Office of Bridges and Structures

Bridge Maintenance Manual

Issue Date: January 1, 2014

Developed By:

PROJECT NO. TR-646 SPONSORED BY THE IOWA HIGHWAY RESEARCH BOARD

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CHAPTER 1
DECK EXPANSION JOINTS

1.1 TYPES OF JOINTS AND THEIR USES

A number of different types of deck expansion joint systems are commonly used for bridges in the state of Iowa throughout the federal, state, and local highway system. Although some small bridges incorporate simple open gaps in the bridge deck to accommodate bridge expansion and contraction, the preference is to use sealed joints to prevent bridge runoff from penetrating below the bridge deck and causing corrosion or deterioration of bridge components. The predominant types of closed joint systems used in Iowa are strip seal joints for low movement joints and finger joints for higher movement joints. However, other joints encountered could include modular joints, compression seal joints, and bolt-down joints. Components of joint systems could also include steel sliding plates for bridge decks, barrier rails, or sidewalk elements at expansion joints. Finally, with the push to move toward jointless bridge systems using integral or semi-integral abutments, the expansion movement may be moved completely off the bridge itself and thermal expansion accommodated by a compressible material placed between the end of the approach slab and the beginning of the roadway paving.

A **strip seal joint**, shown in Figure 1.1-1, consists of extruded steel elements on each side of the joint that are anchored into the surrounding concrete of the bridge deck and/or abutment backwall, usually with welded steel plate anchors. A flexible neoprene gland is tightly fitted into each steel extrusion to provide a water-tight seal between the extrusions and to allow for bridge expansion and contraction movements up to approximately 4 inches.

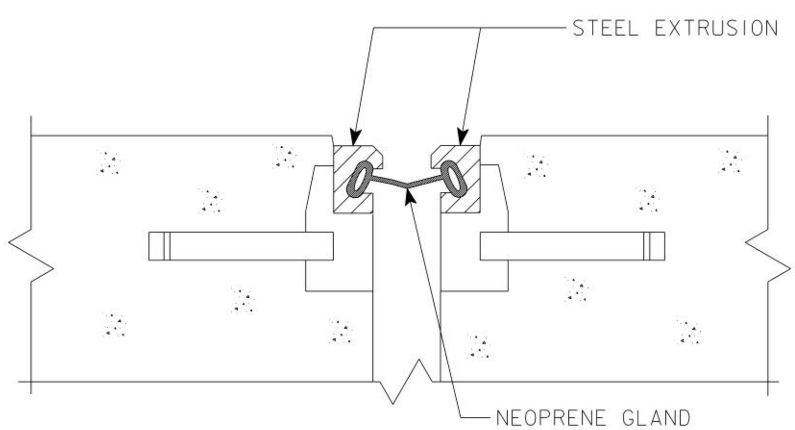


Figure 1.1-1. Strip Seal Expansion Joint

A **finger joint**, shown in Figure 1.1-2, is usually used for joint movements greater than 4 inches and consists of steel plates cut in a saw-tooth pattern to accommodate movements. The teeth of the joint intertwine and allow for thermal expansion of the bridge through the side-by-side movement of the adjacent teeth. Because the teeth cantilever from the point where they are anchored into the bridge deck, the steel plates used for finger joints can become rather thick in order to support the weight of a wheel load. Generally, a neoprene trough is positioned under the opening of the joint to capture and channel away bridge deck runoff and to prevent the runoff from contacting bridge bearings and other corrosion-susceptible bridge components.

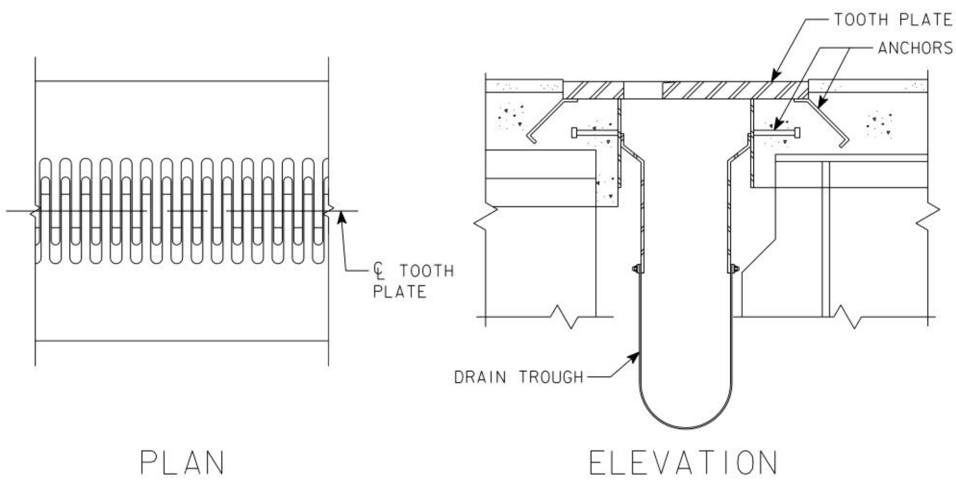


Figure 1.1-2. Finger Joint

Modular joints, although not commonly used in Iowa, are sometimes used for high movement joints, particularly for heavily skewed or curved bridges where the thermal movement of the bridge may not coincide with the longitudinal axis of the bridge. A modular joint, shown in Figure 1.1-3, consists of multiple steel extrusions with neoprene glands stretching between the extrusions to provide a watertight seal. The steel extrusions are supported from below by support bars that slide on small bearing pads and that use a spring-loaded, self-adjusting system to maintain a uniform gap between adjacent steel extrusions. Joint components shown in Figure 1.1-3 may vary by manufacturer.

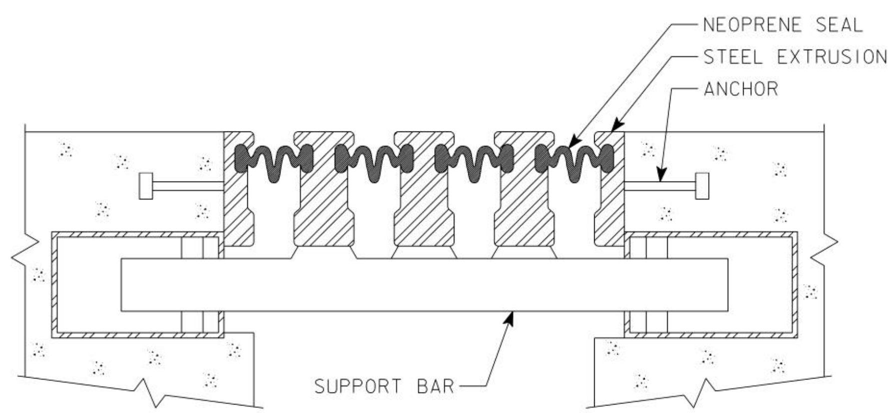


Figure 1.1-3. Modular Expansion Joint

A **compression seal joint**, shown in Figure 1.1-4, is a low-movement joint system that consists of a compressible neoprene gland. The gland is generally pre-compressed and inserted between two bulkheads. As the bridge expands and contracts, the gland also expands and contracts to maintain a waterproof seal between the bulkheads. A compression seal joint can be used for joint openings ranging from 0.625 inch to approximately 4.5 inches in width.

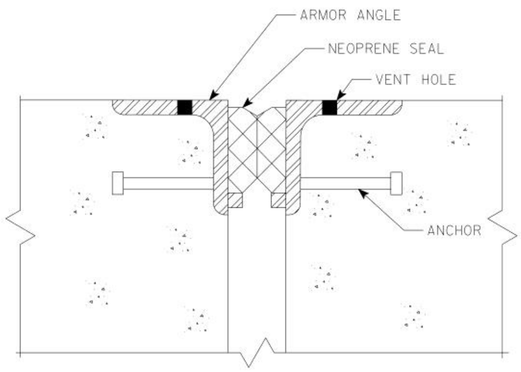


Figure 1.1-4. Compression Seal Expansion Joint

A **bolt-down expansion joint**, shown in Figure 1.1-5, consists of monolithically molded elastomeric panels reinforced with steel plates that are bolted down on each side of the joint. The bolt heads are typically recessed within the profile of the reinforced elastomeric panel and are covered with a rubber cover or plug.

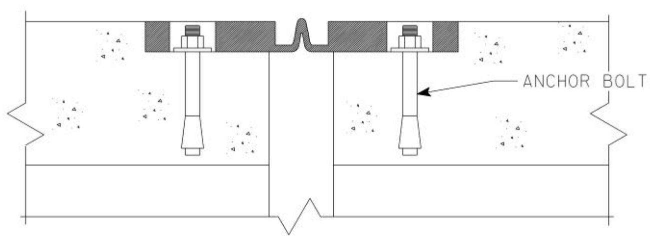


Figure 1.1-5. Bolt-down Expansion Joint

The joints described above provide a means to either seal the bridge joint from water intrusion or to capture the bridge runoff before it comes in contact with structural members or bearing devices located below or near the bridge joint. On many older bridges, a simple open joint or **sliding plate joint**, shown in Figure 1.1-6, is used instead. For a typical sliding plate joint at a bridge abutment, one side of the joint consists of a horizontal plate at the top of the deck that is welded to a vertical bulkhead plate anchored into the end of the bridge deck. On the abutment side of the joint, an armor angle is anchored into the top of the abutment backwall. As the bridge deck expands and contracts, the horizontal plate slides over the armor angle to cover the joint and help prevent road debris from falling through the joint opening. However, the joint is not watertight; therefore, salt-laden runoff can easily come in contact with structural elements below the joint.

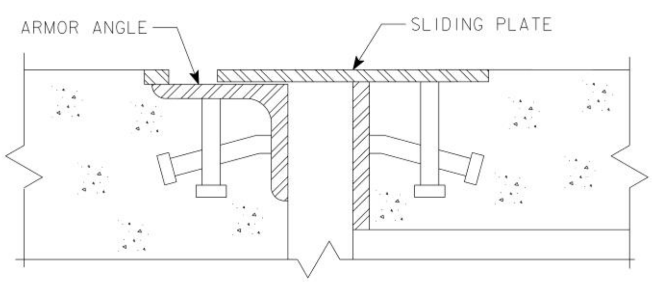


Figure 1.1-6. Sliding Plate Expansion Joint

In addition to the physical joints that allow for thermal movement of the bridge deck, thermal movement of associated bridge barriers and sidewalks must also be accommodated. For large thermal movements, in order to prevent a vehicle from snagging on the gap created at the ends of bridge barriers, a system of steel sliding barrier plates is often used. These sliding barrier plates are typically anchored to the barrier on the approaching traffic side of the joint and slide over the barrier on the exiting traffic side of the joint. Likewise, steel sliding cover plates are often used at joints on sidewalk surfaces to maintain handicap accessibility requirements across the joint.

1.2 COMMON PROBLEMS AND CONSEQUENCES OF POOR MAINTENANCE

Bridge deck expansion joints are prone to a number of problems because, by their nature, expansion joints incorporate moving components and because they are subjected to pounding load conditions and environmental factors. As components of expansion joints move, they may shift out of their proper alignment and snag on each other. In addition, a snowplow blade could snag on the misaligned components and cause further damage. Expansion joints are also subject to the pounding load as trucks and vehicles continually pass over them. As a result, concrete spalls adjacent to expansion joints can lead to failure of the joint systems as the anchorages of the joints deteriorate. Joints that use a flexible gland component are subject to sand, gravel, and road debris becoming lodged in the gland, thus leading to puncture or tearing of the gland. Expansion joints are also subject to environmental damage, whether it is degradation of neoprene components due to sun exposure, wear and abrasion of neoprene components, or exposure to deicing salt. The direct result of joint failures includes the increase in corrosion and deterioration of other bridge components resulting from failed or leaking expansion joints.

More than nearly any other bridge maintenance issue, poor joint maintenance can directly contribute to deterioration of other critical bridge components. With the potential to allow damaging deicing salts to contact other components, it is important to maintain waterproof joints in order to preserve other portions of the structure. The following are some of the problems that can develop when deck joints are not adequate or are not maintained properly:

- **Damaged End Diaphragms and Lateral Bracing** – Steel diaphragms and lateral bracing members directly under leaking expansion joints are subject to paint failure, accelerated corrosion, and loss of section. Pack rust to the top flanges of the diaphragm can also cause an upward pressure on the bottom of the deck and cause transverse deck cracking. Concrete diaphragms are subject to chloride ion intrusion, resulting in corrosion of reinforcing steel and subsequent spalling of concrete as the corroded reinforcing bars enlarge in volume and burst the concrete cover.
- **Damaged Beam Ends** – Ends of steel beams below leaking expansion joints are subject to the same deterioration as steel end diaphragms. This deterioration is critical because the ends of beams at the support points carry the highest shear stresses for any point along the span. The nooks and crannies surrounding the bearing stiffeners are particularly susceptible to trapping moisture and debris. Ends of prestressed concrete beams are also subject to deterioration in the critical end anchorage zones of prestressing strands.
- **Damaged Bearings** – With sediment and moisture trapped around beam bearings, steel bearings are prone to accelerated deterioration and corrosion. Often steel bearings that were designed to accommodate the superstructure movement will lock up due to corrosion. Because of this, the bridge is subjected to stresses not accounted for in the original design.
- **Damaged Beam Seats and Caps** – Chloride-laden runoff from the bridge also attacks the reinforcing steel in the beam seats. Unchecked, spalling and cracking at the beam seats can ultimately result in loss of support adjacent to beam bearings.

- **Damage from Erosion** – Excessive bridge runoff passing through leaking expansion joints can cause erosion damage along the bridge berms and can undermine the abutment foundation or expose the piles.

Each type of expansion joint has typical problems associated with it. For strip seals, breakdown of the neoprene gland can occur as the result of non-compressible material being lodged in the joint when the opening is expanded. As the joint closes, these materials become wedged in the gland and can cause a rupture with loss of water tightness of the joint. Breakdown of the gland can also occur as the result of traffic movement over debris-filled joints. Damage to the steel extrusions or their anchorages can occur from a snowplow blade impact or from repeated wheel impacts from traffic.

Finger joints, which by their nature are fairly robust, are also subject to snowplow blade or wheel impact and deterioration at embedded anchors. In addition, in time, the neoprene troughs under a finger joint may fail, leading to a leaking joint.

Modular joints, which incorporate more moving parts than simpler finger joints, have potential for a wider range of component failures. Also, for many years, the welds connecting the steel extrusions to their supporting steel bars were not designed to accommodate the fatigue loading to which these members are subjected. Beginning in the mid-1990s and later mandated in the 2002 AASHTO bridge design codes, support bar spacing was decreased and full penetration welds to the steel extrusions were required to address this concern. As with strip seals, the neoprene glands are subject to puncture or tearing, and any misalignment of the steel extrusions could subject the joint to snowplow damage or deterioration to the joint anchorages and surrounding concrete.

For compression seals, it is critical that the neoprene glad is properly sized for the joint opening. If the opening is too large, the seal will separate from the deck in cold weather and could fall out. If the opening is too small, the seal will be damaged by the compressive forces in hot weather. Additionally, if the opening is too small or if the seal is placed too close to the surface, it will be damaged by traffic in hot weather as it bulges due to compression.

Bolt-down-type joints have performed poorly over the years. Due to the repeated pounding from passing trucks or snowplows, it is not unusual for the anchor bolts to fail and entire sections of the elastomeric panels to come loose. Also, like other gland-type joints, punctures or tears are common problems.

Components of sliding plate joints are also subject to damage from snowplows. In addition, being steel components exposed to constant de-icing salts, pack rust can form and cause members to separate or protrude into traffic. This is also a concern for sidewalk cover plates.

1.3 JOINT MAINTENANCE AND REPAIR PROCEDURES

1.3.1 Clean Strip Seals and Gland-type Joints

General Considerations: Cleaning of strip seal and gland-type joints should coincide with deck cleaning activities at the end of winter operations. Work is most efficiently completed during cool but not freezing weather, when bridge elements are in a thermally contracted condition and joints are in an open configuration.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities. If joints are located over active traffic, provide traffic control for the roadway below.

2. Perform deck cleaning operations; remove large debris by hand or with a loader.
3. Clean joint glands by using high pressure water or oil-free compressed air. Sweeping and brushing may be used in conjunction with the high pressure water or compressed air. Care must be taken to avoid puncturing the gland with the high pressure water or compressed air.
4. Collect all debris with a shovel and loader bucket. To prevent clogging, do not dispose of sand, gravel, or road debris into joints or bridge scuppers.
5. If pressure washing is used for deck cleaning, during pressure washing operations, provide an observer below the joint to determine if the joint is leaking. If the joint shows signs of leakage, check the joint for punctures or tears and, if necessary, schedule follow-on maintenance to replace the joint gland (see Section 1.3.4).

1.3.2 Cut Out Portions of Loose Steel Sliding Plate Expansion Joints

General Considerations: The primary purpose of this repair is to trim or remove only those damaged sections that could snag on a snowplow or cause damage to vehicles. Sliding plate expansion joints usually consist of a fixed segment attached to an embedded angle with tap screws or by welds, or attached to a header plate by welds; the sliding plate typically slides over another embedded angle on the other side of the joint. Even if loose or damaged portions of the sliding plate need to be removed, there is a benefit to maintaining the portion of the sliding plate near the bridge gutter lines adjacent to barrier rails to allow road debris to flow over the sliding plate rather than through an open joint.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities. If joints are located over active traffic, provide traffic control for the roadway below.
2. Remove sections of slider plate assemblies with deteriorated anchorages or loose sections of sliding plate by cutting to length with a torch; remove tap screws or cut welds to remove the loose section of the sliding plate. Limit removal to only those sections that are damaged.
3. Clean and remove pack rust and grind smooth any remaining weld slag or sharp edges on the embedded plate.
4. Temporarily retrofit joint using the options shown in Figure 1.3.2 until the joint is replaced.
5. If the open joint is a low-movement joint (that is, a relatively short bridge with only minor thermal range of expansion) and if the bulkheads and/or steel armoring on each side of the joint are in good condition, consider sealing the joint using a properly sized foam backer rod and Dow-Corning 902RCS ultra-low modulus, 100% silicone rubber joint sealant, or equal. Clean contact surfaces thoroughly prior to application of silicone sealant to ensure optimum bond.

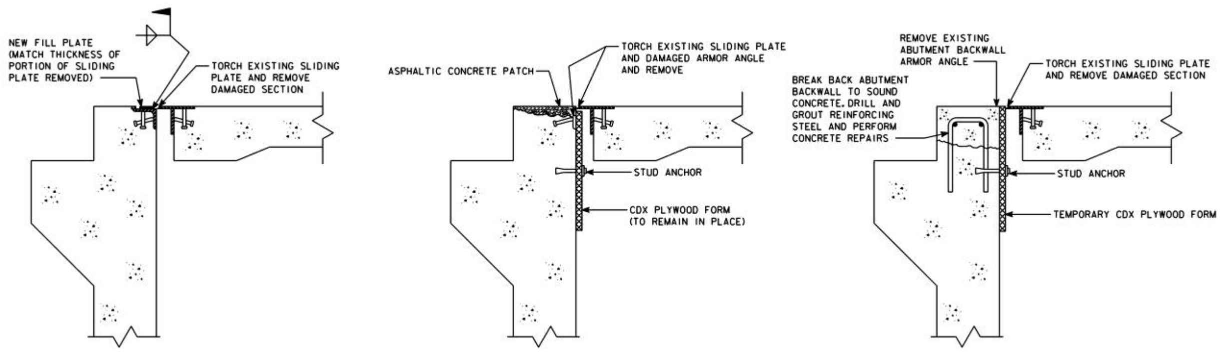


Figure 1.3.2. Steel Sliding Plate Retrofit Options

1.3.3 Replace Neoprene Compression Seals and Strip Seal Glands in Expansion Joints

General Considerations: Typically, compressions seals can be expected to last approximately 10 to 15 years after initial installation, and strip seals can be expected to last 15 to 20 years. Replacement should be scheduled during cool but not freezing weather, when bridge elements are in a thermally contracted condition or an open position. When determining replacement glands for joints, each joint opening should be measured so that an appropriately sized gland is ordered; this method is preferred to simply ordering the size specified on the as-built plans because the joint may not be expanding and contracting as anticipated. For strip seal joints, glands should be ordered from the appropriate joint manufacturer because the geometry of the lug cavities vary by manufacturer. The manufacturer should be consulted for more information, as needed.

Procedures – Replacement of Neoprene Compression Seal:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. Completely remove the existing compression seal.
3. If the existing joint does not include stop blocks or ledges at the base of the joint to provide a seat for the bottom of the compression seal gland, consider adding stop blocks or, if faces of joint bulkheads are concrete, saw cutting the concrete bulkheads to the depth of the compression seal to provide a bottom ledge. Replace corroded or deteriorated steel stop blocks.
4. Thoroughly clean edges of the joint by sandblasting. Vacuum clean as necessary.
5. Check the length of the replacement compression seal for fit; miter cut and glue mitered ends together for bends at curbs or raised medians.
6. Apply lubricant/adhesive to edges of the joint bulkhead; precompress the compression seal and install it while lubricant/adhesive is still wet.
7. Install the top of the compression seal to a depth of 0.5 to 0.75 inch below the top of the deck surface.

Procedures – Replacement of Strip Seal Glands:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.

2. Completely remove the existing strip seal gland. This is accomplished most easily by splitting the existing strip seal gland down the middle, initiating the removal at the curb, and upon removing the first few feet, tying a strap to the loosened section and pulling the gland away while maintaining an angle low to the surface of the deck.
3. Thoroughly clean the edges of the steel lug cavity using a 2-inch wire brush on a rotary grinder. Sandblast as needed using medium grit sand. Remove all old glue and gland material along the entire length.
4. Obtain a replacement gland from the original manufacturer of the strip seal. Check the replacement gland for proper length, including upturns at curbs or raised medians. The replacement gland shall be one piece from end to end of the steel extrusion and shall be installed with the V-groove fold of the gland pointing down.
5. Apply lubricant/adhesive to the replacement gland or to the lug cavity of steel extrusions. Do not over-apply lubricant/adhesive; less is better.
6. Fold the gland and, starting at the curb detail, push the gland into the opening, letting the lower lug fold out into the extrusion opening. Using the manufacturer's installation tool, have one worker, with a tool in each hand, roll the top of the gland's lugs into the lug cavities. After the lug is snapped in, have a second worker use a pry bar to wedge the lower part of the gland's lug into the lug cavity using the opposite steel extrusion rail as a fulcrum; this relaxes the lower lug and allows the gland to settle into the extrusion. Working from one side of the joint to the other in approximately 4 foot sections, install the new gland across the deck from curb to curb while lubricant/adhesive is still wet.

1.3.4 Replace CF Joint Material with Crumb Rubber Joint Material

General Considerations: Over time, joint filler for CF joints may deteriorate or begin to work its way out of the joint. Many of these joints were previously filled with foam board material and liquid sealant. Current policy is to replace the joint material with crumb rubber and top it with joint sealant material. The intent of the resulting joint is to provide a compressible but not necessarily watertight joint. Reference road design standard PV-101.

Procedures:

1. Remove old joint material. If old joint material consists of sections of foam board, usually the material can be easily removed by hooking onto it with a tine attached to a skid loader bucket and pulling the material free.
2. Clean out the joint and blow it free of debris with compressed air.
3. Coating of the sides and bottom of the joint with CRS2 oil emulsion or approved equal is optional, if it is felt this helps hold the crumb rubber in place.
4. Fill the joint with crumb rubber in one or two lifts, topping each layer with CRS2 or approved equal. Avoid compressing the crumb rubber during installation. The top of the crumb rubber and CRS2 or approved equal should be kept ¾ inch below the driving surface to prevent tracking of the material onto the deck.
5. If the topping is not kept ¾ inch below the driving surface, place a final layer of crumb rubber over the top to minimize the oil emulsion from tracking onto the roadway surface.

This joint is not intended to be water tight. It is intended to allow the proper expansion and contraction of the pavement and bridge by keeping uncompressible material out of the joint.

1.3.5 Repair Components of Modular Expansion Joints

General Considerations: Due to the variation in components from one manufacturer to another and the restricted accessibility of modular joint components due to their enclosure within support boxes, the original manufacturer should first be consulted prior to any attempts to repair or replace components of modular joints. Replacement parts should be obtained from the original manufacturer. The manufacturer should be consulted regarding repair of welds between steel extrusion rails and their support bars as welds are a function of the spacing of the support bars.

Procedures:

1. Obtain replacement parts from the original manufacturer and consult with the manufacturer regarding replacement procedures.
2. For replacing neoprene glands of modular joints, follow procedures similar to those described for replacement of strip seal glands in Section 1.3.3 of this manual. Modular joints incorporate positioning springs to maintain consistent gaps between adjacent steel rail extrusions; follow the manufacturer's procedures when varying the gap between rails for gland replacement.
3. If repairs include any repainting, mask any elements that are not to be painted, such as Teflon slide surfaces of support bar bearings.

CHAPTER 2
BRIDGE DECKS AND OVERLAYS

2.1 TYPES OF BRIDGE DECKS AND OVERLAYS

2.1.1 Concrete Bridge Decks

Concrete bridge decks in Iowa generally consist of one of the following systems:

- A full depth cast-in-place concrete bridge deck, usually 7 to 8 inches thick
- A two-course cast-in-place concrete bridge deck in which the lower course is a full depth structural slab, usually 7 to 8 inches thick, and the upper concrete wearing course is installed upon initial construction, usually 2 inches thick
- An original 7- to 8-inch-thick full depth cast-in-place concrete deck with a concrete overlay applied a number of years after the original deck construction.
- Precast concrete subpanels used as a stay-in-place form for a cast-in-place concrete topping with full depth cast-in-place concrete deck cantilevers
- A series of full depth, full bridge-width precast concrete panels that are post-tensioned together and topped with a concrete overlay

2.1.2 Steel Bridge Decks

Steel bridge decks used in Iowa are generally open grid steel deck systems, although steel grid decks with a concrete topping may also be found. Steel grid decks are typically used where a weight savings is desired to increase the overall load carrying capacity of the bridge.

2.1.3 Timber Bridge Decks

Timber deck systems are generally limited to local road system bridges. Timber decks generally consist of one of the following systems:

- Transverse timber planks spanning the width of the bridge between stringer lines.
- Transverse timber planks topped with longitudinally placed running boards in the wheel lines.
- A “Hollywood” timber deck consisting of a layer of transverse timber planks and a full width layer of longitudinally placed timber planks.
- A nail laminated timber deck where the timber planking is oriented on edge transversely across the deck width and planks are nailed to the adjacent planks. Nail laminated timber decks are typically used to span greater distances between longitudinal stringers or beams.

2.2 COMMON PROBLEMS AND CONSEQUENCES OF POOR MAINTENANCE

Being subjected to deicing salts and constant loading variation from the wheel loads of passing vehicles, bridge decks are subject to a number of environmental factors as well as variable loading conditions. Concrete bridge decks are subject to spalling, cracking, and potholes as salt-laden water penetrates through microcracks and pores in the concrete. The trapped moisture expands during freeze-thaw cycles, and the chloride ions attack the reinforcing steel in the concrete deck. Both of these actions work to expand the microcracking and lead to larger cracks, spalls, and potholes. Problems are most prominent where moistures ponds and accumulates adjacent to barrier rails, on the underside drip line of the bridge deck, and at natural depressions such as at bridge scuppers. Cyclic loading from wheel impact also attacks the edges of embedded angles of joints, causing stress-induced concrete cracking and deterioration at these joints. As concrete deck deterioration progresses and the deck weakens, map cracking and signs of leaching on the underside of the deck may become more prominent.

Steel grid decks are more flexible than concrete bridge decks, and deflection of these steel grid decks under load can lead to weld cracks where the deck is welded to steel stringers. If steel decks are mechanically fastened to their stringer supports, the fasteners can become loose over time as the steel grid panels distort and deflect. In addition, steel decks are subject to the same corrosive effects of salt-laden moisture from the deck.

Being a natural material, timber decks are subject to rot from varying moisture cycles as well as wear from the constant abrasion of wheel loads. As the moisture content of timber naturally decreases over time, the timber planks are more susceptible to checks, splitting, and cracking. In addition, being the most flexible of the three decking materials, timber decks are also subject to fasteners working loose, causing movement and distortion of the deck surface.

2.3 DECK MAINTENANCE AND REPAIR PROCEDURES

2.3.1 Clean and Wash Decks

General Considerations: For maximum effectiveness, deck cleaning activities should typically be performed shortly following the end of winter operations.

Procedures – Concrete Bridge Decks and Steel Grid Decks with Concrete Topping:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities. If road debris can fall on active traffic below the bridge, provide traffic control to the roadway below.
2. Remove large debris by hand or with a loader.
3. Clean the deck surface by mechanical sweeping, vacuum truck, or high pressure wash.
4. Collect all debris with a shovel and loader bucket; to prevent clogging, do not dispose of sand, gravel, or road debris into joints or bridge scuppers.

Procedures – Timber Decks:

1. For timber decks with gravel overlays, periodically clean the deck of excess gravel with a road grader to prevent excess buildup of gravel that can trap moisture and overload structural members.

2.3.2 Remove Delaminated Concrete from Bottoms of Bridge Decks

General Considerations: Delaminated concrete on the bottoms of bridge decks in areas over active vehicular traffic, active pedestrian traffic, navigable waterways, and railroads should be removed to prevent personal injury or property damage.

Procedures:

1. Provide traffic control in the work area below the bridge to prevent personal injury or property damage during concrete removal operations.
2. Remove large sections of delaminated concrete using a maximum 15-pound jack hammer.

3. Use hand tools to remove remaining loose or unsound concrete.
4. If falling concrete is a ongoing issue, install catch nets or, if working between interior beam lines, install temporary wood platforms between the bottom flanges of beams to catch loose concrete.

2.3.3 Seal Deck Cracks

General Considerations: Specific cracks in bridge decks may warrant sealing. The purpose of this type of crack sealing is to resist moisture penetration of the concrete element.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. Remove contaminants by high pressure water, oil-free compressed air, or vacuum. When using water to clean a crack, blow out the crack with oil-free compressed air and allow the area to dry naturally before applying a sealer.
3. Follow the sealer supplier's recommendations for application and curing.

2.3.4 Epoxy Inject Deck Overlays

General Considerations: Localized delaminations between the interfaces of a structural bridge deck and a concrete overlay can be addressed by epoxy injecting the interfaces between the concrete components to bond them together.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. Identify locations of overlay delaminations by means of a chain drag using a sweeping motion. Map and mark the approximate perimeter of the delaminated areas by sounding the surface of the delaminated areas with a hammer.
3. Identify areas with an apparent higher degree of delamination (areas with the most distinctive hollow sound) and mark these areas as injection port locations. Mark additional injection port locations at approximately 18-inch spacing for larger voided areas and at 8-inch to 12-inch spacing for smaller areas (less than 10 square feet).
4. Using a ½-inch vacuum concrete drill bit, hammer drill, and shop vacuum, drill each port location to a depth where the void is penetrated. In some cases, the depth of penetration may be apparent by a significant and immediate drop as the drill bit penetrates into the void and at other times the depth of penetration may require the user's judgment as the hammer drill tapping provides a more solid sound. Do not perform drilling operations when the concrete is wet or during rain in order to avoid clogging the vacuum bit. After drilling, use a 1/4-inch to 3/8-inch tube attached to a vacuum to remove the concrete fines.
5. At injection port locations, insert a tap that will accept the plastic tube from the epoxy mixing nozzle. Drive the tap into place using a hammer and a hollow steel pin that holds the tap.
6. Prepare epoxy injection equipment, including epoxy dispenser, epoxy mixer, air compressor and rubber hoses. Prior to beginning epoxy injection of the deck overlay, test equipment and mixing of epoxy by taking a sample of the mixed epoxy. Within 10-15 minutes of mixing, the epoxy sample should begin to heat up and harden.

7. Starting near the center of the delaminated area, place the 1/4-inch tubing that extends from the mixer over an injection port. Begin injection at a pressure of approximately 30 psi. Avoid pressures greater than 35 psi to prevent pop-outs of the deck delamination. Where the cycling rate of the dispenser is very slow or not progressing, check the back pressure at the injection port tap. A significant amount of back pressure would indicate a different port should be selected. Periodically have someone check the bottom of the deck to verify that epoxy is not exiting through a seam or fissure. If so, immediately cease pumping operations until the epoxy can set up and seal the crack.
8. Monitor the progress of the epoxy injection by hammer sounding the delaminated area and observing adjacent injection ports. Once it is determined a region of the delaminated area is nearing complete injection based on the cycling rate of the dispenser, the back pressure at the port, or both, stop epoxy flow by closing the control valve. Remove the injection hose and clamp the port using a ferrule. Repeat injection operations as subsequent injection ports.
9. Upon completion of the injection process, immediately clean all mixing and dispensing equipment and hoses. Remaining injection ports should be sheared off using a flat head shovel. Mix large epoxy spills with mason sand and then shovel from the deck. Sprinkle smaller spills with mason sand. Traffic can be allowed to travel on the deck immediately after completion of injection.

2.3.5 Patch Bridge Decks with Asphaltic Concrete

General Procedures: Patching bridge decks with asphaltic concrete (ACC) should be considered a temporary fix only to minimize further deck damage until weather conditions will allow permanent repairs with concrete. ACC patches are typically installed when adverse weather conditions preclude proper preparation of the repair area. ACC does not provide the structural capacity of concrete and should not be used as a permanent bridge deck patch material, nor should it be used for full depth deck patches.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. Broom pothole to remove loose material, and clean with oil-free compressed air.
3. Shovel cold patch ACC into the pothole, slightly overfilling the hole.
4. Allow active traffic to run over patch material to compress it into the pothole and flatten it.

2.3.6 Patch Bridge Decks with Concrete

General Considerations: Potholes and large spalls on the surface of the bridge deck should be permanently patched with concrete as weather conditions permit. Unattended potholes and spalls will trap additional moisture leading to further freeze-thaw damage and corrosion of reinforcing steel.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities. If the patch could extend full depth, provide traffic control for the roadway below.
2. Using a 2-inch-wide chisel-point jackhammer, remove unsound concrete and/or ACC patch material from the damaged area of the deck, extending the limits of the damaged area until sound concrete is encountered. Depth of removal shall be a minimum of 2 inches or to the minimum

depth recommended by the manufacturer of the concrete patch material. If unsound concrete extends below the top mat of reinforcing steel, remove unsound concrete to at least 0.75 inches below the top reinforcing steel.

3. Provide a 0.75-inch-deep vertical saw cut around the perimeter of the damaged area to square up the repair area and eliminate feathered edges. Jackhammer as needed to extend removals to the saw cut lines.
4. Clean corroded reinforcing steel. If needed, replace damaged reinforcing steel with new bars, and securely tie new reinforcing steel into place. Touch up exposed surfaces of epoxy coated reinforcing steel with an approved coating material.
5. Clean the repair area by sandblasting. Protect epoxy coated reinforcing from the cleaning process. Clean epoxy coated reinforcing with hand tools that will not damage the epoxy coating. Follow with an air blast of oil-free compressed air. Repair area may be damp, but there should be no standing water.
6. Fill the damaged area with a high-early strength concrete patch material from the approved products list. Maintain traffic control around the patched area until the concrete has cured in accordance with the manufacturer's recommendations.

2.3.7 Weld Loose Steel Decking to Steel Stringer Beams

General Considerations: The tight spacing of bearing bars for open grid steel decks makes access for welding difficult.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. Grind smooth remnants of previous welds and existing weld slag if access is available for grinding.
3. Weld loose steel decking to steel stringer beams using a certified welder and pre-approved welding procedures in accordance with the ANSI/AWS D1.1 Structural Welding Code.

2.3.8 Replace Timber Deck Planks

General Considerations: For timber bridge decks consisting of transverse and longitudinal courses of timber planking, replacement of damaged timber planks for the lower course of planks will first require removal of the upper course planks in conflict.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. For timber decks with a gravel overlay, remove the gravel overlay with a road grader or locally remove gravel at the damaged timber plank by sweeping.
3. Remove the damaged timber plank and all associated fasteners.
4. Trial fit a new plank and cut it to length. Provide a 0.25-inch gap between adjacent deck planks to allow for drainage, expansion, and air circulation.
5. Fasten the new plank to existing stringers.

CHAPTER 3
BRIDGE DRAINAGE SYSTEMS

3.1 TYPES OF BRIDGE DRAINAGE SYSTEMS

Bridge drainage systems consist of multiple components to remove rainwater and snowmelt runoff from the surface of the bridge deck. For short bridges where the quantity of runoff at the gutters remains small, no specific bridge drainage system may be needed. Runoff would simply flow over the joints at the ends of the bridge and would be captured either in storm drains along the roadway approaches or dispersed onto the shoulder areas of the approach roadway.

For longer bridges where the quantity of runoff could encroach into the driving lanes of the bridge, deck drains or scuppers would be placed strategically along the length of the bridge to intercept runoff at the gutter lines and drain it off the bridge. As shown in Figure 3.1, deck drains could consist of a steel tube that would penetrate through the deck and extend to a point below the bottom of the bridge beams, slots through the concrete barrier, or grated drains and scupper collection boxes with an attached steel drain tube that would extend below the bridge beams. In general, open drainage systems as described above are favored over a closed system due to the reduced potential for clogging. However, when conditions below the bridge dictate that drainage does not free-fall to the ground, a closed pipe system may be required to direct the drainage to ground level and thus prevent it from dropping on railroad tracks or roadways below the bridge.

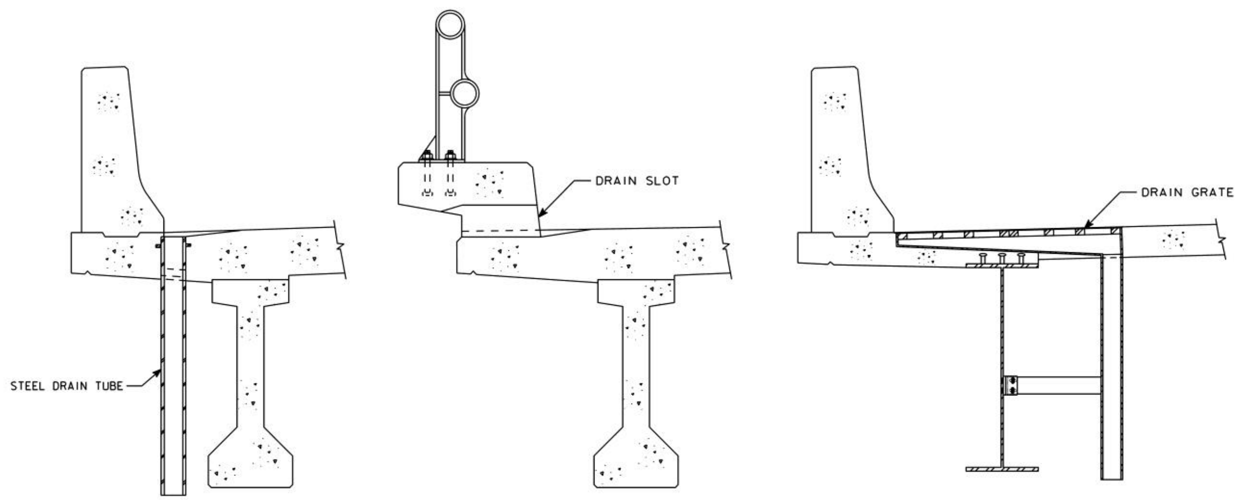


Figure 3.1. Examples of Bridge Deck Drains

Another component of the bridge drainage system might include drainage troughs under the open joints of a bridge. These troughs collect runoff that passes through the joints and directs it away from key bridge components under the joint, such as bridge bearings, the ends of bridge beams, end diaphragms, and beam seats. In addition, drainage that infiltrates through the approach embankment at the ends of the bridge is captured by subdrains behind the bridge abutments. With the runoff from these subdrains, the joint troughs, and drainage dropping to the ground from open drain pipes, it is important to protect the berm slopes of a bridge from erosion using rock revetment, Macadam stone, or concrete slope protection.

3.2 COMMON PROBLEMS AND CONSEQUENCES OF POOR MAINTENANCE

A common problem resulting from poor maintenance of bridge drainage systems is clogging of the drains. This can result in runoff encroaching into the driving lane and freezing or ponding. Failure of bridge drainage systems also causes runoff to be directed where it is not intended. As a result, bridge components could be exposed to corrosive deicing salts, thus leading to premature deterioration of those components. Also, if one drain is clogged, it could cause an adjacent drain to be overloaded, again causing runoff to be directed where it is not intended.

Clogging and deterioration of the bridge drainage system can be caused by corrosion, excessive build up of sand and gravel from winter operations, build up of animal nesting material, and road debris (for example, soda cans or bottles).

3.3 BRIDGE DRAINAGE SYSTEM MAINTENANCE AND REPAIR PROCEDURES

3.3.1 Unplug Deck Drains

General Considerations: Efforts to unplug deck drains should be scheduled annually at a minimum and should generally coincide with joint and deck cleaning activities at the end of normal winter operations.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. For bridge drains and scuppers with attached grates, remove the grate to provide access to the drain tube. Remove the drain tube clean-out plugs (if present).
3. Remove visual obstructions by hand or with appropriate hand tools. Clean out scupper boxes with a shovel. Do not dispose of debris in bridge drains or joints.
4. For inaccessible drain clogs, use high pressure water, compressed air, or a drain snake to clear obstructions.
5. Following removal of obstructions, flush the drain with water to ensure unimpeded flow.
6. Replace drain grates and clean-out plugs; thoroughly tighten attachment bolts or screws.
7. Clean sediment and/or debris from auxiliary bridge components, bridge bearings, and beam seats.

3.3.2 Repair Deck Drains and/or Add Extensions

General Considerations: Downspouts for deck drains, particularly drain pipes that incorporate bends in the downspout piping that are more prone to clogging, may rust out over time and require repair. In addition, if downspout piping does not currently extend below the bottom of the beam, deck runoff could be falling on the lower flange of the beam and causing deterioration of the beam. Finally, downspout piping may be concentrating runoff onto the berm slope in front of the abutment and causing erosion, thus requiring the runoff to be redirected.

Procedures – Damaged Deck Drain Downspout:

1. Remove the damaged portion of the deck drain downspout pipe by cutting it with a torch.
2. Grind the free ends of the downspout pipe to a planar section and remove all burs.

3. Couple in place a new section of steel drain pipe using flexible mechanical pipe couplers at each end (Dressler coupling or equal).
4. Alternatively, using double-walled corrugated polyvinyl chloride (PVC) pipe (which has a smooth wall on the inside), connect the remaining extensions of steel pipe to corrugated PVC pipe using pipe clamp bands.

Procedures – Drain Extension Addition:

1. Remove the existing steel drain pipe to within 6 to 8 inches of the bottom of the bridge deck.
2. Fit an oversized smooth-walled PVC pipe over the existing steel pipe extension, and attach the PVC pipe to the bottom of the bridge deck with L-brackets and stud anchors.
3. Alternatively, extend the drain pipe by attaching a section of double-walled corrugated PVC pipe (which has a smooth wall on the inside) of comparable diameter to the existing downspout pipe using pipe clamp bands.

3.3.3 Clean and Repair Expansion Joint Drainage Troughs

General Considerations: Efforts to clean and repair expansion joint drainage troughs should be scheduled to coincide with joint and deck cleaning activities at the end of normal winter operations.

Procedures:

1. If cleaning operations are staged from the top of the bridge deck, establish traffic control operations on the bridge to ensure worker safety during maintenance activities. If drainage troughs are located over active traffic, provide traffic control for the roadway below.
2. Flush expansion joint drainage troughs with a high volume of pressurized water to remove sand, gravel, and road sediment. Working from above the joint or from the end of the trough, progress from the high side of the trough to its low point. Maintain a water pressure that will not damage neoprene trough material but will provide adequate volume to flush debris from the trough.
3. For torn or damaged neoprene trough drapes, remove damaged sections of drape and replace them with new sections of neoprene drape.
4. Once the drainage trough is cleared, scoop or shovel sediment from the collection box. Snake the drainpipe from the collection box to the outlet to ensure free flow of drainage to the outlet point.
5. Clean accumulated sediment and/or debris from auxiliary bridge components, bridge bearings, and beam seats.

CHAPTER 4
BRIDGE RAILINGS

4.1 TYPES OF BRIDGE RAILS

A variety of barrier rail configurations are used on bridges throughout Iowa. Most new Iowa highway bridges designed for only vehicular traffic use the Iowa Department of Transportation's (Iowa DOT's) F-shape standard barrier rails, shown in Figure 4.1-1. The standard 34-inch-tall barrier rails meet National Cooperative Highway Research Program (NCHRP) Report 350 Test Level 4 (TL-4) requirements, and the standard 44-inch-tall barrier rails meet Test Level 5 (TL-5) requirements. If safety considerations require use of a TL-4 open railing, a 34-inch-tall concrete post and rail system is available that meets TL-4 requirements, shown in Figure 4.1-1.

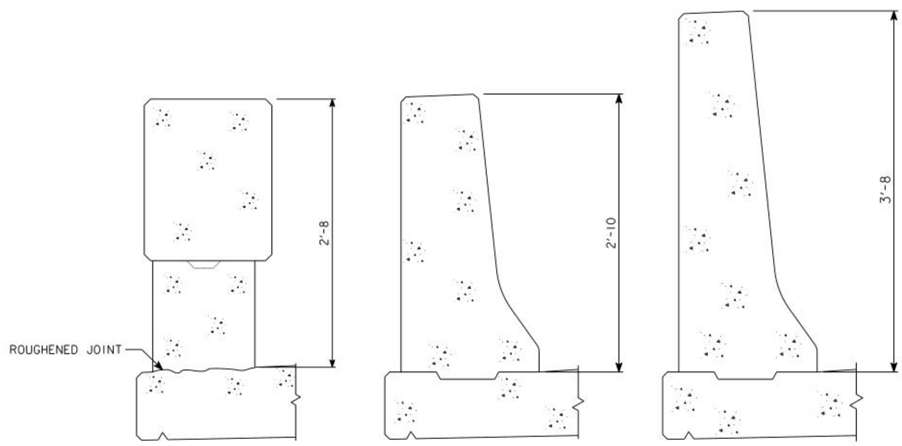


Figure 4.1-1. Open Rail TL-4 Barrier, F-Shaped TL-4 Barrier, and F-Shaped TL-5 Barrier

Many older bridges use a combination bridge rail system consisting of either a steel or aluminum rail bolted to a lower concrete parapet. The Iowa DOT Office of Bridges and Structures has had the policy of upgrading these existing barrier rails to a TL-4 standard as a part of repair, overlay, or paving projects. As a consequence, the metal rails are often removed and the lower concrete parapet is extended upward to meet the height and crash worthiness requirements of the TL-4 standard.

Bridges that incorporate a sidewalk or trail on the structure typically use a concrete separation barrier, shown in Figure 4.1-2, to separate the vehicular and pedestrian traffic. This separation barrier may include a steel handrail when accommodating bicycle traffic, and commonly, the outside edge of the sidewalk or trail uses a chain link fence to provide for fall protection from the elevated bridge surface. Some variation in these typical details may exist from bridge to bridge, particularly to accommodate aesthetic requirements of the structure.

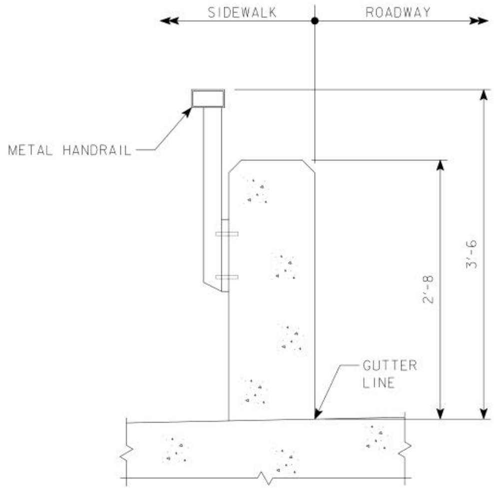


Figure 4.1-2. Separation Barrier

Local system bridges that were not designed for TL-4 or TL-5 requirements and that have not yet been retrofitted as part of a bridge repair project, could still be using simple steel or timber bridge rails that do not meet current crash worthiness standards.

4.2 COMMON PROBLEMS AND CONSEQUENCES OF POOR MAINTENANCE

The most common problem associated with poorly maintained bridge rails is impact damage from vehicular collision with the bridge rail. An outdated or damaged bridge rail may not be able to fulfill its primary purpose to confine errant vehicles and prevent the vehicles from leaving the elevated surface of the bridge deck.

Another common maintenance problem with bridge rails is the potential for corrosion damage from deck runoff. Because rainfall runoff and snow are often concentrated at the gutter lines against the bridge rails and because the bridge rails are constantly attacked by salt spray from passing vehicles, the moisture and salt environment can cause deterioration of the bridge rail, particularly reinforcing steel or steel anchor bolts that anchor the rail to the bridge deck.

4.3 BRIDGE RAILING MAINTENANCE AND REPAIR PROCEDURES

4.3.1 Seal Barrier Rails with Penetrating Sealer

General Considerations: New barrier rails or new sections of barrier rails should not be sealed within their initial 28-day concrete cure period because the sealer may prevent proper curing of the concrete.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. Remove loose barrier rail concrete by hand methods or sandblasting.
3. Clean all surfaces to be sealed with a light sandblast (brush blast) followed by oil-free compressed air to remove road film and contamination to the existing concrete. Ensure that the surface is dry before applying sealer.

4. Apply sealing material meeting the requirements of the Standard Specifications, Article 4139.01.B, to the tops and traffic sides of the barrier rail as well as to a section of the roadway surface of the bridge deck extending 1 foot into the roadway from the gutter line.

4.3.2 Patch Concrete Barrier Rails and Curbs

General Considerations: To minimize water intrusion and active deterioration of barrier rails, deteriorated areas of barrier rails and curbs should be repaired to maintain their structural integrity.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. Using a 2-inch-wide chisel-point jackhammer, remove unsound concrete from the damaged area of the barrier rail, extending the limits of the damaged area until sound concrete is encountered.
3. Using a chop saw, provide a 0.75-inch-deep saw cut around the perimeter of the damaged area to square up the repair area and eliminate feathered edges. Jackhammer as needed to extend removals to the saw cut lines. Limit jackhammer size to a nominal 30-pound class, and limit chipping hammer size to 15-pound class.
4. Clean or remove corroded reinforcing steel. If needed, replace damaged reinforcing steel with new bars and securely tie new reinforcing steel into place. Touch up exposed surfaces of epoxy coated reinforcing steel with an approved coating material.
5. Clean the repair area by sandblasting. Protect epoxy coated reinforcing from the cleaning process. Clean epoxy coated reinforcing with hand tools that will not damage the epoxy coating. Follow with an air blast of oil-free compressed air.
6. For shallow repairs (0.75 to 1.5 inches deep where no form work is used to support the patching material), first apply a bonding grout conforming to the Standard Specifications, Article 2426.02.B.1; ensure that the repair area is dry before placing grout. Concrete for shallow repairs shall conform with the Standard Specifications, Table 2426.02-1. Place concrete before the grout dries out.
7. For regular repairs (a minimum depth of 1.5 inches or 0.75 inch behind an unbonded reinforcing bar and where form work is used), no bonding grout is required. Use a Class O concrete mix for the repair concrete. Ensure that the existing concrete surface is dry before placing new concrete.
8. Apply a white pigmented curing compound to the concrete immediately following concrete finishing or immediately after removing forms. The application rate shall be 100 square feet per gallon.

4.3.3 Repair/Replace Aluminum or Steel Bridge Rail Damaged by Vehicular Impact

General Considerations: Aluminum or steel rail that has been damaged or loosened by impact may not be adequate to redirect an errant vehicle or prevent a vehicle from leaving the elevated bridge deck surface.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. Cut the damaged portion of the rail or remove anchor bolt nuts to allow removal of damaged sections of the metal rail.

3. Where rail post anchor bolts are bent, remove the post and add a temporary nut to the bent anchor bolts so that the anchor bolts can be straightened with a hammer without damaging the threads. Replace broken or damaged anchor bolts by drilling out the damaged anchor bolt and grouting in a new anchor bolt in accordance with the Standard Specifications, Article 2405.03.H.2.a.
4. Install a new section of metal rail and posts to replace damaged sections. Anchor post sections with anchor bolts.

4.3.4 Repair Concrete Barrier Rails Damaged by Vehicular Impact

General Consideration: Sections of concrete barrier rail that have experienced total failure or extensive cracking due to vehicular impact may require total replacement of the damaged section to reestablish crash worthiness of barrier rail system.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. Using a 2-inch-wide chisel bit, jackhammer and remove the damaged section of concrete barrier rail. Remove concrete back to sound concrete. Limit jackhammer size to a nominal 30-pound class, and limit chipping hammer size to 15-pound class.
3. Straighten and re-use existing reinforcing steel that is still intact.
4. Where vertical barrier rail reinforcing steel has been broken away at the barrier rail/deck interface, drill and grout new anchor reinforcing steel into the bridge deck. Use a polymer grout system in conformance with Materials I.M. 491.11. The depth of the grout hole shall be in accordance with the grout manufacturer's recommendations. Ensure that the depth of the hole does not result in punching through the bottom of the deck.
5. Replace damaged longitudinal reinforcing steel that cannot be incorporated in the repaired section. Provide adequate lap splice to the existing longitudinal reinforcing steel, or drill and grout new reinforcing steel into the existing barrier using hydraulic cement grout conforming with the requirements of Materials I.M. 491.13 or polymer grout conforming with Materials I.M. 491.11. Securely tie all reinforcing steel in place. Touch up damaged epoxy coating for reinforcing steel with an approved coating material.
6. Clean the concrete interface surface of the existing concrete barrier rail by sandblasting. Follow with an air blast of oil-free compressed air.
7. Form area of barrier rail to be replaced, and cast replacement section with Class C concrete mix. Construction joints shall be spaced at a minimum of 20 feet on centers. Construction joint contact surfaces shall be coated with an approved bond breaker material.
8. Apply a white pigmented curing compound to the concrete immediately following form removal. The application rate shall be 100 square feet per gallon.

CHAPTER 5
BRIDGE BEARINGS

5.1 TYPES OF BEARINGS

The common types of bearings used in Iowa include conventional fabricated rocker bearings or bolsters, shown in Figure 5.1-1; sliding metal plate bearings as shown in Figure 5.1-2; curved steel pintle plates sitting on either a steel masonry plate (fixed bearing) or a steel plate that rests on a laminated neoprene pad (expansion bearing), shown in Figure 5.1-3; plain neoprene bearing pads (under prestressed concrete beams at fixed piers); or disc bearings, shown in Figure 5.1-4, which are generally used for high load and/or multi-rotational applications.

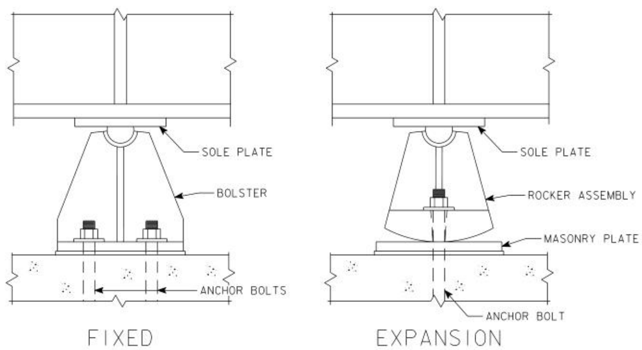


Figure 5.1-1. Fabricated Rocker Bearing or Bolster

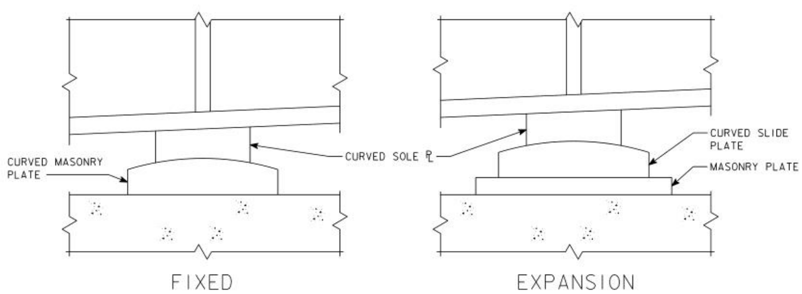


Figure 5.1-2. Metal Sliding Plate Bearings

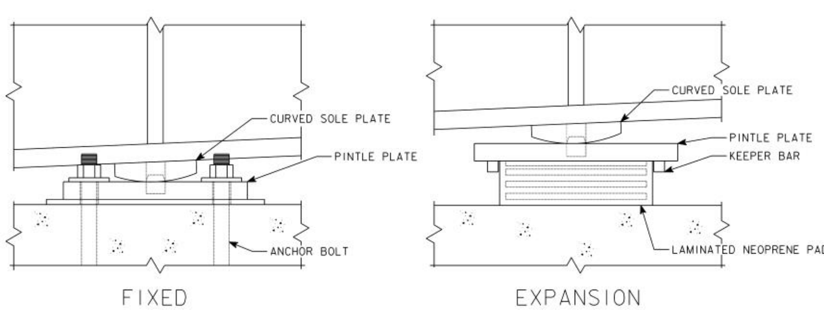


Figure 5.1-3. Steel Pintle Plate Bearings

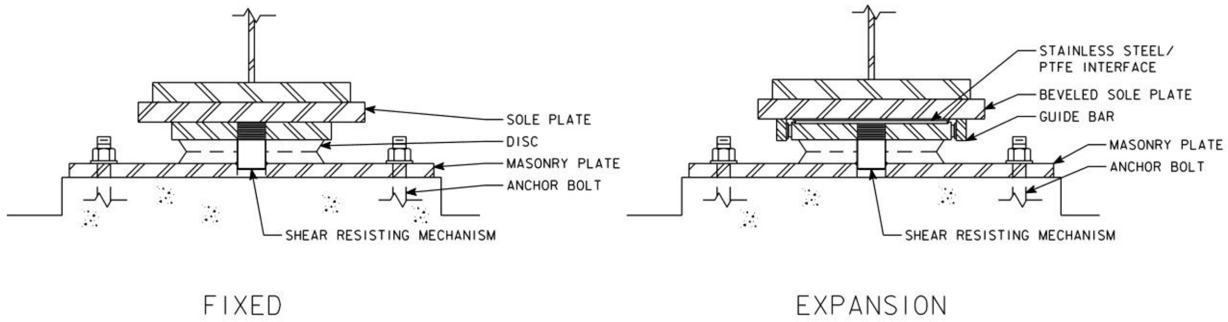


Figure 5.1-4. Disc Bearings

Although the above-mentioned bearing types are most common throughout Iowa, other types of bearings could be encountered, such as lubricated bronze plate bearings, pot bearings, or elastomeric pads (with or without Teflon sliding surfaces).

Other forms of bearing systems designed to accommodate thermal movement of the bridge are either a pin or a pin and hanger system for steel bridges or a mechanical hinge for concrete bridges. These members are integrated to the structural beams to allow differential movement and rotation.

5.2 COMMON PROBLEMS AND CONSEQUENCES OF POOR MAINTENANCE

Being located below the surface of the bridge deck, leaking deck joints often allow bridge deck runoff, deicing salts, grit, and road debris to come in contact with bridge bearings. Often, the sand and other road debris accumulates around the bearings, thus trapping moisture and subjecting the metal components of bearings to constant wetting and the resultant corrosive action of the salt-laden moisture. As bearings deteriorate and corrode, or as sliding surfaces become fouled, the bearings can lock up and no longer function properly to accommodate thermal movement and rotation under bridge loading conditions. As a result, structural members that do not see relief of thermal loads or that are restrained from rotation would be subjected to secondary stresses for which they are not designed, and member damage or failure can result.

Pins, pin and hanger systems, and hinges are also located under deck joints and are subjected to the same corrosive conditions when the joints leak. Corrosion can result in pack rust around the hanger links and, unattended, could cause failure of the link bars or failure of the connecting pins. Frictional wear on the pin can occur due to the bearing load of the link plates rubbing against the pins. Finally, if a pin and hanger assembly locks up due to corrosion, it can impart large torsional forces to the pin and may cause a crack in the pin. Pin and hanger members are often fracture critical members; therefore, failure of a member could result in collapse of the span or the bridge.

5.3 BRIDGE BEARING MAINTENANCE AND REPAIR PROCEDURES

5.3.1 Wash, Clean, and Seal/Paint Bearings

<u>General Considerations</u>: Although the best preventative maintenance to ensure proper function of bridge bearing components is to maintain watertight deck joint seals, maintaining joint integrity is an ongoing struggle. Because joints will inevitably fail, periodic washing and either painting or sealing of bridge bearings will also be required.

Procedures – Bearing Sealing:

1. Remove dirt and debris from bearings and bearing seats with hand tools.
2. Remove built-up pack rust by hammering, scraping with a putty knife, or sandblasting. Air blast with oil-free compressed air to remove grit and residue.
3. Coat steel bearing surfaces with a rust converter compound.
4. Coat and lubricate steel bearing components with a polymer encapsulant such as Bridge-Mate or an approved equal.

Procedures – Bearing Painting:

1. Remove dirt and debris from bearings and bearing seats with hand tools. Power wash to remove debris trapped in crevices of bearing components.
2. Mask non-metal bearing surfaces, such as laminated neoprene pads, elastomeric pads, or Teflon slide surfaces.
3. Sandblast steel bearing surfaces to remove rust and corrosion. Remove residual grit that could trap moisture, inhibit surface-to-surface sliding, or restrict rotation by vacuuming or by a brush blast of oil-free compressed air. Ensure that steel surfaces are clean and dry prior to painting.
4. Repaint steel bearing surfaces (except stainless steel sliding surfaces) with one coat of Rust-Oleum primer and one coat of Rust-Oleum final coat or approved equal primer and final coat.

5.3.2 Reset or Replace Bearings

General Considerations: Thermal movement of the bridge that exceeds the travel range of slide bearings or the rotational capacity of a rocker bearing could require the bearings to be reset. In addition, if corrosion and deterioration of a bridge bearing is excessive such that it is suspected that the bearing is no longer functional or can no longer adequately support the applied loads, replacement of the bearings may be warranted.

Resetting or replacing bearings usually requires removing dead and live load from the bearing in order to perform the repair operations. Therefore, temporarily closing the bridge, temporarily closing or restricting traffic near the members supported by the bearings, or providing for auxiliary shoring of the affected bridge members during the repair operations may be required. To prevent overstress to adjacent members, it may be necessary to jack all bearings uniformly at a common substructure (pier or abutment). A structural engineer should be consulted prior to any repair procedures that involve jacking operations.

Procedures:

1. Provide traffic control or auxiliary shoring of affected bridge members as required for bearing repair activities.
2. Position hydraulic jacks adjacent to existing bearings at jacking stiffener locations.
3. Measure girder temperature adjacent to the bearings to determine the required bearing adjustment for temperature effects.
4. If required, disconnect barrier sliding plates, expansion joints, or conduit that are continuous through joints at lifting point so as to prevent damage during jacking operations to these secondary components.
5. While simultaneously jacking adjacent beam lines at the same substructure support, lift all girders only as required to relieve load from bearings (a maximum of 0.5 inch).

6. Use lock-off nuts on jacks or blocking to support loads so that hydraulic pressure does not need to be maintained during bearing resetting/replacing operations.
7. For bearings to be reset, reposition bearings to provided adequate travel distance for expansion bearings and rotational capacity for rocker bearings. Bearing orientation should be set to correspond to the expected movement at the ambient temperature of the beams.
8. For bearings to be replaced, remove existing damaged bearings by cutting welds to sole plates and/or removing retainer nuts for anchor bolts. Clean existing steel surfaces of beams by sandblasting or grinding. Set new bearings into the proper orientation, taking into account adjustments required for the ambient temperature of the beams.
9. Slowly release hydraulic jacks to reload bearing components.
10. For new bearings, weld new sole plates to beams and attach and tighten anchor bolt nuts.
11. Clean and repaint previously painted surfaces of steel beams with one coat of Rust-Oleum primer and one coat of Rust-Oleum final coat or approved equal primer and final coat.

Note: This procedure is intended to be a guide for resetting bearings and is not intended to be an all-inclusive process for any bearing type.

CHAPTER 6
BRIDGE SUPERSTRUCTURES

6.1 COMMON PROBLEMS AND CONSEQUENCES OF POOR MAINTENANCE

Bridge superstructures are subject to damage or deterioration from a number of sources. These sources of damage and deterioration may include impact damage from vehicle collision or stream debris, environmental damage (for example, concrete deterioration, corrosion, rot, fire damage, or thermal stress), load-induced damage from overload conditions, or a combination of these factors.

As primary load-carrying members of a bridge, poorly maintained and inadequately repaired bridge superstructures result in, at least, a reduced service life for the bridge and, at worst, possible failure or collapse of the bridge. Additionally, deferring maintenance on bridge superstructures often leads to the need for more severe repairs later, which are generally more costly and translate into longer, more involved repair delays to the traveling public.

6.1.1 Reinforced Concrete and Prestressed Concrete Beams

A common type of damage to reinforced concrete or pretressed concrete beam superstructures is impact damage from vehicle collision. Prestressed concrete beam bridges are frequently used for highway and railroad overpass structures, and impact damage from overheight vehicles is a common occurrence. As a result, repair procedures are outlined in Section 6.2, below, for dealing with concrete spalls and cracks resulting from vehicle strikes.

Another common source of damage for reinforced concrete beam and prestressed concrete beam bridges is damage to the ends of beams from leaking bridge joints. As salt-laden bridge runoff is deposited on the ends of these beams, the concrete is subjected to moisture penetration and constant freeze-thaw deterioration. As the moisture penetrates through the concrete cover, steel reinforcing bars and pretressing strands begin to corrode. As they corrode, steel reinforcing bars and pretressing strands increase in volume and cause bursting of the concrete cover, thus accelerating the rate of deterioration of these types of beams.

6.1.2 Steel Girder or Rolled Steel Beam

Like concrete beams, steel beams are also subject to impact damage. Although somewhat more robust to impact damage, bent and damaged steel members are subject to stress concentrations that could adversely affect the performance of the steel beam.

Another form of deterioration for steel beams is fatigue cracking from the cyclic application of live loads. Fatigue cracking occurs in zones of steel girders that are subject to variable tensile stresses or reversal of stresses from compression to tension. For a steel girder, the most common sign of fatigue failure is the initiation of a fatigue crack in a tensile zone of the girder. Left unattended, a fatigue crack can continue to propagate and ultimately can lead to total member failure.

Steel bridge superstructures are also subject to the corrosive action of salt-laden bridge runoff. The chlorides in bridge runoff create a cathodic reaction with exposed steel, which promotes rust and, ultimately, loss of section of the steel member. Once the protective coating for a steel member (paint) fails, corrosion can begin and accelerates at an ever-increasing rate.

6.1.3 Timber Stringer

The primary sources of damage to timber superstructures are environmental damage as the superstructure members age. Being an organic material, timber stringers are subject to rot if exposed to a constantly wet or moist environment. Conversely, if not exposed to regular moisture, timber tends to dry out over its service life, thus making the wood fibers less pliable, less flexible, and subject to shrinkage and splitting.

As timber superstructures weaken over their service life, they are also more susceptible to overstress caused by overload conditions. A split or check in a timber stringer caused by the member drying out over time can be the source of a full-depth crack if the structure should be subjected to a large vehicle load. That member may have been able to sustain the vehicle load in its original condition, but the change in the member over time would leave it in a weakened state.

6.2 BRIDGE SUPERSTRUCTURE MAINTENANCE AND REPAIR PROCEDURES

6.2.1 Periodically Wash Down Structural Elements (Prior to Biennial Bridge Inspections)

General Considerations: A number of major bridges, particularly some of the newer Missouri River and Mississippi River crossings, have been constructed with static wash down piping systems. These systems are equipped with quick-connect couplings for connection to a pumper truck so that the pipe system can be charged and maintenance crews can wash down structural elements while working from a snooper truck, maintenance catwalk, or the tops of bridge piers. Maintenance crews should consult the operations and maintenance manuals for these wash down systems for proper procedures regarding their use, particularly draining of the system to prevent freeze damage.

For other bridges not equipped with wash down systems, an independent water pumping truck or portable high pressure washing system shall be used to remove debris, bird nesting material, bird feces, and other foreign material from bridge components. Washing operations should be scheduled after the completion of winter operations (to prevent freezing) and prior to biennial bridge inspections.

Procedures:

1. Confirm that all environmental permits are in place, including permits affecting migratory birds. Make note of any restrictions for removing active nests.
2. Provide traffic control to protect washing equipment and maintenance personnel during washing operations. If working over active traffic, provide traffic control to the roadway below.
3. Because pressurized water alone may not be sufficient to adequately clean bridge members, precede washing operations by physically removing nesting materials and buildup of road debris.
4. Using pressurized water, shovels, brooms, and other hand tools, remove buildup of road debris, bird nesting material, and bird feces from structural members. Where possible, work away from structural joints to avoid trapping debris at joints. Water pressure should be limited to 1000 psi when washing painted surfaces.
5. Through cleaning operations, leave key welds and structural members free of debris that might hinder inspection operations.
6. Following washing operations, confirm that all washed members are freely draining and do not trap water.

6.2.2 Seal Prestressed Concrete Beam Ends

General Considerations: Typically, sealing of prestressed concrete beam ends is performed to help prevent damage to beam ends from bridge deck runoff through leaking deck joints. However, deck joints should be repaired as part of these operations to eliminate the source of damage.

Procedures:

1. Remove unsound concrete at beam ends by hand methods or sandblasting. Take care to avoid excessive concrete removal in strand anchor zones of prestressed concrete beams. Extensive concrete removal in the anchor zones of prestressed strands could result in loss of bond strength to the prestressing strands.
2. Coat exposed steel surfaces of prestressing strands with a rust converter compound.
3. Coat exposed portions of steel prestressing strands with a polymer encapsulant such as Bridge-Mate or an approved equal.
4. As an additional option, lightly sandblast (brush blast) the end 5 feet of prestressed beams followed by air cleaning with oil-free compressed air to remove surface contaminants. Apply sealing material meeting the requirements of the Standard Specifications, Article 4139.01.B to the end 5 feet of the concrete beams.

6.2.3 Epoxy Inject Concrete Beams Damaged by Vehicular Impact

General Considerations: Often, prestressed beams that have sustained damaged due to vehicular impact may show evidence of cracking above the impact point. The crack(s) typically start along the top flange, where the beam is restrained from movement by the bridge deck, and arc downward on either side of the impact point. If damage to the bottom flange is not too severe, the beam may be able to perform functionally with the assistance of epoxy injection of the cracks and some patching at the point of impact. Patching of the spalled concrete at the impact location can be performed using one of the methods described in Section 6.2.4 of this manual.

Procedures:

1. Establish traffic control operations on the bridge and on the road below the bridge to ensure worker and vehicle safety during maintenance activities.
2. Locate the cracks that are to be injected and surface seal them with a Hi Mod gel to contain the epoxy during injection. Cracks that measure less than 0.001 inch may be too small to inject, but should be surface sealed with Hi Mod gel.
3. Use a vacuum drilling system to set the injection ports. Glue the ports in place with a Hi Mod gel. The spacing of the ports should not be more than the thickness of the element being injected.
4. Inject from the lowest to the highest point of a vertical crack. For other cracks, inject progressively from one end to the other. Epoxy should penetrate and come out of adjacent open ports.
5. Careful monitoring of the machine for injection flow is necessary to prevent the machine from setting up with cured epoxy. Discarding epoxy from time to time from the hose will extend the epoxy cure time, especially on a slow port.
6. Injection pressures will typically be higher than what is used for a deck injection.

7. Cap the injection ports or crimp the crimp rings to seal the ports when finished. The ports do not need to be cut flush with the concrete surface unless a Fiber Reinforced Polymer (FRP) wrap is being installed over the damaged area.

6.2.4 Repair Concrete Beams Damaged by Vehicular Impact

General Considerations: Due to their high tensile strength, Fiber Reinforced Polymer (FRP) strips can be externally bonded to concrete to increase the flexural capacity of concrete beams and slabs. Although more expensive, FRP strips with carbon fibers are preferred for strengthening concrete elements. FRP is much lighter than steel or concrete and is inert to corrosion. Typically, FRP strips are bonded to the bottom of the beam or slab in positive moment zones. Prior to the repair, a structural engineer shall determine the width, length, thickness, location, and the number of strips to be bonded so that the mode of failure remains as a tensile failure under overload rather than a compression failure.

Procedures – Repairs with FRP Wrap:

1. Refer to Developmental Specification DS-12023 for detailed requirements of FRP repair for damage pretensioned prestressed concrete beams.
2. Establish traffic control operations on the bridge and on the road below the bridge to ensure worker and vehicle safety during maintenance activities.
3. Thoroughly inspect the concrete substrate and remove and repair unsound concrete. Inject cracks and fill surface defects with an epoxy resin. Ensure that the resulting surface is clean and dry.
4. Using gloves, masks, and goggles, cut the FRP strip to size using heavy duty shears.
5. Prime the concrete surface with an epoxy resin using a spatula for a width approximately 0.5 inch wider than the FRP strip.
6. Coat the face of the FRP strip to be bonded to the concrete with the same epoxy resin as used to prime the concrete substrate.
7. After preparation of concrete substrate and FRP strip, place the strip on the concrete and use a rubber roller and pressure to embed the FRP strip into the resin base.
8. Allow FRP repair to stand for 24 hours without disturbance.
9. After FRP has properly cured, the FRP must be coated with an approved paint to prevent degradation and deterioration of the FRP from exposure to ultraviolet light.

Procedures – Repairs without FRP Wrap:

1. Establish traffic control operations on the bridge and on the road below the bridge to ensure worker and vehicle safety during maintenance activities.
2. Remove loose/hollow concrete from damaged area.
3. If the spall is shallow (less than 1 or 2 inches deep), pre-grout the location with Rhenderoch HBA mortar or approved equal. While grout is still wet, mix a portion of the mortar to a consistency needed to trowel onto the spalled area.
4. If the spall is greater than 2 inches deep, forming of the patched area will be necessary.
5. Fit up the forms to the desired area. Do not attach forms at this time.

6. Pre-grout the patch area as in Step 3. While keeping the grout wet, install the forms coated in bond breaker over the patch area. Stud anchor the forms in place with ¼ inch stud anchors, being careful not to damage the prestressing strands.
7. Mix a batch of Rhenderoch HBA mortar or approved equal and pack the form full, taking care to complete the filling of the form before pre-grout is dry.
8. Remove the form work after the grout has cured. Remove the exposed portion of the stud anchors with a disk grinder and drive the remaining portion of the stud into the beam. Grout the holes left by the stud anchors.
9. Use a grout mix to even out the patch area and blend the edges of the patch into the original girder.

6.2.5 Grind and Smooth Steel Member Nicks and Gouges

General Considerations: Impacted steel beams are often bent or gouged in the flange at the point of impact. These impact locations are often located in the bottom flange of the steel beams in the positive moment areas, which is normally a high tensile zone. The resulting damage can cause stress risers in these tension zones. An engineer should be consulted before performing any maintenance on damaged steel members.

Procedures:

1. Establish traffic control operations on the bridge and on the road below the bridge to ensure worker and vehicle safety during maintenance activities.
2. Grind out nicks and gouges to remove the stress risers. Remove indentations using a 10:1 transition. Work the grinder longitudinally along the girder in the direction of the stresses.
3. For flange or web members that are torn and require a splice repair, a structural engineer shall provide a splice design to replace the capacity of the portion of the damaged flange or web. This could consist of bolted angles and spacer plates. Provide predrilled splice members for the repair. Prepare the faying surfaces as directed by the engineer. Clamp the splice material into place and use the predrilled holes as templates to prepare and drill the beam web and flange for the bolted splice member. Bolt the splice members in place using high strength bolts.
4. After the repair is completed, paint the repaired area with one coat of Rust-Oleum primer and one coat of Rust-Oleum final coat or approved equal primer and final coat.

6.2.6 Replace/Tighten Loose or Missing Bolts in Superstructure

General Considerations: The Standard Specifications, Article 2408.03.S.5.d.1, does not allow reuse of high strength bolts and nuts. Bolted connections should be made with new high strength bolts, nuts, and washers meeting the requirements of the Standard Specifications, Article 4153.06.

Procedures:

1. Remove and discard the existing loose bolt, nut, and washer.
2. For painted applications, if necessary, clean and prime the faying surfaces with zinc silicate paint. For unpainted applications, blast clean the faying surfaces to remove mill scale; faying surfaces shall be free from paint, lacquer, dirt, burrs, pits, or other defects that would prevent solid seating of parts or would interfere with development of the friction between parts.

3. Provide a hardened washer under the turned part. Tighten the high strength fastener using the turn-of-nut method as described in the Standard Specifications, Article 2408.03.S.5.b.
4. For painted applications, remove lubricating oil from the fastener with solvent and coat the installed fastener with one coat of Rust-Oleum primer and one coat of Rust-Oleum final coat or approved equal primer and final coat.

6.2.7 Loosen Diaphragm Bolts as Retrofit to Out-of-Plane Bending Cracks in Girder Web

General Considerations: For steel girder bridges subject to frequent and heavy truck loads, fatigue cracks may form at the welded connection between a transverse diaphragm connection stiffener and the web of the steel girder due to out-of-plane bending and the rigidity of the diaphragm connection. A structural engineer may recommend loosening of select diaphragm connection bolts to remove some of the rigidity of the connection and help prevent fatigue crack formation in tension zones, as shown in Figures 6.2.7-1 through 6.2.7-3.

Note: For horizontally curved steel girder bridges, the diaphragm members are considered as primary load carrying members and are critical components for load distribution. Diaphragm bolts for diaphragms of horizontally curved steel girder bridges should NOT be loosened.

Procedures (diaphragms and cross frames for straight steel girder bridges):

1. Loosen the specified high strength fastener(s) with an impact wrench. Bolts need to be loosened only until the bond between connecting parts is broken.
2. Hand tighten the loosened fastener.
3. Precautions must be taken to prevent the loose nuts and bolts from falling off the bridge. Precautions could include, but are not limited to, the following:
    a. Determining that the paint coating on the threads of the bolts will keep nuts from coming off.
    b. Providing double nuts tightened against each other if adequate bolt thread length is available.
    c. Using a liquid mechanical thread-locking material such as Loctite if adequate bolt thread length is available.
    d. Tack welding nuts and bolts together.
    e. Intentionally damaging the threads of the bolt with a chisel.

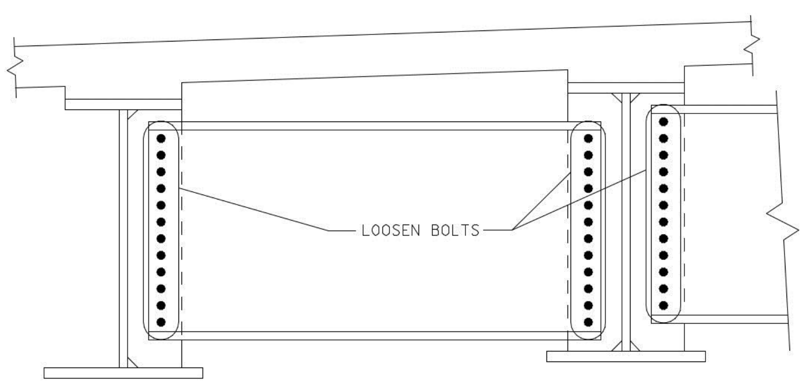


Figure 6.2.7-1. Loosening Bolts for Bent Plate or Channel Type Diaphragms

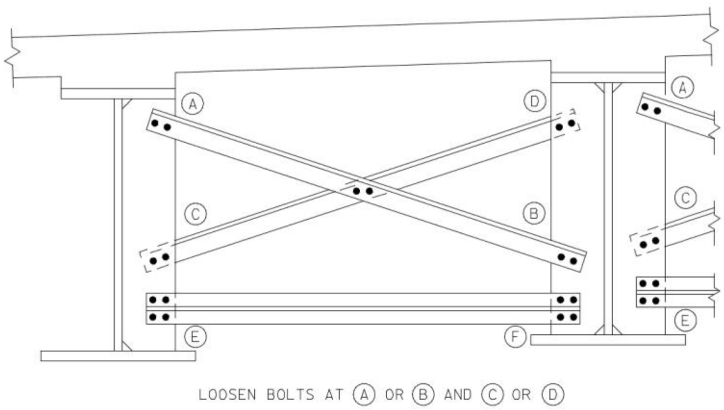


Figure 6.2.7-2. Loosening Bolts for X-Braced Cross Frame

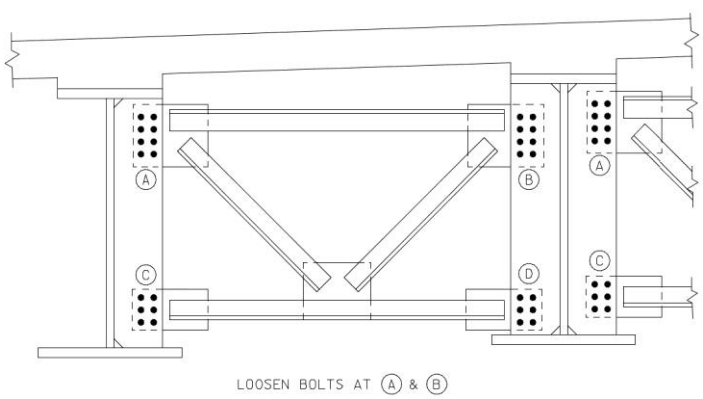


Figure 6.2.7-3. Loosening Bolts for K-Braced Cross Frame

6.2.8 Repair or Strengthen Steel Members on Bridges

General Considerations: Specific repairs or retrofit strengthening of steel members shall be designed by a structural engineer. However, depending on the severity of the repairs, the work may be accomplished by local bridge repair crews. All repairs or retrofit shall use the material and procedures specified by the structural engineer.

Procedures:

1. Conduct all repairs in accordance with the design provided by the structural engineer.
2. Use good workmanship, including grinding burrs from drilled holes for bolted connections with an emery wheel grinder or flapper wheel, using a certified welder and approved welding procedures, and providing one coat of Rust-Oleum primer and one coat of Rust-Oleum final coat or an approved primer and final coat to all damaged paint surfaces.

6.2.9 Drill 1-inch Crack Arresting Holes at Ends of Cracks in Steel Members

General Considerations: Often, the end of a fatigue crack cannot be determined by simple visual inspection. It is important to use a non-destructive test method such as magnetic particle testing to establish the end point of a fatigue crack to determine the appropriate location to initiate drilling for a crack arresting hole. An engineer should be consulted before performing any maintenance on cracked steel members.

Procedures:

1. Use magnetic particle testing to locate the end of the fatigue crack. If the crack is visible from both sides, determine the end point of the crack on the side where the crack has propagated the furthest.
2. Position the center of the drill hole beyond the visible extremity of the crack so that the edge of the hole coincides with the visible end of the crack. A 1-inch diameter hole should be used if a bolt will not be installed in the hole.
3. Drill the hole with its axis perpendicular to the surface of the steel member; remove burrs with an emery wheel grinder or flapper wheel.
4. At the bridge owner's discretion, drill a 15/16 inch diameter hole and install a ⅞-inch-high strength fastener into the hole with a hardened washer under the tightened element and a high strength nut. Tighten the fastener using the turn-of-nut method in accordance with the Standard Specifications, Article 2408.03.S.5.b to induce compressive stresses into the metal surrounding the hole.
5. For painted applications where a fastener is installed in the hole, remove lubricating oil from the fastener with a solvent, and coat the installed fastener with one coat of Rust-Oleum primer and one coat of Rust-Oleum final coat or approved equal primer and final coat.
6. For painted applications where a fastener is not installed in the hole, paint the area of the hole, including the interior of the hole, with one coat of Rust-Oleum primer and one coat of Rust-Oleum final coat or approved equal primer and final coat.

6.2.10 Core Large Diameter Holes to Retrofit Fatigue Crack Prone Locations

General Considerations: Another common retrofit for fatigue cracks is to core a 2- to 4-inch-diameter hole at the location of the crack to both encompass the tip of the crack as well as to help relieve the restraint at the detail that may be contributing to the crack formation (See Figures 6.2.10-1, 6.2.10-2 and 6.2.10-3). An example of this application is at the weld termination of a transverse diaphragm stiffener in the tension zone of a steel girder. Typically, the problem detail involves a situation where the stiffener is not connected to the tension flange of the girder, as is currently required by design codes. As the diaphragm induces load to the stiffener, the end of the stiffener attempts to bend the girder web in its weak axis, and a crack may initiate in the girder web at the end of the web-to-stiffener weld or along the web-to-tension-flange weld. Do not use this retrofit detail if the hole will not encompass the end of the crack.

Procedures – Fatigue Crack Retrofit at Diaphragm Connection Stiffener:

1. Use magnetic particle testing to locate the end of the fatigue crack.
2. Using a plug from a previous hole as a guide, locate the intended position of the 3- to 4-inch-diameter core hole in the girder web to encompass the end of the crack and encroach into the web-to-stiffener weld and the web-to-tension flange weld by ⅛ inch.

3. Use a guide plug to center punch the hole, thus providing a guide point to drill the relief hole. Use a guide plug to secure the drilling apparatus during the drilling operation.
4. Drill a pilot hole at the location of the center punch. Attach the guide plug to the girder.
5. Core the 3- to 4-inch-diameter relief holes in the girder web. Regardless of whether there is an existing fatigue crack on both sides of the stiffener, core holes shall always be drilled on both sides of the stiffener to prevent potential propagation of the crack on either side. If the location is such that the core cannot be recovered, remove the guide plug after cutting to mid-depth of the web plate before completing the cutting of the core so the guide plug is not lost with the core.
6. Remove all burrs and sharp edges along the perimeter of the hole with an emery wheel grinder or flapper wheel.
7. Grind the inside perimeter of the hole to a recommended ANSI 250 finish.
8. Provide one coat of Rust-Oleum primer and one coat of Rust-Oleum final coat or an approved primer and final coat to all damaged paint surfaces.

Figure 6.2.10-1. Diaphragm Connection Stiffener Fatigue Crack Retrofit

<u>Procedures – Fatigue Crack Retrofit at Lateral Bracing Gusset Plate</u>:

1. Use magnetic particle testing to locate the end of the fatigue crack.
2. Using a plug from a previous hole as a guide, locate the intended position of the 3-inch-diameter core hole in the lateral bracing gusset plate to encompass the end of the crack. Edges of the core hole shall be flush with the edge of the girder web and the intermediate stiffener (or floorbeam connection plate).
3. Use a guide plug to center punch the hole, thus providing a guide point to drill the relief hole. Use a guide plug to secure the drilling apparatus during the drilling operation.

4. Drill a pilot hole at the location of the center punch. Attach the guide plug to the gusset plate.
5. Core the 3-inch-diameter relief holes in the lateral bracing gusset plate. Regardless of whether there is an existing fatigue crack on both sides of the stiffener, core holes shall always be drilled on both sides of the stiffener to prevent potential propagation of the crack on either side. If the location is such that the core cannot be recovered, remove the guide plug after cutting to mid-depth of the gusset plate before completing the cutting of the core so the guide plug is not lost with the core.
6. Remove material between the core hole and the corner junction of stiffener to web by grinding.
7. Grind smooth the transitions at all four weld terminations.
8. Remove all burrs and sharp edges along the perimeter of the hole with an emery wheel grinder or flapper wheel.
9. Grind the inside perimeter of the hole to a recommended ANSI 250 finish.
10. Provide one coat of Rust-Oleum primer and one coat of Rust-Oleum final coat or an approved primer and final coat to all damaged paint surfaces.

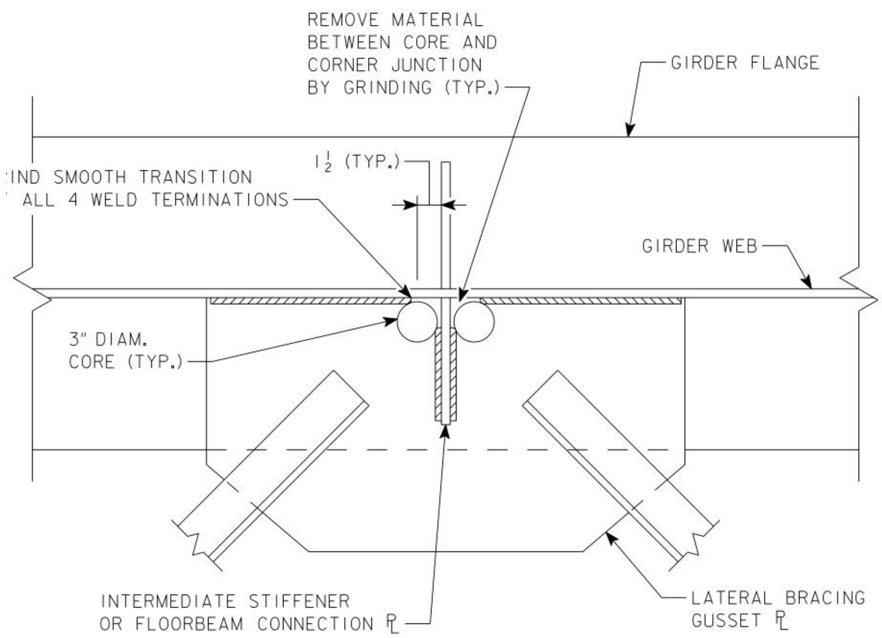


Figure 6.2.10-2. Lateral Bracing Gusset Plate Fatigue Crack Retrofit

<u>Procedures – Fatigue Crack Retrofit at Bearing Stiffener</u>:

1. Use magnetic particle testing to locate the ends of the fatigue crack.
2. Using a plug from a previous hole as a guide, locate the intended position of the 2- to 3-inch-diameter core holes in the girder web plate to encompass the ends of the crack and encroach into the bearing stiffener-to-web welds and the top flange-to-web weld by approximately ⅛ inch.
3. Use a guide plug to center punch the holes, thus providing a guide point to drill the relief holes. Use a guide plug to secure the drilling apparatus during the drilling operation.
4. Drill pilot holes at the locations of the center punch. Attach the guide plug to the girder.

5. Core 2- to 3-inch-diameter relief holes in the girder web adjacent to the bearing stiffener. Regardless of whether there is an existing fatigue crack on both sides of the stiffener, core holes shall always be drilled on both sides of the stiffener to prevent potential propagation of the crack on either side. If the location is such that the core cannot be recovered, remove the guide plug after cutting to mid-depth of the web plate before completing the cutting of the core so the guide plug is not lost with the core.
6. Remove all burrs and sharp edges along the perimeters of the holes with an emery wheel grinder or flapper wheel.
7. Grind the inside perimeters of the holes to a recommended ANSI 250 finish.
8. Provide one coat of Rust-Oleum primer and one coat of Rust-Oleum final coat or an approved primer and final coat to all damaged paint surfaces.

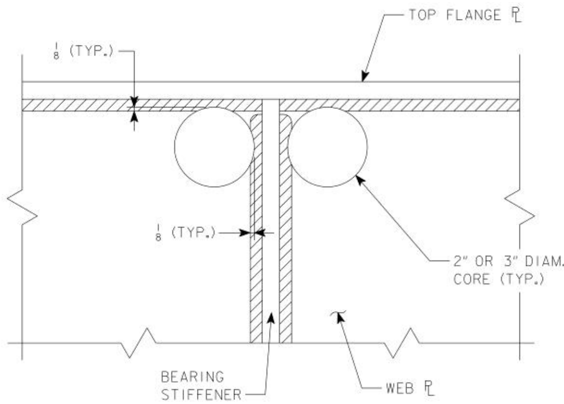


Figure 6.2.10-3. Bearing Stiffener Fatigue Crack Retrofit

<u>Procedures – Retrofit where Gap between Bearing Stiffener and Web-to-flange Weld is < ¼ inch</u>

This retrofit is recommended due to the effects of tri-axial -constraint. Tri-axial constraint is a condition where a steel element is so constrained, the steel will not yield before it fractures. When the welds at a bearing stiffener are within ¼ inch of each other, it is felt that this will cause tri-axial constraint in the girder web.

1. Using a plug from a previous hole as a guide, locate the intended position of the 2- to 3-inch-diameter core holes in the girder web plate to encroach into the stiffener-to-web welds and the top flange-to-web weld by approximately ⅛ inch.
2. Use a guide plug to center punch the holes, thus providing a guide point to drill the relief holes. Use a guide plug to secure the drilling apparatus during the drilling operation.
3. Drill pilot holes at the locations of the center punch. Attach the guide plug to the girder.
4. Core 2- to 3-inch-diamter relief holes in the girder web adjacent to the bearing stiffener. Core holes shall always be drilled on both sides of the stiffener to prevent potential propagation of a crack on either side. If the location is such that the core cannot be recovered, remove the guide plug after cutting to mid-depth of the web plate before completing the cutting of the core so the guide plug is not lost with the core.

5. Remove all burrs and sharp edges along the perimeters of the holes with an emery wheel grinder or flapper wheel.

6. Grind the inside perimeters of the holes to a recommended ANSI 250 finish.

7. Provide one coat of Rust-Oleum primer and one coat of Rust-Oleum final coat or an approved primer and final coat to all damaged paint surfaces.

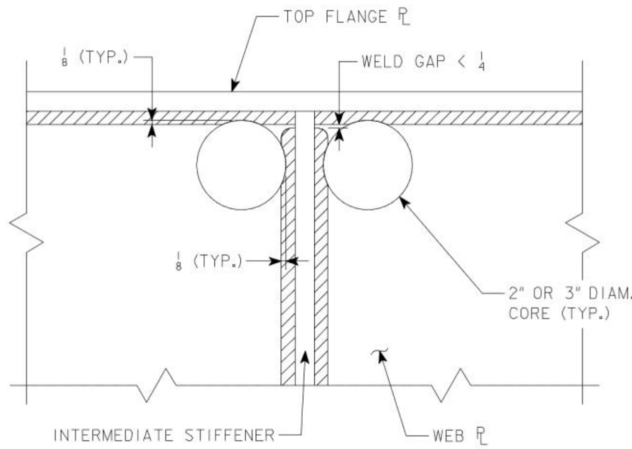


Figure 6.2.10-4. Retrofit where Gap between Bearing Stiffener Weld and Web-to-flange Weld is < ¼ inch

6.2.11 Repair Timber Stringer

General Considerations: Fully cracked timber stringers with cracks extending all the way to the extreme tension fibers of the stringer should not be repaired. Repair procedures should only be used on splits or checks that do not extend to the tension fibers of the stringer. The repair involves installation of a series of plates to the top and bottom of the stringer along the length of the crack and draw-up bolts placed on both sides of the stringer that can be tightened between the top and bottom plates to compress and close the split or check in the stringer. See Figure 6.2.11. A structural engineer should determine the size and number of plates and bolts needed.

This type of repair applies best to bridges that incorporate a timber deck with an asphalt overlay or a Hollywood timber deck that uses deck planks oriented transverse to the stringers and a top layer of longitudinal planks forming a wearing course. For these types of decks, the protruding bolt heads for the draw-up bolts can be covered by either the asphalt wearing surface or the wearing course planks. For bridges with just a single layer of deck planks, bolt heads for the draw-up bolts would protrude above the top surface of the deck and thus would not be satisfactory.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. For bridges with a single layer of transverse timber decking, remove decking planks above the damaged portion of the stringer.
3. For a timber deck with a concrete or bituminous wearing surface or a Hollywood timber deck consisting of an upper wearing course of longitudinally placed timber planking over a lower layer of transversely placed timber planking, remove only the wearing course over the damaged stringer.

4. For a timber deck with a concrete, bituminous, or timber wearing course, after the wearing course over the stringer is removed, drill holes in the transverse timber deck planking on each side of the stringer for draw-up bolts.
5. Install plates above and below the stringer and tighten bolts to close the split or check in the timber stringer. Add additional plates and draw-up bolts as required along the length of the stringer split or check.
6. Replace wearing surface. For Hollywood timber wearing course, route a cavity in the underside of the timber planking to accommodate the protruding top anchor plate and bolt heads.

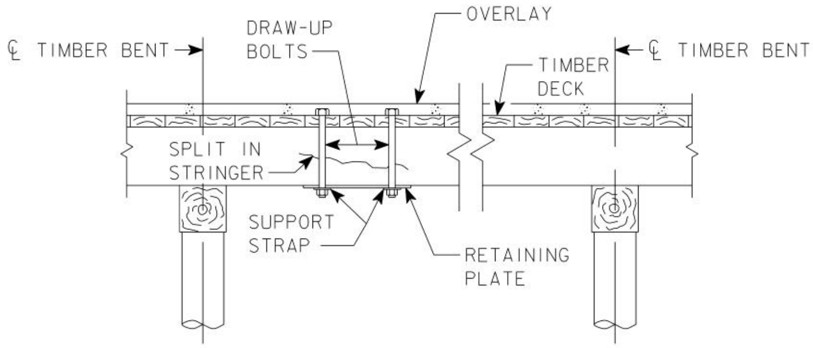


Figure 6.2.11. Timber Stringer Repair

6.2.12 Replace Rotten/Broken Timber Stringers

General Considerations: Working from above the deck to replace a damaged stringer will require removal of substantial deck plank members in order to replace the stringer. If possible, work should be conducted from below to minimize deck removal as shown in Figure 6.2.12.

Procedures:

1. Establish traffic control operations on the bridge to stop traffic during stringer replacement activities.
2. Assuming the damaged stringer is left in place, remove blocking or crib bracing between the damaged stringer and adjoining stringers.
3. Place two jacks in adjoining bays to the damaged stringer on each pier cap that supports the damaged stringer. Use steel plates to distribute jack loads to avoid crushing the timber fibers of deck planks.
4. Jack up the deck approximately 0.5 inch to clear the stringer.
5. If the replacement stringer is warped, orient the camber upwards to ensure bearing on all deck members.
6. Cut a wedge approximately 6 inches tall and 2 feet long from the top corner at one end of the new stringer. Cut approximately 45° bevel cuts at the top and bottom corners at the other end of the replacement stringer. Treat cut portions of the timber stringer with wood preservative.
7. Place the end of the stringer with the cut wedge onto one pier cap, and push it far enough onto the cap to allow the other end to be lifted to just clear its cap.
8. Lift the beveled end of the stringer onto its cap.

9. Anchor a come-along to the bent cap under the beveled end of the stringer, and attach the free end of the cable to the wedge-cut end of the stringer.
10. Using the come-along, pull the stringer into final position to provide equal bearing on both pier caps.
11. Drive wedges under each end of the stringer to provide full contact with the deck. Nail wedges in place such that they can be adjusted in the future to account for sag.
12. Install new blocking or crib bracing between the new stringer and adjacent stringers.
13. Remove jacks and spike the deck to the new stringer.

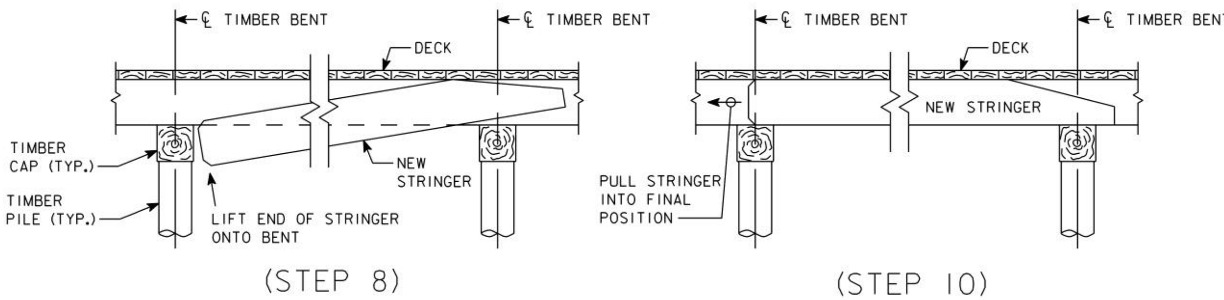


Figure 6.2.12. Timber Stringer Replacement

CHAPTER 7
BRIDGE SUBSTRUCTURES

7.1 COMMON PROBLEMS AND CONSEQUENCES OF POOR MAINTENANCE

Common problems and causes of deterioration associated with bridge substructure components include typical damage due to overload conditions, such as abutment rotation or pier tilting from excess lateral soil loads; damage from flood debris impact, vessel collision, or vehicle impact; settlement and scour at foundations; and material deterioration generally caused by poor control of roadway or bridge runoff.

7.1.1 Reinforced Concrete Substructures

Reinforced concrete substructures may experience cracking, spalling, delamination, and corroding of reinforcing steel. Movement, rotation, or settlement of an abutment or wingwall may initiate damage, and once cracks form and allow intrusion of water and chlorides, advanced deterioration may follow as reinforcing steel corrodes and expands further. Pier elements exposed to bridge runoff due to leaking expansion joints can experience similar deterioration. In addition, bridge bearings that have failed and no longer slide or rotate as intended can impart added loads to concrete substructures and cause spalling or cracking as the unintended loads are transmitted to substructure members. Reinforced concrete substructure members may also experience damage from impact of flood debris, vessels, or vehicles.

7.1.2 Steel Trestle

Steel trestle supports and abutments consisting of steel piles with steel sheet pile backwalls and wingwalls are less rigid substructure elements when compared to reinforced concrete substructures and are more susceptible to lateral movement due to unbalanced soil loads or locked-up bridge bearings. Such movements not only can overstress steel members but also can overstress bolted connections and cause welds to crack. Steel substructures are also susceptible to corrosion if the protective paint coating fails. Failed coatings and loss of section at the waterline where steel piles experience alternating wetting cycles are common problems.

7.1.3 Timber Trestle

Timber trestles and abutments are subject to rot; insect damage; material failures such as splits, checks, and shakes; and natural imperfections such as knots. Excessive lateral soil loads at abutment wingwalls or backwalls may fail the timber planks retaining the soil. Rot of timber piles is common particularly at the waterline where cyclical wetting cycles occur.

7.2 BRIDGE SUBSTRUCTURE MAINTENANCE AND REPAIR PROCEDURES

7.2.1 Wash Bridge Beam Seats

General Considerations: Regular cleaning of bridge beam seats at abutments and pier caps should be performed to remove accumulated dirt and debris that can trap moisture and promote concrete deterioration, steel corrosion, and timber rot. Cleaning also flushes concentrations of corrosive roadway salts. Generally, washing of bridge beam seats should be scheduled annually at a minimum and should coincide with bridge joint and deck cleaning activities at the end of normal winter operations.

Procedures:

1. Use shovels, brooms, hand scrapers, and other hand tools to physically remove large accumulations of roadway debris, dirt, bird nesting material, and bird excrement from beam seats.
2. Using a source of fresh water free of contaminants, remove salt contaminants, dirt, and other detrimental foreign matter with a high pressure wash. Use a water flow rate of at least 5 gallons per minute and a maximum water pressure of 1,000 psi.

7.2.2 Seal Bridge Beam Seats

General Considerations: Sealing bridge beam seats following beam seat washing is effective to minimize chloride intrusions into concrete.

Procedures:

1. Remove loose or unsound material by hand methods or sandblasting.
2. At a minimum, use a light sandblast (brush blast) followed by air cleaning on all designated surfaces to receive concrete sealer. Clean sufficiently to remove road film and contamination from existing concrete surfaces. Ensure that all surfaces to be sealed are clean, sound, and dry.
3. Apply sealer material in accordance with the manufacturer's recommendations. Sealing material and coverage rates shall conform with requirements of Materials I.M. 491.12.

7.2.3 Repair Tops of Abutment Backwalls with Concrete

General Considerations: The tops of abutment backwalls may deteriorate due to mechanical action of approach slab rotation against the backwall combined with intrusion of chloride-laden bridge runoff into the joint between the abutment and the approach slab. In addition, deterioration of expansion joint components that are embedded into the abutment backwall may contribute to deterioration. Refer to Figure 1.3.2 for repairs associated with damaged sliding plate expansion joints at abutments.

The repairs described below apply to abutment backwall deterioration limited to the area above the paving notch of abutments.

Procedures:

1. Establish traffic control operations on the bridge to ensure worker safety during maintenance activities.
2. Remove concrete down to sound concrete above the paving notch. Limit jackhammer size to a nominal 30-pound class, and limit chipping hammer size to 15-pound class. Where existing reinforcing steel is sound, incorporate the existing reinforcing steel into new work.
3. Clean or remove corroded reinforcing steel. If needed, replace damaged reinforcing steel with new bars and securely tie new reinforcing steel into place. Touch up exposed surfaces of epoxy coated reinforcing steel with an approved coating material. Replace unsound vertical reinforcing steel by drilling and grouting new vertical dowels into the existing backwall. Use a polymer grout system in conformance with Materials I.M. 491.11. The depth of the grout hole shall be in accordance with the grout manufacturer's recommendations.
4. Clean the repair area by sandblasting. Protect epoxy coated reinforcing from the cleaning process. Clean epoxy coated reinforcing with hand tools that will not damage the epoxy coating. Follow with an air blast of oil-free compressed air.

5. Install forms for new concrete repair. Ensure that the existing concrete surface is dry before placing new concrete.
6. Use a Class O, C, M, or a rapid set mix as appropriate for the site conditions for the new concrete used for repairs. Place concrete according to the Standard Specifications, Article 2403.03.C.
7. Apply a white pigmented curing compound to the concrete immediately after removing forms. The application rate shall be 100 square feet per gallon.

7.2.4 Epoxy Inject Cracked Wingwalls, Abutments, and Piers

General Considerations: Localized cracks in wingwalls, abutments, and piers may be addressed by pressure injecting cracks with epoxy. Note that for “working” cracks, the underlying cause of the cracking should be determined first so that corrective action can be taken to alleviate the cause of the cracking.

Procedures:

1. For work adjacent to active traffic, establish traffic control operations to ensure worker safety during maintenance activities.
2. Clean the surface area of the crack for approximately 0.5 inch on each side of the crack with a wire brush (mechanical grinders may fill the crack with unwanted dust).
3. Where concrete surfaces adjacent to the crack are deteriorated, route the crack in a V-groove sufficient to reach sound concrete.
4. Remove contaminants by high pressure water, oil-free compressed air, or vacuum. When using water to clean a crack, blow out the crack with oil-free compressed air and allow the repair area to dry naturally before injecting it with moisture-sensitive epoxies.
5. Using a manufacturer- approved adhesive, install epoxy injection port adapters (surface mounted or socket mounted). Spacing of port adapters will depend on the length and width of the crack.
6. For horizontal cracks, mark the location of the widest part of the crack.
7. Trowel a cap seal over the crack and around bases of the port adapters to contain pressure injected epoxy. Allow the cap seal and port adapter adhesives to properly cure.
8. For vertical cracks, start injection of epoxy at the lowest port adapter. For horizontal cracks, start injection at the widest part of the crack. Begin injection and continue until refusal or until epoxy vents from an adjacent port. When an adjacent port bleeds, cap the port being injected and move to the adjacent port. Continue injection in a similar fashion, working along the length of the crack.
9. For hairline cracks not suited for injecting until refusal, increase the injecting pressure to approximately 200 psi as needed. However, monitor injection to prevent a blowout of the cap seal or ports.
10. Upon completion of the injection process and curing of epoxy, remove the cap seal and ports by cutting off flush.

7.2.5 Concrete Repair (Shallow and Regular) at Wingwalls, Abutments, and Piers

General Considerations: For spalls, delaminations, and general deterioration in wingwalls, abutments, and piers that are more extensive than simple cracks, concrete deterioration may be repaired as either shallow or regular concrete repairs in accordance with the Standard Specifications, Article 2426, for Structural Concrete Repair.

Procedures:

1. For work adjacent to active traffic, establish traffic control operations to ensure worker safety during maintenance activities.
2. Remove unsound concrete from the damaged area of the substructure element, extending the limits of the damaged area until sound concrete is encountered. Limit jackhammer size to a nominal 30-pound class, and limit chipping hammer size to 15-pound class.
3. Using a chop saw, provide a 0.75-inch-deep saw cut around the perimeter of the damaged area to square up the repair area and eliminate feathered edges. Jackhammer or use hand tools as needed to extend removals to the saw cut lines.
4. Clean or remove corroded reinforcing steel. If needed, replace damaged reinforcing steel with new bars and securely tie new reinforcing steel into place. Touch up exposed surfaces of epoxy coated reinforcing steel with an approved coating material.
5. Clean the repair area by sandblasting. Protect epoxy coated reinforcing from the cleaning process. Clean epoxy coated reinforcing with hand tools that will not damage the epoxy coating. Follow with an air blast of oil-free compressed air.
6. For shallow repairs (0.75 to 1.5 inches deep where no form work is used to support the patching material), first apply a bonding grout conforming to the Standard Specifications, Article 2426.02.B.1; ensure that the repair area is dry before placing grout. Concrete for shallow repairs shall conform with the Standard Specifications, Table 2426.02-1. Place concrete before the grout dries out. For shallow repair areas where the patching material cannot support itself, forms may be needed, and in these areas, no bonding grout is required.
7. For regular repairs (a minimum depth of 1.5 inches or 0.75 inch behind an unbonded reinforcing bar and where form work is used), no bonding grout is required. Use a Class O concrete mix for the repair concrete. Ensure that the concrete surface is dry before placing new concrete (Standard Specifications, Article 2403.03.I.1). When repairing a vertical face, place the patch in heights not to exceed 4 feet; provide access ports in the forms at 4-foot intervals for concrete placement and vibration.
8. Apply a white pigmented curing compound to the concrete immediately following concrete finishing or immediately after removing forms. The application rate shall be 100 square feet per gallon.

7.2.6 Reconstruct Paving Notch at Integral Abutments

General Considerations: This type of work on stub abutments generally requires extensive reconstruction of the upper portion of the abutment backwall, which involves removal and replacement of an expansion device as well as the paving notch. As such, this work is generally contracted to outside forces. General procedures for replacement of a paving notch on an integral abutment are listed below.

Procedures:

1. Establish traffic control operations on the bridge and approach slabs to ensure worker safety during maintenance activities. For a two-lane bridge with traffic in both directions, full closure of the bridge would likely be required. For a two-lane bridge with traffic in one direction only, the work could be staged to do one lane at a time, which would allow for staged replacement of the approach slabs and the paving notch.
2. Remove the bridge approach slab for a minimum of 5 feet (measured along centerline of approach roadway) beyond the end of bridge floor according to the Standard Specifications,

Article 2529.03.C.4. For staged construction, remove one lane of approach slab and provide support for the vertical face of the excavated area along the removal line to support traffic during construction.

3. Excavate behind the abutment to below the paving notch.
4. Remove the existing paving notch; removals should also create an 8 inch by 1 ½ inch keyway in the abutment for the new paving notch with keyway removals initiated by ¾ inch sawcuts. Limit jackhammer size to a nominal 30-pound class, and limit chipping hammer size to 15-pound class. Where existing reinforcing steel is sound, incorporate the existing reinforcing steel into new work.
5. Clean or remove corroded reinforcing steel. New top and bottom paving notch reinforcing steel shall be provided by drilling and grouting new bars into the abutment. Use a polymer grout system in conformance with Materials I.M. 491.11. The depth of the grout hole shall be in accordance with the grout manufacturer's recommendations. Securely tie new horizontal reinforcing steel for the paving notch into place. Touch up the exposed surfaces of epoxy coated reinforcing steel with an approved coating material.
6. The existing concrete surfaces shall be roughened to ensure a good bond with new concrete. Clean the repair area by sandblasting. Protect epoxy coated reinforcing from the cleaning process. Clean epoxy coated reinforcing with hand tools that will not damage the epoxy coating. Follow with an air blast of oil-free compressed air.
7. Compact granular backfill below paving notch before installing forms for new the abutment backwall and/or paving notch. Ensure that the existing concrete surface is dry before placing new concrete.
8. Use a Class C concrete mix for the new concrete. Place concrete according to the Standard Specifications, Article 2403.03.C. Concrete slump requirements shall be as specified in Standard Specifications, Article 2403.02.B.2.a.
9. Apply a white pigmented curing compound to the concrete immediately after removing forms. The application rate shall be 100 square feet per gallon.
10. Replace and compact the backfill behind the abutment according to the Standard Specifications, Article 2402.03.I. Place and compact a 1-foot minimum depth of modified subbase under the new approach slab according to the Standard Specifications Article, 2115.03.B.4; extend the subbase to a point 3 feet from the approach slab removal line. In the absence of site-specific approach slab details, reinforce the 1-foot thick approach slab with #6 bars at 1-foot centers longitudinally on top, #9 bars at 1-foot centers longitudinally on the bottom and #5 bars at 1-foot centers transversely top and bottom. Provide 2'-2" long, #6 tie bars at 1-foot centers, drilled and grouted into the existing approach pavement at mid-depth of the pavement slab along the removal line; embed the tie bars 10 inches minimum into the existing approach pavement concrete. Provide a joint between the end of bridge floor and the new approach slab sized in accordance with Standard Road Plan RK-19A. Use Class C concrete in accordance with the Standard Specifications, Article 2301.03.R.4. Form and pour the new approach slab section according to Standard Specifications, Article 2529.03.H. Upon final curing of approach slab concrete, reopen the completed portion to traffic.
11. For staged construction, repeat steps 2-10 for the remaining portion of approach slab and paving notch.

7.2.7 Repair Bridge Seats Under Bearings

General Considerations: The following procedures assume that deterioration below beam seats is extensive, where there is possible loss of support. Repair procedures assume that jacking of the beams to support bearing loads will be required while repairs are completed.

Procedures:

1. Provide traffic control or auxiliary shoring of affected bridge members as required for bridge seat repair activities under bearings.
2. Position hydraulic jacks adjacent to existing bearings at jacking stiffener locations, or position jacks at an auxiliary support bent adjacent to existing bearing supports.
3. If required, disconnect barrier sliding plates, expansion joints, or conduit that are continuous through joints at lifting point so as to prevent damage during jacking operations to these secondary components.
4. While simultaneously jacking adjacent beam lines at the same substructure support, lift all girders only as required to relieve load from bearings (a maximum of 0.5 inch).
5. Use lock-off nuts on jacks or blocking to support loads so that hydraulic pressure does not need to be maintained during beam seat repair operations.
6. Remove unsound concrete from the damaged area of the bridge seats, extending the limits of the damaged area until sound concrete is encountered. Limit jackhammer size to a nominal 30-pound class, and limit chipping hammer size to 15-pound class.
7. Using a chop saw, provide a 0.75-inch-deep saw cut around the perimeter of the damaged area to square up the repair area and eliminate feathered edges. Jackhammer as needed to extend removals to the saw cut lines.
8. Clean or remove corroded reinforcing steel. Replace damaged reinforcing steel with new bars and securely tie new reinforcing steel into place. If necessary, drill and grout new dowels into the sound concrete using a polymer grout system in conformance with Materials I.M. 491.11. The depth of the grout hole shall be in accordance with the grout manufacturer’s recommendations. At the owner’s preference, zinc anodes may be installed to inhibit corrosion of the reinforcing.
9. Clean the repair area by sandblasting. Protect epoxy coated reinforcing from the cleaning process. Clean epoxy coated reinforcing with hand tools that will not damage the epoxy coating. Follow with an air blast of oil-free compressed air.
10. Form the repair area for receiving new concrete. Ideally, a Class O concrete mix for the repair concrete (Standard Specifications, Article 2426.02.B.2.b) should be used. Ensure that the existing concrete surface is dry before placing new concrete (Standard Specifications, Article 2403.03.I.1).
11. Apply a white pigmented curing compound to the concrete immediately following concrete finishing or immediately after removing forms. The application rate shall be 100 square feet per gallon.
12. Allow new concrete to reach the specified concrete strength (3000 psi minimum) prior to transferring bearing load to reconstructed beam seats. Ensure that bearings are properly set to adjust for temperature prior to releasing the jacking load.
13. Slowly release hydraulic jacks to reload bearing seats.

7.2.8 Repair or Replace Timber Trestle Piling, In or Out of Water

General Considerations: Individual timber piles for trestle bents can be rendered ineffective due to deterioration from insect infestation or rot, thus requiring repair or replacement of the pile. Depending on the extent of the deterioration, the timber piles could be strengthened by either bolting steel channels to the outside of the timber pile to strengthen the timber pile or encasing the damaged section of pile in a concrete jacket. Cutting out the damaged section of piling and posting/splicing a replacement section of piling in place is also an option. No more than half the piles in a bent should be repaired using this method due to loss of lateral resistance. Supplementing the damaged pile with a helper bent oriented transverse to the existing bent may also be considered.

For bridges with tall timber bents that would allow it, it may be possible to install a new pile adjacent to an existing damaged pile. Due to conflicts with the existing pile bent cap, pile driving would be initiated ahead of or behind the existing cap beam and installed at a slight batter toward the centerline of the pile bent. After the pile is driven, the pile would be pulled into a vertical orientation with a come-along.

Procedures – Strengthening Piles with Steel Members:

1. Determine the length of pile deterioration and provide pre-drilled steel channels that will extend at least 18 inches above and below the deteriorated section into sound timber to strengthen the deteriorated pile section. This repair should be limited to piles with a length of deterioration less than approximately 18 inches.
2. Clamp steel channels into place and drill through the timber pile for through-bolt connections. Locate through-bolts in the sound timber section of the pile and treat drill holes with timber preservative.
3. Bolt steel channels into place using galvanized steel bolts.

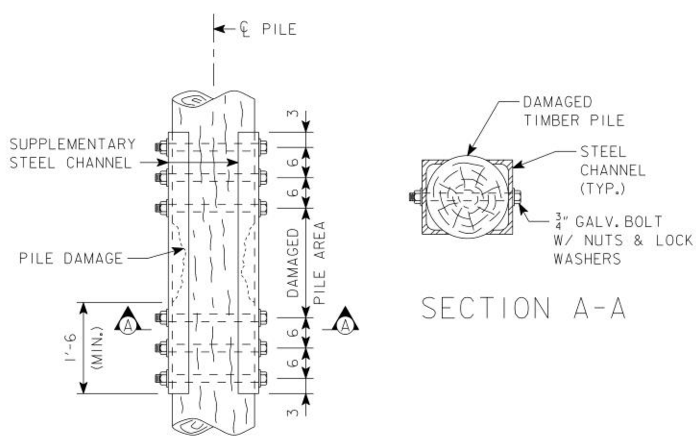


Figure 7.2.8-1. Strengthening Timber Pile with Steel Channels

Procedures – Strengthening Piles with Concrete Jacket:

1. Determine the length of pile deterioration and provide a concrete form that will extend at least 18 inches above and below the deteriorated section to sound timber. Concrete form options include a split section of corrugated metal pipe, a split section of high-density polyethylene (HDPE) pipe,

a split fiberboard form (Sono tube), or a flexible fabric form. Inside diameter of form should be at least 12 inches greater than the nominal timber pile diameter.

2. Providing 3 inches of cover around the original timber pile cross section, tie a reinforcing steel cage consisting of 6 x 6 – W12 x W12 welded wire mesh around the pile. Provide spacers to set the reinforcing steel cage away from the outside of the pile and to provide 3 inches of clear cover between the reinforcing steel cage and the jacket form.
3. Install the split form or fabric jacket, and hold the form in place with steel pipe clamp bands. Seal the bottom of the form against the pile.
4. Pump Class O concrete into the form from the top and finish the top with a chamfer sloping away from the face of the pile.

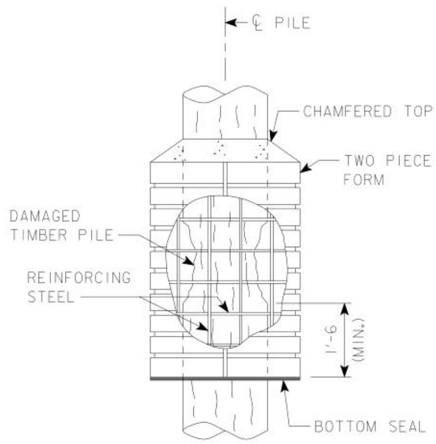


Figure 7.2.8-2. Strengthening Timber Pile with Concrete Jacket

<u>Procedures – Posting/Splicing Piles</u>:

1. Provide traffic control or auxiliary shoring of affected bridge members as required for pile repair activities.
2. Jack cap beam from an auxiliary support (or cribbing installed below the bent) adjacent to the damaged pile to relieve load from the damaged pile.
3. Cut out the damaged or deteriorated section of pile approximately 1 foot above and below the damaged section of pile. Treat cut ends with preservative.
4. Cut a new section of timber pile approximately ¼ inch shorter than the section removed. Treat cut ends with preservative. (Note: a steel post or steel pile with end plates could also be used.)
5. Slide in the new section of pile.
6. Provide four steel splice plates spaced equally around the circumference of the pile to splice the new post to the remaining sections of the existing timber pile. Treat drill holes with timber preservative, and lag screw or through-bolt the steel splice members into sound sections of the existing timber pile. Alternatively, encase the splices in a reinforced concrete jacket (see procedures above for “Strengthening Piles with Concrete Jacket”).
7. After splice plates are in place or concrete has reached adequate strength, release the jack to reload the pile.

Procedures – Replacing Piles:

1. Temporarily close the bridge to traffic.
2. Cut holes in the bridge deck or, in the case of a timber plank deck, remove timber deck planks over the damaged timber pile.
3. Position the new timber pile adjacent to the bent cap immediately ahead of or behind the centerline of the bent and adjacent to the damaged pile. Drive the pile with a slight batter through the opening in the timber deck to align the pile with the centerline of the bent at the ground line.
4. Cut off the pile approximately 1inch below the bottom of the pile bent cap beam.
5. After the pile is driven, excavate on the back side of the pile for a depth of approximately 5 feet below the ground line.
6. Attach to the top of the pile a come-along that is anchored at the other end to an adjacent bent or abutment. Pull the pile into a vertical position and center it under the pile cap; backfill firmly around the repositioned pile.
7. Shim the top of the new pile firmly up against the bottom of the existing pile cap. Spike through the pile cap into the top of the new pile and/or strap the top of the new pile to the sides of the pile cap with steel strap plates and lag bolts.
8. Release the come-along, replace deck planks or patch the deck, and reopen the bridge to traffic.

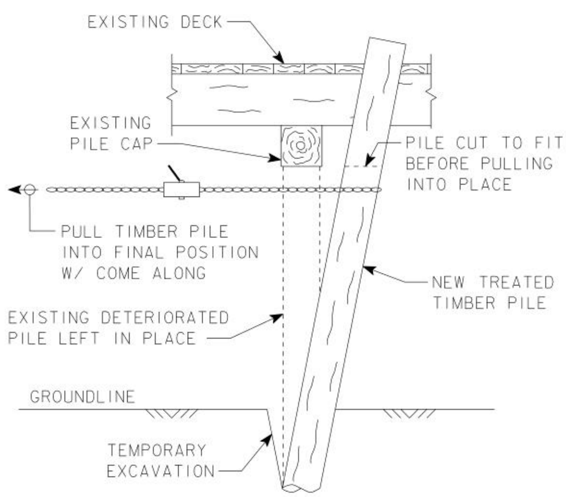


Figure 7.2.8-3. Timber Pile Replacement

Procedures – Supplementing Piles with Helper Bent:

1. Temporarily close the bridge to traffic.
2. Cut holes in the bridge deck or, in the case of a timber plank deck, remove timber deck planks over the damaged timber pile.
3. Drive one new steel H-pile in front of the pile bent adjacent to the damaged pile and one new steel H-pile behind the pile bent adjacent to the damaged pile.

4. Install corbel brackets to the newly driven piles. Position a new steel "helper" crossbeam between the new piles under the existing bent cap. Use corbel brackets to jack the new "helper" cross beam into position and take the load into the new piles. Bolt or weld the new "helper" cross beam to the steel H-piles.
5. Release the jacks, replace deck planks or patch the deck, and reopen the bridge to traffic.

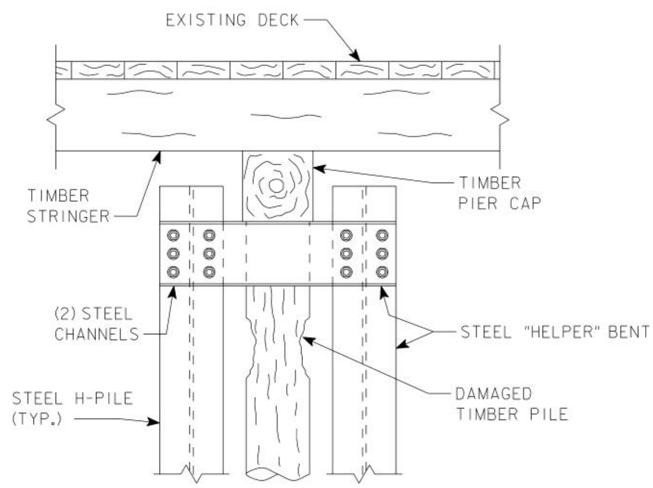


Figure 7.2.8-4. Helper Bent for Damaged Timber Pile

7.2.9 Encase Concrete Trestle Piling, In or Out of Water

General Considerations: Encasing a damaged concrete trestle piling follows similar procedures as used for strengthening timber piles with a concrete jacket. The procedures below assume that the pile is still structurally sound but requires repair to the exterior surface.

Procedures:

1. Determine the length of pile deterioration and provide a concrete form that will extend at least 18 inches above and below the deteriorated section to sound concrete. Forms may be either rigid or flexible and may be left in place for added protection to the pile or removed when the concrete is cured. Inside diameter of forms should be at least 12 inches greater than the nominal diameter of the concrete pile (for round piles) or at least 12 inches greater than the diagonal dimension of the pile (for square piles).
2. Remove all unsound concrete, being careful not to compromise the structural integrity of the pile. Use high pressure water jets if needed for removing unsound concrete and cleaning the concrete surface and reinforcing steel below the water line. If damage extends below the mudline, excavate below the mudline to extend the repair zone.
3. For surfaces above the water line, sandblast the surface to clean the pile, ensure proper bonding of repair concrete, and to remove corrosion and rust from existing reinforcing steel.
4. Providing 3 inches of cover around the original concrete pile cross section, enclose the damaged pile in a reinforcing steel cage consisting of either welded wire fabric or #4 vertical bars spaced at 6 inches and #4 ties spaced at 12 inches. Provide spacers to set the reinforcing steel cage away

from the outside of the pile and to provide 3 inches of clear cover between the reinforcing steel cage and the jacket form.

5. Install the split form or fabric jacket, and hold the form in place with steel pipe clamp bands. Seal the bottom of the form against the pile.
6. Place concrete by either dewatering the form or by using the tremie method. Pump Class O concrete into the form from the top and finish the top with a chamfer sloping away from the face of the pile.

7.2.10 Replace Timber Abutment Backwall Planks

General Considerations: Timber abutment backwall planks may be replaced in kind, or steel sheet piles could be driven behind the existing abutment backwall to take the place of the damaged backwall planks. Use of steel sheet piles is generally a more viable option if the backwall damage is extensive and the speed of repair is important.

Procedures:

1. Temporarily close the bridge to traffic.
2. Excavate behind the abutment to expose broken and damaged backwall planks.
3. Remove damaged planks and replace with new timber planks. If the bridge abutment uses timber piles, spike the new planks to existing timber piles.
4. Backfill the bridge abutment and reopen the bridge to traffic.

7.2.11 Replace Timber Piles at High Abutments

General Considerations: If conditions allow, the maintenance staff should determine if a new pile could be driven next to a damaged pile and in front of the abutment cap beam and then pulled into place to center the pile under the abutment cap beam. Procedures for this type of pile replacement would be similar to those described in Section 7.2.8 of this manual for "Replacing Piles" for a timber trestle.

However, the procedures below assume that the cap beam for the abutment would be in the way for driving a new pile in place immediately adjacent to an existing pile, thus requiring some level of removal for the deck, stringers, and abutment cap beam to allow for pile replacement. Due to the high level of end span removals that this would require, it is assumed that this type of repair is feasible only for a timber stringer bridge with a timber plank deck, and the procedures are developed accordingly.

Procedures:

1. Temporarily close the bridge to traffic.
2. Remove timber deck planks in the end span of the bridge.
3. Remove the end span stringers and the abutment cap.
4. Drive a new timber pile adjacent to the damaged timber pile.
5. Replace the abutment cap beam, end span stringers, and end span timber deck planking.
6. Reopen the bridge to traffic.

7.2.12 Remove Unbalanced Soil Load from Substructure

General Considerations: An appreciable difference in soil height on opposite sides of a bridge pier can cause tipping of the pier from the unbalanced soil load. In these cases, removal of soil from the high side of the pier may be necessary to relieve the unbalanced soil condition. The unbalanced soil loading could result from stream flow cutting the channel adjacent to the pier or stream flow depositing excess sediment behind the pier.

Procedures:

1. Using a skid loader, excavate soil from the high side of the pier and, if necessary, deposit the soil on the low side of the pier to create a generally level bench at the pier location.
2. Slope soil away from the bench at a slope that can be maintained (2:1 minimum).
3. If necessary, provide revetment on the stream side of the pier and newly cut channel bank to prevent further stream cutting adjacent to the pier. Be careful to prevent filling of the stream that could cause a change to backwater conditions for properties upstream of the bridge.
4. When placing material in a waterway, permit requirements from the Corps of Engineers or the Department of Natural Resources (DNR) must be investigated.

CHAPTER 8
BRIDGE APPROACHES AND APPROACH SLABS

8.1 COMMON PROBLEMS AND CONSEQUENCES OF POOR MAINTENANCE

Although the bridge approaches are not primary structural components of a bridge, satisfactory performance of bridge approaches and approach slabs is important to the proper function of a bridge system. Settlement of bridge approach slabs is a common problem, which may be caused by infiltration of water into the earth fill below the approach slabs. Another common problem may be the development of potholes in the approach slab paving. Both of these problems should be addressed by regular maintenance procedures.

8.2 BRIDGE APPROACH MAINTENANCE AND REPAIR PROCEDURES

Typical maintenance for bridge approaches includes procedures to seal joints where water may infiltrate below the approach slab, repair embankment erosion from roadway runoff, patch potholes, and maintain guardrails or repair guardrails damaged by vehicle impact.

8.2.1 Seal Gaps or Mastic Joints between Shoulder Panels and Wingwalls

General Considerations: A common detail for many bridges in Iowa is to carry the bridge rail off the end of the bridge along the top of the abutment wingwalls. As a result, the paved shoulder panel of the approach slab typically abuts the wingwall and results in an open gap against the wingwall requiring periodic sealing.

Procedures:

1. Establish traffic control operations on the bridge and approaches to ensure worker safety during maintenance activities.
2. Clean the joints of existing joint sealer, vegetation, dirt, and all foreign materials to the depth of the bottom of the existing backer material. Sandblast the edges of the joint throughout the depth of the proposed joint sealer, leaving a clean, dry, newly exposed concrete surface on the vertical edges. Either vacuum the prepared joint or provide a brush blast of oil-free compressed air to remove contaminants and debris from the joints prior to installing joint sealer. Ensure that the joint is dry before initiating sealing operations.
3. Install a properly sized backer rod or approved alternate bond breaker at the bottom of the joint. Apply a silicone joint sealer into the joint following the manufacturer's recommendations for application and curing.
4. Reopen lanes to traffic.

8.2.2 Backfill Approach Embankment and Bridge Berm Erosion Holes

General Considerations: Bridge runoff may be directed onto the bridge berms by bridge drain scuppers located over the bridge berms. Alternatively, runoff from the bridge that is not captured by bridge drain scuppers may flow off the end of the bridge and exit the driving surface at the ends of the bridge wingwalls. These concentrations of flow may cause erosion of the approach embankments or the bridge berms.

Procedures:

1. Using shovels, other hand tools, or a skid loader, backfill erosion holes to level the ground surface with the surrounding ground line.
2. For locations under the outlets for bridge drain scuppers, consider creating a splash basin under the drain consisting of a 10-foot-long by 10-foot-wide by 2-foot-deep layer of erosion stone underlain by engineering fabric. Embed the splash basin into the bridge berm so that the top of the erosion stone is level with the top of the bridge berm. Alternatively, consider extending deck drain outlet pipes to the ground line using corrugated PVC pipe clamped to the drain pipe outlet to limit the energy of the falling water.
3. Provide Macadam stone armoring at the ends of the wingwalls to limit erosion from bridge runoff.

8.2.3 Fill Voids Under Approach Slabs

General Considerations: Voids under bridge approach slabs may be suspected when fill material appears at the outlet ends of weep holes or abutment subdrains. Cracking in the approach slabs may also indicate loss of support caused by the presence of voids. If the approach slab is still intact, proactive efforts to define and fill the voids could prevent more expensive repairs that would involve replacing the full approach slab. Often the depth and limits of voids under approach slabs can be determined by coring holes in the approach slab to probe and define the void limits.

Procedures:

1. Establish traffic control operations on the bridge and approaches to ensure worker safety during maintenance activities.
2. Core a 6-inch diameter hole in the approach slab at the suspected void location to determine the limits and depth of the void. Once the limits are determined, core additional 6-inch-diameter holes at spacings equal to approximately one-half the depth of the void.
3. Fill the void through the core holes with saturated sand to within 1 foot of the bottom of the approach slab.
4. Top-off the sand-filled void to the bottom of the approach slab with flowable fill mortar with a maximum compressive strength of 50 psi.
5. Patch core holes and reopen the lanes to traffic.

8.2.4 Patch Approach Paving Pot Holes with HMA

General Procedures: Hot Mixed Asphalt (HMA) patches are typically used to repair potholes for concrete approach slabs to provide a semi-permanent repair with minimal traffic disruption. Because HMA repairs are not a structural repair, HMA patches should not be used when damaged areas extend through the full depth of the approach slab.

Procedures:

1. Establish traffic control operations on the bridge and approaches to ensure worker safety during maintenance activities.
2. Remove loose and unsound concrete from the damaged area of the pothole. Limit jackhammer size to a nominal 30-pound class, and limit chipping hammer size to 15-pound class. Take care to avoid punching through the bottom of the approach slab.

3. Remove loose debris and clean the repair area with a brush blast of oil-free compressed air.
4. Shovel HMA patch material into the pothole. Spade the HMA material to fill all voids and to initiate compaction of the HMA material. Slightly overfill the hole with HMA to allow for compaction of the HMA.
5. Compact the HMA patch with a portable vibratory roller or flat plate vibratory compactor.
6. Reopen the repair area to traffic.

8.2.5 Cut/Re-Cut/Install Pressure Relief Joint

General Considerations: Over time, joint filler for pressure relief joints may deteriorate or begin to work its way out of the joint. Many of these joints were previously filled with foam board material and liquid sealant. Current policy is to replace the joint material with crumb rubber and top it with joint sealant material to keep out uncompressible material. The intent of the resulting joint is to provide a compressible but not necessarily watertight joint. Reference road design standard PV-101.

Procedures:

1. Remove old joint material. If old joint material consists of sections of foam board, usually the material can be easily removed by hooking onto it with a tine attached to a skid loader bucket and pulling the material free.
2. Clean out the joint and blow it free of debris with compressed air.
3. Coating of the sides and bottom of the joint with CRS2 oil emulsion or approved equal is optional, if it is felt this helps hold the crumb rubber in place.
4. Fill the joint with crumb rubber in one or two lifts, topping each layer with CRS2 or approved equal. Avoid compressing the crumb rubber during installation. The top of the crumb rubber and CRS2 or approved equal should be kept 0.75 inch below the driving surface to prevent tracking of the material onto the deck.
5. If the topping is not kept 0.75 inch below the driving surface, place a final layer of crumb rubber over the top to minimize the oil emulsion from tracking onto the roadway surface.

This joint is not intended to be water tight. It is intended to allow the proper expansion and contraction of the pavement and bridge by keeping uncompressible material out of the joint.

8.2.6 Bridge Approach Resurfacing with HMA

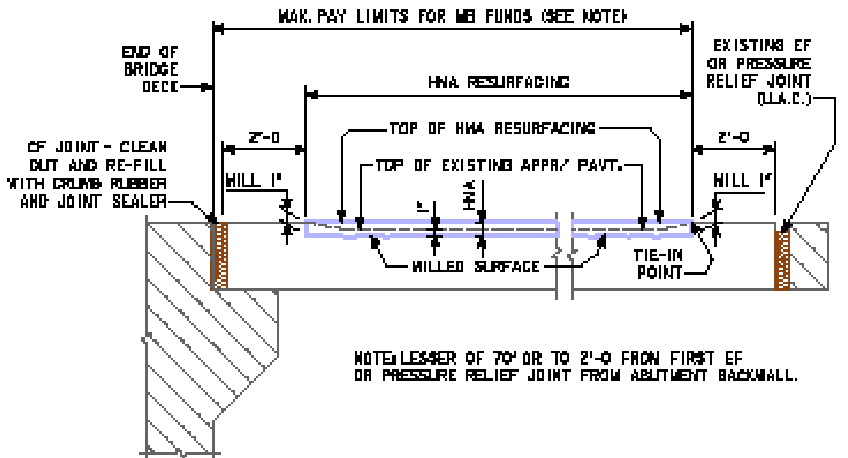
General considerations:
Settlement of the bridge approach pavement is a common problem. The main problem caused by the settlement is rough ride. It may occur right at the end of bridge where the approach pavement rests on the paving notch or at some distance away from the end of bridge. Settlement over the paving notch can occur when the paving notch has failed. This typically occurs when the gap between the backwall and approach pavement is large and a portion of the notch shears off due to large loads applied to a narrow band of the notch; misplacement of the reinforcing steel in the paving notch often contributes to the failure. It is important to determine if the paving notch has failed or not. If paving notch is broken, placement of the HMA resurfacing is not likely to result in a long term fix. For a broken paving notch it is recommended that an MB project be programmed to replace the bridge approach pavement.
Not all cases of settlement over the notch are the result of notch failure. It is quite common that a layer of subbase was placed between the top of the notch and bottom of approach pavement. Settlement occurs when water infiltrates the joint opening and washes the subbase material out from under the approach pavement.

The following guidelines shall be followed:

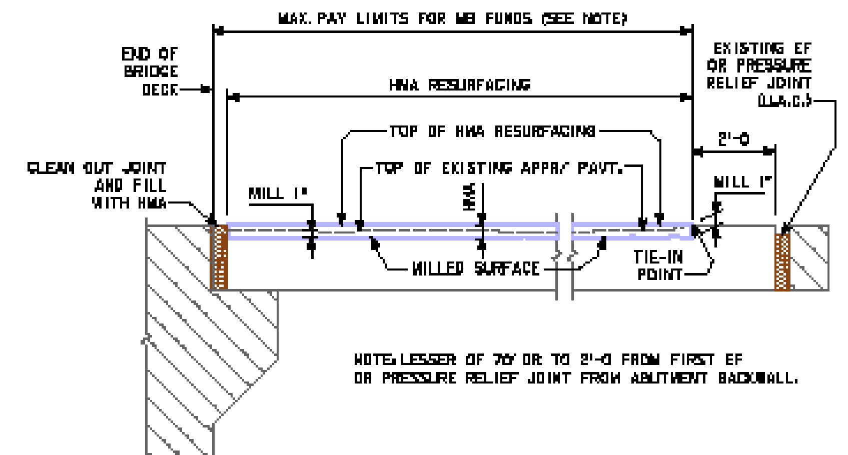
- HMA should not be placed against compressible joint materials.
- Maximum depth of milling shall be 1 inch except for case 3.
- Minimum thickness of new HMA is 1 inch.
- For bridges with a length of 200' or less with integral abutments where bridge approach pavement is dropped at the end of bridge, the expansion joint at end of bridge deck can be cleaned out and filled with HMA. This is not allowed for integral abutment bridges longer than 200' (See Case 3).
- Maximum limits for resurfacing bridge approach pavement with HMA is the lesser of 70' or to 2'-0 from first EF or pressure relief joint from end of bridge deck or face of backwall. This limit only applies to projects funded with MB money.
- Follow the details and notes on the included sketches.

Procedures:

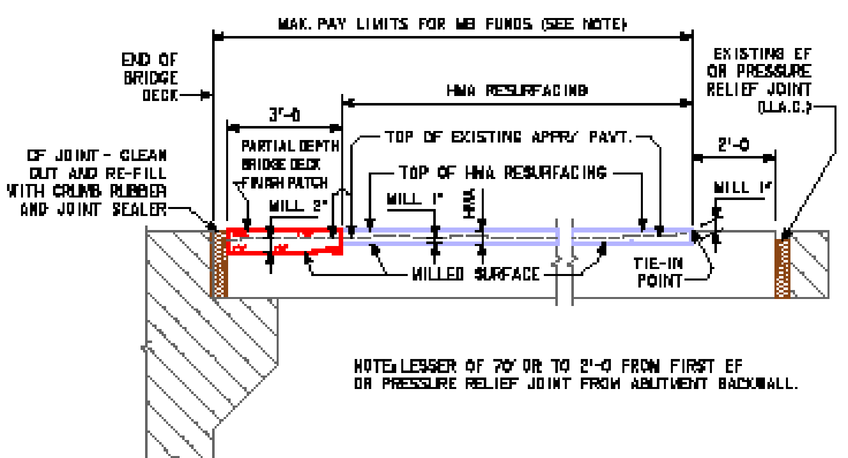
1. Establish traffic control operations on the bridge and approaches to ensure worker safety during maintenance activities.
2. Clean the CF or E joints of existing joint sealer, vegetation, dirt, and all foreign materials to the full depth of the joint. Either vacuum the prepared joint or provide a brush blast of oil-free compressed air to remove contaminants and debris from the joint prior to filling the joint. Ensure that the joint is dry before initializing sealing operations.
3. Mill the appropriate areas to a depth of 1” (See Case 3). Clean the milled surfaces using scrapers, air hoses, or brooms as necessary to ensure the base is free of foreign material at the time the HMA is placed.
4. Place "Partial Depth Bridge Deck Finish Patch" if required.
5. Place and compact the HMA resurfacing material.
6. Reopen lanes to traffic.



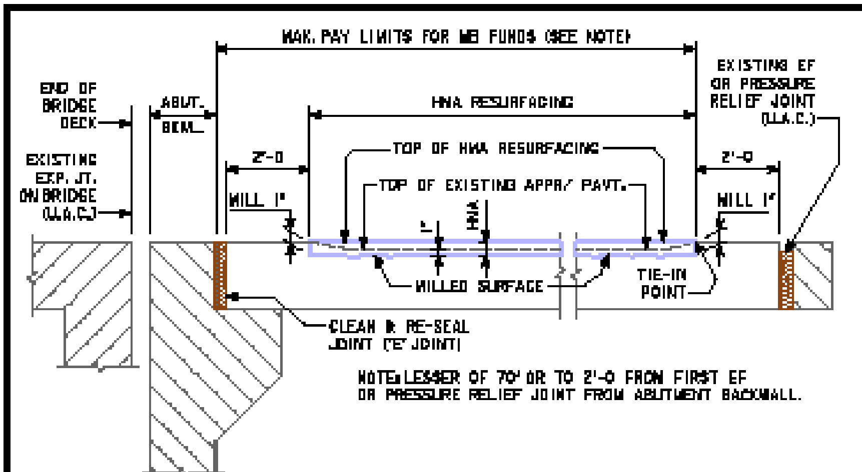
CASE 1
INTEGRAL ABUT., SLAB NOT DROPPED, ANY BRIDGE LENGTH



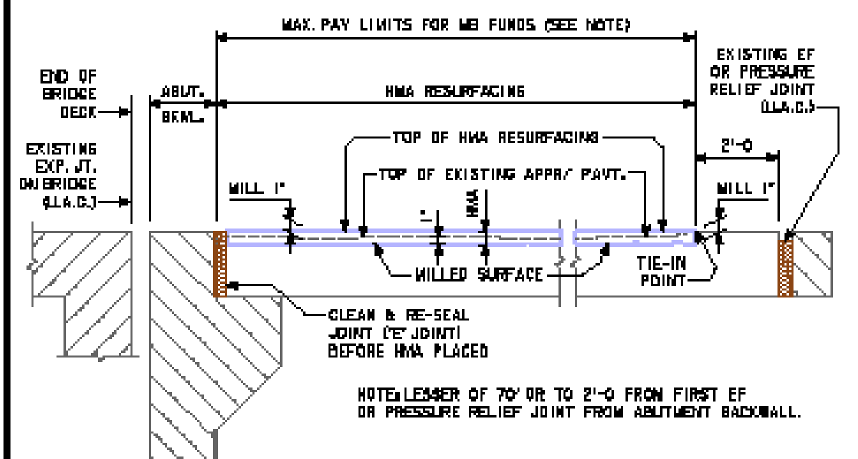
CASE 2
INTEGRAL ABUT., SLAB DROPPED, BRIDGE LENGTH ≤ 200'



CASE 3
INTEGRAL ABUT., SLAB DROPPED, BRIDGE LENGTH > 200'



CASE 2
STUB ABUT., SLAB NOT DROPPED, ANY BRIDGE LENGTH



CASE 5
STUB ABUT., SLAB DROPPED, ANY BRIDGE LENGTH

CHAPTER 9
CULVERTS

9.1 COMMON PROBLEMS AND CONSEQUENCES OF POOR MAINTENANCE

Culverts are subject to a number of common problems that can decrease the effectiveness of culverts for water passage as well as lead to premature failure of the culvert structures. This section of the manual primarily focusses on common problems for reinforced concrete box culverts.

One common problem is silting of the culvert. For normal flow conditions, velocities through a culvert are typically fairly low; therefore, it is not uncommon for silting of the culverts to occur. Debris and timber buildup at the entrance of the culvert can also decrease flow velocities, leading to silting. As culverts silt, their flow capacity is decreased. The determination of whether to remove silt from the bottom of a culvert is somewhat dependent on whether the resulting constriction of flow is causing issues with insurable structures upstream of the culvert. Generally, for multiple-cell box culverts, silt removal is performed if one of the barrels is approximately half full with silt.

Other common problems with concrete culverts include piping below the culvert floor or behind the culvert walls, and failure of floor and wall joints allowing infiltration/exfiltration of water through joints.

9.2 CULVERT MAINTENANCE AND REPAIR PROCEDURES

Functional maintenance procedures for culverts include removal of silt and debris to restore full flow capacity. Structural repairs of concrete culverts are generally focused on joint repair to prevent exfiltration of water through the joints, which can lead to piping behind the culvert walls and below the floor. Likewise, joint repair can prevent infiltration of water.

9.2.1 Repair Culvert Walls, Floors, and Joint Separations

General Considerations: By proactive repair of wall and floor surfaces as well as of open joints, additional problems related to piping along the outside of the culvert, infiltration of water through joints, and exfiltration of water through joints can also be controlled. Concrete repairs shall be performed according to the Standard Specifications, Article 2426 for Structural Concrete Repair.

Procedures – Repairing Culvert Wall and Floor Surface Spalls:

1. Remove unsound concrete from the damaged area of the culvert walls or floor, extending the limits of the damaged area until sound concrete is encountered. Limit jackhammer size to a nominal 30-pound class, and limit chipping hammer size to 15-pound class.
2. Using a chop saw, provide a 0.75-inch-deep saw cut around the perimeter of the damaged area to square up the repair area and eliminate feathered edges. Jackhammer or use hand tools as needed to extend removals to the saw cut lines.
3. Clean or remove corroded reinforcing steel. If needed, replace damaged reinforcing steel with new bars and securely tie new reinforcing steel into place.
4. Clean the repair area by sandblasting. Follow with an air blast of oil-free compressed air.
5. For shallow repairs (0.75 to 1.5 inches deep where no form work is used to support the patching material), first apply a bonding grout conforming to the Standard Specifications, Article 2426.02.B.1; ensure that the repair area is dry before placing the grout. Concrete for shallow

repairs shall conform with the Standard Specifications, Table 2426.02-1. Place concrete before the grout dries out. For shallow wall repair areas where the patching material cannot support itself, forms may be needed, and in these areas, no bonding grout is required.

6. For regular wall repairs areas (a minimum depth of 1.5 inches or 0.75 inch behind an unbounded reinforcing bar and where form work is used), no bonding grout is required. Use a Class O concrete mix for repair concrete. Concrete slump should be 3 inches, +/- 1 inch. Ensure that the concrete surface is dry before placing new concrete (Standard Specifications, Article 2403.03I.1). When repairing a vertical face, place the patch material in heights not to exceed 4 feet; provide access ports in the forms at 4-foot intervals for concrete placement and vibration.
7. Apply a white pigmented curing compound to the concrete immediately following concrete finishing or removing forms. The application rate shall be 100 square feet per gallon.

Procedures – Filling Voids Behind Culvert Walls or Below Culvert Floor:

Note: The procedures below provide for filling voids through holes drilled from within the culvert. For culverts with minimal fill, an alternative for filling voids behind culvert walls or near the top of a culvert may instead incorporate coring holes in the pavement over a culvert and filling the voids with flowable fill placed from above. Use similar methods for sounding the pavement to locate the voids and delineate the limits of the voids.

1. Determine the location of the void by sounding the floor or wall with a sounding rod, hammer, or chain drag. Where the hollow sound is most pronounced, which generally corresponds with the deepest area of the void, provide an initial 6-inch diameter core hole in the floor or wall and probe the void to determine its approximate depth. Use a sounding hammer to identify and mark the perimeter limits of the void.
2. Provide additional 6-inch-diameter core holes in the floor or wall in the vicinity of the void. Spacing of core holes should be approximately equal to one-half the depth of the void.
3. Fill void with flowable fill mortar with a maximum compressive strength of 50 psi. For voids behind walls, work from the lowest access hole to the highest, temporarily plugging the holes as the void is filled.
4. Patch core holes with Class O concrete.

Procedures – Repairing Culvert Wall and Floor Joints:

1. Where concrete surfaces adjacent to the joint are deteriorated, use hand tools as needed to remove unsound concrete. Shape the surfaces on each side of the joint in a V-groove sufficient to reach sound concrete.
2. Clean the repair area by sandblasting. Blow out the joint and the holes for wedge anchors with oil-free compressed air.
3. Tuck point the prepared joint with hydraulic cement.
4. If splice plates are to be used, position the splice plates and install and tighten the wedge anchors.

9.2.2 Remove Silt

General Considerations: Siltation typically occurs when the downstream channel aggrades or when the width of the culvert exceeds the natural channel width.

When the downstream channel aggrades this creates a silted-in barrel(s) due to natural accretion of deposits in the natural channel. Excavating the sediment within Right-of-Way will not improve the hydraulics of the culvert unless the downstream channel can be excavated to provide positive drainage.

When the culvert is wider than the natural channel, this creates a silted-in barrel(s) due to the natural geometry of the channel and banks causing accumulation of sediment in one or more barrels to replicate the natural channel width.

Cleaning out culverts involves considerable equipment, manpower, and experience. For larger concrete box culverts and larger multi-cell box culverts, silt removal using a skid loader may be the most cost effective methodology.

If a barrel is half full, the situation should be reviewed by a hydraulics engineer before removal of silt is scheduled.

Procedures:

1. Remove timber debris, vegetation, and large rocks or revetment from the entrances of concrete box culverts to allow for improved access.
2. For large concrete box culverts, use a skid loader to remove excess silt from the bottom of the box culvert.
3. For smaller culverts, use hand tools or high pressure water to remove excess silt from the bottom of culverts.

CHAPTER 10
MISCELLANEOUS BRIDGE AND STRUCTURE MAINTENANCE

10.1 MISCELLANEOUS MAINTENANCE AND REPAIR PROCEDURES

The following procedures address bridge maintenance and repairs that are not otherwise addressed in this manual.

10.1.1 Monitor Various Bridge Elements as per Bridge Inspection Reports

Bridge Inspection Reports typically list general maintenance and repair items that should be addressed by maintenance staff. Such items could be as simple as replacing missing or damaged load posting and lateral delineator signs or they could be more complex maintenance and repair recommendations. Often, the bridge inspector may encounter a condition that requires occasional monitoring by maintenance staff. For example, if it is suspected that a pier or substructure component is tilting or leaning, the bridge inspector may recommend survey monitoring of the pier or substructure element over time to monitor the movement. Likewise, erosion of bridge berms or stream banks may not pose an immediate concern, but continued stream migration or erosion could eventually undermine a substructure component and require periodic monitoring. The Bridge Inspection Report may specifically call for monitoring of a particular condition by local bridge maintenance staff. Alternatively, the recommendation may call for Special Inspections that are scheduled at intervals more frequently than the biennially scheduled Routine inspections to ensure consistent monitoring of the identified condition.

10.1.2 Repair/Replace Concrete or Macadam Stone Slope Protection

General Considerations: Excessive drainage runoff or misdirected roadway drainage could cause undermining of concrete slope protection or failure of Macadam stone slope protection. Left unattended, this deterioration of the area in front of the bridge abutments could lead to undermining of the abutments. Additionally, by not proactively addressing these slope protection failures, the extent of the damage could quickly increase, thus requiring more extensive and costly repairs.

For concrete slope protection, early attention to the failure may require replacing only a single panel of concrete slope protection. Or, if the panel has not yet cracked and collapsed, placement of flowable fill below the concrete slope protection could prevent failure of the slope protection altogether. For more extensive damage, simply rubblizing the damaged concrete slope protection may be the simplest and most cost effective solution. Procedures are provided below for filling voids below concrete slope protection, replacing individual panels of concrete slope protection, and repairing Macadam stone slope protection.

Procedures – Filling Large Voids Below Concrete Slope Protection:

1. Establish traffic control operations for the route under the affected bridge to ensure worker and motorist safety during maintenance activities.
2. Core a hole in the concrete slope protection at the suspected void location to determine the limits and depth of the void. Once the limits are determined, core additional holes at spacings equal to approximately one-half the depth of the void.
3. Fill the void through the core holes with sand to within 1 foot of the bottom of the concrete slope protection.

4. Top-off the sand-filled void to the bottom of the concrete slope protection with flowable fill mortar with a maximum compressive strength of 50 psi.
5. Patch core holes in concrete slope protection with Class O concrete.

Procedures – Replacing Panels of Concrete Slope Protection:

1. Establish traffic control operations for the route under the affected bridge to ensure worker and motorist safety during maintenance activities.
2. Saw cut the full depth through the existing concrete slope protection and remove the damaged panel(s) of slope protection.
3. Blow sand into any voids found under sections of the concrete panels that remain. Backfill voids in the area of concrete panels that were removed using granular subbase material. Dampen, vibrate, and screed the granular subbase to provide a uniform bedding for new concrete slope protection panels.
4. Cast replacement panels for concrete slope protection. Finish the panels to match the existing slope protection and cure the concrete panels in accordance with the Standard Specifications.
5. Seal the joints around the new panels with an approved sealer.

Procedures – Repairing/Replacing Macadam Stone Slope Protection:

1. Establish traffic control operations for the route under the affected bridge to ensure worker and motorist safety during maintenance activities.
2. Remove and stockpile Macadam stone from areas affected by slope failure or erosion. Extend Macadam stone removal to a distance of 18 inches beyond the eroded area.
3. Backfill eroded areas with Class 10 borrow material and fill to match the bottom of the existing perimeter Macadam stone.
4. Place engineering fabric over the backfilled area. Lap 12 inches with existing engineering fabric and stake into place.
5. If necessary, reestablish edges of Macadam stone slope protection with 4-inch by 6-inch treated timber edging in accordance with Standard Bridge Plan 1006C or 1006D.
6. Reinstall stockpiled Macadam stone in repaired area.

10.1.3 Install Rip Rap Revetment or Gabions

General Considerations: Where bridges over streams are experiencing erosion or slumping of the streambanks adjacent to the bridge, countermeasures such as rip rap revetment or stone-filled gabions may be needed to help prevent further channel deterioration. In some cases, adding revetment to the top of the existing stream bank could further restrict the channel and cause unintended backwater impacts upstream of the bridge. In these cases, the existing channel slope may need to be excavated to allow for the added volume to be occupied by the revetment. However, if the streambanks have already eroded, the additional channel protection would likely just replace soil material that has already been scoured away.

An engineer should be consulted to determine the extent of the repair area as well as the size of the revetment or gabions.

Procedures – Installing Rip Rap Revetment:

1. If necessary, remove the top 2 feet of soil in the repair area to compensate for the added volume of revetment.
2. Grade the streambank in the repair area to remove erosion holes, provide a stable slope, and tie the grades into the natural contours.
3. Install a layer of engineering fabric on top of the prepared slope, and turn down the ends and edges of the engineering fabric, burying the ends a minimum of 1 foot into the ground.
4. Uniformly spread erosion stone or properly sized revetment materials for a minimum depth of 2 feet over engineering fabric. Take care to avoid tearing or puncturing the engineering fabric.
5. Seed and repair disturbed areas of streambanks that are not treated with revetment in accordance with the Standard Specifications, Section 2601.

Procedures – Installing Gabions:

1. Excavate and smooth the area as necessary for proper placement of gabions. Add special backfill as required and compact the prepared surface to support the gabions.
2. Place engineering fabric in vertical strips behind the gabion baskets. Lap strips a minimum of 3 inches.
3. Assemble the baskets into rectangular shapes, weaving the base, lid, and sides into single units. Carefully place the baskets into their proper position. Slope the front faces of the baskets at a slope of 1(horizontal) to 6 (vertical).
4. Securely connect adjacent baskets at vertical corner edges and diaphragms. Stacked gabion baskets are to be connected at the horizontal edges, front and back.
5. Carefully fill baskets with properly sized revetment stone. Although machine placement is allowed, considerable handwork is necessary to orient stones for maximum density without bulges and to achieve maximum aggregate contact with the lid and other adjoining baskets. For gabions 3 feet high, place stone in three 1-foot lifts, orienting stones as necessary for each lift.
6. Fasten lids in place at edges and at diaphragms.
7. Upon completion of the gabion structure, complete earthwork; seed and repair disturbed areas of streambanks that are not treated with gabions in accordance with the Standard Specifications, Section 2601.