FUNDAMENTALS OF BRIDGE MAINTENANCE AND INSPECTION

NEW YORK STATE DEPARTMENT OF TRANSPORTATION
CORNELL LOCAL ROADS PROGRAM

FUNDAMENTALS OF BRIDGE MAINTENANCE AND INSPECTION

MANUAL FOR A WORKSHOP ON BRIDGE MAINTENANCE/INSPECTION
PREPARED BY THE COMMUNICATION/TRAINING SUBCOMMITTEE
OF THE STATEWIDE CONFERENCE ON LOCAL BRIDGES

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Transportation Maintenance Division
Structures Design and Construction Division
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NEW YORK STATE DEPARTMENT OF TRANSPORTATION

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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 activity 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 supplements the New York State Department of Transportation′s one-day workshop on ″Bridge Maintenance/Inspection.″ More specifically, it is intended as a handy reference for **preventive**-maintenance and **correctiv**e-maintenance activities applicable to local bridges, as described in the workshop.

The workshop and manual have four objectives: 1) teaching attendees general bridge anatomy and identifying 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 local 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, nor 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 nor to violate safety codes, nevertheless local laws, 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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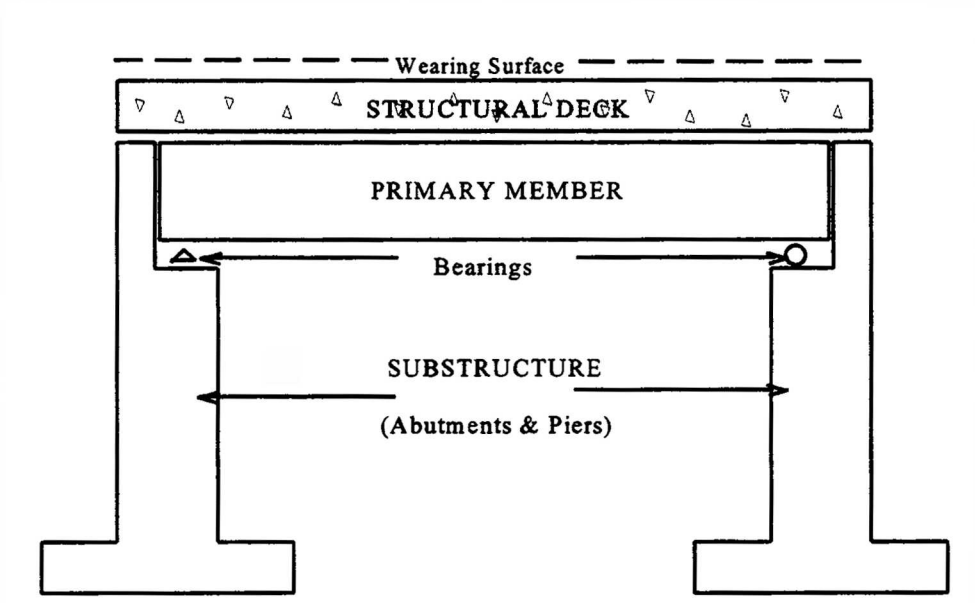


1. INTRODUCTION

Bridge Anatomy

Some common terms widely used in describing condition of structures should provide a framework for subsequent discussion of bridge inspection and maintenance 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 moves, 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.

<u>Structural Deck</u>

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 planks
- Metal orthotropic plates
- Asphalt-filled 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 thirteen typical **primary members:**

- Reinforced-concrete I-beams, T-beams, slabs
- Prestressed-concrete box-beams, I-beams, slabs (solid or hollow)
- Steel multi-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
-

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
- 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 Thruway, new attention also focused on underwater inspection of bridge foundations. (The New York State Department of Transportation, however, was already developing its own underwater-inspection procedures.)

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. This is the standard and most common type, federally mandated for all new or reconstructed bridges within 60 days after opening to traffic or upon contract acceptance -- whichever comes first.

Type 2: Interim. The state requires that some structures be examined during the year between biennial inspections, because of one or more of the following deficiencies:

- A ″general recommendation″ (by an inspector) of 3 or less (see ″Rating Scale″ on the next page)
- Condition rating (weighted average of individual item ratings) or 3.00 or less
- Presence of an active or inactive **red flag,** or an active **yellow flag** (see next page)
- 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 biennial inspection must occur within 60 days of their reopening. Type 4 inspections are also required for temporary detour bridges carrying traffic during reconstruction -- temporary structures are the contractor′s responsibility and are not inspected under BIIS.

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 1** (biennial) or **Type 2** (interim), with all documentation required by this manual.)

Inspection Team Qualifications and Responsibilities

New York has the most stringent inspection-personnel requirements of any state, specified for each position in the *Uniform Code of Bridge Inspection*. All 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 ff 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.

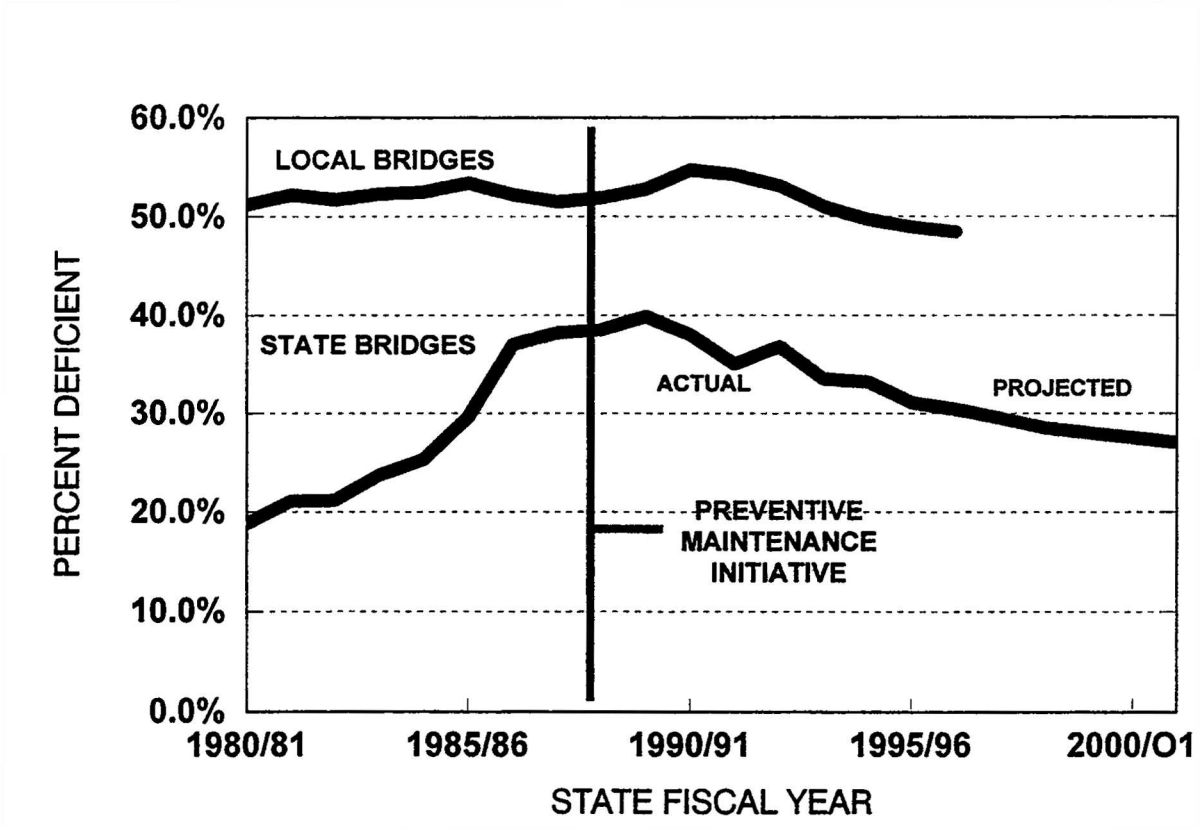
Yellow Structural Flag: used to report a potentially hazardous condition that would probably become a clear and present danger if left unreported beyond the next anticipated inspection. This flag can also be used to report actual or imminent failure of a non-critical structural component, if its failure 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 making 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, in providing appropriate repair, or in determining that existing condition is adequate.

The Benefits of Preventive Maintenance

The benefits of preventive maintenance are obvious. That is why most people regularly change the oil in their vehicles, replace filters in their furnaces, and repaint their houses. Conclusive studies demonstrating the benefits of preventive maintenance for bridges, while eliminating or controlling all other variables, are rare. Few bridge owners have sufficient resources to sacrifice a structure for such a study. Moreover, the time-frame required to conduct such a study, and to observe the effects of preventive maintenance on a bridge throughout its service life, is generally prohibitive. This is not to say there is no evidence of the value of preventive maintenance. First, a recent study of counties having lowest rates of bridge deterioration found that they typically had dedicated bridge-maintenance resources and active preventive-maintenance programs. Second, there is a strong correlation between implementation of the state′s bridge preventive-maintenance initiative and turn-around in percent of deficient state bridges -- as shown in the graph on the next page. In summary, preventive maintenance works. Timely cyclical and corrective-maintenance activities are critical elements in cost-effective preservation of bridges.



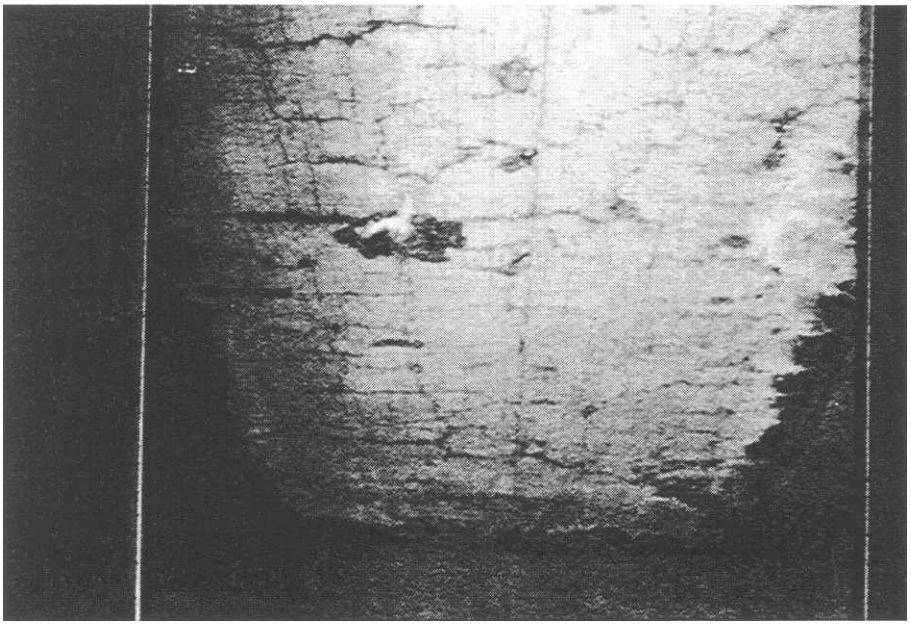
2. INTERPRETING INSPECTION REPORTS

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-maintenance activities that could have helped prevent the exhibited deterioration, and to corrective-maintenance activities that can repair the deterioration.

WEARING SURFACE

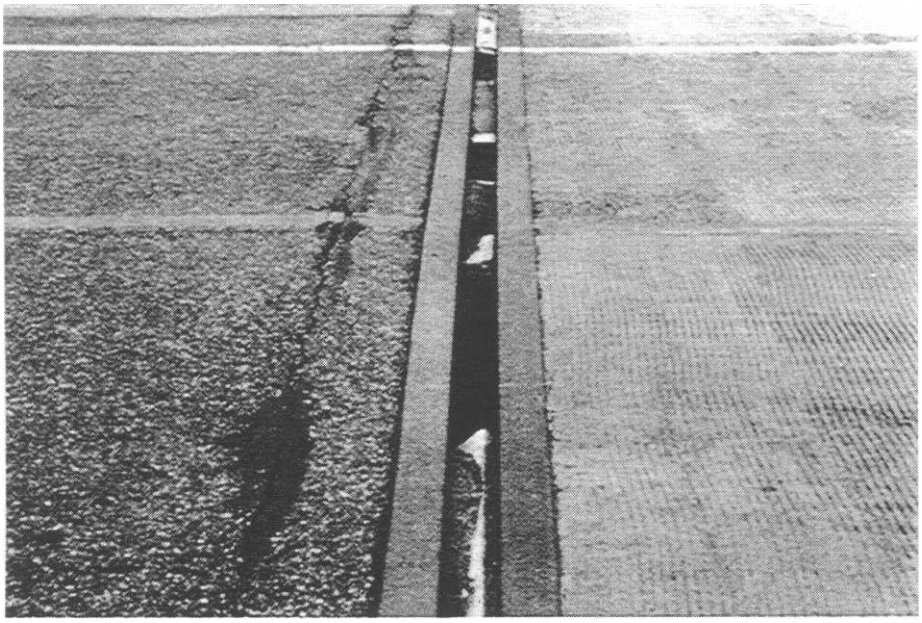
Rating:	3	
Description:	Wearing surface is cracked, patched, and potholed. Riding quality is poor. Wearing surface is not watertight.	
Cyclical Maintenance:	Clean the Bridge	page 18
	Seal Cracks in the Wearing Surface	page 20
	Replace the Wearing Surface	page 26
Corrective Maintenance:	Repair the Asphalt Wearing Surface	page 38

STRUCTURAL DECK



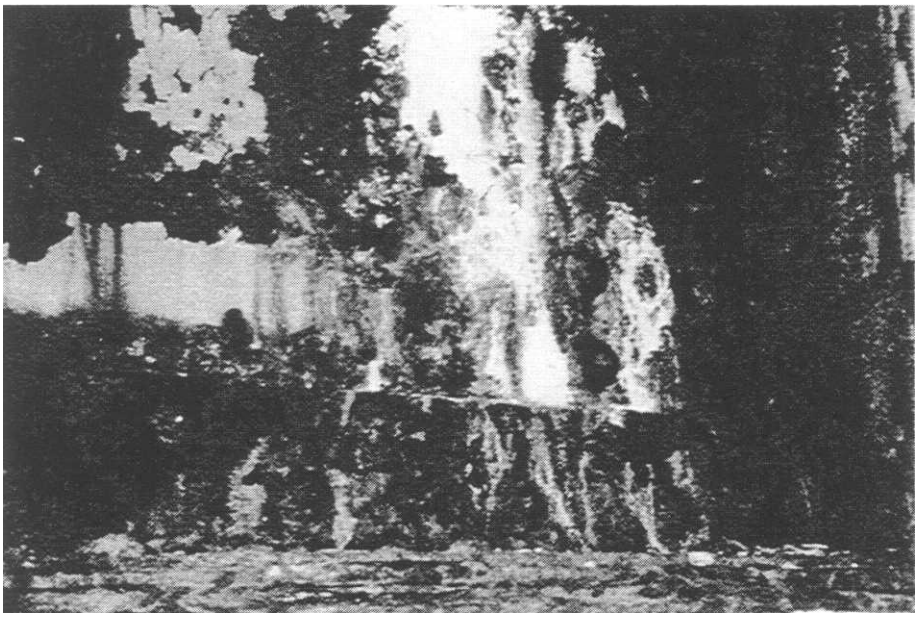
Rating:	3	
Description:	Underside of reinforced concrete deck is map cracked over entire area, leakage at top flanges, and efflorescence.	
Cyclical Maintenance:	Clean the Bridge	page 18
	Seal Cracks in the Wearing Surface	page 20
	Seal the Concrete Deck	page 24
	Replace the Asphalt Wearing Surface	page 26
Corrective Maintenance:	Repair the Concrete Deck	page 41
	Repair the Asphalt Wearing Surface	page 38

DECK JOINTS



Rating:	2	
Description:	Sealer material no longer bonded to armored angles. Water and debris pour through the joint, corroding elements below.	
Cyclical Maintenance:	Clean the Bridge	page 18
Corrective Maintenance:	Repair/Replace the Joints	page 44

STEEL PRIMARY MEMBERS

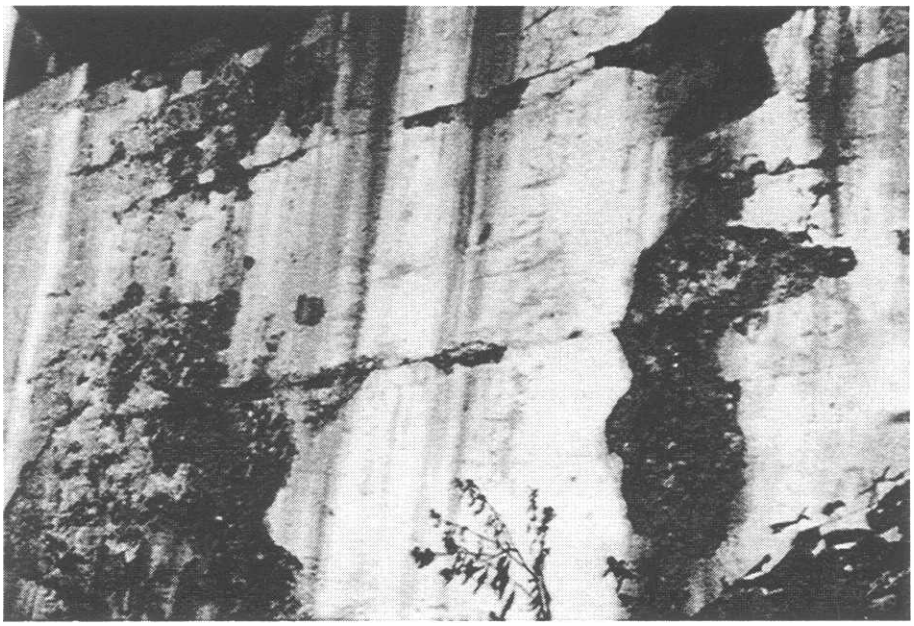


Rating:	3	
Description:	Heavy corrosion of the web, bottom angles, and rivet heads.	
Cyclical Maintenance:	Clean the Bridge	page 18
	Paint the Bridge	page 34
Corrective Maintenance:	Repair/Replace Steel Members	page 47

BEARINGS

Rating:	3	
Description:	Steel bearing has corroded, reducing allowable movement.	
Cyclical Maintenance:	Cleand the Bridge	page 18
	Lubricate the Bearings	page 29
Corrective Maintenance:	Repair/Replace the Bearings	page 50

SUBSTRUCTURE



Rating:	3	
Description:	Large areas of spalled concrete, map-cracking, and heavy efflorescence. Concrete sounds hollow when struck with hammer.	
Cyclical Maintenance:	Clean the Bridge	page 18
	Seal Substructure Concrete	page 32
Corrective Maintenance:	Repair/Replace Substructure Concrete	page 54

EROSION

Rating:	3
Description:	Stream bank has eroded, impacting stability of the wingwall and damaging fish and wildlife habitat.
Cyclical Maintenance:	None
Corrective Maintenance:	Repair Erosion or Scour page 57

3. CYCLICAL PREVENTIVE-MAINTENANCE PROCEDURES

This chapter describes seven 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

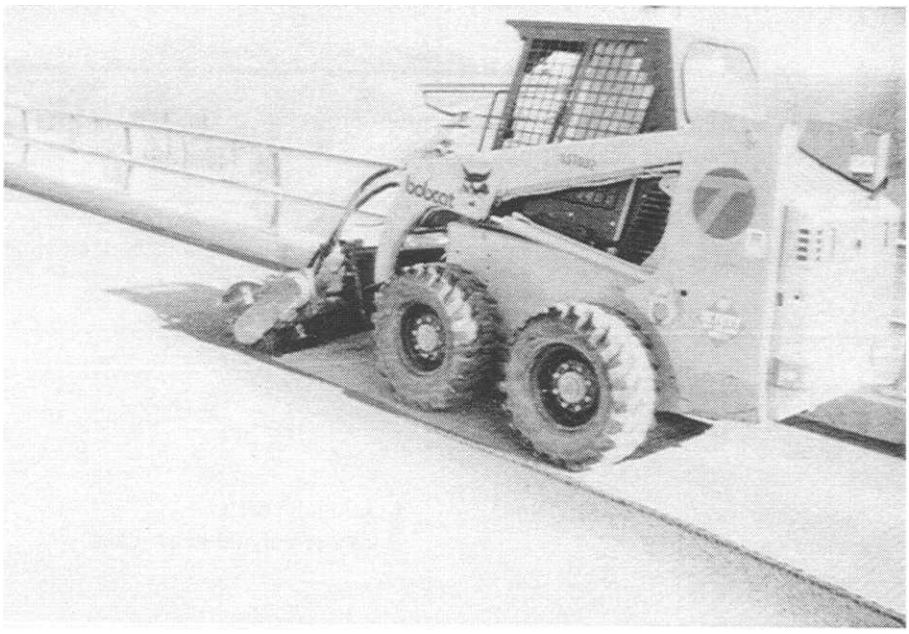
Equipment:

Water trailer	High-pressure water pump w/hoses, etc.
Sewer snake	175-CFM compressor w/hoses, etc.
Long-handle scraper	Ladders & scaffolding
Square-point shovels	Pickaxe
Brooms	Stiff brushes
Crowbar	Brush clippers & saw
Personal safety equipment	Various handtools

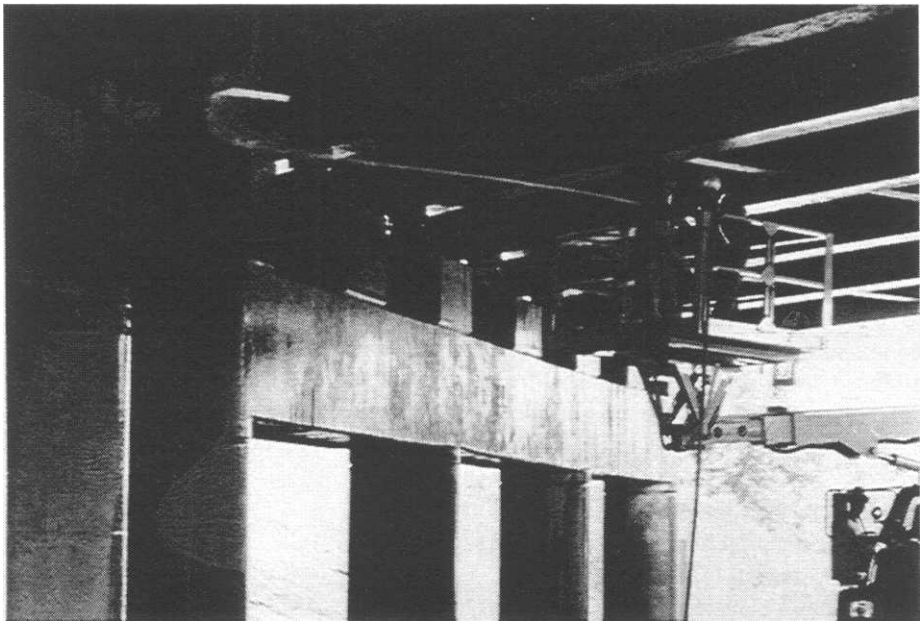
Tasks: The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Coordinate with Regional Environmental Unit and obtain any necessary permits from the Adirondack Park Agency, NYS Department of Environmental Conservation, 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, ladders & scaffolding, 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-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.



Pressure-washing seats and bearings after hand-sweeping
and vacuuming the bridge underside and supporting elements.

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: Seal cracks at least once every four years. Generally perform this work on all bridges regardless of wearing surface.

Procedure:

Labor Skills	Physical labor	
Material	Crack-sealer meeting ASTM D 3405	Liquid joint sealer
	Blasting sand	Epoxy or polyurethane sealer
	Water	
Equipment	Crack-sealer heater/melter	Wand, hoses, & nozzles
	Compressor w/hoses, etc.	Shovels & brooms
	Putty knives & brushes	Concrete saw
	Grinder	Sandblaster
	Injection system	Drill
	Personal safety equipment	Various handtools,

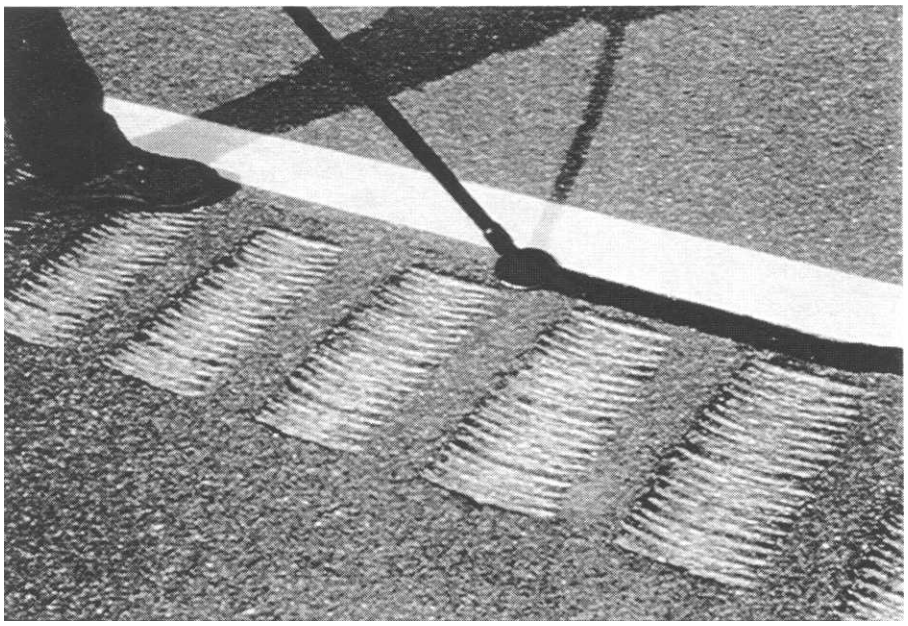
Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Prepare work-zone (i.e., traffic control, environmental protection, equipment).
- Loosen and shovel off heavy dirt deposits.
- Clean wearing surface by sweeping and/or using compressed air.
- Clean cracks and joints using water or compressed air, and a ginder 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 liquid joint sealer to joints according to manufacturer's instructions, allowing adequate time for material to dry.
- Apply D 3405 crack sealer to cracks in asphalt using a wand.
- Avoid excessive material that may reduce skid resistance.
- Seal surface of cracks in PCC using epoxy.
- Drill injection holes along the joints, if necessary, and inject sealant.

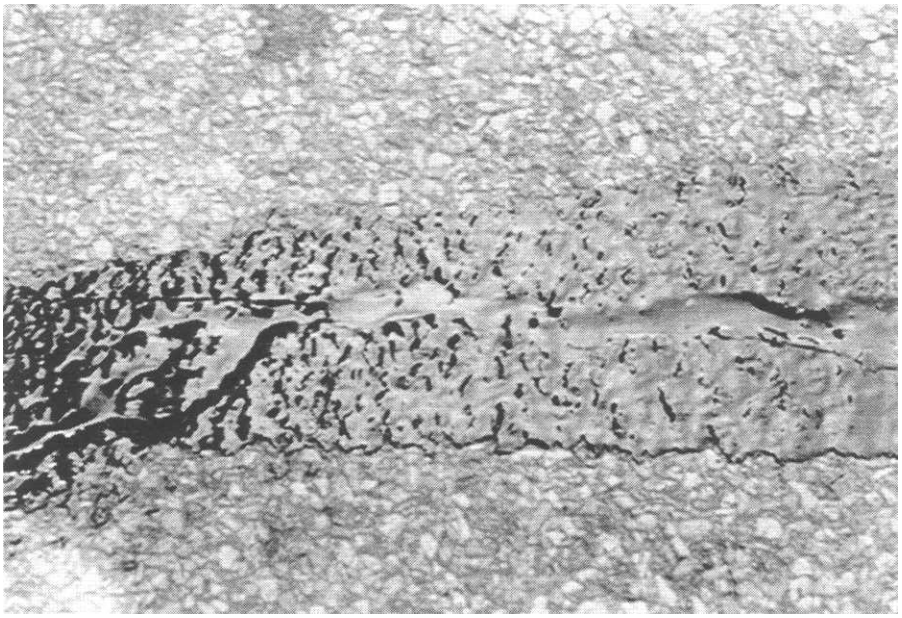
Safety Typical work-zone procedures as appropriate for specific site.
Avoid excessive material that may reduce skid resistance.

Typical crack-filling equipment and setup.

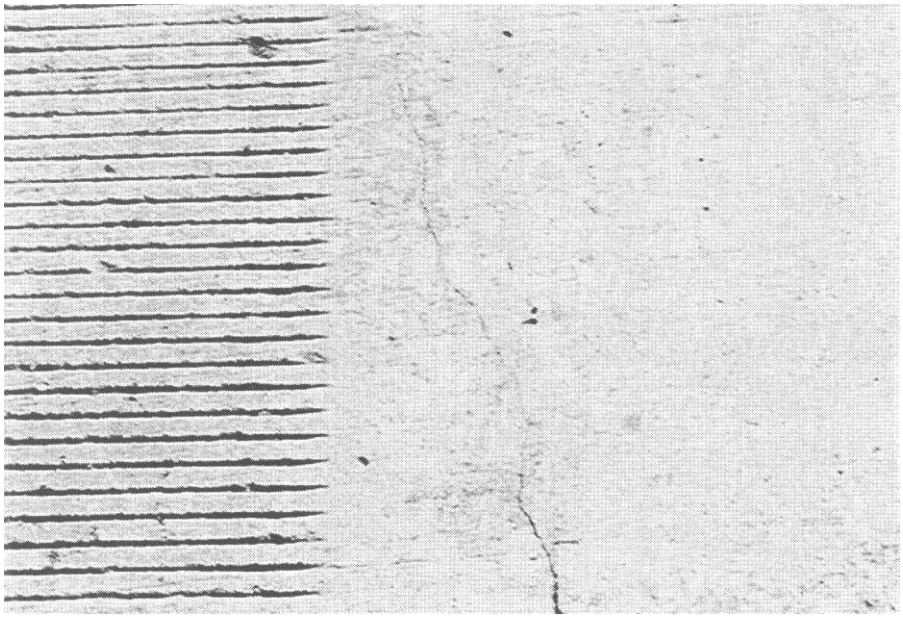
Clean out crack with compressed air.



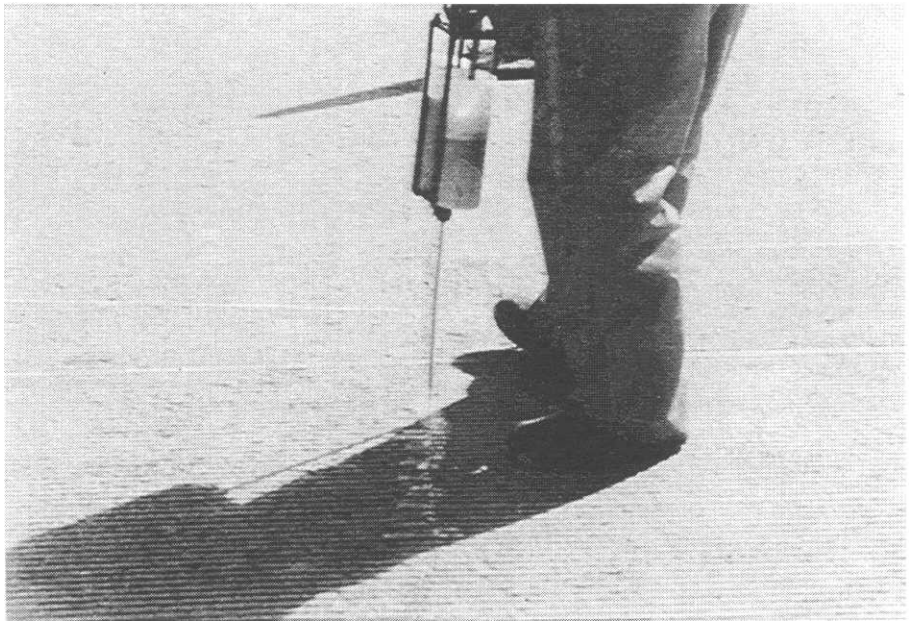
Apply liquid-asphalt material with wand.



Completed treatment with little or no overflow on adjacent pavement.



Crack in concrete wearing surface.



Application of two-part sealer to crack.

SEALING THE CONCRETE DECK

Description: Apply sealant to concrete deck, curbs, sidewalks, and fascia and apply liquid joint 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.

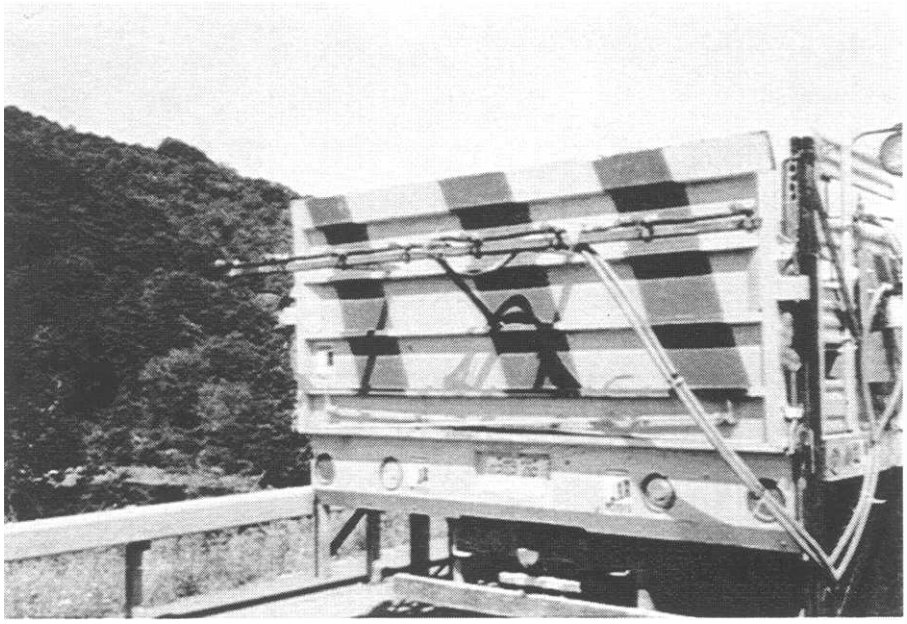
Procedure:

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 handtools
	Steel-shot blaster	

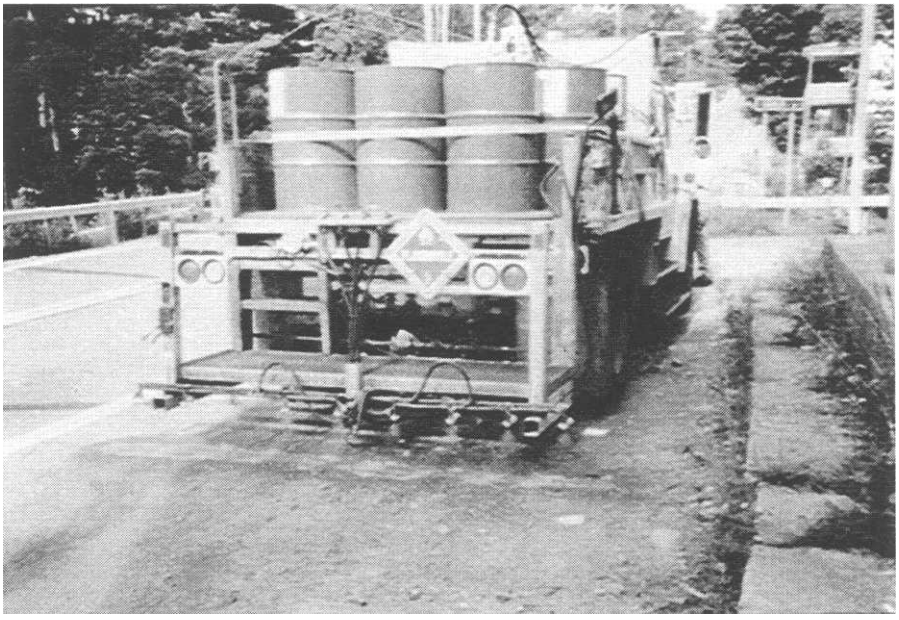
Tasks The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- 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 penetrating 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.

bridge with an existing asphalt wearing surface.

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 handtools

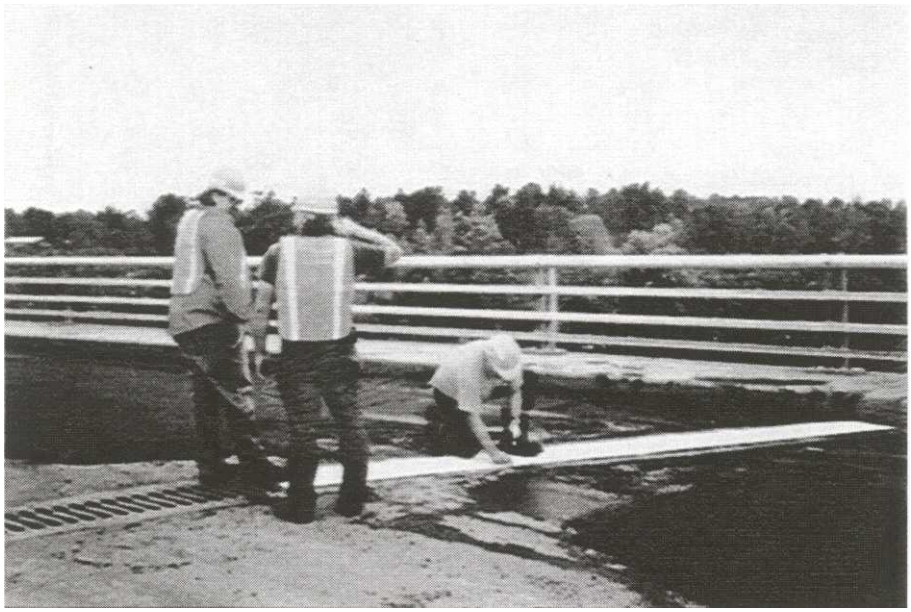
Tasks: The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Check load rating to ensure that bridge can safely support additional load.
- 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 [see *Repairing the Concrete Deck (p. 41)* for details].
- 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).

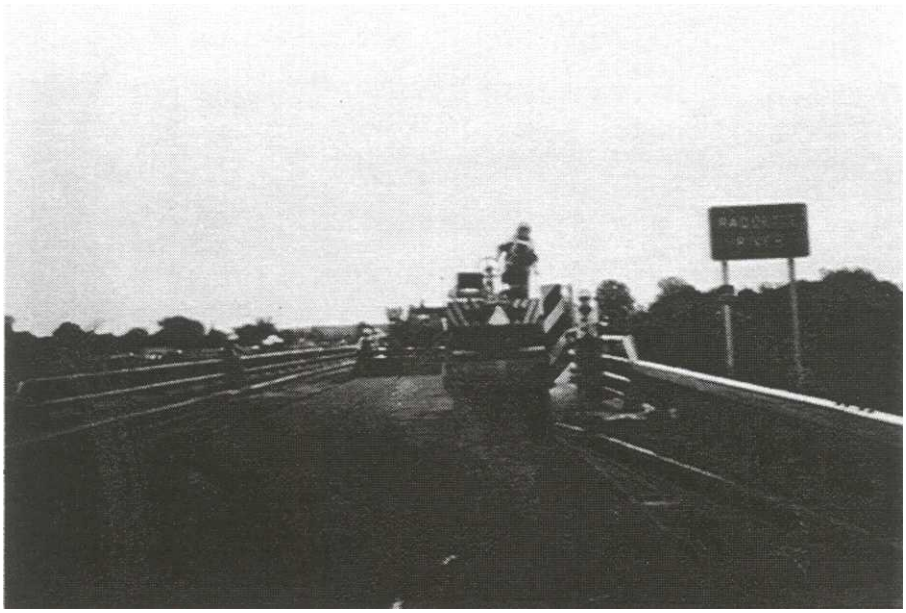
Safety: Typical work-zone procedures as appropriate for specific site.

Remove existing wearing surface

Place waterproof membrane.



Cover joints and drainage structures.



Place and compact 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

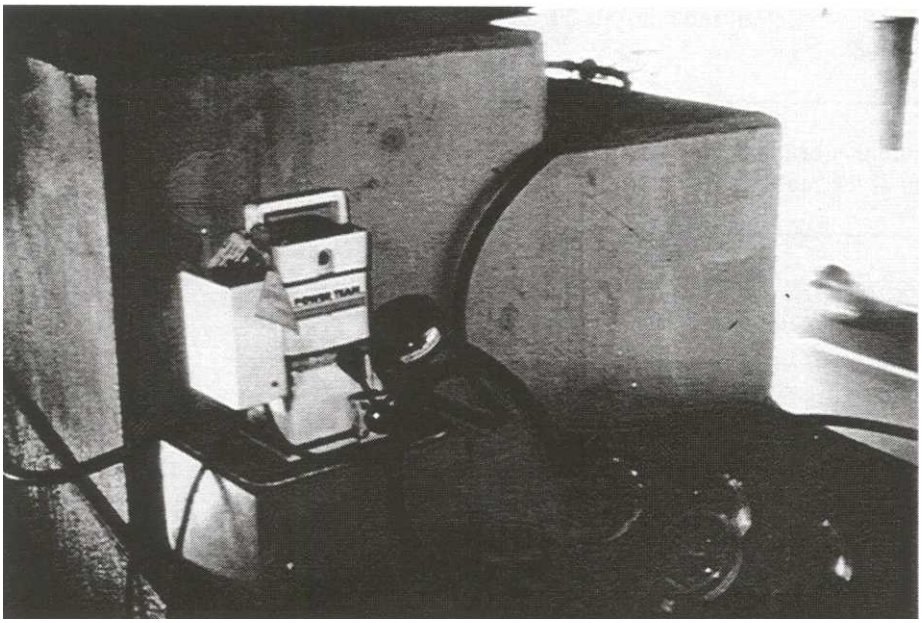
Material:
- Blasting sand
- Penetrating oil
- Grease
- Paint
- Lubricating oil
- Water

Equipment:
- Hydraulic jacks
- Water trailer
- High-pressure water pump
- Sandblaster
- Steel grinder
- Various handtools
- Ladders & scaffolding
- 150-CFM compressor w/hoses, etc.
- Stiff brushes
- Scaling hammer
- Personal safety equipment

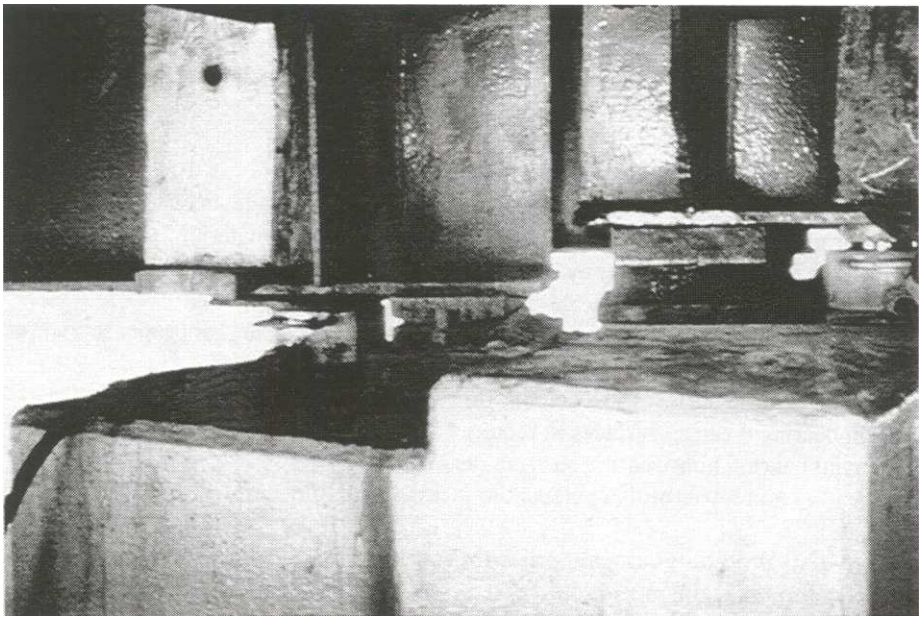
Tasks: The following tasks are general steps typically associated with this maintenance activity. These tasks are not all-inclusive, nor always required.

- Develop 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.

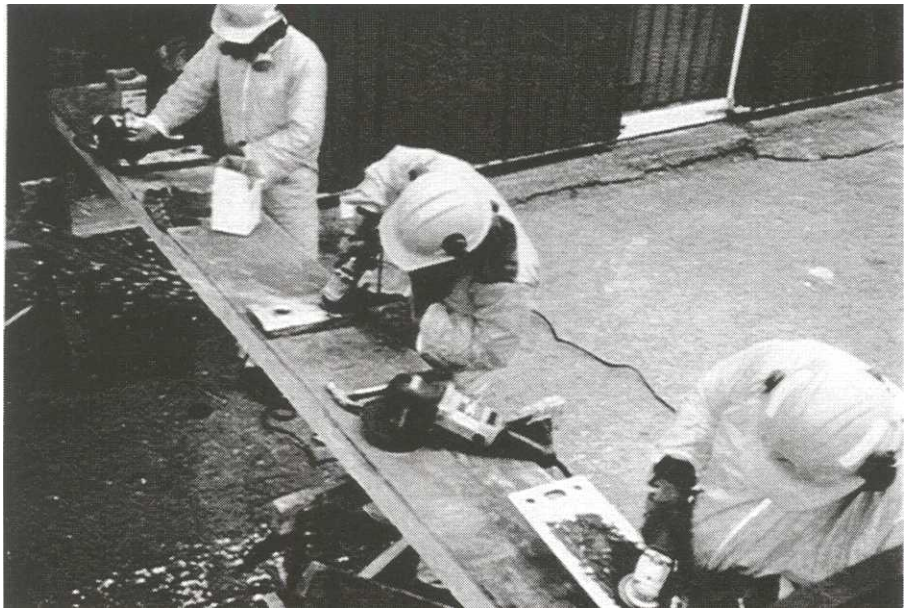
Safety: Typical work-zone procedures as appropriate for specific site.
Restrict traffic during jacking operation.
Consider environmental and worker safety issues (i.e., asbestos exposure).



Typical bridge jacking for bearing removal (pump and manifold system).



Typical bridge jacking for bearing removal (hydraulic jack).



Clean and grind bearing surfaces to a smooth finish.

Grease or oil bearing wearing surfaces as required, based on bearing type.

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 handtools	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.

Two-part epoxy paint system.
Moisture-cure paint system (proposed).

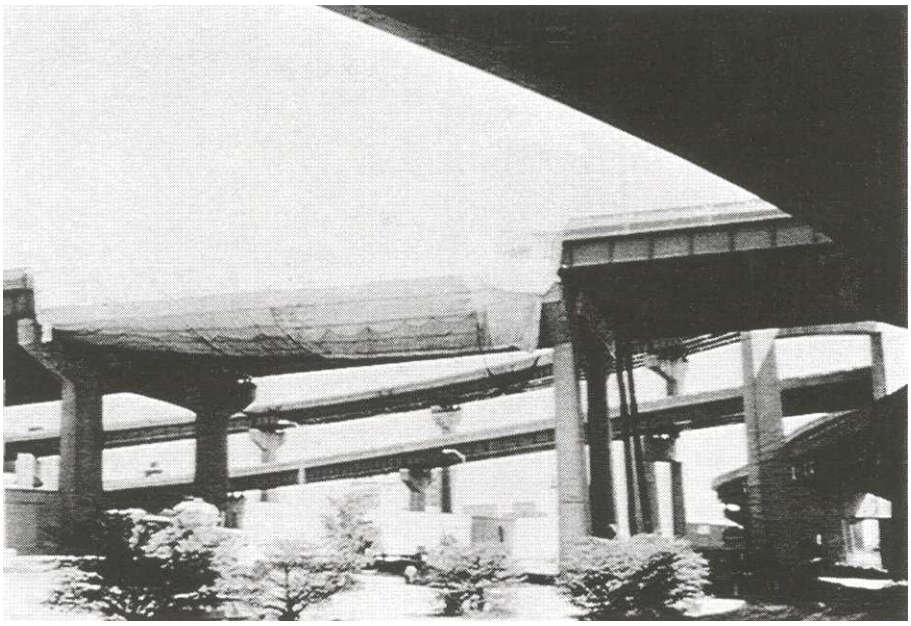
Equipment — Per contract and NYSDOT specifications.

Tasks — NYSDOT does all bridge painting by contract. Several basic considerations help determine best approach and appropriate specifications, including:

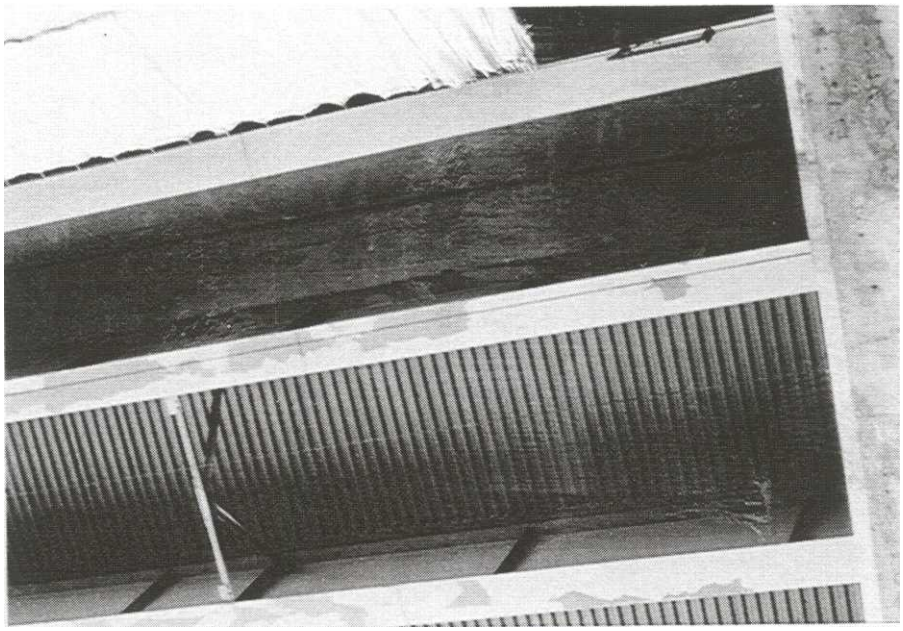
- Extent of rust and paint deterioration.
- Whether structure crosses water.
- Whether site is urban or rural.

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).



Typical paint project with Class A containment.



Steel properly prepared for painting.

4. CORRECTIVE 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 seven 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 ASPHALT WEARING SURFACE

Description: Remove and replace damaged portions of wearing surface and membrane waterproofing.

Objective: To restore waterproof integrity of the wearing-surface portion of the deck to prevent water and chlorides from reaching reinforcing steel. Also to restore a smooth riding surface and improve safety for the traveling public.

Selection Criteria: Consider this treatment for any bridge with an asphalt-cement-concrete wearing surface and wearing-surface condition rating less than 5.

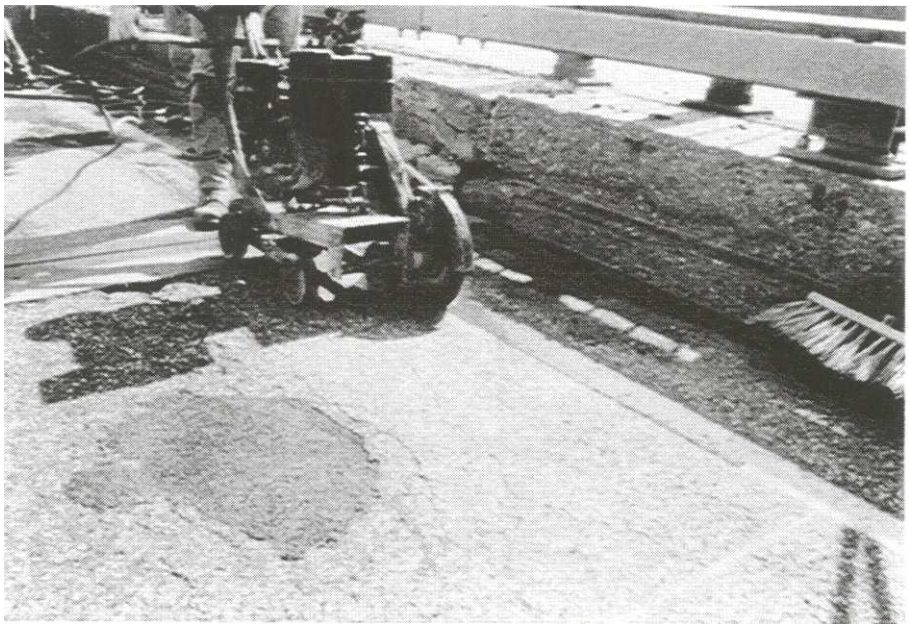
Procedure:

Labor Skills	Physical labor	
Material	Asphalt concrete	Membrane-waterproofing system
	Water	Concrete-patching material
	Citrus Solvent	
Equipment	Concrete saw	450-CFM compressor w/hoses, etc.
	Generator	Jackhammer
	Shovels & rakes	Brooms, brushes, & pickaxe
	Squeegees & pails	Roller & plate compactor
	Personal-safety equipment	Various handtools

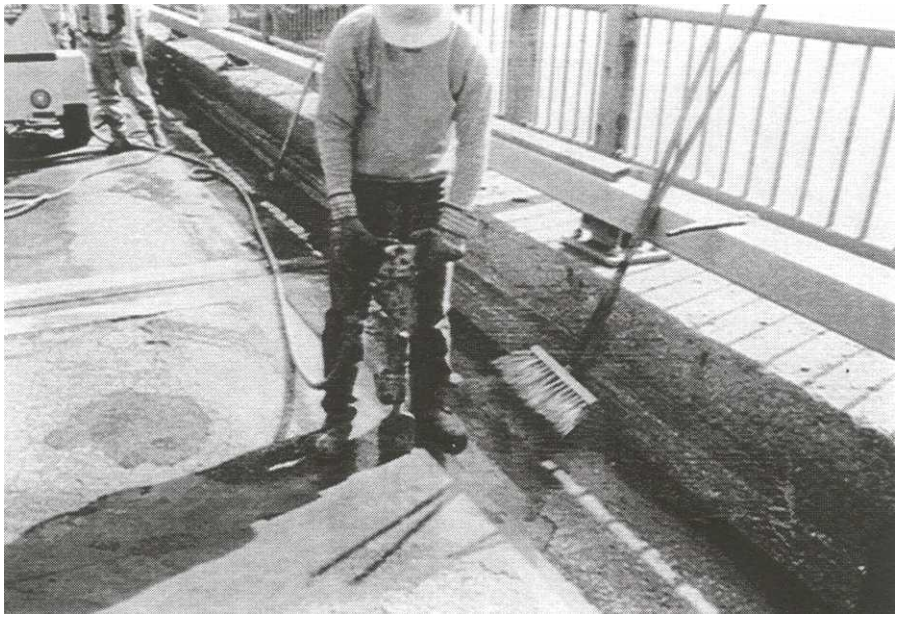
Tasks The following tasks are the general steps typically associated with this maintenance activity. They are not all-inclusive, nor always required.

- Prepare work-zone (i.e., traffic control, environmental protection, equipment).
- Identify and mark extent of damaged areas on wearing surface.
- Sawcut outside the damaged area (straight cuts).
- Remove damaged areas of the wearing surface and underlying waterproof membrane (if present) by hand methods. Remove additional asphalt to allow for 6- in. Overlap of membrane patch over existing membrane.
- Clean the area using compressed air.
- Make deck repairs as necessary (see *Repairing Concrete Decks, p. 41*, for details).
- Apply waterproof membrane to patch area according to manufacturer's instructions, depending on type (performed sheet membrane or liquid membrane). Patch edges may be tack-coated with a liquid-asphalt. Keep asphalt hot to ensure bond.
- Place and compact asphalt concrete in the patch area (2-in. minimum compacted).

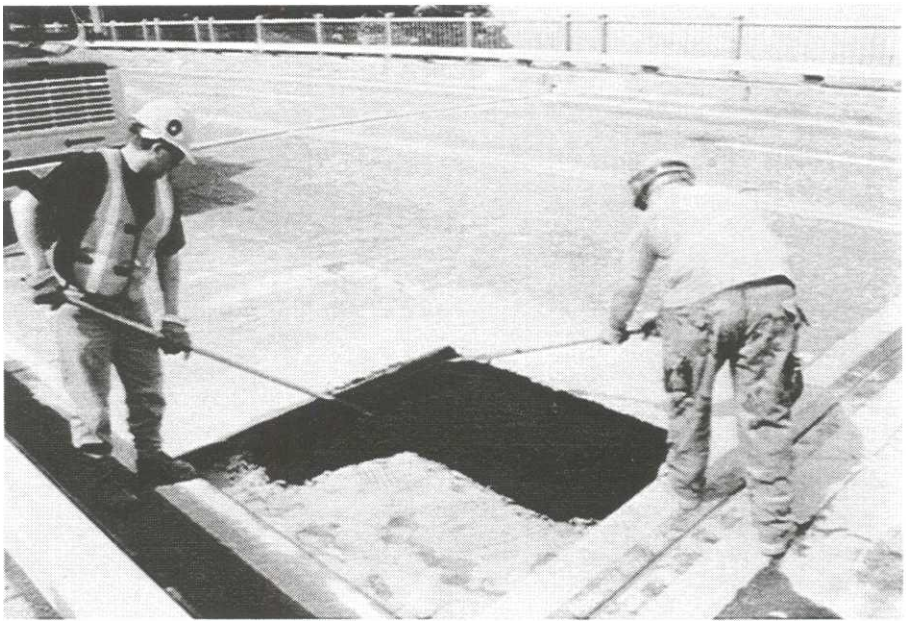
Safety Typical work zone procedures as appropriate for specific site.



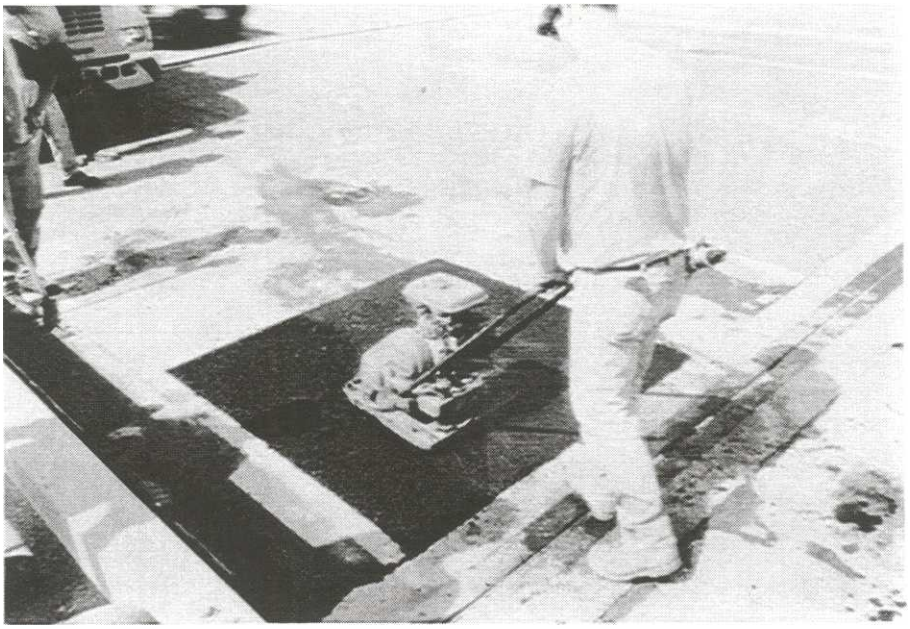
Sawcut around edges of material to be repaired.



Remove existing asphalt wearing surface.



Apply new asphalt material in lifts.



Compact new material.

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:

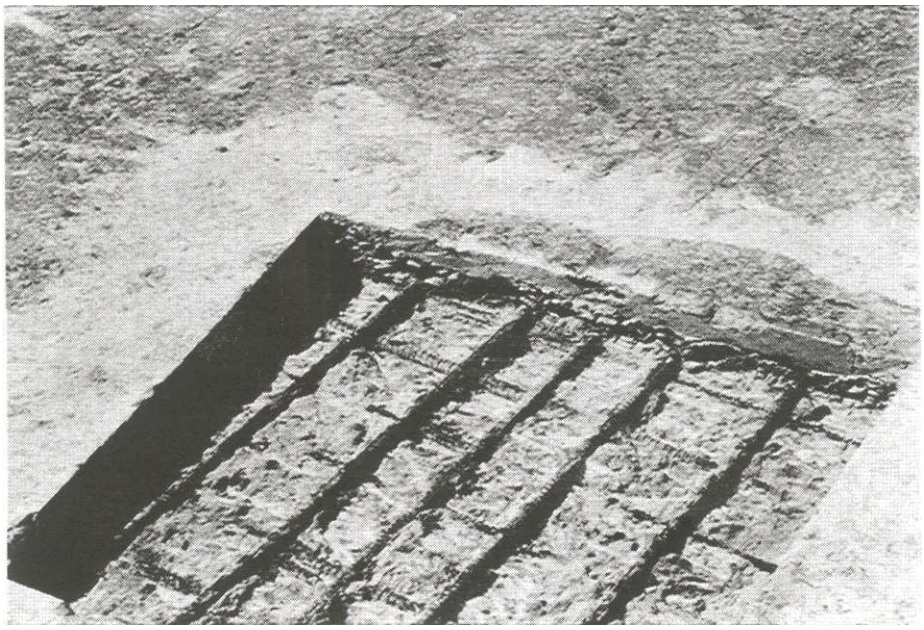
Concrete saw	450-CFM compressor w/hoses, etc.
Generator	Sandblaster
Concrete mixer	Pneumatic hammer (<30 lb)
Shovels & pickaxe	Brooms & brushes
Sounding hammer	Various handtools
Personal-safety equipment	Steel-short blaster

Tasks: The following tasks are the general steps typically associated with this maintenance activity. They 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 handtools to 1 in. 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.
- Weld or mechanically fasten additional reinforcing steel to the existing steel if section loss is 20% or more.
- Form underside of deck for any of full-depth repairs.
- Apply a bounding agent of neat cement paste or 1:1 sand-cement grout mix to remaining concrete, if necessary
- Place new concrete or patching material (depending on repair depth).
- Broom-finish surface of the patch.
- Provide for proper cure to avoid shrinkage cracks.

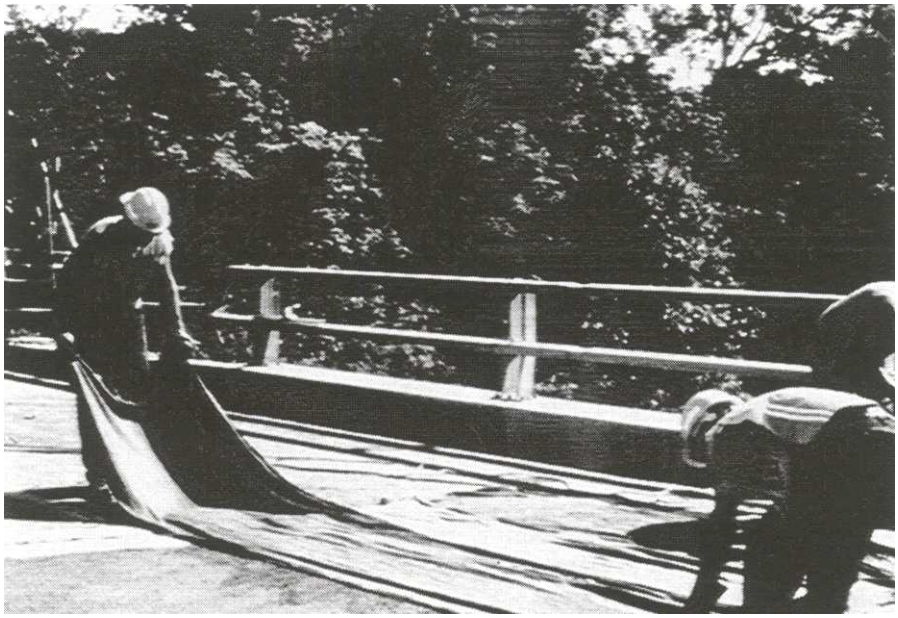
Safety: Typical work zone procedures as appropriate for specific site.

Marking edges of proposed patch.



Cleaned out patch area before placing repair material.

Placing repair material.



Covering patch to allow proper curing.

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:

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

Clip angles (3"x4' 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/acetelene torches	Concrete mixer
Concrete vibrator	Concrete saw
Rubber seal installation tolls	Joint levelers
Personal-safety equipment	Various handtools

Elastomeric mixing, placement, and curing items:

50,00-Btu salamanders	Heating tank
Propane tanks & torches	Paddle mixers
Thermometers	Curing hoods

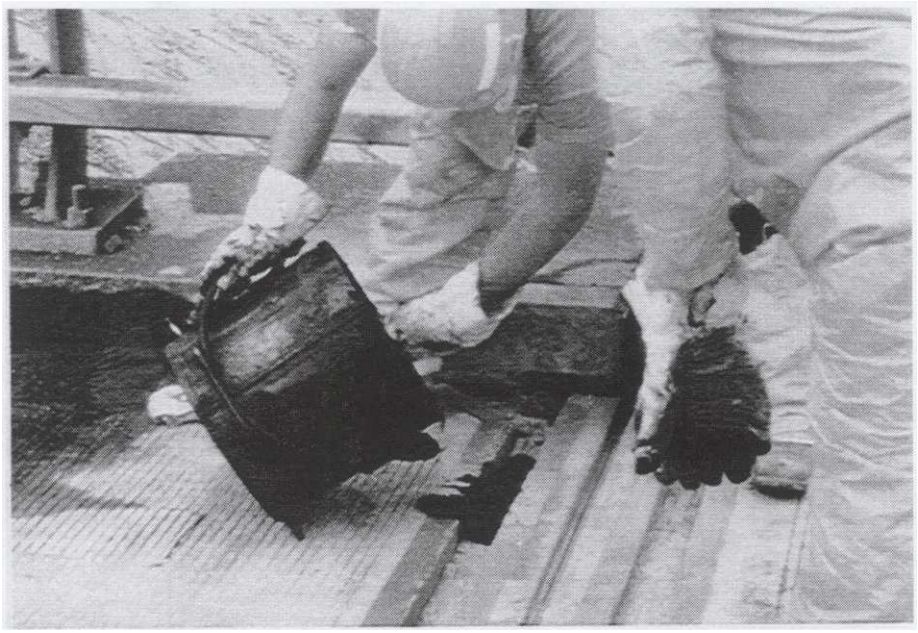
Tasks: The following tasks are the general steps typically associated with this maintenance activity. They are not all-inclusive, nor always required.

- 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.

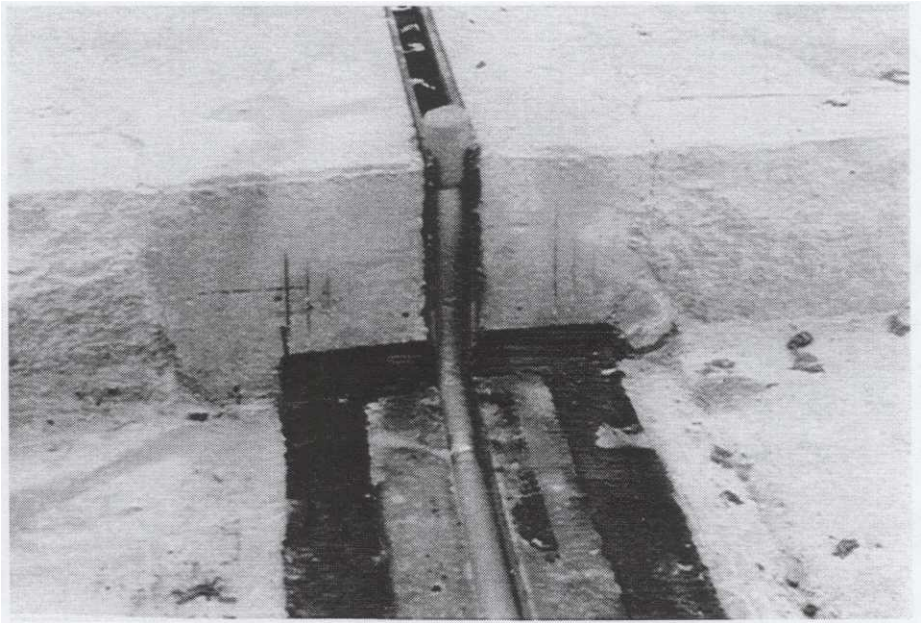
Safety: Typical work zone procedures as appropriate for specific site.
Consider environmental and worker-safety issues (i.e., asbestos exposure).

Sawcutting adjacent to the joint.

Removing concrete adjacent to the joint.



Placing the elastomeric concrete header material.



Installing the joint seal backer rod.

REPAIRING/REPLACING STEEL MEMBERS

Description: Repair or replace deteriorated or damaged steel sections.

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

Selection Criteria: Consider this treatment for any bridge with steel elements having a condition rating less than 5, 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.

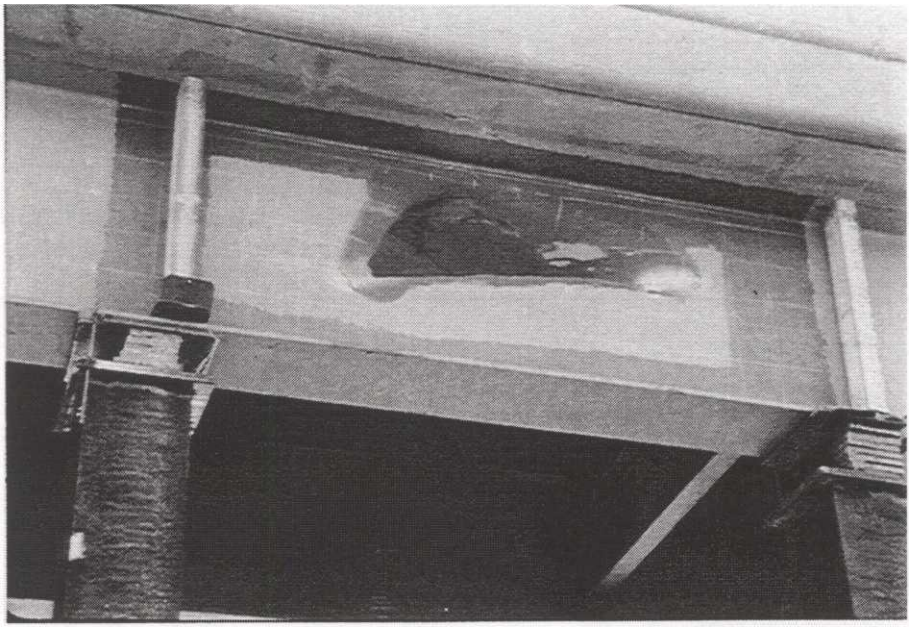
Material
- Steel
- High-strength bolts
- Welding rod
- Blasting sand

Equipment -
- Compressor w/hoses, etc.
- Welder
- Scrapers & stiff brushes
- Grinder
- Sandblaster
- Shroud
- Various handtools
- Magnetic drill
- Paint rollers & brushes
- Vacuum paint-removal tools
- Generators
- Acetylene torches
- Personal-safety equipment

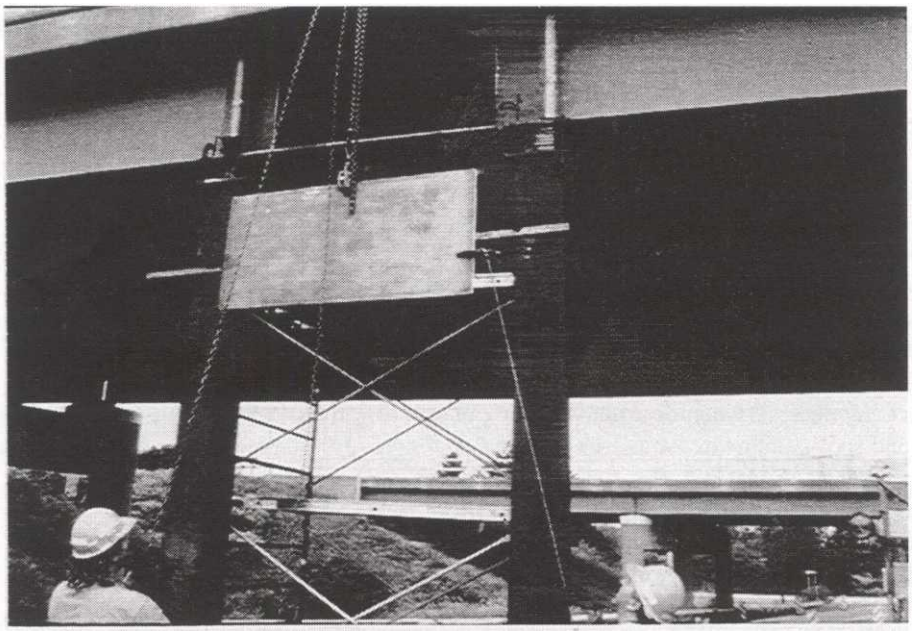
Tasks — The following tasks are the general steps typically associated with this maintenance activity. They are not all-inclusive, nor always required.

- Develop repair plan. CAUTION: consult a licensed 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 [see *Bridge Painting (p. 34)*]appropriate references for painting).

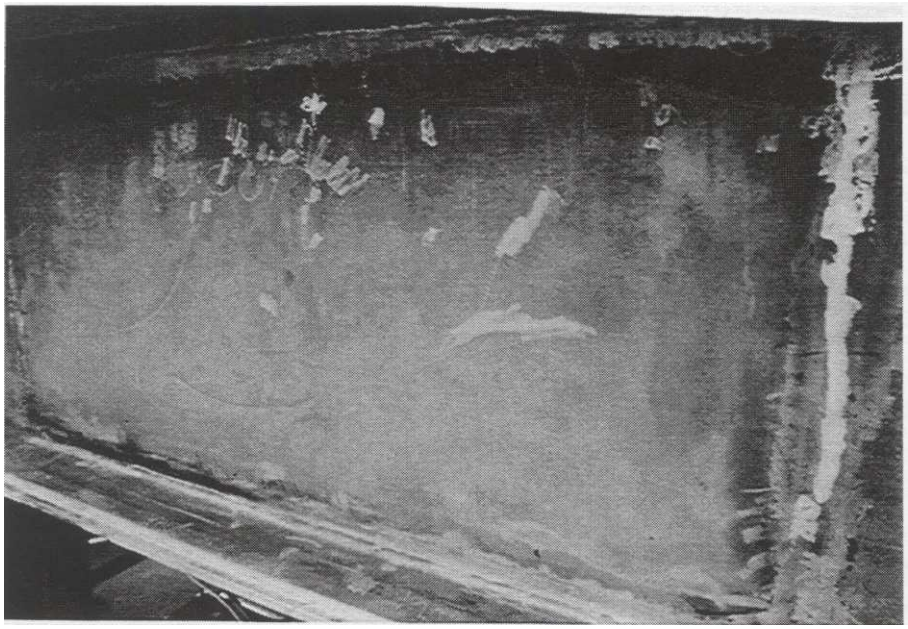
Safety — Typical work zone procedures as appropriate for specific site.
DO NOT attempt steel repairs without proper knowledge and qualifications.
Consider environmental and worker-safety issues (i.e., lead exposure).



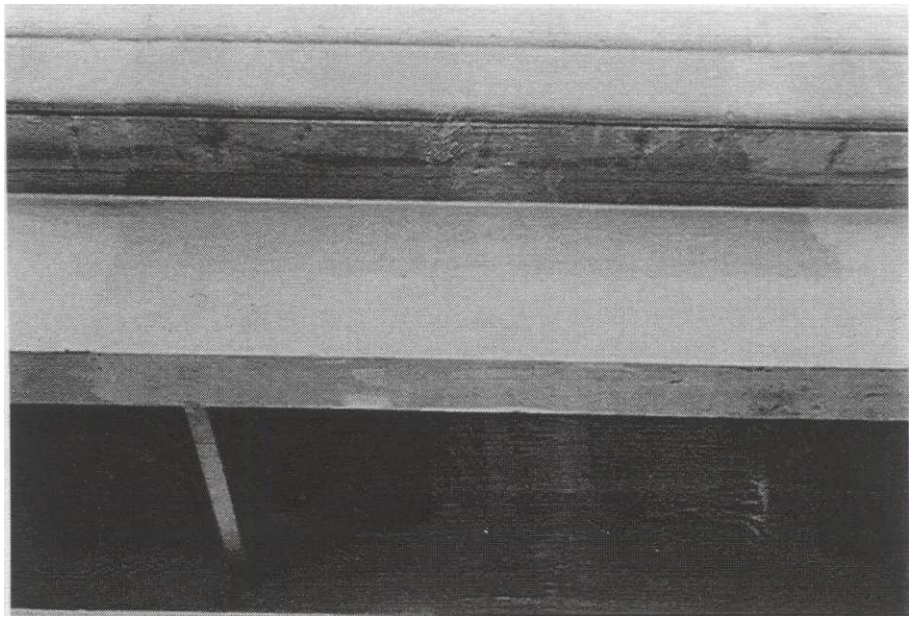
Mark extent of deteriorated/damaged material to be removed.



Provide adequate temporary support.



Install new section steel.



Finish repaired area.

REPAIRING/REPLACING BEARING

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 for any bridge with a bearing condition rating less than 5.

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 handtools
	Personal-safety equipment	

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

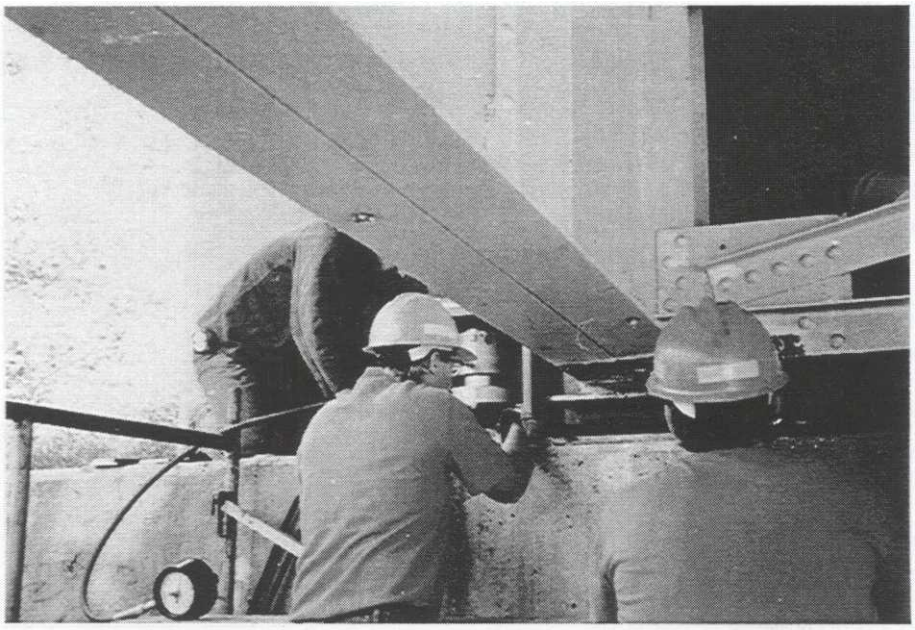
1. **Repair sheared anchor-boltson slider bearings by installing anchor straps in front of bearing base-plates and properly lubricating sliding surfaces.**

- 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.

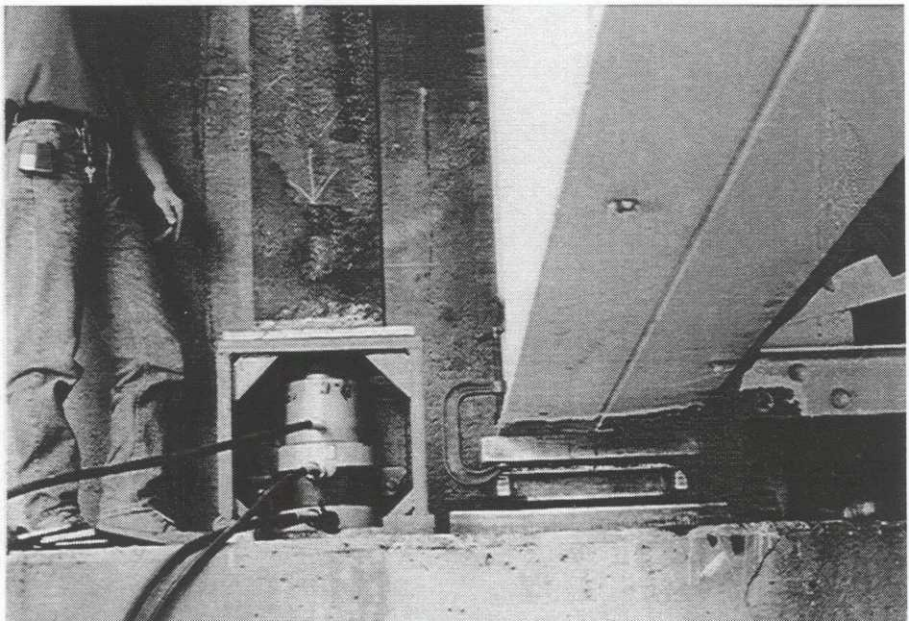
2. Replace roller-nest bearings with elastomeric bearings or pads

- 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.

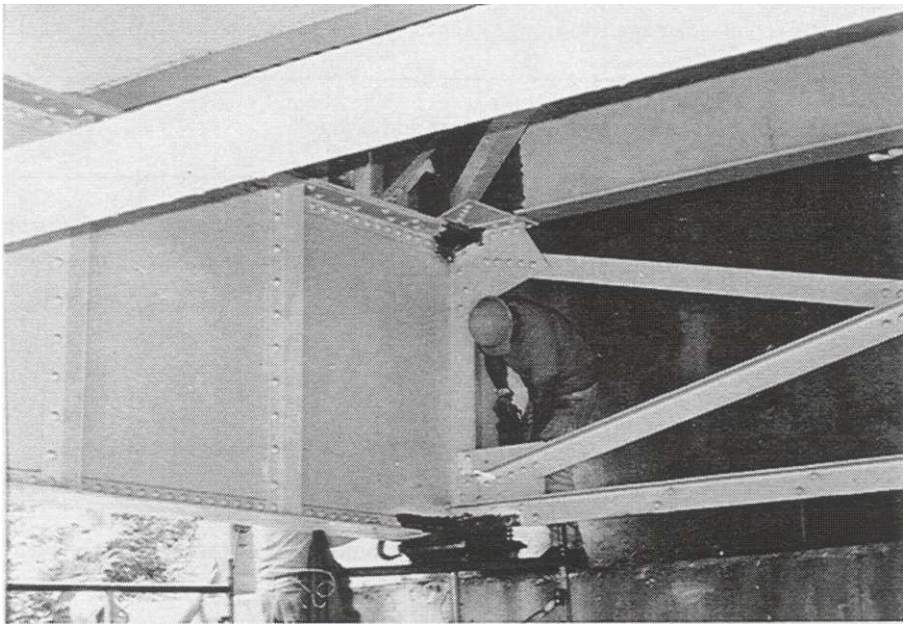
Safety Typical work-zone as appropriate for specific site.
Restrict traffic during jacking operation.
Consider environmental and worker-safety issues (i.e., asbestos exposure).



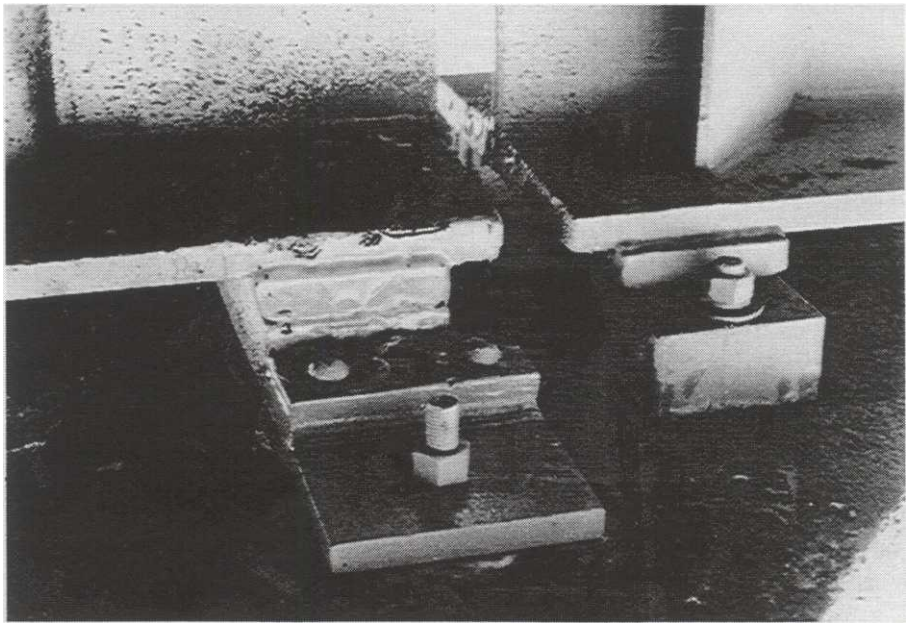
Remove existing bearing.



Re-install refurbished bearing.



Drill holes for new anchor bolts.



Install new bearing plate anchor straps/plates.

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).

Labor Skills: Physical labor, carpentry, masonry.

Material:
- Blasting sand
- Water
- Reinforcing steel
- Shim plate
- Portland cement concrete (or other patching material)

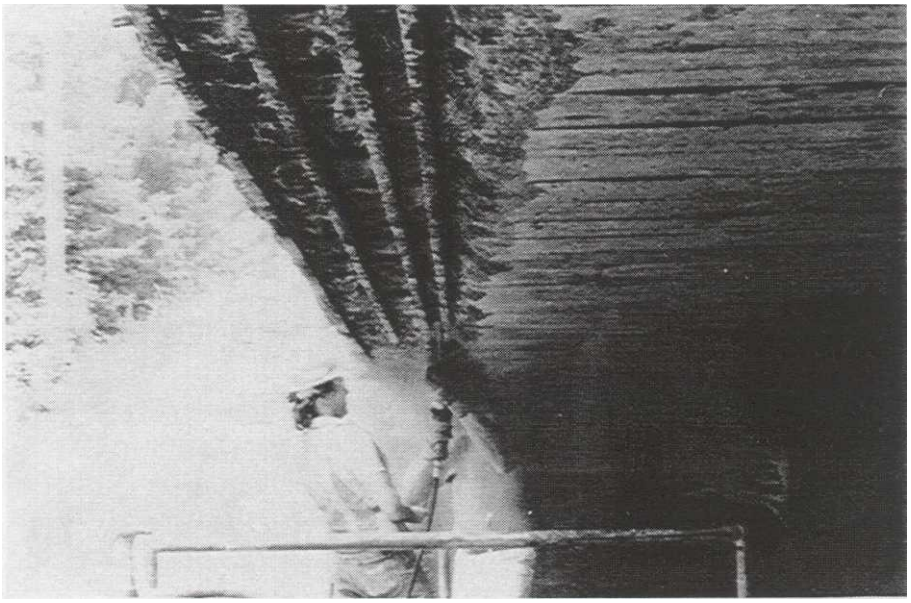
Equipment:
- Concrete saw
- 450-CFM compressor w/hoses
- Generator
- Sandblaster
- Sounding hammer
- Pneumatic hammer
- Concrete mixer
- Concrete pump
- Hydraulic pump
- Various handtools
- Personal-safety equipment

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

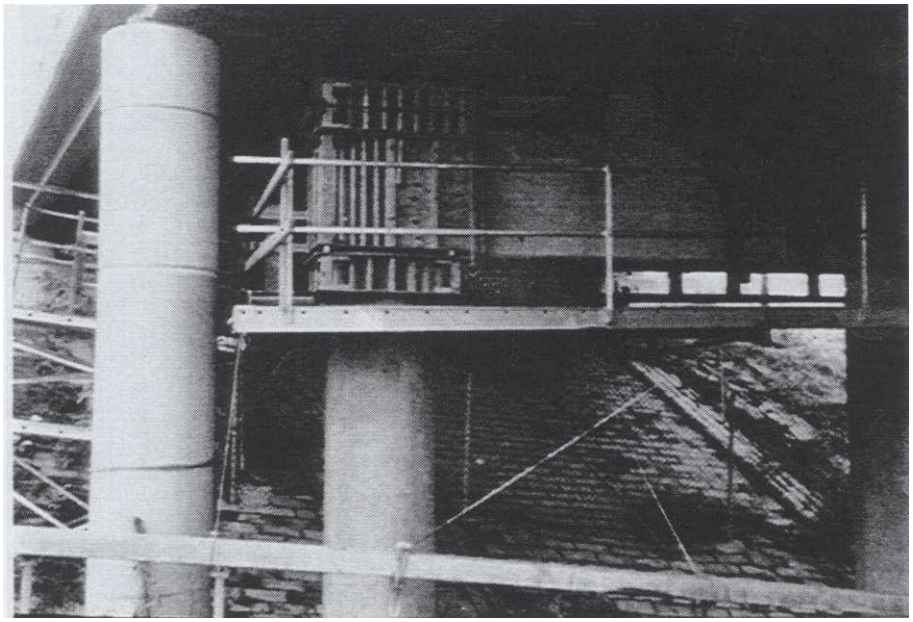
- Prepare work-zone (i.e. traffic control, environmental protection, equipment).
- Identify and mark extent of damaged areas of substructure concrete.
- Install temporary support of superstructure as required.
- Sawcut outside deteriorated areas. Straight cuts (vertical or horizontal) about 1-in. deep should not be made outside planned repair areas.
- Remove deteriorated concrete, using pneumatic hammers and handtools, 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.
- Weld or mechanically 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 as appropriate for specific site.

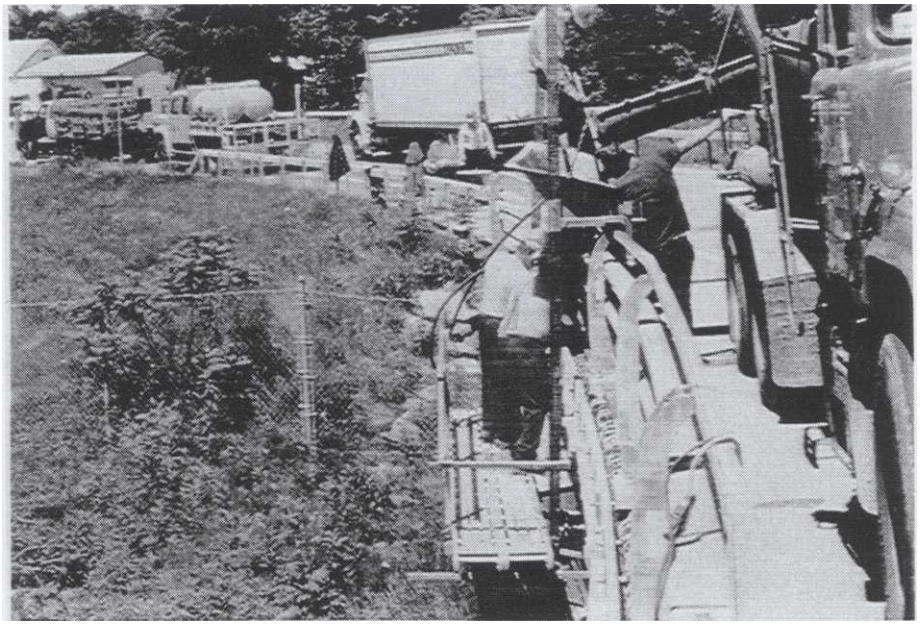
Determine extent of deteriorated concrete.



Remove deteriorated concrete and adequately expose steel reinforcing.



Prepare formwork.



Place concrete or other repair material.

REPAIRING EROSION/SCOUR

Description: Repair undermined foundations and/or scoured or eroded stream channels with concrete, 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 5, or if flood monitoring or a flag report indicate a potential problem.

Procedure:

Labor Skill: Physical labor

Material:
- Gravel
- Geotextile fabric
- Concrete
- Grout bags
- Bedding material
- Rip-rap
- Heavy stone fill

Equipment:
- Bulldozer
- Backhoe
- Dump truck(s)
- Barge
- Core drill
- Personal safety equipment
- Skid-steer loader
- Hydraulic excavator
- Crane
- Concrete pump
- Various handtools

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, Corps of Engineers, or NYC Department of Environmental Protection and consult with DEC, as required.
- 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 apart.
- Pump concrete through holes, vibrating frequently.
- 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.

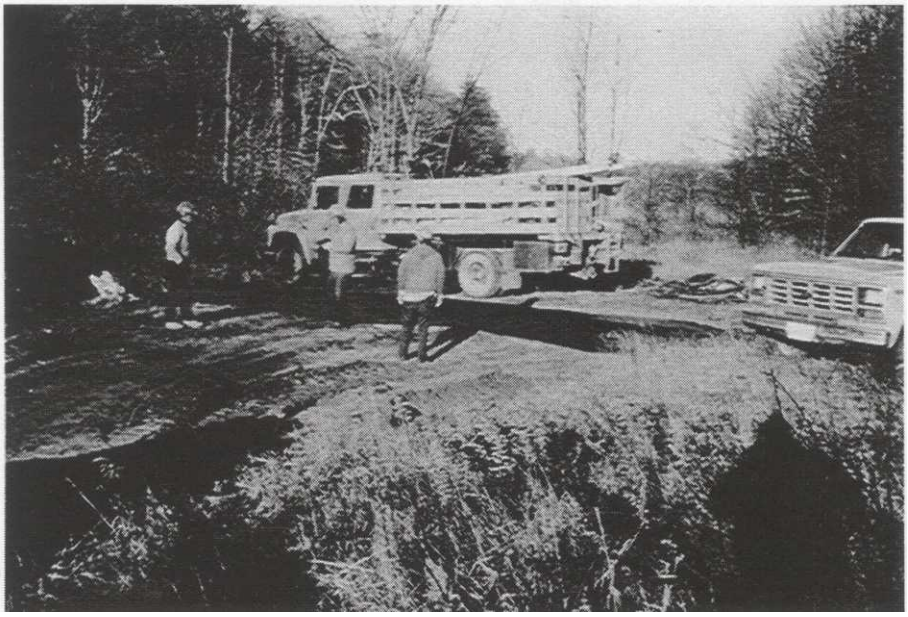
2. Repair scour hole.

- Coordinate with Regional Environmental Unit and obtain any necessary permits from Adirondack Park Agency, NYS Department of Environmental Conservation, Corps of Engineers, or NYC Department of Environmental Protection and consult with DEC, as required.
- 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.

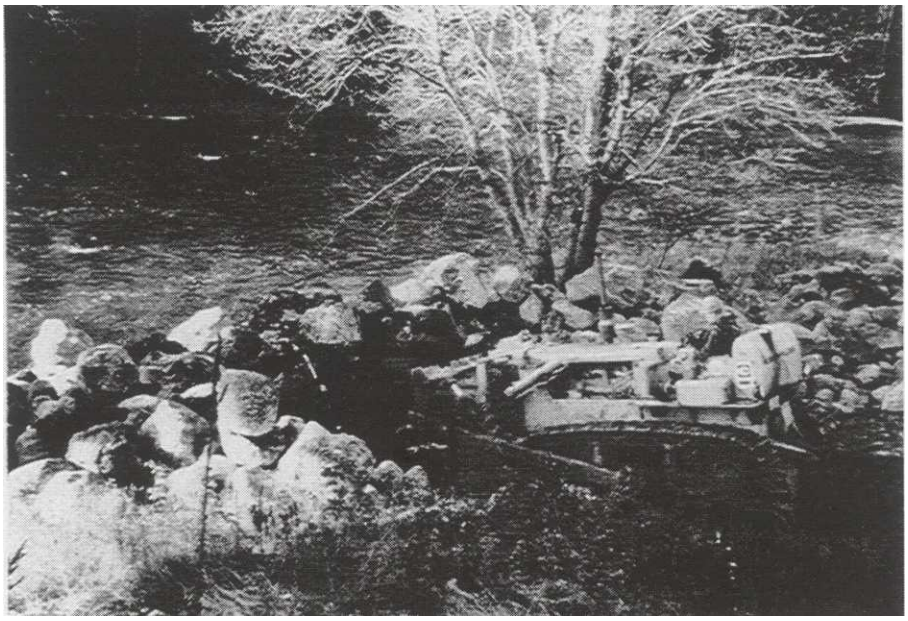
- Place gravel or bedding material in the scour hole, as required, if silt is a problem.
- Place geotextile fabric over the bedding material.
- Place stone into the scour hole, working off a stone pad and progressing into the hole.
- Shape stone as close as possible to existing channel elevation.

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.



Unrolling geotextile fabric before placement.



Placing stone fill or rip-rap.

APPENDIX

RECOMMENDED GENERAL REFERENCE DOCUMENTS

Current NYSDOT Standard Specifications
Current NYSDOT Materials Bureau Approved Lists
Current NYSDOT Engineering Instructions and Engineering Bulletins
Examples: 94-030 Maintenance Cleaning and Washing of Bridges
95-053 Design Guidelines for Use of Penetrating and Coating Type Sealers for Concrete
95-054 Specifications for Use of Penetrating and Coating Type Sealers for Structural Concrete
Current NYSDOT Safety Bulletins
Examples: SB-96-7 OSHA Standards for Fall Protection, Aerial Lift Devices, and Working Over or Near Water
SB-96-3 Respiratory Protection
SB-96-1 Lead
SB-95-05 Welding, Cutting, Brazing and Heating
SB-95-1 Abrasive Blasting
SB-94-4 Histoplasmosis
NYS Steel Construction Manual

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STREET _____

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PRE-PAYMENT REQUIRED/CHECK ONLY

PUBLICATION	PRICE	QTY	AMOUNT
Standard Specifications (SPCE)	$25.00		
Standard Specifications - Manual (SPECM)	$25.00		
NYS Steel Construction Manual (NYSCM)	$13.00		
Manual of Uniform Record Keeping (MURK)	$7.00		
Contract Administration Manual (MURK Part 1A)	$19.00		
Construction Division Safety & Health Program Manual (MURK Part 1C)	$11.00		
Bridge Inspection Manual (BI)	$11.00		
Bridge Inventory Manual (BII)	$11.00		
Construction Supervision Manual (CSM)	$20.00		
Weighted Average Bid Prices (WABP)	$14.00		
Traffic Volume Report (TVR)	$10.00		
Highway Design Manual/ Vol. I & II with revision (HDM)	$38.00		
Highway Design Manual: (please circle choices) Revision 20 Revision 22 Revision 24 Revision 26 Revision 28 Revision 21 Revision 23 Revision 25 Revision 27 Revision 29	$3.50 each		
Standard Spec. for Highway Bridges (SSHB)	$15.00		
Standard Details for highway Bridges (SDHB)	$26.00		
Policies & Standards for Entrance to State Highways (PSESH)	$2.00		
Highway Miileage Report (HMR)	$6.00		
NYS Highway Sufficiency Rating Manual (HSRM)	$10.00		
NYSDOT Communications Directory (CD)	$8.00		
Prestressed Concrete Construction Manual (PCCM)	$20.00		
Rights of Way Mapping Procedure (ROW)	$56.50		
Bridge Deck Evaluation (BDE)	$43.00		
How to do Business with NYSDOT (HBNY)	N/C		
Registry of Disadvantaged Business Enterprises (DBE)	N/C		
Registry of Certified D/M/WBE Architectural & Engineering Firms (A&E/DBE)	N/C		
Reference Marker Manual (RMM)	N/C		
Vertical Highway Alignment Sight Distance Charts (VHAS)	$3.50		
Design Procedure Manual (DPM)	$20.00		
Environmental Procedures Manual (EPM)	$76.40		

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PUBLICATION	PRICE	QTY	AMOUNT
VULNERABILITY MANUAL FOR BRIDGE FAILURE MODE:			
Hydraulic Vulnerability Manual (HVM)	**$5.00**		
Steel Details Vulnerability Manual (SDVM)	**$5.00**		
Overload Vulnerability Manual (OVM)	**$5.00**		
Collision Vulnerability Manual (CVM)	**$5.00**		
Seismic Vulnerability Manual (SVM)	**$5.00**		
STANDARD SHEETS:			
Metric Standard Sheets:	**$35.00**		
Individual Sheets per Sheet	**$2.00**		
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MAINTENANCE BRIDGE PAINTING
BACKGROUND AND GUIDANCE

Background: The cost and effort needed to repaint in-service structures has increased significantly in recent years. Strict EPA regulations are applied to bridge painting projects that involve the removal of existing paint. These regulations control the emissions of dust alone, and dust containing lead debris, into the environment. Ambient air quality standards that regulate the release of particulate and lead particles must be complied with. In addition, OSHA has introduced new and stringent regulations for worker safety, i.e. Interim Standard for Lead in Construction (Title 29 of the Code of Federal Regulations, Part 1926.62).

To meet these standards and regulations, in 1993 the Department issued requirements and guidelines for the use of a negative pressure, Class A containment system. The Class A containment has been successful in containing dust and lead paint debris on bridge painting projects that specify open abrasive blasting as the method of surface preparation. To address worker safety, a lead health and safety program, exposure control plan, and monitoring requirements have been developed for bridge painting work.

Lead standards and worker health issues are here to stay. They will not be eased or eliminated for bridge painting work. There have, however, been some new developments within the painting industry which will both have an effect on and give direction to our painting program.

1. A new, single component moisture-cure paint system has been developed for structural steel work. In laboratory and field tests performed by the Materials Bureau and others, moisture-curing paint systems have performed as well as the current standard epoxy mastic/urethane system.

   Because this paint dries by reacting with moisture in the air, painting work can be performed in conditions of high humidity and damp weather. Multiple recoats are possible within the same work day.

Moisture-curing paints are somewhat tolerant of imperfectly cleaned surfaces. Although the greatest service life will occur on steel cleaned by abrasive blast cleaning, satisfactory performance can be achieved on certain bridges cleaned to a lesser standard using power tools.

2. New research has indicated that abrasive blast cleaning alone will not remove de-icing salts and other soluble pollutants. When left in place these contaminants create active corrosion cells which can lead to early coating failures. The most efficient way to eliminate these corrosion causing residues is to power wash all surfaces before cleaning and painting work begins.

3. A negative pressure, Class A containment system is necessary when performing open abrasive blasting operations. This will usually be the case on bridges with moderate to severe corrosion (e.g. greater than 25% rust), or when cleaning bridges with more complicated designs (e.g. trusses), or when all the existing paint is removed from the structure.

4. A Class B containment system is a simple enclosure design consisting of drapes and covers suspended around the work area. A negative pressure is not specified. Ventilation in the containment is usually by natural means. Filtering or treatment of exit air is not required. In populated areas and in sensitive locations (e.g. near schools and over water), a Class B containment system has proven to be effective for containing paint waste and dust when vacuum shrouded power tools and vacuum blasters are used for paint removal work. A Class B containment is not effective, nor can it be used to contain paint waste and dust generated by open abrasive blast cleaning operations.

5. In unpopulated locations, when vacuum shrouded power tools and vacuum blasters are used for paint removal work, containment for paint waste may be provided by using the simple ground and water protection specified under Items 570.09 and 570.10 (Environmental Ground and Water Protection).

6. Paint that is applied in the winter and seasons of cool weather does not perform well. Painting work should not usually be allowed in the winter months of December through March. If absolutely necessary to complete a project, for example, paint applied during this time period must be allowed to fully dry in a heated enclosure.

7. On structures with significant corrosion and paint deterioration, on complicated structures such as trusses and built-up plates, and on certain other structures in sensitive and highly populated areas, consideration should be given to removing all of the existing lead paint. When total removal is specified, the use of recyclable, reusable abrasives should be encouraged to reduce the quantity of waste material that is generated for disposal as hazardous waste. A lump sum waste disposal payment should be used for this purpose.

8. Paint life is dependent on surface preparation and coating thickness. Research indicates that in over 85% of the investigations performed, premature paint failures are a result of improperly prepared surfaces, or thin coating thicknesses. In general, for spot-cleaning and over coating, a moisture-cure paint system will perform for 10 years on surfaces cleaned using power tools, and for 15 years on surfaces cleaned by abrasive blasting. When all of the paint is blast cleaned from existing structures, the moisture-cure paint system will provide 20 years of service. These paint lives assume that the cleaning standard specified for the method of surface preparation is achieved, and that the specified coating thickness is applied.

9. Paint life is dependent on the quality of paint inspection. In the past few years, with the use of a Class A containment system, the level of inspection at the project site has often been compromised. Workers perform their duties within an enclosure, and inspectors cannot always easily inspect painting activities. The responsibility for ensuring that surfaces are properly cleaned and coatings are properly applied has often been left to the contractor. No painting should ever be allowed unless the cleaned surfaces have been inspected and approved, and the thicknesses of the applied coatings have been measured and approved.

10. Abrasive blast cleaning is the most efficient way to remove rust, millscale, and deteriorated paint from the structure. Blast cleaning is the most productive method of cleaning. It is the

best method for cleaning small and complicated shapes (e.g. lattice pieces, heads of nuts and bolts, edges of bearings and plates), and for cleaning marginally accessible surfaces such as the tops and backsides of structural shapes. Production rates for blast cleaning to a commercial standard (SP-6) are estimated at 1000 - 1500 sf/blast nozzle/day. Abrasive consumption rates for commercial blasting to a bare metal condition are estimated at 4 lbs/sf for non-reusable slag, and 5 - 6 lbs/sf for reusable G-40 steel grit. For estimating purposes, the steel grit or other abrasive such as steel shot, can be considered to be recycled for use at least 20 times.

11. Cleaning with vacuum shrouded power tools, needle guns, grinders, rotary impact hammers, and vacuum blasters is a less efficient and a more labor intensive way to remove rust and deteriorated paint. For this reason, its use is restricted to structures with uncomplicated designs (e.g. highway grade crossings), structures with large, flat surfaces, and structures with minimal coating deterioration. Areas of limited accessibility are difficult to clean with power tools. Production rates are slow. It is not practical to expect a worker using heavy, vibrating power tools to work continuously for a full 8-hour day. Experience has shown that three to four productive hours can reasonably be expected. Depending on the condition of the surface being cleaned, and the type of power tool used, production rates can be from 100 - 400 sf/worker/day. A HEPA filtered vacuum attachment on the power tool reduces dust and helps to control the collection of debris by channeling it to a container. Large pieces and chips of paint will fall to the ground for later collection by HEPA filtered vacuums.

12. It may not always be possible to erect and use a Class A or Class B containment system. Bridges over active railroad lines, restricted highways, and roadways with heavy traffic volumes may require special consideration. The designer must be aware that whenever a Class A or a Class B containment enclosure is specified, traffic may be disrupted beneath structures with low or inadequate clearances. If lane closures cannot be maintained for practical time periods, normally an 8-hour work day, it may not be possible to use a containment system on the portion of the structure that spans the obstruction. In this case the designer must specify that spot cleaning and painting be performed on those spans, or portions of the structure, over the railroad or highway using vacuum shrouded power tools, regardless of the condition of the existing painted surface. If possible, ground or water protection should be specified beneath the work area to collect falling paint chips, or special provisions should be made to collect and vacuum waste that may be spilled from the cleaning work. Spilled paint chips and other waste must be collected. To obtain the longest lasting paint life, spans and areas adjacent to the obstructed area should be cleaned and painted in the normal manner, using an appropriate containment system.

13. Premature coating failures usually occur over the first winter's exposure. Defects normally include the appearance of rust on the edges of plates and angles, bearings, and heads of nuts and bolts. Surfaces that were not adequately cleaned, or on which the paint was not applied at the specified thickness, will show evidence of early deterioration. To minimize the occurrence of early coating failures, a performance proving period extending beyond the first winter season is required.

Site Evaluation: Three basic painting methods are presented in here. The designer/engineer must perform a hands-on evaluation of each structure that is being considered for painting. On larger and more complicated bridges it may be necessary to use "lift" equipment to gain access. Materials Bureau personnel are available to assist if requested.

When the evaluation is performed, the following should be considered:

1. Location. Is the structure in a rural or populated area? Is it in a sensitive location, such as over a stream, or near schools, playgrounds, homes, or public places? Is it near a farm or livestock? This information will be used to select the appropriate containment to control paint waste.

2. Type of Structure. Is this bridge a simple structure, such as a girder or stringer bridge, that has uncomplicated details, with accessible flat surfaces that will be easy to clean with power tools? Or is this a truss bridge consisting of small, riveted pieces, or a structure constructed of built-up plates that will be difficult to access, and may require cleaning using open abrasive blasting methods?

3. Condition of Existing Paint. What is the condition of the existing paint? The extent of surface area on the bridge that needs cleaning to remove corrosion (rust) and deteriorated paint should be estimated as follows:

   Good - less than 25% of surface;
   Moderate - 25 to 50% of surface;
   Poor - greater than 50% of surface.

   On structures in "good" condition, are the corroded and deteriorated areas easily accessible for power tool cleaning, or will abrasive blast cleaning be required?

4. Other Considerations. How thick are the coats of existing paint, and how well are they adhered? Use a dry film gage to measure paint thickness. Use a putty knife, or a pocket knife, or similar tool to get an idea of the adhesion of the existing coats of paint. If the paint is difficult to remove it is probably suitable to overcoat. There are other procedures to test paint adhesion, such as the "crosshatch and tape test," but these require considerable experience by the "tester" and are not recommended for general use. If the thickness of existing coatings exceeds 30 mils (1 mm), and if the coating can be easily removed, or if there are large areas of peeling and delaminating paint, then the total removal should be considered.

   In the 1980's coal-tar epoxy paint was often used to protect the steel from corrosion on surfaces beneath, and five (5') back (in all directions) from transverse bridge joints, and beneath open steel grates. Coal tar coatings are difficult to overcoat and they should be removed or checked carefully to ensure that they are well adhered before new paint is applied.

Throughout the late 1950's, 1960's and early 1970's, an asbestos-coating product called "dum-dum" was used as a fireproofing and waterproofing. The primary use of this material is believed to have been on bridges crossing railroads, and on bridges constructed with open steel grates. On bridges over railroads the entire structure or those spans over the rail lines may have been coated. Typical locations beneath open steel gates would include the steel surfaces of the interior girders and girder fascia immediately below the grating. Dum-dum may also have been used to a lesser extent on some bridges on the steel surface beneath transverse bridge joints, and on steel girders, 5 to 10 feet back in all directions from piers and abutments.

Many of the structures where dum-dum was applied have since been repainted and it is unlikely that many bridges still contain this application. However, the designer should be aware of its existence and evaluate the structure for its presence.

Preliminary identification of dum-dum is by close inspection of the steel. It is approximately between 1/8" and 1/4" thick and will likely be in good condition with existing layers of paint covering it. Visual confirmation of its presence will require close inspection of the steel. Dum-dum may have an exterior appearance similar to coal-tar because it typically will be painted, however, areas where there is damage or where the edges are exposed should indicate a silver and/or rust colored interior with a visible fiber matrix. By comparison, coal tar is typically black or dark red, through the interior, with no fibrous matrix.

If dum-dum material is found or suspected on any structure scheduled for painting it will require prior abatement by a licensed contractor subsequent to any other work. To help determine this need, when this material is identified on projects, the Environmental Analysis Bureau should be contacted at 518-457-5672.

Specifying A Painting Method: Using the information from the site evaluation the designer should now specify a paint method to perform the work. The following three methods (Table 1) are general requirements that should satisfy most project work. There will however be structures that will need special requirements, or that will need more than one procedure to produce a satisfactory job. Using the information in this guideline, and some common sense, the designer should be able to recognize and specify the appropriate specification requirements to develop a "customized" painting method, when one becomes necessary.

Paint Method #1: This painting method is for bridges with simple, uncomplicated designs, that have been rated in "Good" condition with less than 25% rust and deteriorated paint. Bridges that are considered for this painting method will normally be girder or stringer bridges with uncomplicated details and flat surfaces, that will be accessible for cleaning using power tools. All structures meeting this definition should be cleaned and painted using vacuum shrouded power tools and vacuum blasters. The quantity of paint debris and dust from cleaning operations will be minimal as it will not contain abrasive. In non-sensitive rural locations, simple ground and water protection items should be specified to contain dust and debris. In urban settings and sensitive locations (over reservoirs, trout streams, near schools and housing) a Class B containment system must be used. The quantity of paint waste generated by cleaning with power tools will be small, normally less than

TABLE 1
TYPICAL PAINTING METHODS

% Deterioration	METHOD #1 (<25%)				METHOD #2 (25%-50%)	METHOD #3 (>50%)
Design	**Simple**		**Complex**		**All**	**All**
Location	**Urban (Sensitive)**	**Rural (Non-sensitive)**	**Urban (Sensitive)**	**Rural (Non-sensitive)**	**All**	**All**
Containment:						
Item 570.09/570.10	-	x	-	x	-	-
Item 18570-1503	-	-	-	-	x	x
Item 18570. Class B	x	-	x	-	-	-
Cleaning & Painting:	x	x	x	x	-	-
Item	-	-	-	-	x	-
18573.1010/.1011	-	-	-	-	-	x
Item 18573.1010/.1013						
Item 18573.1014/.1015						
Paint Removal Waste:	x	x	x	x	x	-
Item 571.01	-	-	-	-	-	x
Item 18571.1010						

Item 570.09110, Environmental Ground Protection/Water Protection
Item 18570.1503, Class A Containment System for Paint Removal
Item 18575.1010, Class B Containment
Item 18573. 1010/.1011, Field Cleaning and Over coating - SSPC SP11
Item 18573.1012/.1013, Field Cleaning and Over coating - SSPC SP6
Item 18573.1014/.1015, Field Cleaning and Painting - Total Removal
Item 571.01 - Treatment and Disposal of Paint Removal Waste
Item 18571.1010 - Treatment and Disposal of Paint Removal Waste - Lump Sum Payment)

a cubic yard (m^3). Treatment and disposal of paint waste should be paid for as each cubic yard (m^3) of waste material generated.

Paint Method #2: This painting method is for bridges that have been rated as "Moderate." Corroded or deteriorated paint is present on 25 - 50% of the surface area on the structure. Cleaning with power tools on a structure with this quantity of deterioration is not practical because of the slowness of the cleaning operation, and because power tools will be unable to access marginally accessible surfaces. Cleaning on this structure will require abrasive blasting. A Class A containment must be included to contain waste and debris. Spot blasting and painting is the recommended choice for use on this bridge, but total removal may be appropriate in special cases, such as in heavily populated and sensitive locations. Moderate quantities of waste will be generated by spot blasting, and the treatment and disposal of paint waste should be paid as each cubic yard (m^3) of waste material generated. If a total removal item is used, waste disposal should be paid for as a lump sum payment to reduce cost and quantities of paint waste material. A lump sum waste disposal item for spot blasting work is not practical, and should not be used.

Paint Method #3: This painting method is for bridges rated "Poor." Corroded and deteriorated paint is present on 50% or more of the surface area. Cleaning will require abrasive blasting. A Class A containment must be used to contain paint removal waste. Because large quantities of waste material will be generated by the cleaning operation waste disposal will be paid for as a lump sum payment to reduce cost and quantities of waste for disposal. This paint method may also be considered for use in densely populated and sensitive locations where it may be desirable to remove all of the lead paint.

The following table summarizes the typical painting methods and items. It is important to note that this table only includes the items that directly pertain to the painting work (cleaning, painting, containment, and waste disposal). Items for M&PT, worker health and safety, engineers office, phones, and related items are to be included in the project by the designer, as necessary.

Technical Assistance: Questions and requests for technical and project assistance should be directed to the Materials Bureau at 518-457-4285.