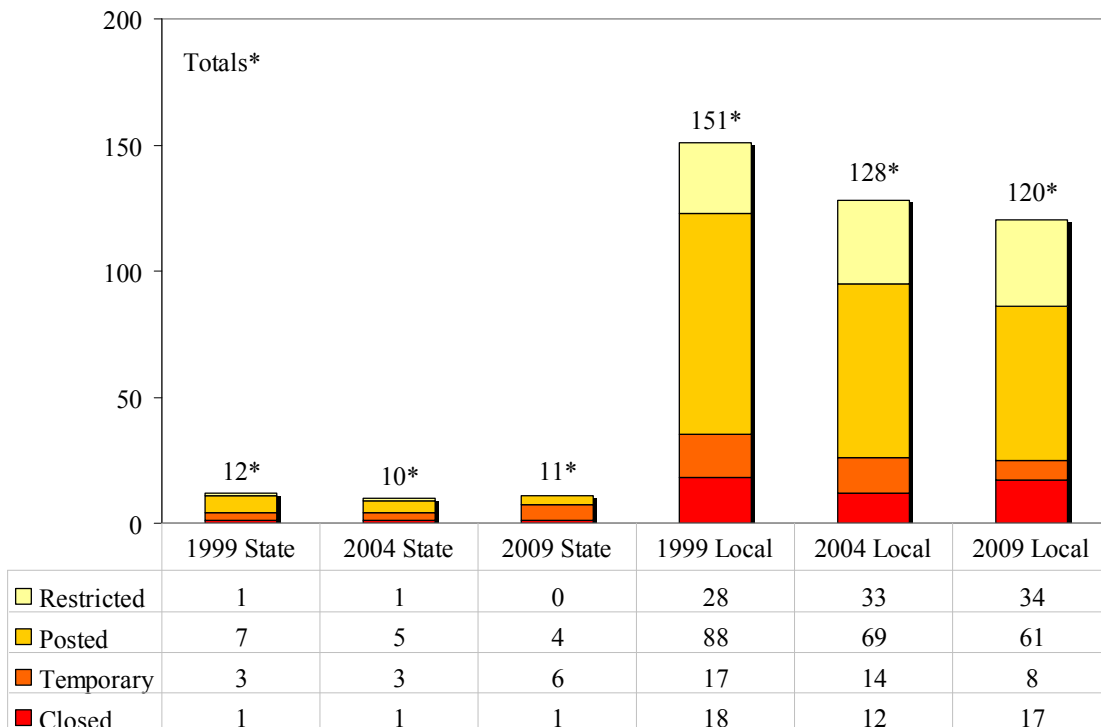
Restrictions

As VTrans searches for the most appropriate performance measures to help target which structures are in most need of repair or rehabilitation, it is important for the Agency to understand how much ground is either being lost or gained in terms of keeping our assets open and unrestricted for public travel.

Restrictions – a limitation of or inability to use a structure – come in four basic categories:

- **Closed:** bridge closed to all traffic.
- **Temporary:** open but with a temporary structure in place to carry legal loads while original structure is closed and awaiting replacement or rehabilitation.
- **Posted:** reduced maximum allowed weight. Posted structures may include other restrictions such as temporary bridges which are load posted.
- **Restricted:** posted for other load capacity restrictions such as speed, number of vehicles, vertical clearance, etc.

Due to recent public attention on the condition of our bridges, many believe Vermont has more restricted bridges than it did 10 years ago, when in fact the state has slightly fewer. Despite this reduction in the overall number of restricted bridges, as our infrastructure ages this trend becomes more difficult to maintain in the future.



Structurally Deficient and Functionally Obsolete

The Agency is evaluating a number of performance measures by which to judge how well we are maintaining our structure assets. Measures such as bridge health index, averaged condition, worst condition, numbers of structurally deficient and functionally obsolete bridges, and the number of restricted, posted, closed, or temporary bridges are all being considered.

For many years, the Federal Highway Administration (FHWA) has used structural deficiency and functional obsolescence as a measure. VTrans, however, uses percent bridges structural deficiency by system (interstate, state highway, and town highway).

Where do the terms structurally deficient and functionally obsolete come from and how are they defined? Both are terms FHWA uses to classify bridges “according to serviceability, safety, and essentiality for public use” to meet the requirements of Title 23 of the United States Code (23 U.S.C. 144). The technical definitions are as follows (source: 23 C.F.R. 650D).

- **Structurally Deficient (SD):** A bridge becomes structurally deficient when at least one of six items from the National Bridge Inventory (NBI) reaches a set threshold. The criteria are a Deck Condition Rating, Superstructure Condition Rating, Substructure Condition Rating, or Culvert Condition Rating of 4 (Poor Condition) or less, or a Structural Evaluation Appraisal Rating or Waterway Adequacy Appraisal Rating of 2 (basically intolerable requiring a high priority of replacement) or less. Any bridge that is classified structurally deficient is excluded from the functionally obsolete category.
- **Functionally Obsolete (FO):** A bridge becomes functionally obsolete when at least one of five items from the National Bridge Inventory reaches a set threshold. The criteria are a Deck Geometry Appraisal Rating, Underclearances Appraisal Rating, Approach Roadway Alignment Appraisal Rating, Structural Evaluation Appraisal Rating or Waterway Adequacy Appraisal Rating of 3 (basically intolerable requiring a high priority of corrective action) or less. Any bridge that is classified structurally deficient is excluded from the functionally obsolete category.

Highway bridges classified as functionally obsolete are not structurally deficient, but according to federal standards their design is outdated. They may have lower load carrying capacity, narrower shoulders or less clearance underneath than bridges built to the current federal standard. Vermont, due to the historic nature of its bridges as well as environmental concerns associated with bridge widening, has established state standards that differ from federal standards. As a result, it is possible for a new bridge built in Vermont to be classified as functionally obsolete. Also, Vermont does not always “modernize” its functionally obsolete bridges. An example is the state’s covered bridges, which are functionally obsolete, but no one wants them altered.

While functional obsolescence is not one of our performance measures, we report it here as a federal measure. It is important to note that when structural repairs are made to structurally deficient bridges the functional obsolescence count may rise.

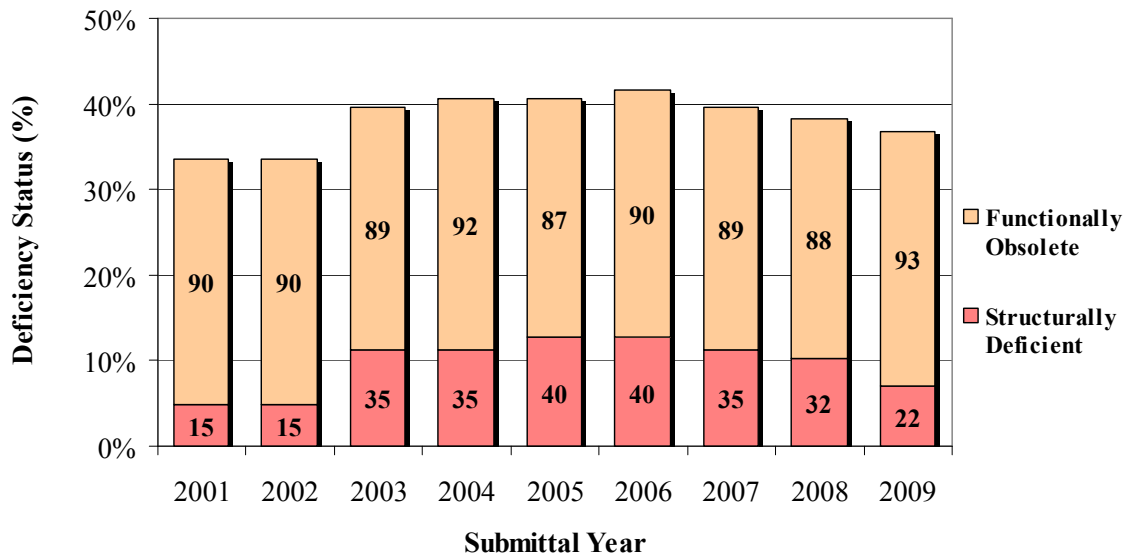
The fact that a bridge is structurally deficient (SD) or functionally obsolete (FO) does not mean the bridge is inherently unsafe. The VTrans' inspection unit takes bridge safety very seriously. If unsafe conditions are identified during an inspection, the structure will be restricted or closed.

Vermont's Functional Obsolescence (FO) and Structural Deficiency (SD) Population
(as of or reported to FHWA in April 2009)

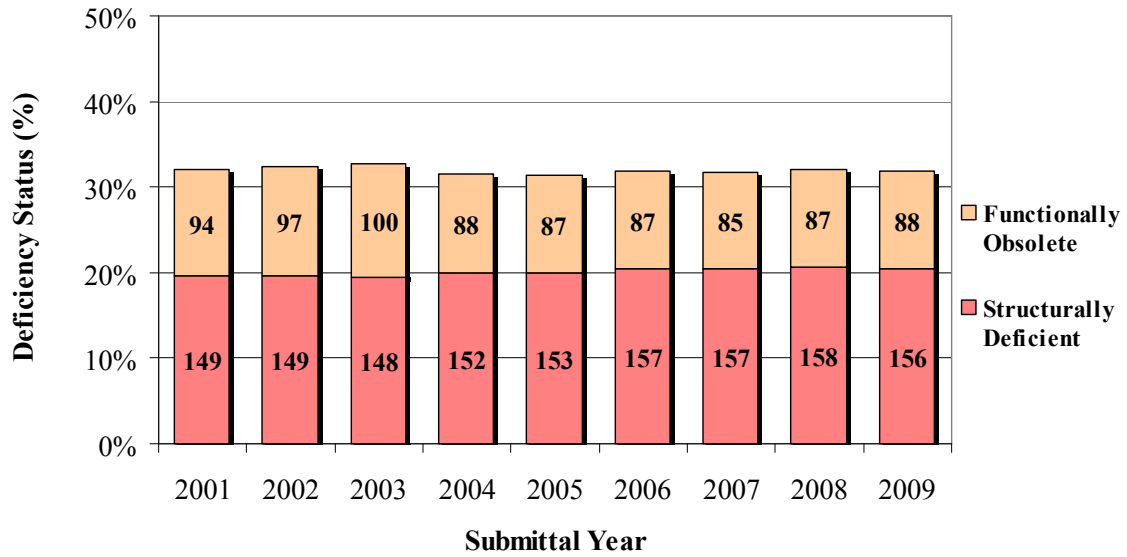
	FO	% FO	SD	% SD
Interstate "Long" Structures	93	29.7%	22	7.0%
State Highway "Long" Structures	88	11.5%	156	20.4%
Town Highway "Long" Structures	336	20.9%	255	15.9%
On-System "Short" Structures	N/A	N/A	173*	13.4%
System Total	517		606	

*Note: FO and SD are federal labels and are not applied to "short" structures. This number represents "short" structures having a condition rating of poor or less.

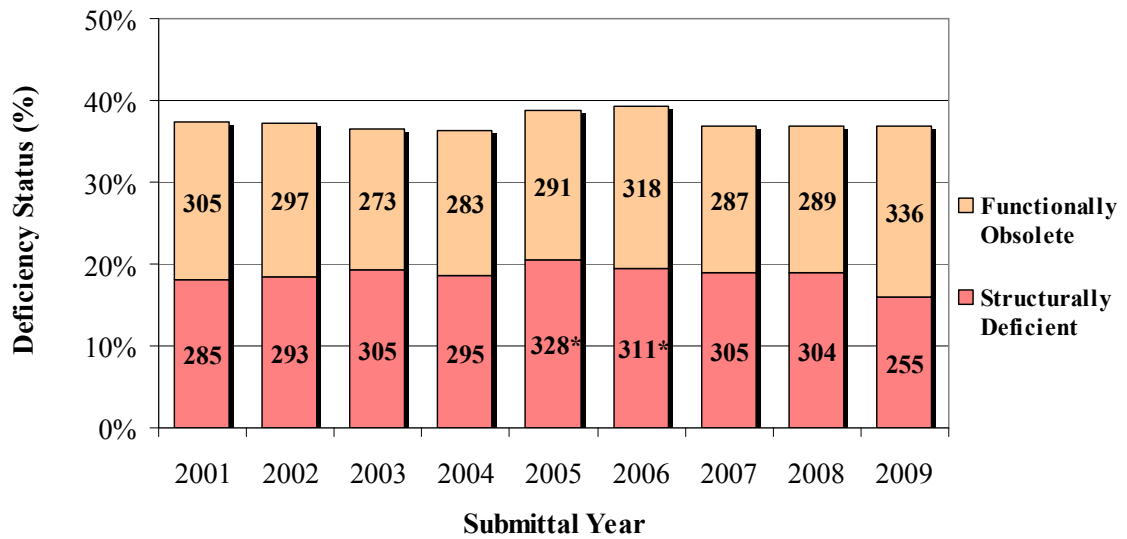
Interstate Trends



State Highway Trends



Town Highway Trends



*Corrected to Reflect Oversight in NBI Inventory Rating Reporting Format

New Performance Goals and Measures

In the past, VTrans relied on the Federal Highway Administration's measures of structural deficiency and functional obsolescence to evaluate bridge condition. Vermont, however, is evaluating new performance measures that VTrans believes better model the average condition of Vermont's bridge network. The federal measures do not do a good job evaluating a bridge's true condition, so VTrans is exploring the use of measures that better quantify critical conditions.

VTrans is not doing away with the federal measures, and the Agency will continue to supply FHWA data for these determinations.

The federal measures – structural deficiency and functional obsolescence – imply but do not really tell us anything about the bridge's overall condition, nor do they tell us how bad a particular bridge component is. The federal measures only indicate that one or more bridge component or components have deteriorated to a point where they are within a range that requires assessment. They may or may not need treatment.

For example, our interest in fitting bridges into the historic Vermont landscape – all covered bridges and many historic truss bridges are considered functionally obsolete – lead to the development of Vermont specific standards that allow us to design bridges narrower than the federal standards. Many of Vermont's new designs and rehabilitations are considered functionally obsolete though they function very well.

To better evaluate our structures, VTrans is working to develop and implement a more holistic approach to measuring the condition and performance of our structures. Although these efforts are still in development, Vermont and the other states see promise in utilizing a health index as an effective management tool that can be compared across state lines.

Average network condition and bridge health index are two measures that reflect the overall health of our bridge population. Recognizing that a bridge is only as good as its worst component, we are also investigating the use of a worst-component condition as a measure. These three show promise as performance measures.

Until the Agency moves to new performance measures, structural deficiency performance goals will continue. These goals are:

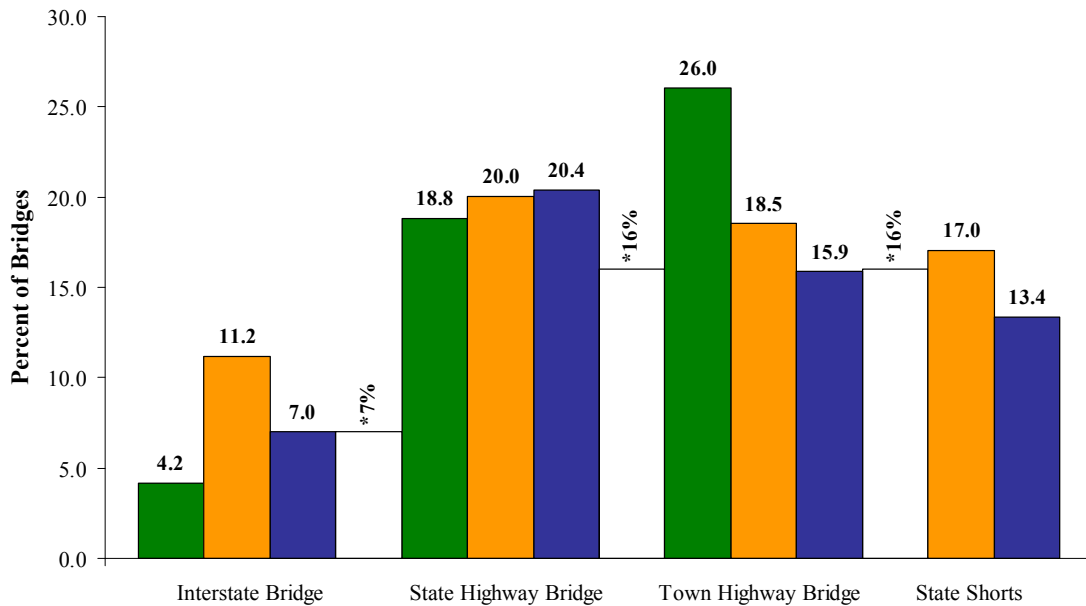
- 7% on the interstate system (21 bridges)
- 16% on the state highway system (122 bridges)
- 16% of the town highway system (257 bridges)
- 12% of interstate/state highway system culverts (155 culverts)

Vermont has met these goals on the interstate and town highway systems though there is much room for improvement on the state highway system. It may be desirable to “raise the bar” if Vermont continues with this measure into the future. The following chart represents the change in percent of structural deficiency by system over a 10-year period.

- 1998 - April 1999 Submittal
- 2003 - April 2004 Submittal
- 2008 - April 2009 Submittal

Structural Deficiency over Time by System

*April Submittal Years 1999, 2004, and 2009



*Performance Goal

The bridge priority system, which is used to rank major bridge replacement and rehabilitation projects, will continue to be used for project selection and determining funding needs. However, this system is not inclusive as it does not rank short structures or maintenance needs, both preventive and routine.

Bridge replacement and rehabilitation projects progress through the VTrans Project Development Process. This process for a typical project is a multi-year effort from inception to construction. The Structures Section is working to both reduce and contain project scope and costs. Reduced scopes will accelerate the projects by streamlining the process and therefore reduce engineering costs.

Scope reduction can be achieved by various methods: reducing approach work, eliminating enhancements and, where possible, closing the roadway during construction. Although sometimes inconvenient for a community, the elimination of a temporary bridge reduces timelines, cost, need for significant right-of-way acquisition, and resource impacts.

Where appropriate, rapid bridge techniques and materials are utilized. The technique minimizes traffic disruptions and congestions, improves work-zone safety, and lessens environmental impacts. Additionally, prefabrication can improve constructability, increase quality, and lower life-cycle costs.

Focusing efforts toward preventive maintenance activities will slow, but not reduce the number of bridges becoming structurally deficient. Preventive maintenance does not correct existing structural deficiencies, but instead retards deterioration so that a bridge's lifespan can be extended, thus preventing the structure from becoming

structurally deficient. To this end, preventive maintenance is essential to slowing the rate at which structural deficiencies evolve over time.

The value of preventive maintenance will be appropriately demonstrated in the future through new performance measures that evaluate a bridge's overall core unit condition or health index.



*paint deterioration



*pavement and membrane failure



*deck cracking and leakage



*concrete spall / visible reinforcement



*undermining of foundation

Project Selection and Prioritization

In compliance with H.523 legislation, a priority ranking system for existing “long” structure projects, rehabilitation and replacement, was developed based on the following factors.

- Bridge Condition (30 points maximum)
- Remaining Life (10 points maximum)
- Functionality (5 points maximum)
- Load Capacity and Use (15 points maximum)
- Waterway Adequacy and Scour Susceptibility (10 points maximum)
- Project Development and Momentum (5 points maximum)
- Regional Input and Priority (15 points maximum)
- Asset – Benefit Cost Factor (10 points maximum)

Points are then summarized for each program, with the highest score receiving the top ranking. Rankings will change from year to year as projects are completed, as bridges change in condition, or as regional planning commissions’ priorities change. These priorities are used in developing the capital program, help in deciding which bridges to advance next, and have enabled us to clear a backlog of projects in a defined, documented, and efficient manner.

Selection for proposed rehabilitation and reconstruction projects will continue to utilize the priority system. To become a project and have design initiated, the bridge will need to be among the highest ranked.

The establishment four years ago of the bridge maintenance program gave us a start, enabling us to perform much needed preventive maintenance on a limited number of bridges, but it was just the beginning. Preventive maintenance is not a high-profile activity. But if done on a routine schedule, its benefits will be obvious as it will extend service life and delay the rate in which our bridges become structurally deficient. The Agency has substantially grown the program from its origins and has now integrated it into the regular program.



*Berkshire VT 108, bridge 57 – before and after deck replacement

Challenges and Opportunities

Both nationwide and here in Vermont, bridges are aging as traffic demands increase. Two major events – the 1927 flood and the construction of the interstate system – saw large numbers of structures built within short time frames. Vermont’s challenge is how to properly plan for and meet the needs of these aging structures. Meeting this challenge is multifaceted and includes everything from having a vigilant inspection program to using asset-management principles to guide decisions and a commitment to maintaining a long-term preventive maintenance program.

To assure public safety, our inspection crews will continue their vigilance and incorporate into their work improved bridge inspection techniques that utilize new and innovative equipment.

Using asset-management principles that utilize both bridge management systems and transportation system-preservation techniques is vital as states work to maintain safe bridge conditions.

Bridge maintenance is not just about fixing bridges when they break down. Proper care uses preventive maintenance to breathe new life into not-so-new bridges before they have the chance to deteriorate. Frequent inspections, not just by trained inspectors but also by those tasked with routine maintenance, along with a robust preventive maintenance program is vital to extending performance, keeping costs down, and maintaining safety.

Although the benefits of preventive maintenance are widely recognized, bridge owners face funding challenges. Without tangible incentives, maintenance deferment will continue. In response, educational outreach efforts have been conducted, coupled with funds targeted for maintenance activities. The purpose of this effort is to address maintenance needs in a timely fashion, and thereby cost-effectively extend the useful life of structures.

Advancing preventive maintenance, improving prediction models, applying emerging technologies, developing decision-making tools, and refining appropriate performance measures and goals are just some of the opportunities that VTrans is committed to moving forward. We will continue to work with municipalities so they not only understand the need, but have the necessary tools to maintain and preserve their assets.

Reducing the number of structurally deficient bridges and improving overall network conditions with both target maintenance and cyclical preventive maintenance treatment is the primary charge of the Structures Section. To prioritize efforts, control costs, and deliver projects efficiently, the Road to Affordability eliminated projects with no foreseeable funding plan. To streamline the process and therefore save both time and money, the Road to Affordability also emphasizes scope containment, a reduction in the use of temporary bridges, and the proliferation of accelerated bridge techniques and materials where appropriate.

To prepare for potential funding growth in conjunction with possible economic stimulus and bonding packages, efforts in plan development, permit clearance and right-of-way acquisitions will be enhanced to promote a streamlined project development and contracting process.

Alternative contracting methods, including design-build contracts and the use of simplified designs, standards, and contracting are being evaluated. If deemed successful and cost-effective, each method will be considered as an option for future projects. The refinement of bridge priorities, coupled with new and improved bridge performance measures and goals, as well as management predictive models, will continue to evolve and develop into trusted and valuable tools.

Legislative and administration support for bridges remains strong, and diligence will have its rewards. The prospect of a second wave of federal stimulus money as well as the possibility of future bonding to support bridge maintenance and rehabilitation efforts is cause for excitement and a readiness to succeed.



*Randolph TH 60, bridge 40 (Kingsbury Covered Bridge)

Please refer to the online version of this report for additional copies.

<http://www.aot.state.vt.us/progdev/Documents/Structures/2010StructuresAnnualReport.pdf>

The Treasure's report on bridges and culverts is available online as an additional resource.

<http://www.vermonttreasurer.gov/sites/treasurer/files/pdf/misc/TransportationReportRevisedNov1508.pdf>