FUNDAMENTALS OF BRIDGE MAINTENANCE AND INSPECTION





NEW YORK STATE DEPARTMENT OF TRANSPORTATION
OFFICE OF OPERATIONS
OFFICE OF TRANSPORTATION MAINTENANCE

FUNDAMENTALS OF BRIDGE MAINTENANCE AND INSPECTION

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Office of Transportation Maintenance
New York State Department of Transportation

CREDITS

This manual was originally printed in 1997, and was distributed for a workshop on Bridge Maintenance and Inspection at the Local Bridges Conference. It was developed, authored, and presented by the Communication/Training Subcommittee of the Statewide Conference on Local Bridges. The subcommittee was made up of representatives from the NYSDOT Maintenance Division, Structures Design and Construction Division, Transportation Research and Development Bureau, and the Local Roads Program at Cornell University.

This first update would not have been possible without the vision, dedication, and knowledge of the subject matter by those members of the Subcommittee. Because the original manual was broad in scope, comprehensive in specifics, and incorporated recent technologies and materials, the efforts required to update it were not overwhelming.

This current edition (September 2008) has been modified to reflect current-day practices, expand on the inspection rating section, and provide color photographs. Updates include additional information relative to the Bridge Inspection process, as well as added information to the corrective preventive maintenance procedures.

Questions or comments on the manual can be directed to the Bridge Maintenance Program Engineer with the Office of Operations.

PREFACE

Bridges, including those on local roads, are integral elements of our highway systems. Despite their importance, however, they are often the most neglected components of the infrastructure. Demands on limited resources, especially competing roadway priorities for increased capacity and improved riding surfaces, too often result in deferred maintenance for bridges. The consequences are obvious -- bridges are deteriorating far faster than they are being repaired. Without adequate attention, many require replacement or closure long before they are really obsolete, further adding to the demand for limited funds, impacting safety, and discouraging both users and transportation providers.

Establishment of national bridge inspection standards and New York's Uniform Code of Bridge Inspection (NYCRR Part 165), both requiring that all structures more than 20 ft long be inspected at least once every 24 months, have reduced the likelihood of catastrophic failure by mandating appropriate followup after structural or safety citations. However, inspection cannot slow down deterioration; merely identify it -- only properly scheduled, periodic maintenance activities can retard deterioration. Studies have shown that preventive maintenance is a cost-effective investment, and that deferring it only adds to bridge life-cycle cost.

This manual is intended as a handy reference for cyclical **preventive**-maintenance and **corrective** preventive maintenance activities applicable to state and local bridges.

The objectives of behind the manual are: 1) an education on bridge anatomy and those elements requiring periodic inspection, 2) familiarization with the difference between elements functioning as designed and those that are not, 3) identifying maintenance activities that can keep elements functioning as designed for longer periods, and 4) providing repair and rehabilitation options to return elements exhibiting severe deterioration to serviceable condition. A secondary goal is to provide guidance for bridge owners in responding to structural or safety citations (commonly **called flags)** resulting from inspections.

This manual is designed to address the most common types of bridge distress by outlining practical procedures for “preventive” maintenance and repair (or “corrective” maintenance). It is not meant to be all-inclusive, or to rule out other maintenance procedures. Although some routine environmental protection measures are incorporated in most of these procedures, the manual does not address their environmental, historic preservation, or safety implications. Although procedures presented here are not meant to have negative effects on the environment or to violate safety codes, local laws or rules or regulations may render some procedures inappropriate in specific situations. Practitioners, not the New York State Department of Transportation, are responsible for ensuring that procedures considered are consistent with environmental standards and safety codes within the jurisdictions involved, and that any permits required are obtained before starting work.

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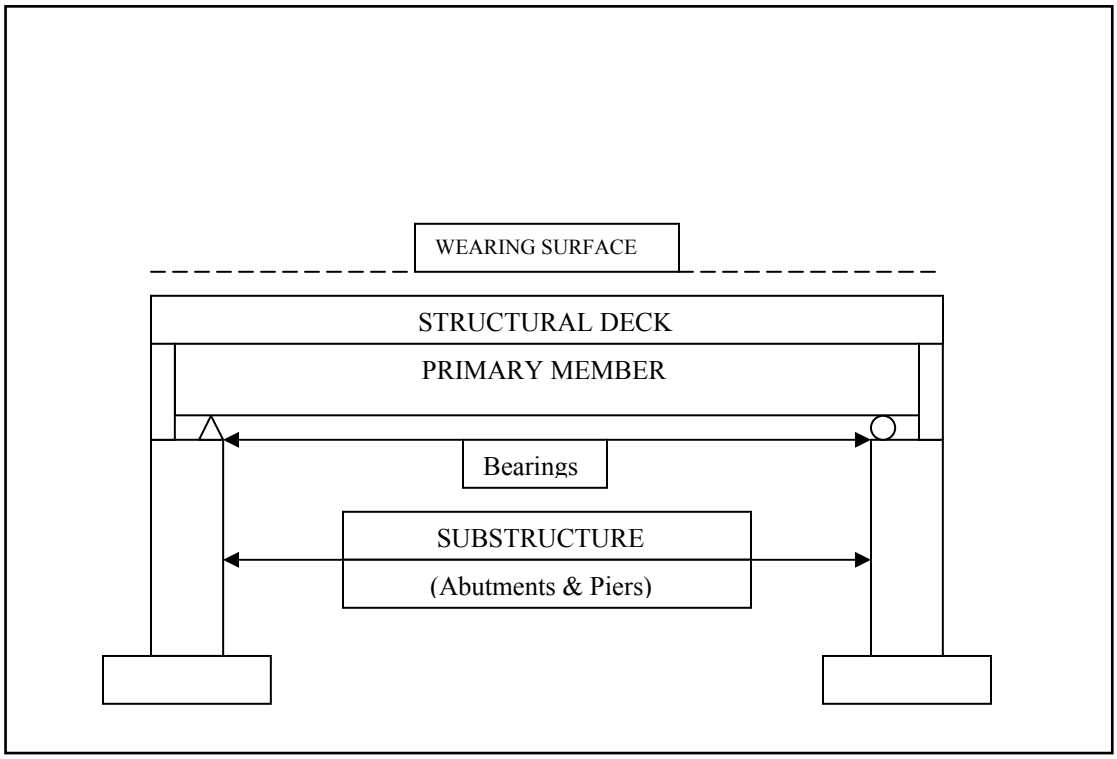

WEARING SURFACE
STRUCTURAL DECK
PRIMARY MEMBER
Bearings
SUBSTRUCTURE
(Abutments & Piers)

1. INTRODUCTION

Bridge Anatomy

Some common terms widely used in describing condition of structures should provide a framework for subsequent discussion of bridge inspection and maintenance. You should know these basic components, what they do, and their significance to help you rank recommendations in your maintenance plan.

Wearing Surface: the riding surface for traffic, comprised of a layer of portland-cement concrete or asphalt concrete, which may be integral with the structural deck or separate from it.

Structural Deck: supports the roadway on which traffic flows, and also distributes traffic (live) loads and dead loads.

Primary Members: support the dead load and live loads transmitted through the deck.

Bearings: support elements transferring load from the primary members to the substructure, while permitting limited rotational and longitudinal movement.

Substructure: elements transferring all loads from the primary members to the ground.

Structural Deck

This is the roof of the bridge. Its primary purpose is to provide a roadway for moving vehicles and to distribute their loads, but from a maintenance perspective it also provides a cover for primary members, bearings, and substructures, protecting them by diverting debris, salt, and moisture. Here are nine typical **structural decks:**

- Reinforced concrete with separate wearing surface
- Reinforced concrete with integral wearing surface
- Open steel grating
- Concrete-filled steel grating
- Timber: planks (nail-laminated, glue-laminated, stress-laminated)
- Jack-arch
- Precast-concrete slabs
- Metal orthotropic plates
- Metal stay-in-place (SIP) forms

Superstructure and Substructure

These are both designed to carry and transmit loads -- some examples of types and materials used for both functions are listed below. Because primary members transfer live and dead loads to the substructure, section losses resulting from corrosion may decrease their load-carrying capacity. The most critical areas when checking for section loss are those 1) directly below deck joints, 2) above and/or below bearings, or 3) at the center of the span. Here are fourteen typical **primary members:**

- Reinforced-concrete I-beams, T-beams, slabs
- Prestressed-concrete box-beams, I-beams, slabs (solid or hollow)
- Steel multi-girders (Rolled Beam or Plate Girders)
- Two- and three-girders (with or without floor beams and stringers)
- Steel box-beams
- Steel or timber trusses
- Timber slabs or stringers
- True arches
- Spandrel arches (open or filled)
- Concrete rigid frames
- Diaphragms attached to curved girders
- Grating support members
- Sidewalk support members
- Bridge Size Culverts

Here are eight typical **abutments:**

- Full-height abutments
- Stub abutments
- Stub abutments with mechanically stabilized earth systems (MSES)
- Gravity abutments
- Counterfort abutments
- Soldier pile and lagging-wall abutments
- Spill-through abutments
- Integral abutments

Here are six typical **piers:**

- Frame piers
- PI piers
- Hammerhead piers
- Column piers
- Solid-stem piers
- Pile-bent piers

Bridge Inspection

Historical Background

Current bridge inspections have resulted largely from responses to disasters -- many major later 20th century collapses resulted from materials failures that might have been identified by periodic inspection and maintenance. With each failure, new facts were learned and new standards implemented. Here is a short list of some events that have dramatically influenced inspection and maintenance practice.

During the bridge construction boom of the 1950s and 1960s, little emphasis was placed on safety inspection or maintenance of bridges. This changed when the 2235-ft Silver Bridge at Point Pleasant, West Virginia, collapsed into the Ohio River on December 15, 1967, killing 46 drivers and passengers. This tragic accident aroused national concern about bridge safety inspection and maintenance. The U.S. Congress added a section to the Federal Highway Act of 1968, requiring the Secretary of Transportation to establish national standards for bridge inspection, and to develop a program to train inspectors. Thus, in 1971 National Bridge Inspection Standards (NBIS) were created, setting national policy for inspection frequency, inspector qualifications, reporting formats, and procedures for inspection and rating. (During the 1970s, attention was also directed to culverts after several collapses claimed more lives, although culverts had not originally been included in these new programs.)

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

Types and Required Intervals for Inspection

New York State performs and reports four types of inspection under BIIS -- the Bridge Inspection and Inventory System:

Type 1: Biennial. Required for all highway bridges every two years and the standard and most common type of inspection. For new or reconstructed bridges, a biennial inspection is required within 60 days of fully opening to traffic or upon contract acceptance -whichever comes first.

Type 2: Interim. Some structures need to be inspected annually because of one or more deficiencies. Interim Inspections are performed during the calendar year between the required biennial inspections, and are required if one or more of the following conditions exist:

- A "general recommendation" (determined by an inspector) of 3 or less
- Condition rating (weighted average of individual item ratings) of 3.00 or less
- Presence of an active or inactive **red flag,** or an active **yellow flag**
- Posting for any load other than R-permit restriction

Type 4: None (Under contract). This is for bridges closed to all traffic during reconstruction. A temporary detour bridge that may be carrying traffic during reconstruction is also covered by the Type 4 inspection; temporary structures are the contractor's responsibility and do not get inspected under BIIS. Note that a biennial inspection must be performed within 60 days of reopening to traffic of the newly constructed bridge or any portion thereof. Any portion of an existing bridge that is under contract and carries traffic, remains on the inspection schedule. The appropriate items are rated on a scale of 1 to 7. Items removed or partially removed would rate 8.

Type 5: Special. Performed to address maintenance and/or inspection concerns unique to a particular bridge. These inspections are not entered into the database, so regular biennial inspections are still required. For large or unusually complex structures, a Type 5 inspection may replace an interim inspection, with written approval of the Deputy Chief Engineer (Structures).

Note: **Type 3** "in-depth" inspections (previously so identified in *Bridge Inspection Manual-82* and the corresponding Form TP 349) are no longer included on BIIS inspection forms. These inspections normally occurred before starting design for rehabilitation or replacement. When a biennial or interim inspection occurs in addition to an in-depth inspection, it must be identified as either **Type I** (biennial) or **Type 2** (interim), with all documentation required by this manual.

At times, additional inspections are performed that are not recorded in the database. These include inspections during flood events, typically referred to as the Bridge Flood Watch, as well as a follow up inspection following flooding events, referred to as the Post Flood inspection.

Inspection Team Qualifications and Responsibilities

Bridge inspection teams include a Team Leader (TL), who must be a professional engineer licensed by New York State, and an Assistant Team Leader (ATL). The TL must ensure that the bridge is inspected completely, and that the inspection report conforms with all requirements of the *New York State Bridge Inspection Manual* and all applicable Technical Advisories, Engineering Instructions, and Engineering Bulletins. The ATL may inspect and measure components, if working under direct supervision of the TL. Other personnel may be assigned as needed, such as Laborers and ATL Trainees. All field work must be reviewed by a Quality Control Engineer (QCE).

Bridge-Orientation Conventions

Almost every bridge has both a begin abutment and an end abutment. These terms must be used correctly on inspection reports to ensure consistency of reported inventory and inspection data throughout the structure's life. These locations also must be identified accurately when specific repair or maintenance work is required for either or both of these substructures.

Orientation is the compass direction used in establishing the beginning abutment and the span numbering system. Direction of orientation is either provided on the preprinted inspection form (Form TP 349), or may be obtained from inventory listings available from NYSDOT Regional Offices.

To identify the begin and end abutments, find the "direction of orientation" either on the inspection form or in the inventory listing. Then, standing on one abutment, sight across the bridge in that compass direction. If the bridge is in front of you, you are on the begin abutment, but if you do not see the structure when facing the direction of orientation, then you are on the end abutment.

The Rating Scale

The current New York State inspection program requires recording condition information for all elements on a span-by-span basis. Elements are rated using the following scale:

1 Totally deteriorated, or in failed condition
2 Used to shade between ratings of 1 and 3
3 Serious deterioration, or not functioning as originally designed
4 Used to shade between ratings of 3 and 5
5 Minor deterioration, but functioning as originally designed
6 Used to shade between ratings of 5 and 7
7 New condition -- no deterioration
8 Not applicable
9 Condition and/or existence unknown

Items rated 3 or lower may require substantial rehabilitation. Items rated 4 or higher may be corrected or improved with maintenance work.

Flagging Procedures and Types

This is a process used in New York State to identify conditions or situations that may pose a significant danger either now or if left unattended. Flags are not mechanisms to initiate repairs. This flagging procedure is a uniform method for timely notification to appropriate responsible persons of serious bridge deficiencies requiring attention. It also establishes requirements for certifying that appropriate corrective or protective measures are taken within an appropriate time frame. This procedure is used to report conditions posing a clear and present danger, or that might become dangerous if left unattended for an extended period. Flags must not be used to identify needed repairs if such danger is not present or potential. NYSDOT's Regional Directors may close any bridge determined to be unsafe at any time, regardless of steps being followed as part of this procedure. These are the three types of flags:

Red Structural Flag: used to report failure or potentially imminent failure of a critical primary structural component. Potentially imminent means that a failure is likely before the next scheduled inspection.

Yellow Structural Flag: used to report a potentially hazardous condition that would probably become a clear and present danger if left unreported beyond the next anticipated inspection. This flag can also be used to report actual or imminent failure of a non-critical structural component, if its failure would reduce the bridge's reserve capacity or redundancy but would not result in structural collapse. A yellow flag is not used to report a condition where service life will clearly extend well beyond the periods defined by scheduled inspection intervals, nor to draw attention to needs for maintenance or routine repair.

Safety Flag: used to report a condition presenting a clear and present danger to vehicle or pedestrian traffic, but not structural failure or collapse. These flags can also be used for closed bridges when their condition threatens vehicles or pedestrians passing beneath them.

In addition, immediate action may be required for a red or safety-flagged condition. An inspector may notify of such a condition by marking the recommendation line for **Prompt Interim Action** on the flag report. "Prompt Interim Action" is a recommendation by an inspection team leader when a red or

safety-flag condition is considered extremely serious and needing immediate attention. It requires action within 24 hours, resulting in closure or load restrictions, providing appropriate repair, or determining that existing condition is adequate.

Preventive Maintenance

Throughout the life of a bridge structure there are anticipated activities that are necessary to realize the full potential of the capital bridge investment. The goal is to maintain the bridge asset at the lowest cost over the life of the structure. Historically it has been found that a strong preventive effort is the most cost effective approach.

- **Preventive Maintenance: "**activities that will preserve bridge components in their present (or intended) condition, forestalling development of a structural deficiency. Preventive maintenance activities can be classified into two groups: scheduled and response."
  - **"Scheduled [Cyclical]** (programmed at intervals) Typical activities that are conducted on a scheduled interval basis include
    - cleaning decks, seats, caps, and salt splash zones;
    - cleaning bridge drainage systems;
    - cleaning and lubricating expansion-bearing assemblies; and
    - sealing concrete decks or substructure elements."
  - **"Response [Corrective or Minor Repairs]** (done as needed and as identified through the inspection process): Typical activities that are performed on an as-needed basis include
    - resealing expansion joints;
    - painting structural steel members
    - removing debris from waterway channels;
    - replacing wearing surfaces;
    - extending or enlarging deck drains…"[1]

Preventive maintenance is typically applied to bridge elements on structures with significant remaining service life. The concept of preventive bridge maintenance suggests that many relatively small repairs and activities are performed to keep the bridge in good condition and thereby avoid large expenses in major rehabilitation or replacement.

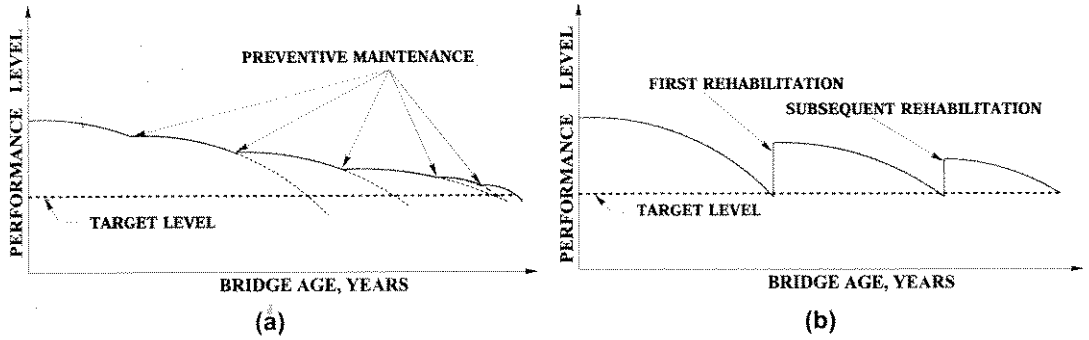


Figure 1: Life extension by subsequent maintenance actions: (a) preventive maintenance only; and (b) essential maintenance only[2]

[1] AASHTO Maintenance Manual § 3.1.1.3 Bridge Maintenance Concepts, 2007.
[2] "Life Prediction of Highway Bridges with or without Preventive Maintenance", Kong, Frangopol, & Gharaibeh

NYSDOT has investigated the effect of preventive maintenance treatments and has concluded that "the benefits of applying … maintenance repairs to bridges significantly extends service life" [3] and a "preventive maintenance program ….. combined with present guidelines for improving deficient bridges, gave the lowest long term cost for the state bridge program[4]".

Figure 2 was derived from a set of bridges which did not receive any major work. Bridges were further divided into those with no improvement in overall condition rating and those that did show an improvement. The study assumes both set of bridges received similar levels of scheduled (cyclical) maintenance. The increase service life can be directly attributed to a series of relatively minor response (corrective or minor repair) maintenance activities done on these structures.

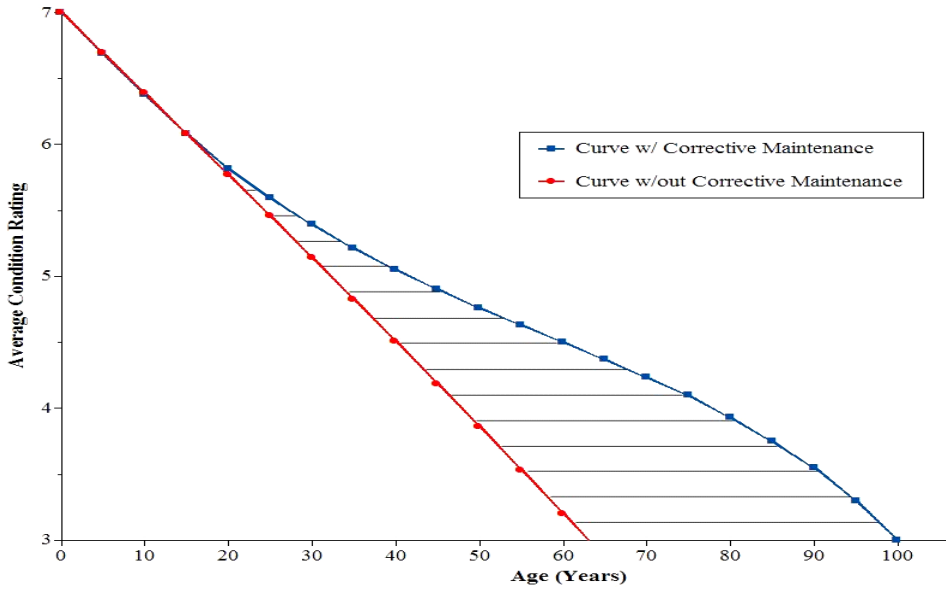


Figure 2. Deterioration Curves with and without Corrective Maintenance (Steel Stringer Bridges)[5]

Ninety percent of NYSDOT's bridge population has significant remaining service life. This group of bridges stands to benefit from the positive effects of preventive maintenance. The costs of these treatments range from minimal for scheduled (cyclical) actions, to moderate for response (corrective or minor repair) actions.

Preventing or correcting minor deficiencies to the elements of a bridge, while the structure is still in "good" or "fair" condition, will ensure the structural reliability of the bridge and forestall the structural deficiency of bridge components. Figure 3 represents a typical bridge inventory and typical treatment costs associated with activities appropriate for the average weighted condition of the bridge. As demonstrated in the graph, service life extension begins to accrue when minor deficiencies are corrected.

[3] "Development of Network-Level Bridge Deterioration Curves for use in NYSDOT's Asset Management Process". DeLisle, Shufon, Adams
[4] "Long Term Effect of Preventive Maintenance on State Structures", G. Hall, 1995.
[5] "Development of Network-Level Bridge Deterioration Curves for use in NYSDOT's Asset Management Process". DeLisle, Shufon, Adams

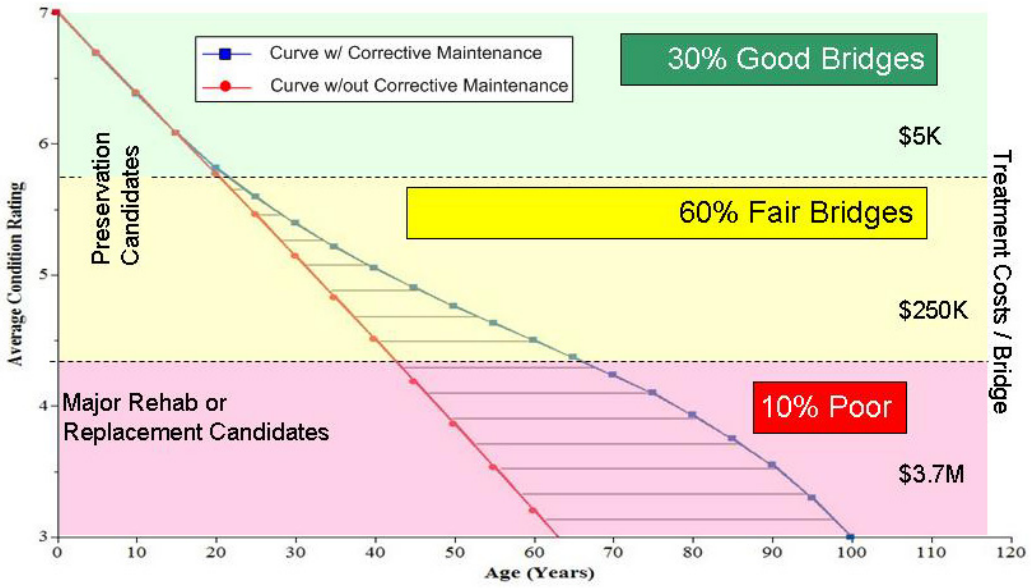


Figure 3. Network-level Program Modeling including using Preventive Maintenance Strategies

Responding to identified needs early in the deterioration process of a bridge element, maintains the reliability of the asset and avoids much more costly repairs in the future. Repairing a leaky expansion joint, in a timely manner, prevents deterioration of the girder ends, pedestals, and bearings. Keeping good bridges good is the cornerstone of preventive maintenance.

Preventative maintenance actions, whether cyclical, work activities completed at regular planned intervals, or corrective, repairing individual work elements or systems as they deteriorate and before they cause more significant damage to the structure are more cost effective than the occasional and more expensive capital actions. The cost of deferring cyclical or corrective work is an increased need for future capital replacement and rehabilitation projects.

2. INTERPRETING INSPECTION REPORTS

This section provides photographs and descriptions of several deteriorated bridge elements, and indicates appropriate condition ratings for these elements. Each photo is also accompanied by a reference to cyclical preventive-maintenance activities that could have helped prevent the exhibited deterioration, and to corrective-maintenance activities that can repair the deterioration.

WEARING SURFACE

Rating:	3
Description:	Indicates a more serious spalling and delamination problem with about 25 percent of one lane affected and poor riding quality. Wearing surface has cracks or spalls and has a well worn and polished aggregate.
Cyclical Maintenance:	Replace the Asphalt Wearing Surface
Corrective Maintenance:	Repair the Concrete Wearing Surface Repair the Asphalt Wearing Surface

WEARING SURFACE

Rating:	5
Description:	Indicates beginning of a spalling problem with no more than two or three isolated, moderate spalls or delaminations. There may be only scattered tight cracks and moderate surface wear with good riding quality.
Cyclical Maintenance:	Clean the Bridge Seal Cracks in the Wearing Surface Seal the Concrete Deck
Deck Treatments:	Apply "Healer/Sealer" Thin Polymer Overlay Asphaltic Pavement Preservation Treatment

STRUCTURAL DECK

Rating:	3
Description:	75 percent or more of the deck has leakage, only localized spalled areas, and efflorescence along the girder top flanges.
Corrective Maintenance:	Repair/Replace the Concrete Deck Repair/Replace the Asphalt Wearing Surface

STRUCTURAL DECK

Rating:	5
Description:	Only localized areas of leakage (e.g., single longitudinal crack with leakage, or deck edges showing only spotty leakage).
Cyclical Maintenance:	Clean the Bridge Seal Cracks in the Wearing Surface Seal the Concrete Deck
Deck Treatments:	Apply “Healer/Sealer” Thin Polymer Overlay Asphaltic Pavement Preservation Treatment
Corrective Maintenance:	Repair the Concrete Deck Repair the Asphalt Wearing Surface

DECK JOINTS

Rating:	2
Description:	Adhesion between sealer material and the armored angles has failed completely. Water and debris may freely enter the opening, leading to substantial damage to bridge elements below.
Corrective Maintenance:	Repair/Replace the Joints

DECK JOINTS

Rating:	5
Description:	Joint components may show some deterioration such as minor asphalt raveling next to armor angles or filler material deterioration, but the joint is still watertight.
Cyclical Maintenance:	Remove debris from the Joint
Corrective Maintenance:	Repair the Joints

STEEL PRIMARY MEMBERS

Rating:	1
Description:	Severe and extensive section loss in critical areas, or major impact damage resulting in a substantial reduction of load carrying capacity. Member has cracks in girder tension zone.
Corrective Maintenance:	Repair/Replace Steel Members

STEEL PRIMARY MEMBERS

Rating:	5
Description:	Minimal section loss- member can still function at full capacity. Little or no crevice corrosion and impact damage that does not reduce load carrying capability.
Cyclical Maintenance:	Clean the Bridge Paint the Steel Members

BEARINGS

Rating:	3
Description:	Serious deterioration or deformation of the bearings, improper positioning of the bearing and/or frozen bearings. Secondary effects of frozen bearings, such as sheared anchor bolts and/or cracked pedestals may be evident.
Cyclical Maintenance:	Remove, Clean, and Lubricate the Bearings
Corrective Maintenance:	Repair/Replace the Bearings

BEARINGS

Rating:	5
Description:	Minor deterioration, but still allow movement, if required. Bearings should be reasonably close to proper position for the ambient temperature.
Cyclical Maintenance:	Clean the Bearings Lubricate the Bearings

SUBSTRUCTURE PIER COLUMNS

Rating:	2
Description:	Deterioration of concrete would be significant and characterized by wide-spread mapcracking, efflorescence, spalling and/or scaling. Corroding rebars may be delaminating the rebar cover. There may also be active structural cracks.
Corrective Maintenance:	Repair/Replace Substructure Concrete

SUBSTRUCTURE PIER COLUMNS

Rating:	5
Description:	For concrete columns, mapcracking and efflorescence may be evident, but doesn't exceed 25% of the column surface and hammer sounding indicates little or no delamination.
Cyclical Maintenance:	Clean the Substructure Seal Substructure Concrete
Corrective Maintenance:	Repair Substructure Concrete

SUBSTRUCTURE ABUTMENT

Rating:	2
Description:	Extensive deterioration and widespread mapcracking, efflorescence, spalling and/or scaling.
Corrective Maintenance:	Repair/Replace Substructure Abutment

SUBSTRUCTURE ABUTMENT

Rating:	5
Description:	Minor deterioration, such as mapcracking with effloresence covering up 25% of the stem surface. Some spalling may occur covering no more than 10% of the stem nor would it encroach on the bridge seats or pedestals.
Cyclical Maintenance:	Clean the Substructure Seal the Substructure Remove Brush & Debris
Corrective Maintenance:	Repair Substructure Abutment

EROSION

Rating:	1
Description:	Major loss of material in the channel banks or streambed, including loss of material behind wingwalls and at the roadway embankment. The foundations are exposed and possibly undermined and the loss has occurred over a period of three years or less.
Corrective Maintenance:	Repair Erosion or Scour Repair/Replace Concrete Foundations

EROSION

Rating:	5
Description:	Minor erosion or scour is occurring at banks away from the bridge, but is not causing problems at the bridge. General streambed degradation (not affecting the bridge) has occurred over decades.
Cyclical Maintenance:	Clean the Foundations Remove Brush and Debris Maintain Stream Channels Maintain Bank Protection and Walls
Corrective Maintenance:	Repair Erosion or Scour

3. CYCLICAL PREVENTIVE MAINTENANCE PROCEDURES

This chapter describes cyclical maintenance activities that bridge owners can perform as planned actions, in advance of critical need, to reduce the rate of deterioration of critical bridge elements. These activities, when undertaken at appropriate regular intervals, can significantly reduce or sometimes eliminate the occurrence of advanced deterioration identified in this Manual's previous chapter, **Interpreting Inspection Reports.** These activities are essential for a bridge to reach its maximum useful life and maintain its designed level of service.

These activities generally depend on a top-down approach, with the overall goal of keeping water away from sensitive elements of the bridge, thus enhancing its long-term performance. Although the deck is designed to carry traffic loads, it also protects the components below from water, like the roof on a house. Decks must be kept watertight and clean to perform this protective function. When decks have separate wearing surfaces, those surfaces must be kept watertight to protect and preserve the underlying deck. Similarly, joints allowing each deck span to move independently must be kept watertight, or water will reach the beams, bearings, or substructure concrete below, causing deterioration. Drainage systems, designed to carry surface water safely off the deck and away from the bridge, must be kept clean to ensure water flow. Plugged drainage systems allow water to pond on the deck, where it will eventually attack critical bridge elements.

Besides maintaining the waterproof cover provided by the bridge deck, other cyclical activities focus on maintaining the bridge's protective coatings (paints and sealers), and keeping all bridge elements clean and free of harmful materials.

Most of these activities can be readily performed by in-house forces and are cost-effective investments. However, as with all highway-related work, the practitioner must ensure that preventive maintenance procedures contemplated for use are consistent with environmental standards and safety codes within the jurisdiction, and obtain any required permits before commencing work.

BRIDGE CLEANING

Description: Remove all salt, dirt, and grit from the deck and supporting members, bearings, pedestals, capbeams, and bridge seats. Unplug and clean the drainage system (scuppers, open joint troughs, and downspouts) on the bridge. Clean debris and vegetation from around the structure and approaches.

Objective: Remove de-icing salt to prevent corrosion and remove debris to enable elements to function properly. Ensure proper drainage on and around the bridge.

Selection Criteria: Clean bridge at least once every two years, preferably in early spring. Generally perform cleaning on all bridges except culverts.

Procedure:

Labor Skills	Physical Labor	
Material	Clean Water	
Equipment	Water Trailer	High-pressure water pump w/hoses, etc.
	Sewer snake	175-CFM compressor w/hoses, etc.
	Long-handle scrapers	Ladders & scaffolding
	Square-point shovels	Brooms
	Brush clippers & saw	Personal safety equipment

Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Coordinate with Regional Environmental Unit and obtain any necessary permits from the Adirondack Park Agency, NYS Department of Environmental Conservation, US Army Corps of Engineers, or NYC Department of Environmental Protection; and consult DEC, particularly for acceptable months to wash over trout streams.
- Prepare the work-zone (i.e. traffic control, environmental protection, other equipment).
- Cut and remove vegetation from around substructures and approaches, minimizing removal to limit habitat loss, erosion, and sedimentation.
- Collect and remove trash, dirt, and other debris on and around the bridge (including underside, supporting elements, and approaches) by sweeping, shoveling, vacuuming, or other suitable methods.
- Loosen dirt and debris with scrapers and stiff brushes, as necessary.
- Properly dispose of all collected material. If sand, dirt, or other similar material is to be disposed of on-site, place it in an upland area from which it cannot enter a stream, water body or wetland.
- Pressure or Flood wash the structure, generally beginning at the highest point and working downward, using clean, fresh water. Carefully avoid excessive pressure that may damage paint, grout, or other materials.
- Flush scuppers and drainage system, but prevent sediment and debris from discharging into streams and other surface-water bodies.

- Remove scupper gratings and downspout clean-out plugs to flush and snake trapped debris, as necessary.
- Use caution to control water pressure used in flushing drainage systems.
- Portions of structures with loose paint chips should not be pressure-washed, and care should be taken to collect and properly dispose of any dislodged paint chips.

Safety Typical work-zone procedures as appropriate for specific site.
Consider safety needs for feature crossed.
Be aware of and avoid histoplasmosis.

Removing dirt and other debris from the bridge wearing surface.

Volume washing the bridge deck.

SEALING CRACKS IN THE WEARING SURFACE

Description: Clean out and seal cracks in the wearing surface to protect the underlying structural deck. Also apply liquid joint sealer where appropriate.

Objective: Ensure that the wearing surface provides waterproof protection for underlying structural deck and that asphalt-cement-concrete wearing surface achieves full 12-year life.

Selection Criteria: Bituminous-based materials should be reapplied every four years and can be placed on concrete or asphalt surfaces. Polymer-based products should be reapplied every 10 years and cannot be used on asphalt.

Procedure:

Labor Skills	Physical Labor	
Material	Crack-sealer meeting ASTM D 6690 or Polymer-based "healer/sealer"	
	Blasting sand	Epoxy or polyurethane sealer
	Water	
Equipment	Crack-sealer heater/melter	Wand, hoses, & nozzles
	Compressor w/hoses, etc.	Shovels & brooms
	Concrete saw (Crack-chaser)	Sandblaster
	Personal safety equipment	

Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Prepare the work-zone (i.e. traffic control, environmental protection, equipment).
- Loosen and shovel off heavy dirt deposits.
- Clean wearing surface by sweeping and/or using compressed air.
- Clean cracks and joints using water or compressed air, and a grinder or putty knife to scrape out larger deposits or old joint material.
- Prepare joint surfaces by sandblasting, sawcutting, or grinding, if necessary.
- Clean all loose dirt and sandblast material from pavement surface.
- Cracks and joints should be clean and dry before applying sealing material.
- Apply D 6690 crack sealer or Polymer-based material liquid joint sealer to joints according to manufacturer's instructions, allowing adequate time for material to dry.
- Avoid excessive material that may reduce skid resistance.

Safety Typical work-zone procedures as appropriate for specific site.
Avoid excessive material that may reduce skid resistance.

Typical crack-filling equipment and setup.

Topical application of two part “healer/sealer”.

CRACK SEALING ON PORTLAND CEMENT CONCRETE DECKS

Description: Applying ASTM D 6690 Joint and Crack sealant to longitudinal cracks along prestressed concrete box beam bridge decks.

Objective: Minimize or eliminate water and chlorides entering the structure through these cracks. Extend the service life of the existing bridge deck.

Selection Criteria: The deck will exhibit longitudinal cracks above/in line with precast box beam segments below.

Procedure:

Labor Skills — Physical Labor

Material — Joint and Crack sealant, ASTM D 6690
Blasting sand

Equipment — Compressor w/hoses, etc.
Sandblaster
Personal Protective equipment
Hot tar pot
Walk behind Concrete router

Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Prepare work-zone (i.e. traffic control, environmental protection, equipment).
- Using concrete router, route channel along existing crack to a depth of +/- 1”
- Remove debris from routing operation
- Sandblast routed crack, clean up sandblasting debris
- Surface must be clean, dry, and temperatures must be correct.
- Using tar pot with wand, install properly heated crack sealer (ASTM D 6690) into prepared crack
- Allow sealer to reach initial set prior to opening area to traffic
- This procedure can also be performed on transverse deck cracks

Safety Typical work-zone procedures as appropriate for specific site

Routing Out Existing Crack

Blast Cleaning Routed Crack

Sealing of Crack

Finished Sealed Crack

SEALING THE CONCRETE DECK

Description: Apply sealant to concrete deck, curbs, sidewalks, and fascia and apply liquid deck sealer where appropriate.

Objective: Maintain waterproof integrity of the deck wearing-surface portion to prevent water and chlorides from reaching the reinforcing steel.

Selection Criteria: Generally, concrete decks should be sealed at least once every four years, giving priority to bridges without epoxy-coated reinforcing steel and without high-performance concrete. It is particularly important to seal new decks, and those with hairline cracks less than 0.010 in.

Procedure:

Labor Skills	Physical Labor	
Material	Water	Blasting sand
	Sealer (silanes, siloxanes, silicone, polymers)	Steel shot
Equipment	Compressor w/hoses, etc.	Truck w/pumps & spray bar
	Paint/herbicide spray unit	Paint rollers & brushes
	Shovels, scrapers, & brooms	Sandblaster
	Personal safety equipment	Various hand tools
	Steel-shot blaster	

Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Prepare work-zone (i.e. traffic control, environmental protection, equipment).
- Loosen and shovel off heavy dirt deposits.
- Clean deck by washing, sweeping, and/or using compressed air.
- Sandblast
- Surface must be clean and dry, temperatures correct, and wind calm.
- Apply sealer according to manufacturer's instructions, controlling application rate to avoid running or puddling. Use multiple coats, if necessary.

Safety Typical work-zone procedures as appropriate for specific site.
Use caution because of flammability of some products.

Typical equipment

Applying Sealer

REPLACING THE ASPHALT WEARING SURFACE

Description: Remove entire existing wearing surface, and install waterproof membrane and new wearing surface.

Objective: Ensure that wearing surface provides waterproof protection for underlying structural deck.

Selection Criteria: Replace asphalt wearing surface at least once every 12 years. Bare decks in good repair with no more than 15% - 18% of the deck area deteriorated or with insufficient cover over the reinforcing steel.

Procedure:

Labor Skills	Physical Labor	
Material	Asphalt concrete	Membrane waterproofing system
	Water	Blasting sand
	Solvent for cleanup	Plastic pipe
	Concrete-repair material	Wire screening/mesh
Equipment	Large dump-truck	Loader
	Milling machine	450-CFM compressor w/hoses, etc.
	Concrete saw	Generator
	Bituminous spreader	Roller(s) & plate compactor
	Water tank	Shovels & rakes
	Core drill	Squeegees & pails
	Brooms & brushes	Sandblaster
	Personal safety equipment	Various hand tools

Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Check load rating to ensure that bridge can safely support additional load. The load rating should be updated to reflect any additional loads, including additional wearing surfaces.
- Prepare work-zone (i.e. traffic control, environmental protection, equipment).
- Remove existing wearing surface by milling and/or hand methods.
- Remove material from the site using a loader and heavy dump-trucks.
- Remove dirt and smaller debris by sweeping and shoveling.
- Clean deck with compressed air and prepare surface by sandblasting.
- Make deck repairs as necessary.
- Sandblast repaired areas and again blow the deck clean.
- Drill weep holes and install plastic drain pipes, if necessary.
- Apply waterproof membrane according to manufacturer's instructions, depending on type (preformed sheet membrane or liquid membrane).
- Place and roll asphalt concrete (2-in. minimum compacted).

Safety Typical work-zone procedures as appropriate for specific site.

Place waterproof membrane.

Place and compact the new asphalt wearing surface.

LUBRICATING BEARINGS

Description: Jack structure, clean and lubricate all appropriate bearings and pin-and-hanger connections. Spot-paint these items if required.

Objective: Ensure that bearings function properly to transfer loads from superstructure to substructure, and allow proper movement of the superstructure.

Selection Criteria: Clean and lubricate bearings at least once every four years. Generally perform this work on all steel roller and rocker-type bearings and many types of steel sliding bearings.

Procedure:

Labor Skills	Physical Labor	
Material	Blasting sand	Paint
	Penetrating oil	Lubricating oil
	Grease	Water
Equipment	Hydraulic jacks	Ladders & scaffolding
	Water trailer	150-CFM compressor w/hoses, etc.
	High-pressure water pump	Stiff brushes
	Sandblaster	Scaling hammer
	Steel grinder	Personal safety equipment
	Various hand tools	

Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Develop jacking plan (performed by a licensed engineer).
- Prepare work-zone (i.e. traffic control, environmental protection, ladders & scaffolding, equipment).
- Flush the bearings with high-pressure water or air to remove loose material.
- Remove rust and scale from bearings by scraping, wire brushing, or sandblasting, and reflush, making sure the bearing is not damaged by rust and scale removal.
- Jack structure pursuant to jacking plan and remove bearings, if necessary for proper service, depending on type of bearing.
- Clean and grind bearing surfaces to a smooth finish.
- Grease or oil bearing wearing surfaces as required, depending on bearing type.
- Prime and paint bearing non-wearing surfaces, as necessary.
- Re-install bearing and lower bridge pursuant to jacking plan, if necessary.

Safety Typical work-zone procedures as appropriate for specific site.
Restrict traffic during jacking operation.
Consider environmental and worker safety issues (i.e. asbestos exposure).

Typical bridge jacking for access to grease bearings.

Jack, pump, and small tools.

SEALING CONCRETE SUBSTRUCTURES

Description: Apply sealant to capbeams, seats, and pedestals, and other substructure elements.

Objective: Maintain waterproof integrity of substructure elements to prevent water and chlorides from penetrating the concrete and reaching the reinforcing steel.

Selection Criteria: Concrete substructures should be sealed at least once every six years. Generally perform this work on all bridges with concrete substructures, especially those with hairline cracks, uncoated steel, or located in splash zones.

Procedure:

Labor Skills	Physical Labor	
Material	Water	Blasting sand
	Steel shot	Sealer (silanes, siloxanes, silicones, and polymers)
Equipment	Compressor w/hoses, etc.	Sandblaster
	Backpack (handheld) sprayer	Barrel pump with hose & spray attachment
	Paint rollers & brushes	Shovels & brooms
	Scrapers & stiff brushes	Personal safety equipment
	Various hand tools	Steel shot blaster

Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Prepare work zone (i.e. traffic control, environmental protection, ladders & scaffolding, equipment).
- Loosen and shovel off heavy dirt deposits.
- Clean substructure elements by washing or using compressed air.
- Sandblast or use stiff brushes and scrapers to loosen material if necessary.
- The surface must be clean and dry, temperatures correct, and wind calm.
- Apply sealer according to manufacturer's instructions. Begin sealing at the bottom of the element and work up, controlling application rate to avoid excess running. Use multiple coats, if necessary.

Safety Typical work-zone procedures as appropriate for specific site.
Use caution because of flammability of some products.

Typical equipment (portable spray unit).

Applying penetrating sealer.

PAINTING BRIDGE STEEL

Description: Prepare and repaint paintable bridges.

Objective: Prevent steel section loss.

Selection Criteria: Paint each paintable bridge at least once every 12 years.

Procedure:

Labor Skills — Not applicable

Material — Per contract and NYSDOT specifications.

Three coat system: Zinc-based primer and two layers of two-part epoxy paint. Moisture-cure paint system.

Equipment — Per contract and NYSDOT specifications.

Tasks — Open abrasive blasting is prohibited. Properly designed and approved containment systems are required. Several basic considerations help determine best approach and appropriate specifications, including:

- Extent of rust and paint deterioration.
  Entire structure or Zones (typically fascia and girder ends).
- Whether structure crosses water.
- Whether site is urban or rural.

These factors help establish extent of paint removal, and thus, type of containment system and whether existing paint will be over-coated.

Safety — Environmental and worker safety issues, (i.e. lead exposure, histoplasmosis, etc…)

Typical paint project with Class A containment.

Steel properly prepared for painting.

4. CORRECTIVE PREVENTIVE MAINTENANCE PROCEDURES

Despite even the most aggressive cyclical preventive-maintenance program, some deterioration or damage of bridge elements will occur. To address these deficiencies, this chapter presents eleven corrective procedures -- activities performed to remedy existing problems. Not all these can be readily performed by in-house forces, but must not be neglected. Also, as with preventive maintenance work, the practitioner must ensure that corrective maintenance procedures contemplated are consistent with environmental standards and safety codes within the jurisdiction, and obtain any required permits before starting work.

REPAIRING THE CONCRETE DECK

Description: Remove and replace damaged portions of structural concrete deck and reinforcing steel.

Objective: To restore structural integrity of the deck, provide a smooth riding surface, and improve safety of the traveling public.

Selection Criteria: Consider this treatment for any bridge with a structural-deck condition rating less than 5.

Procedure:

Labor Skills: Physical labor, carpentry, masonry.

Material:

Steel shot	Reinforcing steel
Blasting sand	Water
Portland cement concrete (or other patching material)	

Equipment:

Concrete saw	450-CFM compressor w/hoses, etc.
Generator	Sandblaster
Concrete mixer	Pneumatic hammer (<30 lb)
Shovels & pickaxe	Brooms & brushes
Sounding hammer	Various hand tools
Personal-safety equipment	Steel-shot blaster

Tasks: The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Prepare work-zone (i.e. traffic control, environmental protection, equipment).
- Identify and mark extent of damaged portions. Repair areas should be rectangular.
- Sawcut outside the damaged area (straight cuts).
- Remove deteriorated concrete using pneumatic hammers and hand tools to 1 inch below the steel.
- Periodically sound the remaining concrete.
- Clean the area using water-blasting or sandblasting.
- Sandblast or wire brush exposed steel to remove rust and other contaminants.
- Fasten additional reinforcing steel to the existing steel if section loss is 20% or more.
- Form underside of deck for any full-depth repairs.
- Apply a bonding agent of neat cement paste or 1:1 sand-cement grout mix to remaining concrete, if necessary, or saturate existing surface with water.
- Place new concrete or patching material (depending on repair depth).
- Broom-finish surface of the patch.
- Provide for proper cure to avoid shrinkage cracks.

Safety: Typical work-zone procedures as appropriate for specific site.

Prepare the surface.

Placing repair material.

REPAIRING/REPLACING JOINTS

Description: Repair or remove and replace deteriorated or damaged sections of joint systems, including surrounding concrete. Perform this work on all types of joint systems, as required.

Objective: Provide proper operation of the joint system and safety for the traveling public.

Selection Criteria: Consider this treatment for any bridge with a joint-system condition rating less than 5.

Procedure:

Labor Skills: Physical labor, welding

Material:

Steel shape (armor angle or extrusion)	Blasting sand
Concrete/elastomeric material	Compression gland, or liquid seal
Compression-seal lubricant/sealant	Forming lumber
Styrofoam board & backer rod	Welding rod
Epoxy anchor capsules & anchoring devices	Solvent for cleanup

Clip angles (3"x 4" steel angle to attach joint steel to base concrete)

Equipment:

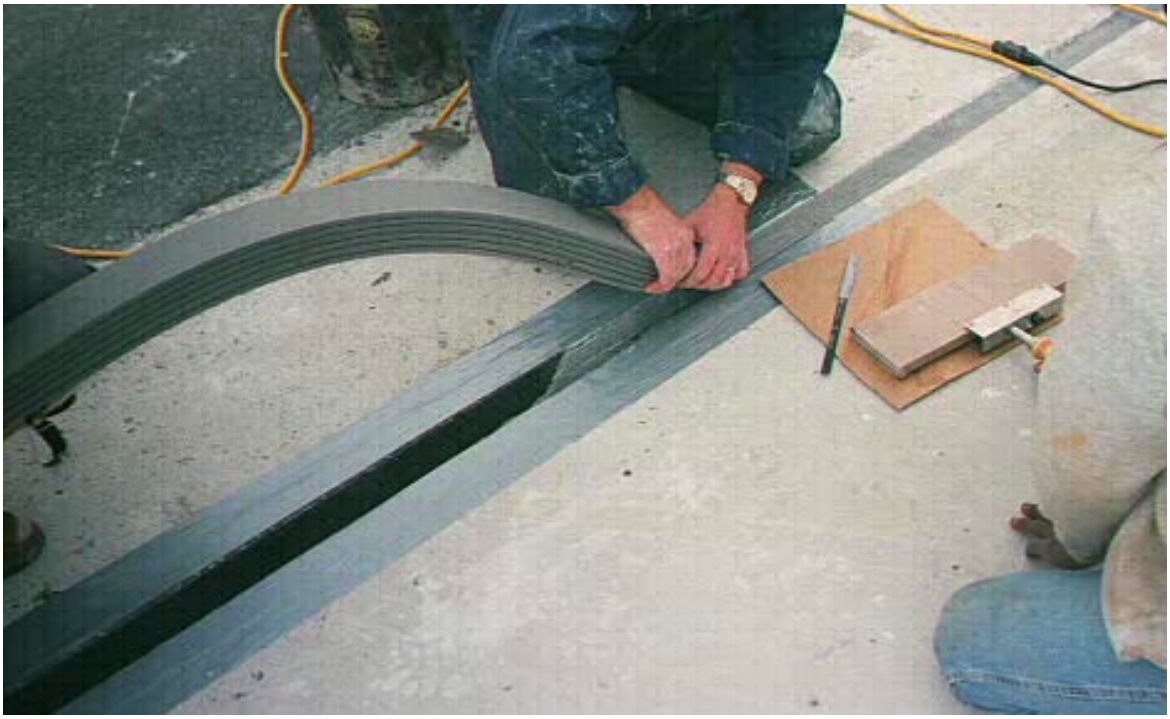
Generator	175-CFM compressor w/hoses, etc.
Sandblaster	Pavement breakers, 35-lb chipping guns
Welder	Hammer drill
Oxygen/acetylene torches	Concrete mixer
Concrete vibrator	Concrete saw
Rubber seal installation tools	Joint levelers
Personal safety equipment	Various hand tools

Tasks: The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Prepare work-zone (i.e. traffic control, environmental protection, equipment).
- Sawcut and chip out concrete adjoining joint.
- Remove existing joint system.
- Prepare box out for new joint system.
- Set, level, drill, anchor, and weld armor angle/extrusion.
- Sandblast all concrete and steel surfaces.
- Place styrofoam and backer rod.
- Place concrete/elastomeric material and cure.
- Install seal.

Safety: Typical work-zone procedures as appropriate for specific site.
Consider environmental and worker-safety issues (i.e. asbestos exposure).

Removing concrete adjacent to the joint.



Installing a pre-formed joint seal.

REPAIRING/REPLACING STEEL MEMBERS

Description: Repair or replace deteriorated or damaged steel sections.

Objective: To re-establish structural load-carrying capacity of steel bridge elements.

Selection Criteria: Consider this treatment for any bridge with steel elements having a condition rating less than 5, or for any member damaged while in service. Steel bridge members exhibiting cracking also need repair.

Procedure:

Labor Skills: Physical labor, iron work, welding, steel fabrication, lead-abatement, painting.

Material	Steel	Welding rod
	High-strength bolts	Blasting sand
Equipment	Compressor w/hoses, etc.	Magnetic drill
	Welder	Paint rollers & brushes
	Scrapers & stiff brushes	Vacuum paint-removal tools
	Grinder	Generators
	Sandblaster	Acetylene torches
	Shroud	Various hand tools
	Personal safety equipment	

Tasks: The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Develop repair plan. CAUTION: consult a licensed professional engineer.
- Prepare work-zone (i.e. traffic control, environmental protection, equipment).
- Provide temporary support for affected members, as necessary.
- Prepare steel area to be repaired by removing paint, rust, dirt, etc.
- Remove paint using vacuum-shrouded power tools.
- Remove rust using vacuum-shrouded tools, wire brushes, scrapers.
- Remove loose dirt and grime with compressed air or high-pressure water.
- Perform repair as required.
- CAUTION: only certified welders should weld structural steel members.
- Conduct any necessary non-destructive testing in accord with NYS Steel Construction Manual.
- Prime and spot-paint treated area.

Safety: Typical work-zone procedures as appropriate for specific site.
DO NOT attempt steel repairs without proper knowledge and qualifications.
Consider environmental and worker-safety issues (i.e. lead exposure).

Mark extent of deteriorated/damaged material to be removed.

Remove paint prior to performing the work.

REPAIRING/REPLACING BEARINGS

Description: Jack structure and repair or replace non-functioning bearing systems or system components for all types of bearings, as required.

Objective: Ensure that the bearings function properly to transfer loads from superstructure to substructure, and allow proper movement of superstructure.

Selection Criteria: Consider this treatment on any bridge with a bearing condition rating less than 5 or with the onset of damage caused by "frozen" steel bearings.

Procedure:

Labor Skills: Physical labor, iron work.

Material:

1-in. steel flat stock	7/8-in. threaded rod
Hilti glue (or equivalent)	Grease
Paint	Steel plates
Bolts/nuts	Concrete (or other patching material)
Water	
New elastomeric bearings or impregnated random fiber pads	

Equipment:

Hydraulic jacks	Grinders
Magnetic drill	Compressor w/hoses, etc.
Generator	Scalers, wire brushes
Ladders & scaffolding	High-pressure water pump w/ hoses, etc.
Oxygen/acetylene torches	Various hand tools
Personal safety equipment	

Tasks: The following tasks are general steps typically associated with two common bearing repair/replacement activities. These tasks are not all-inclusive, nor always required.

1. **Repair sheared anchor bolts on slider bearings by installing anchor straps in front of bearing base plates and properly lubricating sliding surfaces.**

- Develop repair plan, including jacking plan. CAUTION: consult a licensed engineer.
- Measure pedestal width and hole locations.
- In shop, cut straps to size, drill holes, and paint.
- Prepare work-zone (i.e. traffic control, environmental protection, ladders & scaffolding, equipment).
- Drill 1-ft. deep holes in pedestal at planned strap locations.
- Set threaded rods in holes using Hilti glue or similar adhesive. Be sure rods are properly aligned.
- Jack structure pursuant to jacking plan and remove bearings.
- Remove rust and scale from bearings by scraping and wire brushing, and reflush, making sure the bearing is not damaged by rust and scale removal.
- Reinstall bearings and install anchor straps.

- Place dry lube pads and grease on sliding surface.
- Lower structure pursuant to jacking plan.
- Prime and paint bearing non-wearing surfaces as necessary.

2. Replace roller-nest bearings with elastomeric bearings or pads.

- Develop repair plan, including jacking plan. CAUTION: consult a licensed engineer.
- Fabricate filler plates for new bearings in shop, based on repair plan.
- Prepare work-zone (i.e. traffic control, environmental protection, ladders & scaffolding, equipment).
- Jack structure pursuant to jacking plan.
- Remove old bearings.
- Drill holes in pedestal and install new anchor bolts.
- Install new elastomeric pads or elastomeric bearings and filler plates, as necessary.
- Lower structure pursuant to jacking plan.
- Prime and paint bearing non-wearing surfaces, as necessary.

Safety Typical work-zone procedures as appropriate for specific site.
Restrict traffic during jacking operation.
Consider environmental and worker-safety issues (i.e. asbestos exposure).

Remove existing bearing.

Install new bearing and anchor bolts.

REPAIRING/REPLACING CONCRETE SUBSTRUCTURES

Description: Remove and replace damaged portions of substructure concrete and reinforcing steel.

Objective: To restore structural integrity of the substructure and bridge.

Selection Criteria: Consider this treatment for any bridge condition rating less than 5 for substructure elements (i.e. seat & pedestals, backwalls, stems, footings & piles, wingwalls, pier columns, pier caps, pier cap beams).

Procedure:

Labor Skills	Physical labor, carpentry, masonry.		
Material	Blasting sand	Water	
	Reinforcing steel	Shim plate	
	Portland cement concrete (or other patching material)		
Equipment	Concrete saw	450-CFM compressor w/hoses	
	Generator	Sandblaster	Sounding hammer
	Pneumatic hammer	Concrete mixer	Concrete pump
	Hydraulic pump	Various hand tools	
	Personal safety equipment		

Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Prepare work-zone (i.e. traffic control, environmental protection, equipment).
- Identify and mark extent of damaged areas of substructure concrete.
- Install temporary support of superstructure as required.
- Sawcut outside deteriorated areas. Cuts should be dovetailed to hold repair concrete. Straight cuts (vertical or horizontal) about 1-in. deep should not be made outside planned repair areas.
- Remove deteriorated concrete, using pneumatic hammers and hand tools, and expose reinforcing steel to allow placing of concrete behind rebars.
- Periodically sound remaining concrete to determine concrete condition.
- Clean the area using water-blasting or sandblasting.
- Fasten additional reinforcing steel to replace or repair existing steel as necessary to reestablish steel to as-built condition.
- Form area to be repaired.
- Apply grout or other bonding agent to existing concrete surfaces as necessary.
- Place new concrete or patching material. (Apply pneumatic concrete as an alternative).
- Provide proper cure to ensure durable concrete and to avoid shrinkage cracking.
- Remove forms.
- Patch any surface defects resulting from forming.

Safety: Typical work-zone procedures as appropriate for specific site conditions.

Remove deteriorated concrete and adequately expose steel reinforcing.

Job-built forms

Pre-formed forms

REPAIRING EROSION/SCOUR

Description: Repair undermined foundations and/or scoured or eroded stream channels with concrete, grout, stone fill, or rip-rap.

Objective: To protect integrity of bridge substructures and to ensure they continue to function as intended.

Selection Criteria: Consider this treatment for any bridge with an erosion or scour condition rating less than 4, or if flood monitoring or a flag report indicate a potential problem.

Procedure:

Labor Skills	Physical labor	
Material	Gravel	Bedding Material
	Geotextile Fabric	Rip-rap
	Concrete	Heavy stone fill
	Grout	Grout bags
Equipment	Bulldozer	Skid-steer loader
	Backhoe	Hydraulic excavator
	Dump truck(s)	Crane
	Barge	Concrete pump
	Core drill	Various handtools
	Grout mixer	Personal safety equipment

Tasks: The following tasks are general steps typically associated with two common scour and erosion repair activities. They are not all-inclusive, nor always required.

1. Repair undermined foundation.

- Coordinate with Regional Environmental Unit and obtain any necessary permits from Adirondack Park Agency, NYS Department of Environmental Conservation, US Army Corps of Engineers, or NYC Department of Environmental Protection and consult with DEC, as required.
- Also coordinate with the Regional Geotechnical Engineer or Main Office Geotechnical Engineering Bureau on a repair procedure.
- Prepare work-zone (i.e. traffic control, environmental protection, temporary coffer dams, equipment).
- Remove silt and other fine material deposited under the foundation.
- Place sand bags, forms, or bagged concrete along vertical face of foundation.
- Drill holes through footing, approximately 3-ft (0.9 m) apart.
- Pump concrete or grout through holes, vibrating frequently for concrete.
- Remove forms as required.
- As alternative, place grout bags along vertical face of foundation and pump concrete into grout bags until full. Repeat as necessary.
- Place stone fill or rip-rap protection around foundation as noted below.

2. Repair scour hole.

- Coordinate with Regional Environmental Unit and obtain any necessary permits from Adirondack Park Agency, NYS Department of Environmental Conservation, US Army Corps of Engineers, or NYC Department of Environmental Protection and consult with DEC, as required.
- Also coordinate with the Regional Geotechnical Engineer or Main Office Geotechnical Engineering Bureau on a repair procedure.
- Prepare work-zone (i.e. traffic control, environmental protection, temporary coffer dams, equipment).
- Remove silt and other fine material deposited into the scour hole, if possible.
- Dump stone fill or rip-rap as close as possible to scour hole.
- Place gravel or bedding material in the scour hole, as required, if silt is a problem.
- Place geotextile fabric over the bedding material.
- Place stone into scour hole, working off a stone pad and progressing into the hole.
- Shape stone as close as possible to existing channel elevation.

Safety Typical work-zone as appropriate for specific site. Use special care working near water.

Note: Consider addressing site conditions causing scour to prevent recurrence.

A scour incident encountered under a pier supported by drilled shafts.

Rip-rap placed for protection of foundation and channel bank.

THIN POLYMER OVERLAYS

Description: Apply thin polymer overlay to concrete deck where appropriate.

Objective: Maintain waterproof integrity of the deck wearing-surface portion to prevent water and chlorides from reaching the reinforcing steel.

Selection Criteria: The structural deck should have a rating of '5' and concrete wearing surface should still be in good condition based on visual inspection. The deck should be tested to ensure delamination does not exceed 15% - 18% of the deck area. Chloride levels should be tested. The bridge shall remain in service and shall not require significant work for at least the lifespan of the overlay.

Procedure:

Labor Skills	Physical Labor	
Material	Polymer Components	Blasting sand
	Aggregates	Steel shot
	Sand	
Equipment	Compressor w/hoses, etc.	Mixing Paddle
	Sandblaster	Screed
	Steel-shot blaster	Spiked Shoes
	Shovels, scrapers, & brooms	Personal safety equipment
	Rakes, squeegees, & pails	Respiratory equipment
	Mortar Mixer, Bucket, or Trash Barrel	Various hand tools

Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Prepare work-zone (i.e. traffic control, environmental protection, equipment).
- Loosen and shovel off heavy dirt deposits.
- Clean deck by washing, sweeping, and/or using compressed air.
- Steel shot blast and sandblast
- Surface must be clean, dry, and temperatures must be correct.
- Apply polymer according to manufacturer's instructions, controlling application rate to avoid running and non-level surfaces.
- Apply second coat if necessary.
- Add aggregate on surface of overlay to create a friction surface
- Allow sufficient time for overlay to cure before permitting traffic to travel on.

Safety Typical work-zone procedures as appropriate for specific site.
Use caution because of flammability of some products.

Surface preparation

Spreading the polymer material

Placing Aggregate

Low Volume Shotcrete

Description: Continual application of a Portland cement/sand mixture for structural concrete repairs.

Objective: Provide timely, form free structural repairs to concrete structures with minimal clean up.

Selection Criteria: Repairs to damaged concrete on overhead and vertical faces at such locations as bridge deck bottom or fascia, pier, cap beam, pedestal, and culverts. It can also be used for re-pointing stone joints.

Procedure:

Labor Skills — Physical Labor

Material
- Type I or II Portland cement
- Potable Water
- Clean/Washed Mason Sand
- Ali/Cite Waterproofing Cementing Compound
- Cem-Kote Clear Seal Concentrate

Equipment
- PPE
- Low Volume Shotcrete Applicator unit
- Air Compressor with Oil/Water Coalescing Filter
- Small tools, Shovel

Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive.

- Prepare work-zone (i.e. traffic control, environmental protection, equipment).
- Chip out only deteriorated concrete
- Acid wash faces of chipped concrete
- Brush on waterproof bonding cement slurry
- Screen/mix the Portland cement and mason sand
- Apply mix to chipped area with low volume shotcrete applicator gun
- Screed/finish the new repair
- Apply Clear Seal protective cure coat to repaired area
- Daily clean low volume shotcrete unit at the end of the day

Safety
- Temporary traffic work-zone procedures
- Fall safety procedures
- Scaffolding erection procedures

Shooting material for overhead repair

Screeding the surface

FULL DEPTH BRIDGE DECK REPAIRS

Description: Perform full depth repairs of bridge decks as necessary

Objective: Extend service life of existing structure until future major rehabilitation. Improve rideability of wearing surface.

Selection Criteria: This is a response activity to a bridge condition that represents a clear and present danger to the travelling public.

Procedure:

Labor Skills — Physical Labor

Material — Portland cement concrete, Rapid set repair material or Polymer-based materials

Equipment

Compressor	Chipping hammer
Sandblaster	Bobcat
Shovels, broom	Manlift
PPE	Generator

Carpentry tools for form building
Various hand tools, tools to finish chosen repair material

Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Prepare work-zone (i.e. traffic control, environmental protection, equipment).
- Sawcut perimeter of repair
- Use chipping hammer to remove existing deteriorated deck
- Blastclean existing rebar. Replace/repair rebar as necessary
- Construct formwork for repair
- Attach forms to structure. Ensure there is sufficient bracing on bottom side of deck form to prevent a blowout.
- Use a heavy gauge tie wire (9 wire) to help tie form to existing rebar
- Make sure repair area is clean
- Follow repair material manufacturers recommendation for surface prep (wet hole, dry hole)
- Sample repair materials include Portland cement concrete, Elastomeric concrete, or “Liquid” concrete
- Mix repair material as per manufacturers recommendations, install into full depth repair
- Fill repair, consolidate as recommended, then finish surface
- Place aggregate for friction on surface as necessary
- Open deck back up to traffic following appropriate cure time (again as per manufacturers recommendation)

Safety Typical work-zone procedures as appropriate for specific site.

Top of Deck Repair Area

Bottom View

Repair Form - Top View

Repair Form - Bottom View

PREVENTIVE MAINTENANCE ACTIVITIES

TASK DESCRIPTION	FREQUENCY
REMOVE BRUSH - SPOT LOC.	as needed
MAINTAIN STREAM CHANNELS	as needed
MAINTAIN BANK PROTECTION & WALLS	as needed
CLEAN SUBSTRUCTURE	2 years
SEAL SUBSTRUCTURE	6 years
LUBRICATE BEARINGS	4 years
REPAIR BEARINGS	as needed
CLEAN SUPER & DECK	2 years
REPAIR JOINTS	as needed
REMOVE WEARING SURFACE	12 years
PLACE WEARING SURFACE	12 years
PLACE MEMBRANE	12 years
SEAL DECK	4 years
SEAL CURB, SDWK, FASCIA	5 years
FILL CRACKS & JOINTS	4 years
CLEAN DRAINAGE SYSTEM	2 years
SPOT PAINTING	as needed
PAINT BRIDGES	12 years
MAINTAIN ELEC. & MECH. EQUIP.	as needed

Figure 4. NYSDOT Preventive Maintenance Activities

APPENDIX

RECOMMENDED GENERAL REFERENCE DOCUMENTS

2008 NYSDOT Standard Specifications (US Customary)
2006 NYSDOT Standard Specifications (Metric)

Current NYSDOT Materials Bureau Approved Lists

Current NYSDOT Engineering Instructions and Engineering Bulletins
Examples: EI 08-009, Typical Bird/Bat Waste Information
EI 08-012, Anchoring Materials, Chemically Curing, NTSB Safety Recommendations
EI 07-032, Maintenance Cleaning and Washing of Bridges, US Customary

Current NYSDOT Safety Bulletins
Examples: SB 08-1, Working in Proximity to Water
SB 08-2, Aerial Lift Devices
SB 08-3, Fall Protection
SS 07-6, High Visibility Apparel and Hard Hat Policy
SB-94-4 Histoplasmosis

NYS Steel Construction Manual, 3rd Edition, March 2008

NYS Bridge Inspection Manual, May 1999
TA 05-001, New Inspection and Monitoring Requirements for High Rocker Bearings
TA 06-001, Bridge Inspection Guidelines for Inspection in the Bearing Areas of Corroded Primary Members

NYS Bridge Deck Evaluation Manual, May 1992

FHWA Bridge Scour and Stream Instability Countermeasures- Experience, Selection, and Design Guidance Manual