Figure 16.2.18 Vertical Lift Bridge with Power and Drive System on Towers

16.2.5 Special Elements Common to All Movable Bridges

Give particular attention to the special elements found in swing bridges, bascule bridges, and vertical lift bridges during inspection. These elements are commonly found on all types of movable bridges:

- Open Gearing
- Speed Reducers Including Differentials
- Shafts and Couplings
- Bearings
- Brakes
- Drives
- Air Buffers and Shock Absorbers
- Span Locks
- Counterweights
- Live Load shoes and Strike Plates
- Traffic Barriers

Open Gearing

Open gearing is used to transmit power from one shaft to another and to alter the speed and torque output of the machinery. Beveled gears are also used to change direction (see Figure 16.2.19).

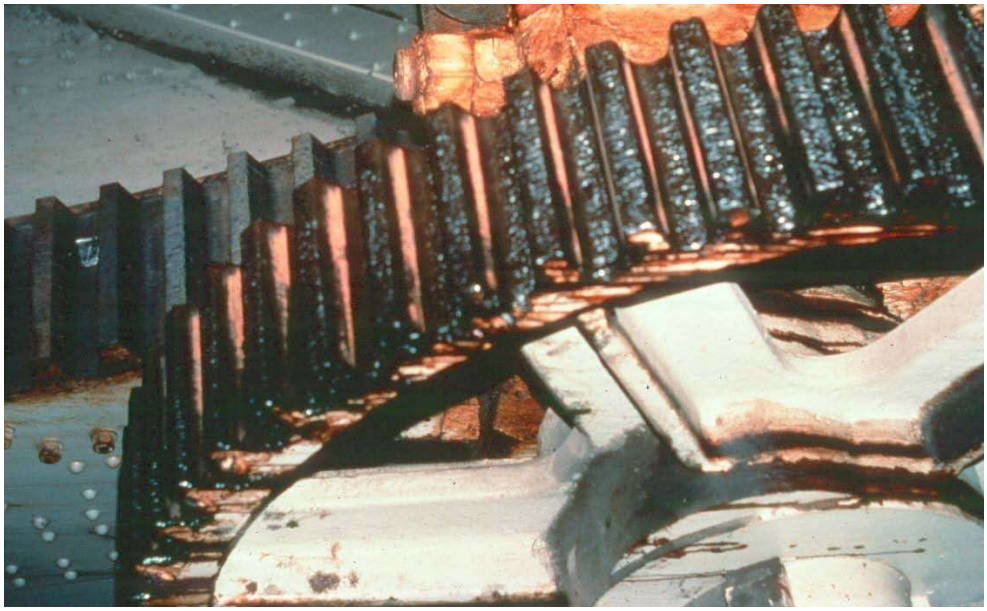


Figure 16.2.19 Open Gearing

Speed Reducers Including Differentials

Speed reducers including differentials serve the same function as open gearing (see Figure 16.2.20). However, they may contain several gear sets, bearings, and shafts to provide a compact packaged unit, which protects its own mechanical elements and lubrication system with an enclosed housing. Differential speed reducers also function to equalize torque and speed from one side of the mechanical operating system to the other.

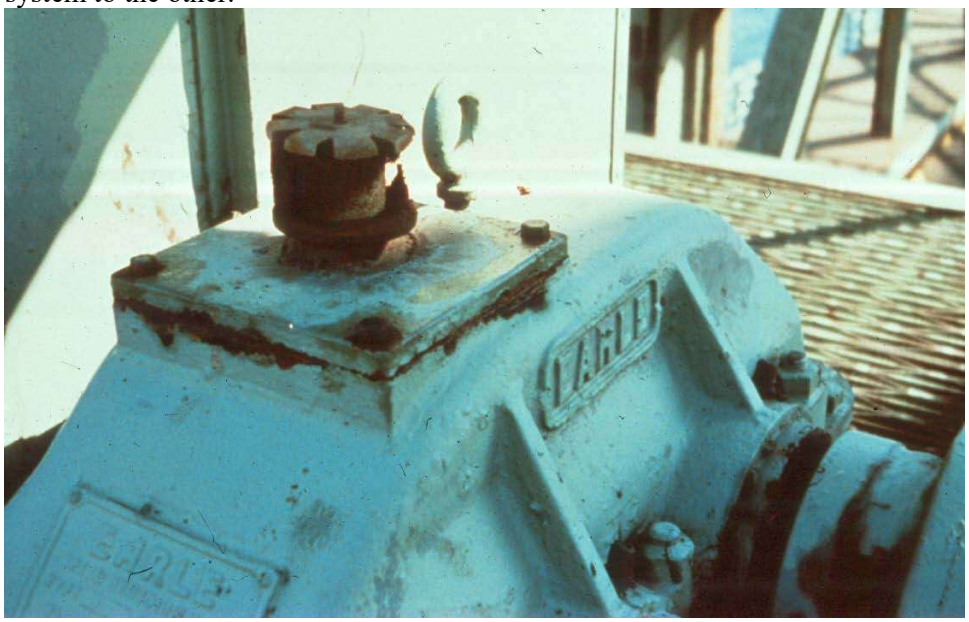


Figure 16.2.20 Speed Reducer

Shafts and Couplings

Shafts transmit mechanical power from one part of the machinery system to another. Couplings transmit power between the ends of shafts in line with one another, and several types can be used to compensate for slight imperfections in alignment between the shafts (see Figure 16.2.21).

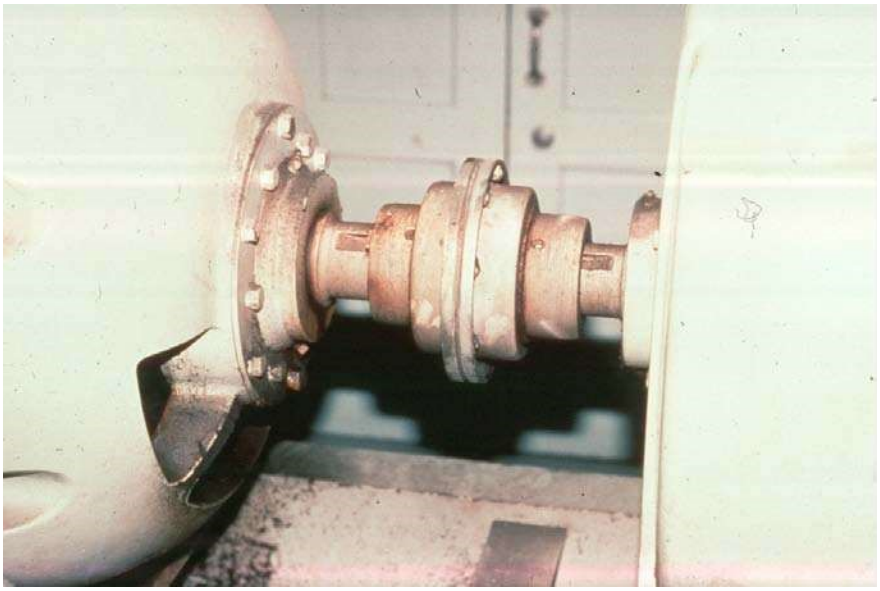


Figure 16.2.21 Coupling

Bearings

Bearings provide support and prevent misalignment of rotating shafts, trunnions, and pins (see Figure 16.2.22).

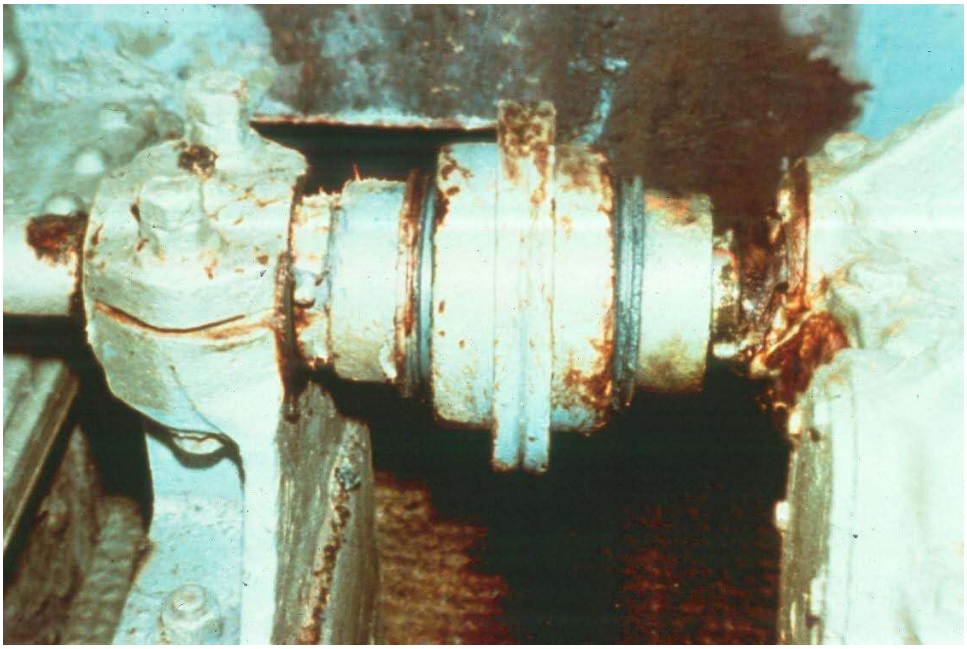


Figure 16.2.22 Bearing

Brakes

Brakes can be of either the shoe type or disc type, and can be released manually, electrically, or hydraulically (see Figures 16.2.23 and 16.2.24). They are generally spring applied for fail safe operation. Motor brakes are located close to the drive to provide dynamic braking capacity, except that some types of drives can provide their own braking capability, thereby eliminating the need for separate motor brakes. Machinery brakes are located closer to the operating interface between movable and fixed parts of the bridge and are used to hold the span statically, in addition to serving as emergency brakes in many cases. Supplemental emergency brakes are sometimes also provided.

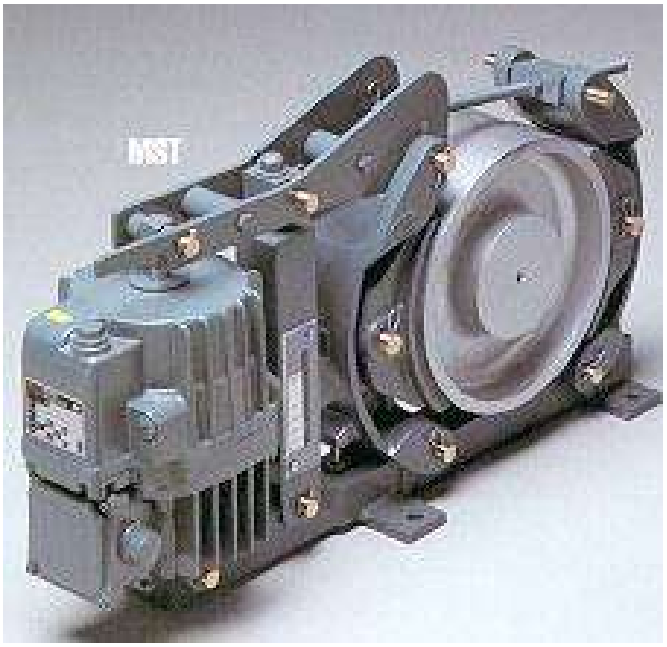


Figure 16.2.23 Shoe Type Break

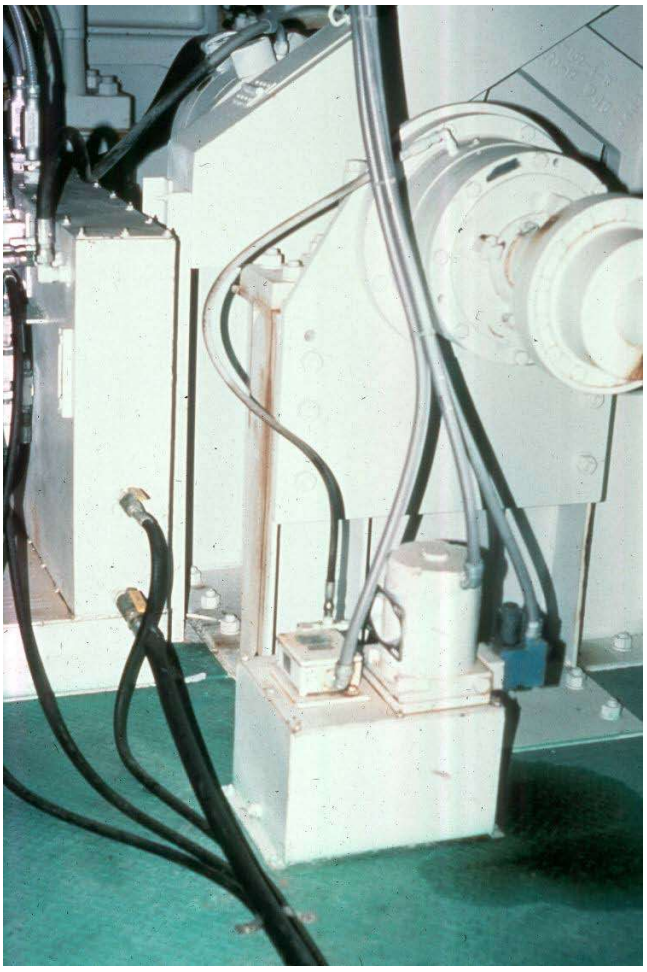


Figure 16.2.24 Spring Set Hydraulically Released Disc Break

Drives

Drives can consist of electric motors, hydraulic equipment, or auxiliary drives.

For electric motors, either AC or DC power may be used. AC power is often used to power wound rotor motors with torque controllers on older bridges, while new bridges may utilize squirrel cage induction motors with adjustable frequency speed control. DC motors can also provide speed control.

For hydraulic equipment, prime movers may include either large actuating cylinders or hydraulic motors (see Figure 16.2.25). Either type of drive must be supplied with pressure to provide force and fluid flow to provide speed to the operating system. Electrically operated hydraulic power units consisting of a reservoir and pump, with controls, provide power to the operating systems.

For auxiliary drives, emergency generators are provided to serve in the event of power failure. Auxiliary motors and hand operators, with their clutches and other mechanical power transmission components, are provided to serve in the event the main drive fails (see Figure 16.2.26). In some cases, to prevent the need for larger auxiliary generators, the auxiliary motors are required for use any time the auxiliary generators are used, requiring increased time of operation.

Figure 16.2.25 Low Speed High Torque Hydraulic Motor

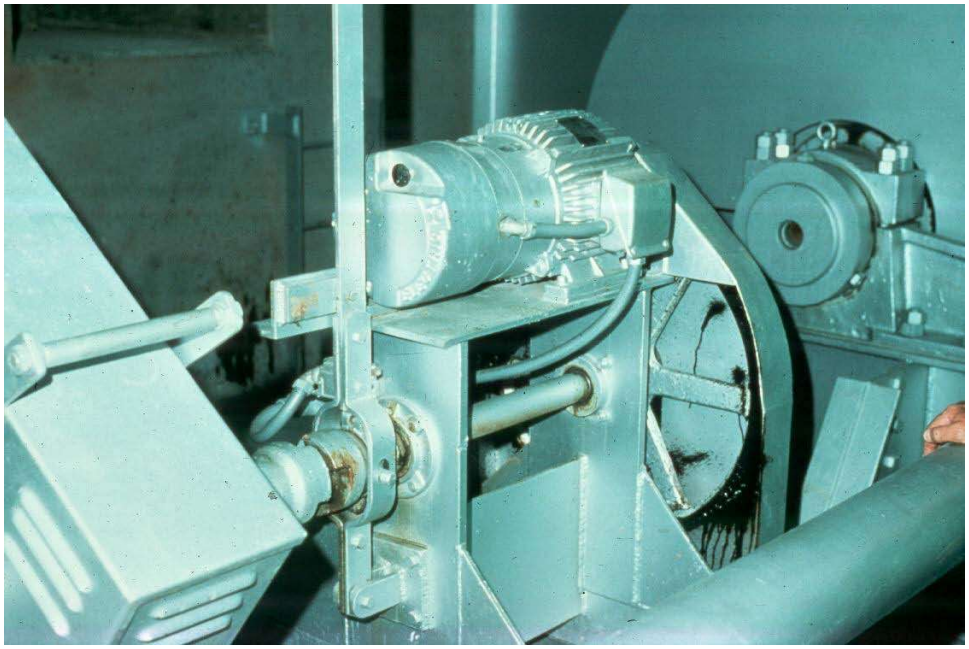


Figure 16.2.26 AC Emergency Motor

Air Buffers and Shock Absorbers

Air buffers and shock absorbers are located between the span and the pier at points where impact may occur between the two (see Figures 16.2.27 and 16.2.28). A cross section of the buffer shows the air chamber and seals on the piston. As the span lowers, the rod is pushed in, causing the air inside to be compressed (see Figure 16.2.29). A pressure relief valve allows the air to escape beyond the pressure setting. Forces are required to build-up and keep the pressure of the air at the movement of the span for a "soft" touchdown on the bearings. Shock absorbers provide the same purpose as the air buffers. However, they are completely self-contained and, therefore, require very little maintenance.

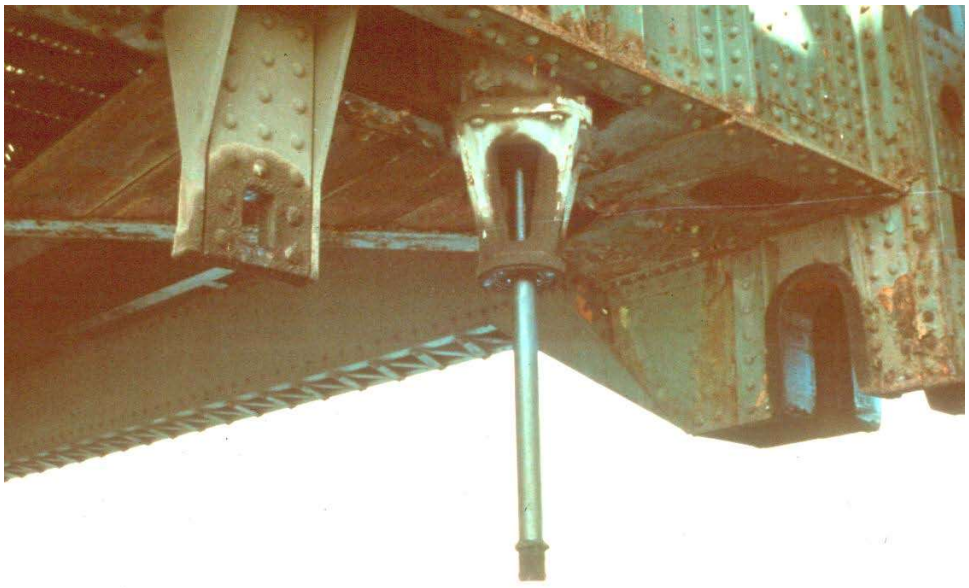


Figure 16.2.27 Air Buffer

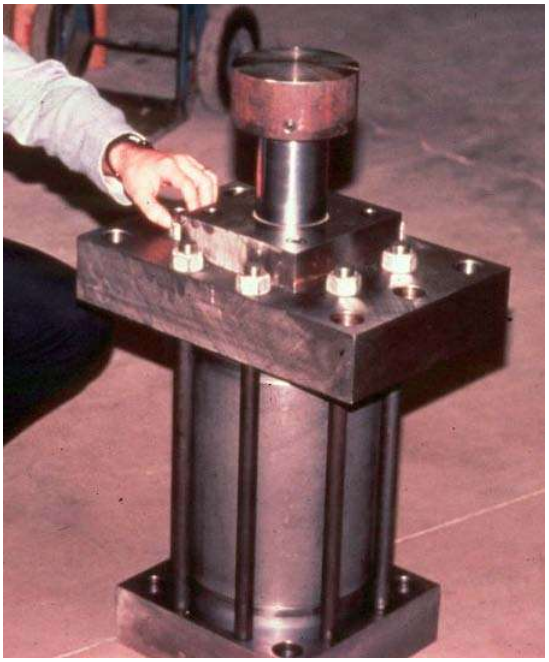


Figure 16.2.28 Shock Absorber

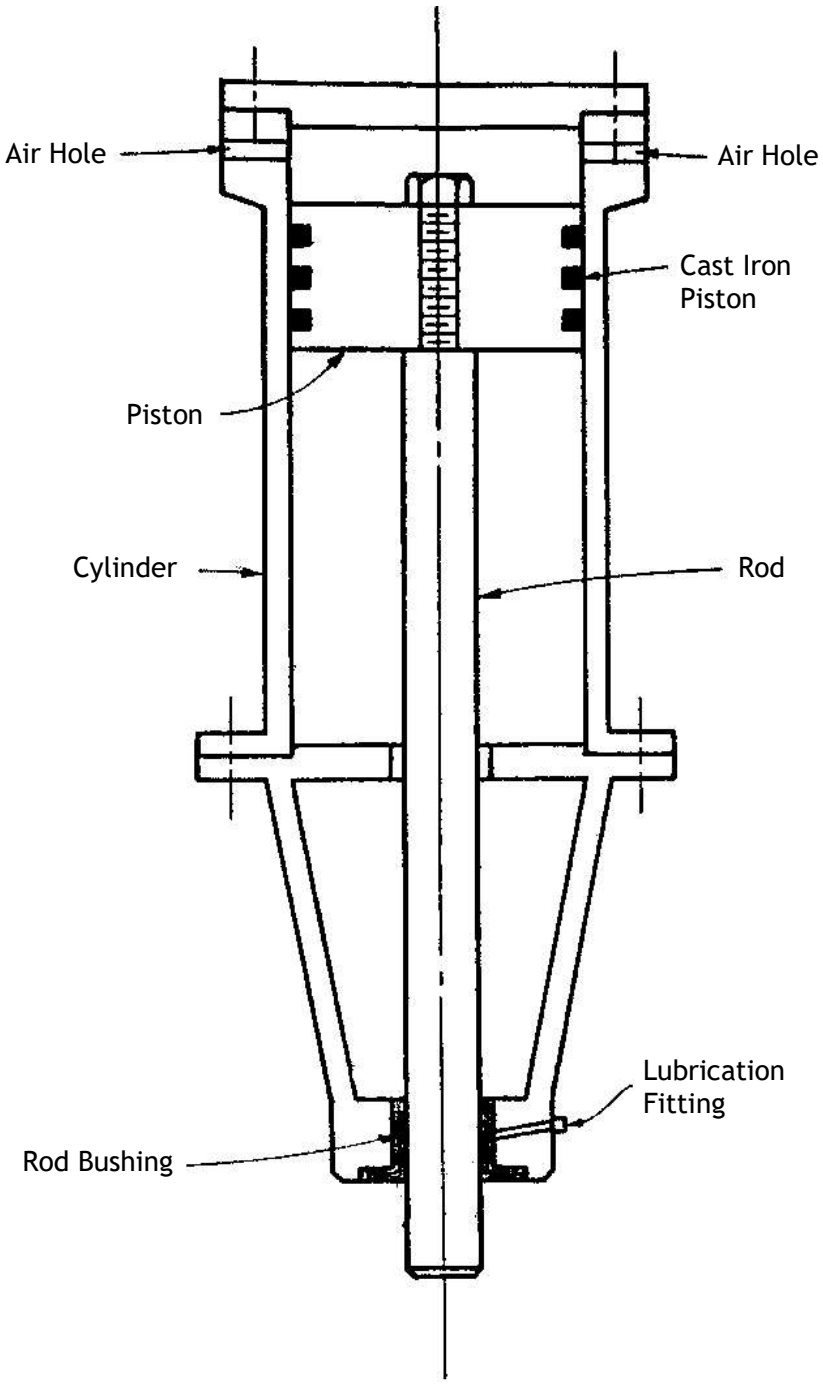


Figure 16.2.29 Typical Air Buffer Schematic

Span Locks

Span lock bars at the end of the span are driven when the span is fully closed to prevent movement under live load. Span locks may also be provided at other locations on the span to hold the span in an open position against strong winds or to prevent movement from an intermediate position. They can be driven either mechanically or hydraulically (see Figures 16.2.30 and 16.2.31).

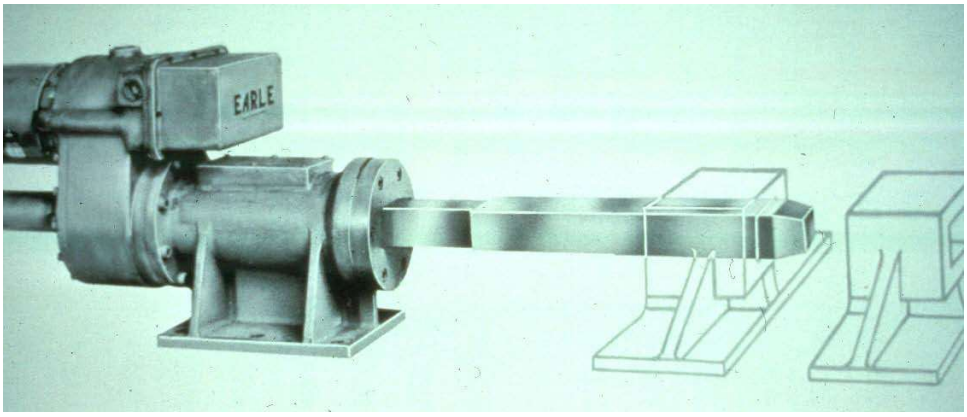


Figure 16.2.30 Typical Mechanically Operated Span Lock

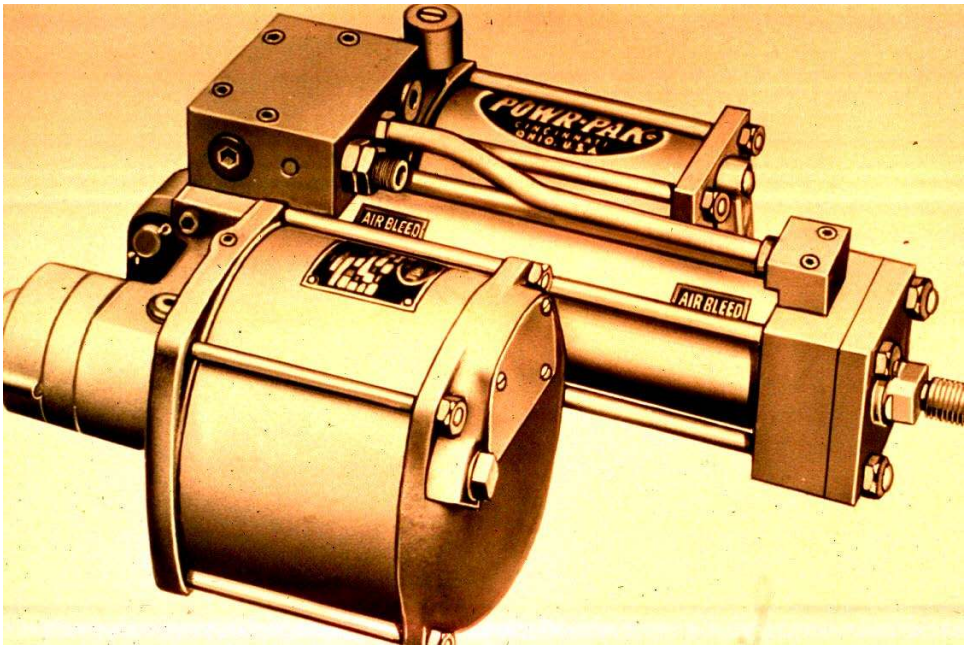


Figure 16.2.31 Hydraulic Cylinder that Drives Lock Bars

Counterweights

Adjustable quantities of counterweight blocks are provided in addition to the permanent counterweight, which is part of the structure so that adjustments may be made from time to time due to changes in conditions (see Figures 16.2.32 and 16.2.33). A movable span is designed to function in a balanced condition, and serious unbalanced conditions will cause overstress or even failure of the mechanical or structural elements.

Figure 16.2.32 Concrete Counterweight on a Single-Leaf Bascule Bridge

Figure 16.2.33 Concrete Counterweight on a Vertical Lift Bridge

Live Load Shoes and Strike Plates

Live load shoes and strike plates between the movable and fixed portions of the bridge are designed to bear most or all of the live load when the bridge is carrying traffic (see Figure 16.2.34).

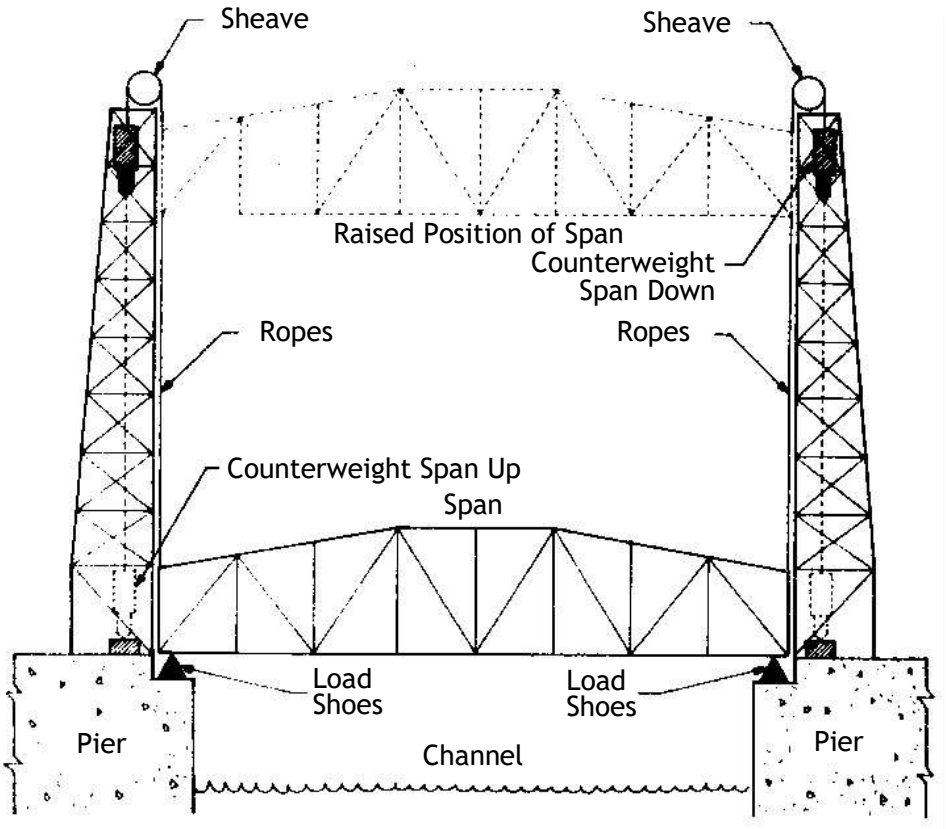


Figure 16.2.34 Closed Span Resting on Live Load Shoes

Traffic Barriers

Traffic barriers are heavy-duty movable gates or posts that are designed to prevent a vehicle from plunging from the roadway into the draw or into the pit below the bridge (see Figure 16.2.35. Their operation is important for public safety. They are used mainly in situations where a large opening exists between the approach span and the movable span when it is open.

Figure 16.2.35 Traffic Barrier

16.2.6 Swing Bridge Special Elements

Swing bridges are designed utilizing the following special elements:

- Pivot Bearings
- Balance Wheels
- Rim-Bearing Rollers
- Wedges
- End Latches

Pivot Bearings

In center-bearing types (with balance wheels), the axially loaded thrust bearing is usually composed of spherical discs, attached to top and bottom bases, enclosed in an oil box to provide lubrication and prevent contamination (see Figure 16.2.36). In rim-bearing types, the pivot bearing is also enclosed but will be radial loaded, maintaining the position of the pivot shaft or king pin.

Figure 16.2.36 Center Pivot Bearing

Balance Wheels

On center-bearing types only, non-tapered balance wheels bear on the circular rail concentric to the pivot bearing only when the span is subjected to unbalanced loading conditions (see Figure 16.2.37). At other times, when the span is not subjected to unbalanced loads, a gap will be present between each wheel and the rail.

Figure 16.2.37 Balance Wheel in-place over Circular Rack

Rim-Bearing Rollers

Usually tapered to allow for the differential rolling distance between the inside and outside circumferences of the rail circle, rim-bearing rollers usually bear at all times.

Wedges

End wedges are used to raise the ends of the span and support live load under traffic (see Figure 16.2.38). The end wedge bearings are under all four corners of the span. Center wedges are used to stabilize the center of the span and to prevent the center bearing from supporting live load. Wedges may be actuated by machinery and linkage, which connects wedges to actuate together or each wedge may have its own actuator (see Figure 16.2.39).

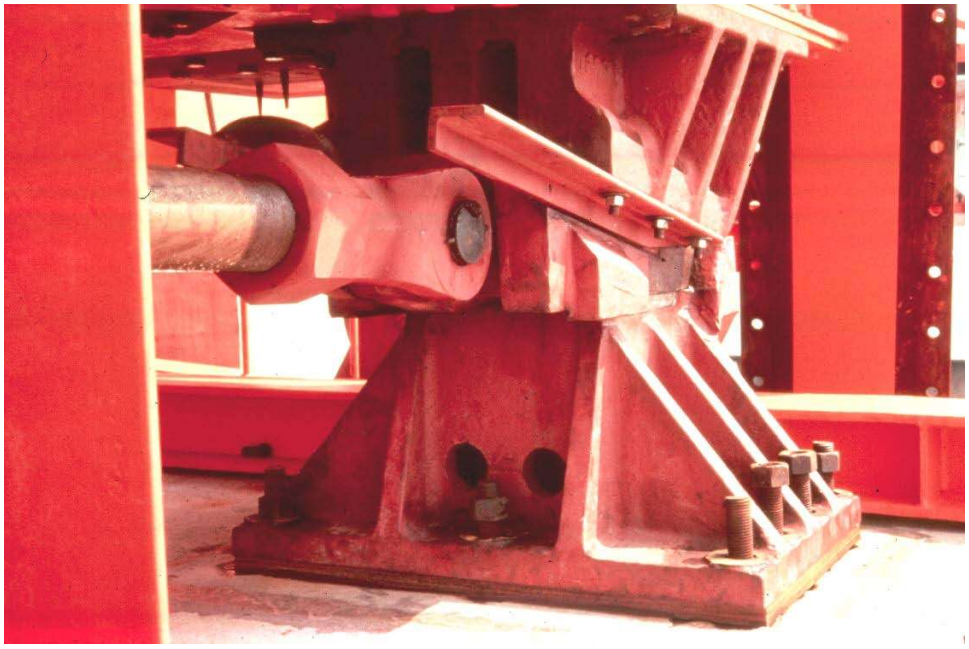


Figure 16.2.38 End Wedge

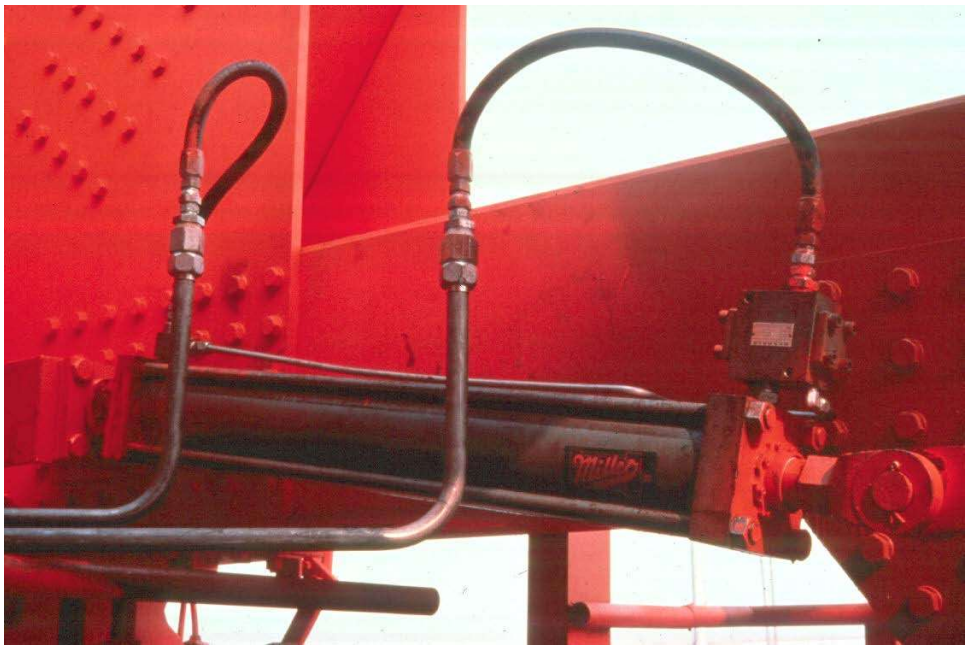


Figure 16.2.39 Hydraulic Cylinder Actuator

End Latches

Located at the center of one or both rest piers, end latches generally consist of a guided tongue with roller mounted on the movable span that occupies a pocket mounted on the rest pier when the span is in the closed position. To open the span, the tongue is lifted until it clears the pocket at the time the wedges are withdrawn (see Figure 16.2.40). As the span is swung open, the latch tongue is allowed to lower or fall into a position in which the roller may follow along a rail or track mounted on the pier. When closing, the tongue rolls along the rail or track and up a ramp which leads to the end latch pocket where the tongue is allowed to drop to center the span.

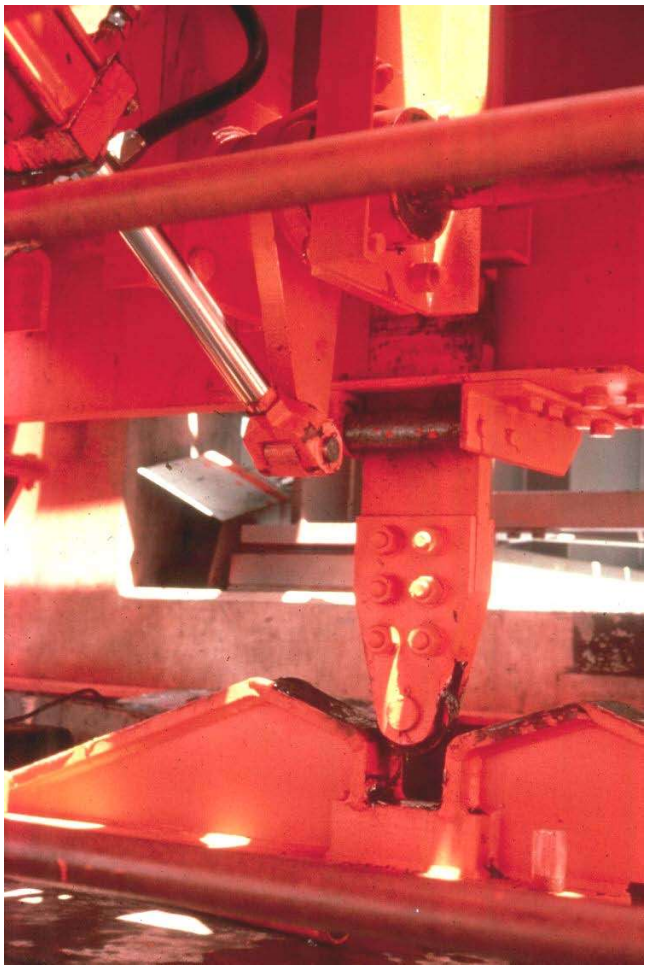


Figure 16.2.40 End Wedges Withdrawn and End Latch Lifted

16.2.7 Bascule Bridge Special Elements

Bascule bridges utilize the following elements specific to their design:

- Rolling Lift Tread and Track Castings
- Racks and Pinions
- Trunnions and Trunnion Bearings
- Hopkins Frame
- Tail (Rear) Locks
- Center Locks
- Transverse Locks

Rolling Lift Tread and Track Castings

Rolling lift tread and track castings are rolling surfaces which support the bascule leaves as they roll open or closed (see Figure 16.2.41). Tread sockets and track teeth prevent transverse and lateral movement of the span due to unbalanced conditions, such as wind, during operation and especially when held in the open position.

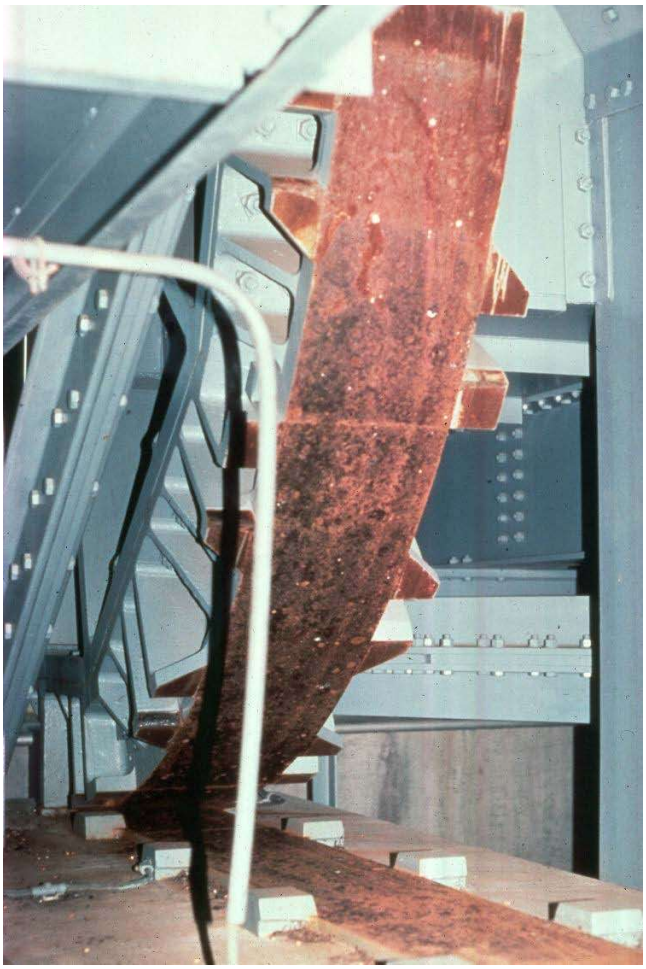


Figure 16.2.41 Circular Lift Tread and Track Castings

Racks and Pinions

In the rolling lift rack and pinion, the driving pinion engages the rack teeth at the centerline of the roll (see Figure 16.2.42).

In the trunnion rack and pinion, the circular rack castings are attached in the plane of the truss (or girder) in front of the counterweight (see Figures 16.2.43 and 16.2.44).

The drive pinions are overhung in order to engage the rack teeth. A cover is placed over the pinions for safety and to keep debris from falling on it.

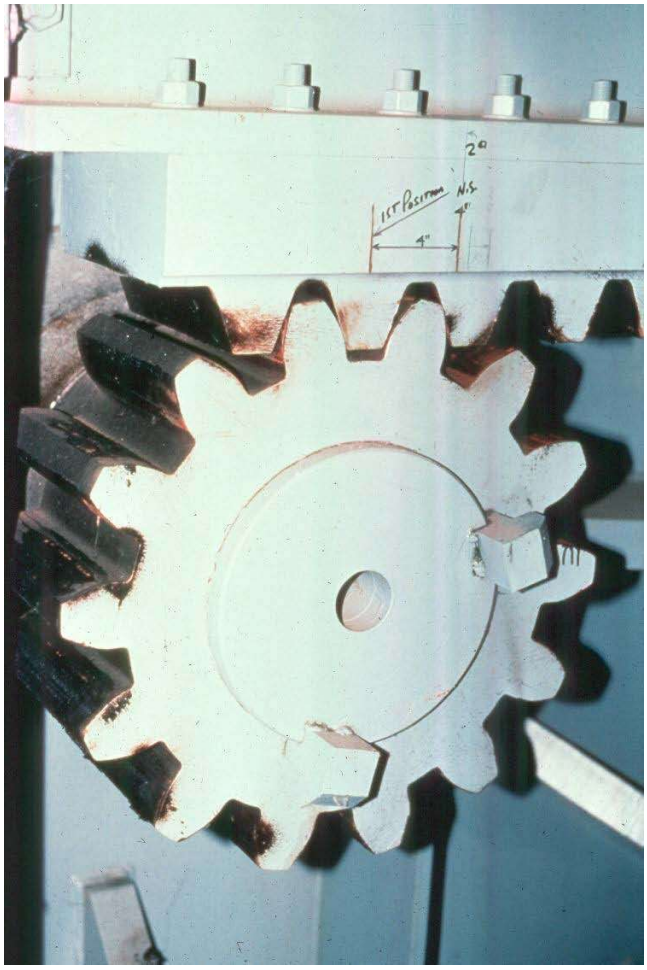


Figure 16.2.42 Rack Casting and Pinion

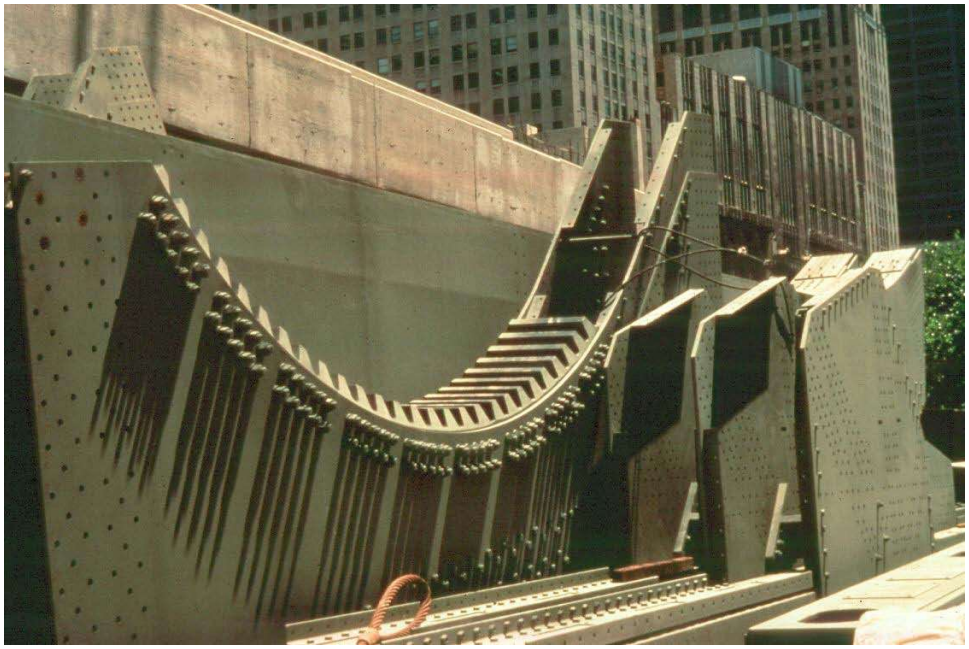


Figure 16.2.43 Rack Casting Ready for Fabrication

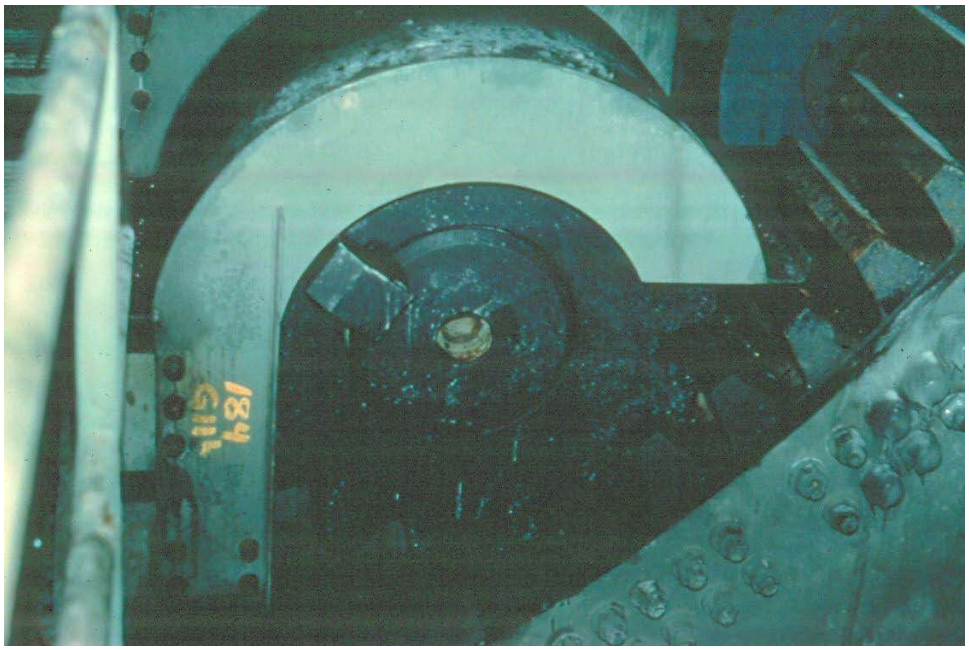


Figure 16.2.44 Drive Pinion

Trunnions and Trunnion Bearings

Trunnions and trunnion bearings (see Figure 16.2.45) are large pivot pins or shafts. Their bearings support the leaf as it rotates during operation as well as supporting dead load when the bridge is closed. Some designs require the trunnions to carry live load in addition to dead load (see Figure 16.2.46).

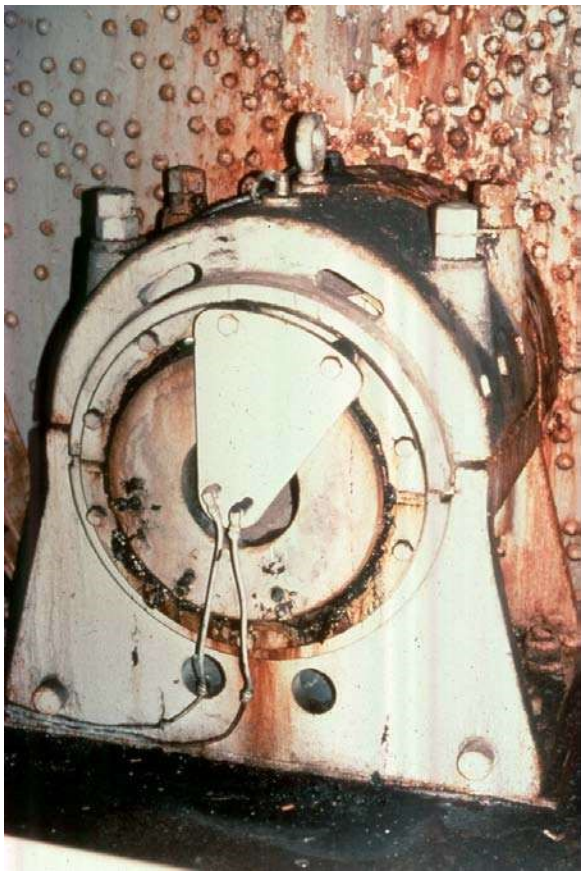


Figure 16.2.45 Trunnion Bearing

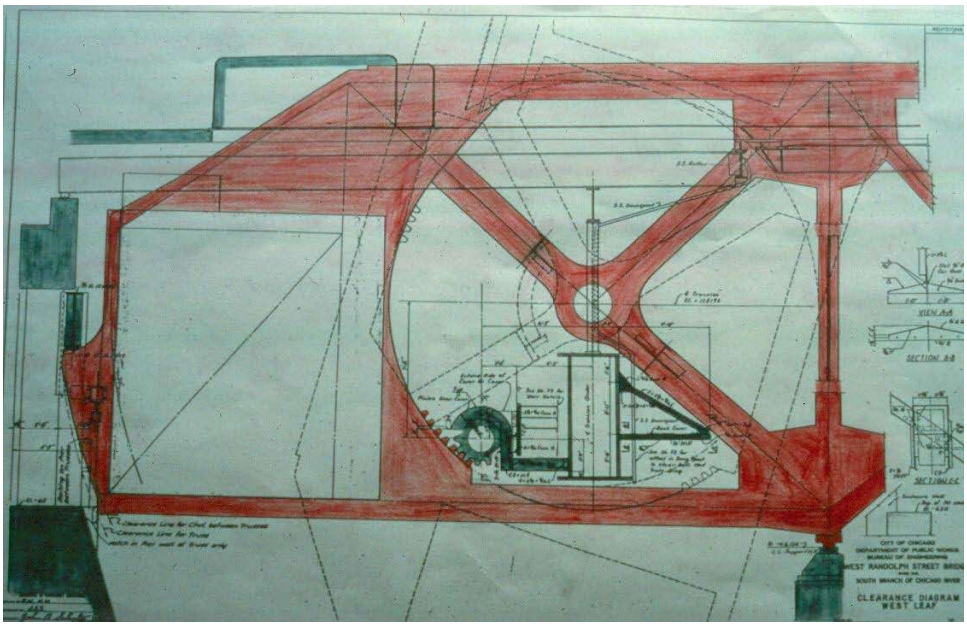


Figure 16.2.46 Trunnion Design Drawing

Hopkins Frame

A Hopkins frame machinery arrangement is provided on some trunnion bascule bridges. The main drive pinion locations are established in relationship to their circular racks by a pivot point on the pier and pinned links attached to the trunnions.

Tail (Rear) Locks

Located at the rear of the bascule girder on the pier, tail locks prevent inadvertent opening of the span under traffic or under a counterweight-heavy condition if the brakes fail or are released (see Figure 16.2.47).

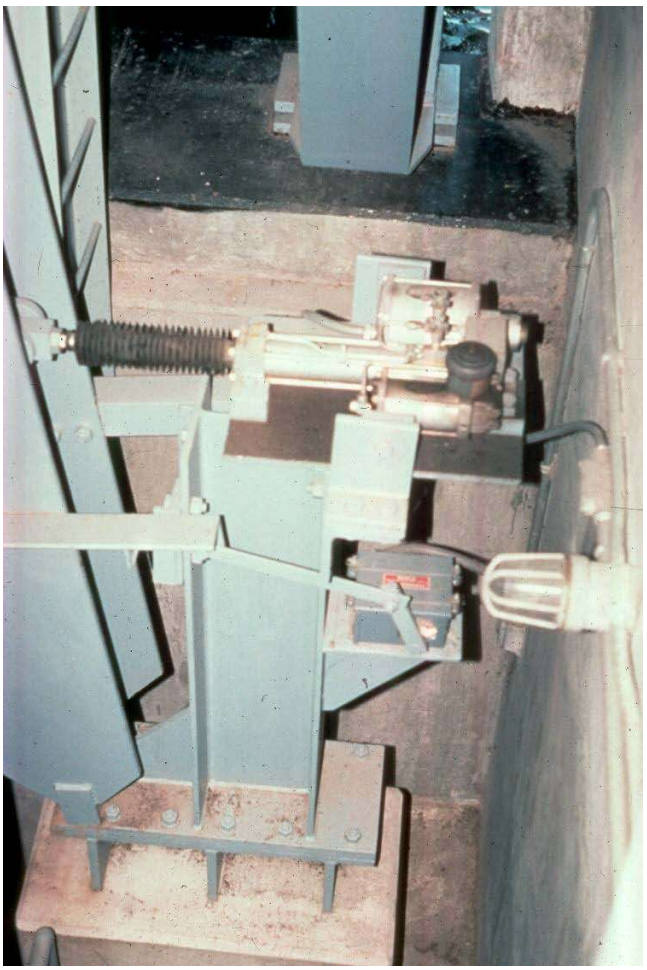


Figure 16.2.47 Rear Lock Assembly

Center Locks

Center locks are provided to transfer shear load from one leaf to the other when the bridge is under traffic. Center locks may consist of a driven bar or jaw from one leaf engaging a socket on the other leaf, or may be a meshing fixed jaw and diaphragm arrangement with no moving parts (see Figure 16.2.48).

The superstructure acts as a cantilever when opening and closing the bridge with the maximum negative moment near the supporting piers and zero moment at the ends of the cantilever. Once the bridge is lowered into position, center locks are engaged. These locking mechanisms are designed to transmit shear necessary to produce equal deflections at mid point under unbalanced transient loads. These center locks are not normally designed to carry superstructure moment.

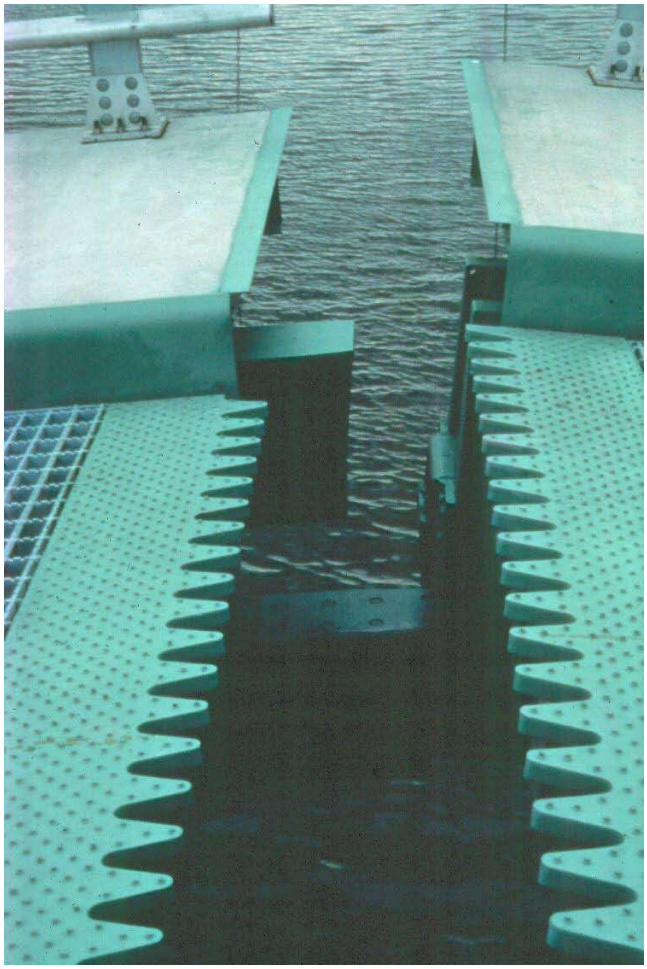


Figure 16.2.48 Center Lock Jaws

Transverse Locks

In twin bascule bridges that are split longitudinally to allow flexibility during construction, repair, or rehabilitation; transverse locks between the inside girders are used to keep the pairs together during operation (see Figure 16.2.49). These are usually operated manually, as they are not normally released for long periods of time.

Figure 16.2.49 Transverse Locks on Underside can be Disengaged

16.2.8 Vertical Lift Bridge Special Elements

Vertical lift bridges may utilize the following elements peculiar to their design:

- Wire Ropes and Sockets
- Drums, Pulleys, and Sheaves
- Span and Counterweight Guides
- Balance Chains
- Span Leveling Devices

Wire Ropes and Sockets

Wire ropes and sockets include up-haul and down-haul operating ropes and counterweight ropes (see Figures 16.2.50 and 16.2.51). Ropes consist of individual wires twisted into several strands that are wound about a steel core. Fittings secure the ends of the rope and allow adjustments to be made.

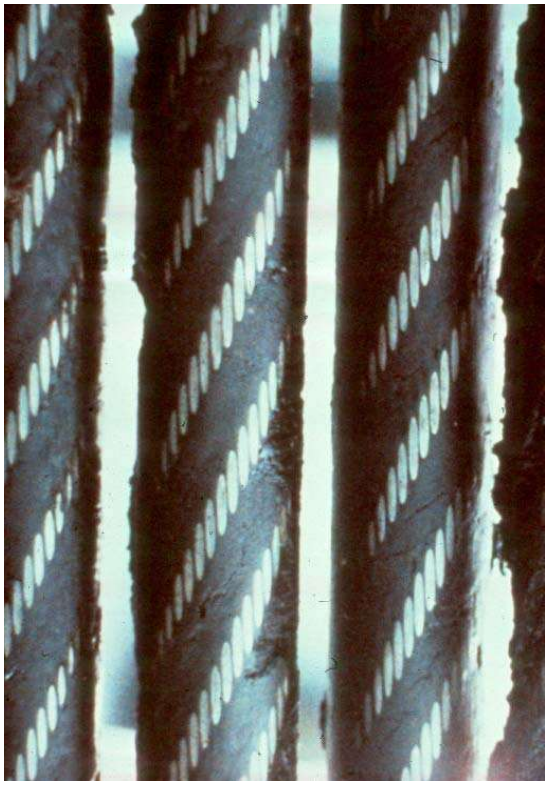


Figure 16.2.50 Wire Rope

Figure 16.2.51 Wire Rope Sockets and Fittings

Drums, Pulleys, and Sheaves

Drums are used to wind a rope several times around to extend or retract portions of the bridge (see Figure 16.2.52). Pulleys and sheaves change the direction of the rope or guide it at intermediate points between ends of the rope.

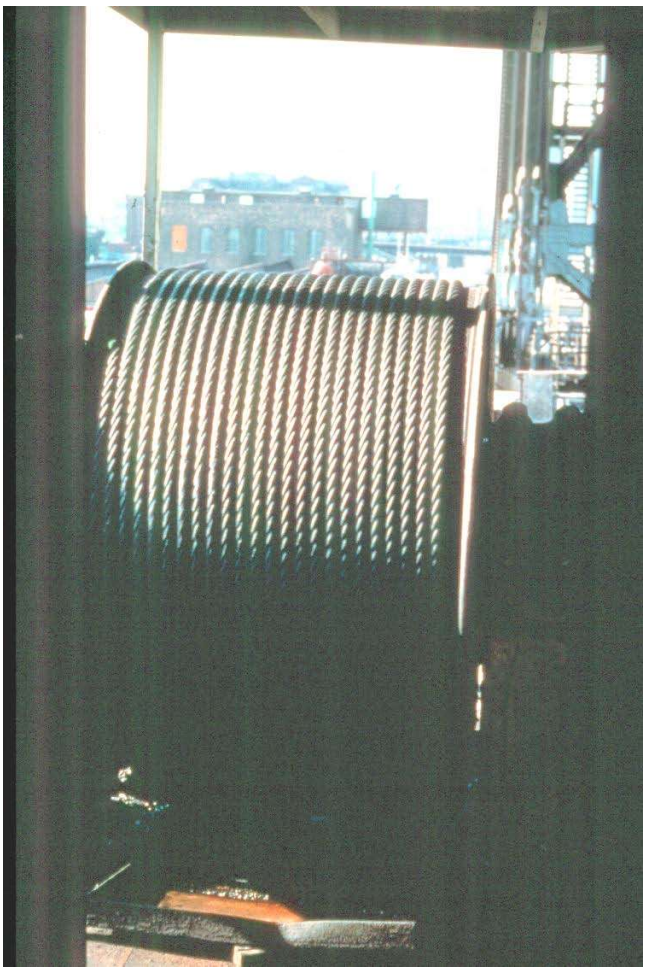


Figure 16.2.52 Drums Wind Up the Up-Haul (Lifting) Ropes as they Simultaneously Unwind the Down-Haul Ropes

Span and Counterweight Guides

Span and counterweight guides are located between tower and span or counterweight to prevent misalignment.

Balance Chains

Balance chains are provided to compensate for the weight of counterweight rope that travels from the span side to the counterweight side of the sheaves at the top of the tower as the span is raised. Weight of chain is removed from the counterweight and is supported by the tower as rope weight is increased on the counterweight side of the sheaves on the tower.

Span Leveling Devices

Mechanical or electrical, span leveling devices compensate and adjust the movement of the two ends of the span during operation to prevent unsynchronized movement.

16.2.9 Overview of Common Deficiencies

Steel

Common deficiencies that can occur to steel members of movable bridges include:

- Corrosion
- Fatigue cracking
- Overloads
- Collision damage
- Heat damage
- Paint failures

See to Topics 6.3.4 – 6.3.7 for a detailed presentation of the properties of steel, types and causes of steel deficiencies, and the examination of steel. Refer to Topic 6.4 for Fatigue and Fracture in Steel Bridges.

Concrete

Common deficiencies that occur to concrete members of movable bridges include:

- Cracking (structural, flexure, shear, crack size, nonstructural, crack orientation)
- Scaling
- Delamination
- Spalling
- Chloride contamination
- Freeze-thaw
- Efflorescence
- Alkali silica reactivity (ASR)
- Ettringite formation
- Honeycombs
- Pop-outs
- Wear
- Collision damage
- Abrasion
- Overload damage
- Internal steel corrosion
- Loss of prestress
- Carbonation

Refer to Topics 6.2.3 – 6.3.8 for a detailed explanation of the properties of concrete, types and causes of concrete deficiencies, and the examination of concrete.

16.2.10 Inspection Locations and Methods - Safety

Movable Bridge Inspector Safety

It is imperative that a movable bridge inspectors coordinate their work with the Bridge Operator and emphasize the need for advance warning of a bridge opening. The Bridge Operator cannot operate the bridge until being notified by all inspectors that they are ready for an opening. There are many ways that this can be accomplished, such as placing a warning note on the control console or opening the circuit breakers and locking the compartment to the equipment that they will be inspecting.

Inspection Considerations

Important considerations for a movable bridge inspector include observing and making comments in the inspection report on the following safety considerations.

Public Safety

Public safety considerations include good visibility of roadway and sidewalk for the Bridge Operator (see Figure 16.2.53), adequate time delay on traffic signals for driver reaction and before lowering gates, all "gates down" before raising bridge (bypass available if traffic signals are on), the bridge is closed before gates can be raised (bypass available if locks are driven), and traffic signals do not turn off until all gates are fully raised (bypass available).

Observe the location of the bridge opening in relation to the gates, traffic lights and bells, and determine whether approaching motorists can easily see them. Check their operation and physical condition to determine if they are functioning and well maintained. Recommend replacement when conditions warrant.

Unprotected approaches, such as both ends of a swing bridge and vertical lift bridge and the open end of a single-leaf bascule bridge, preferably have positive resistance barriers across the roadway, with flashing red lights as provided on the gate arms (see Figure 16.2.54). High-speed roadways and curved approaches to a movable bridge preferably have advanced warning lights (flashing yellow).

Figure 16.2.53 Operator's House with Clear View of Traffic Signals and Lane Gates

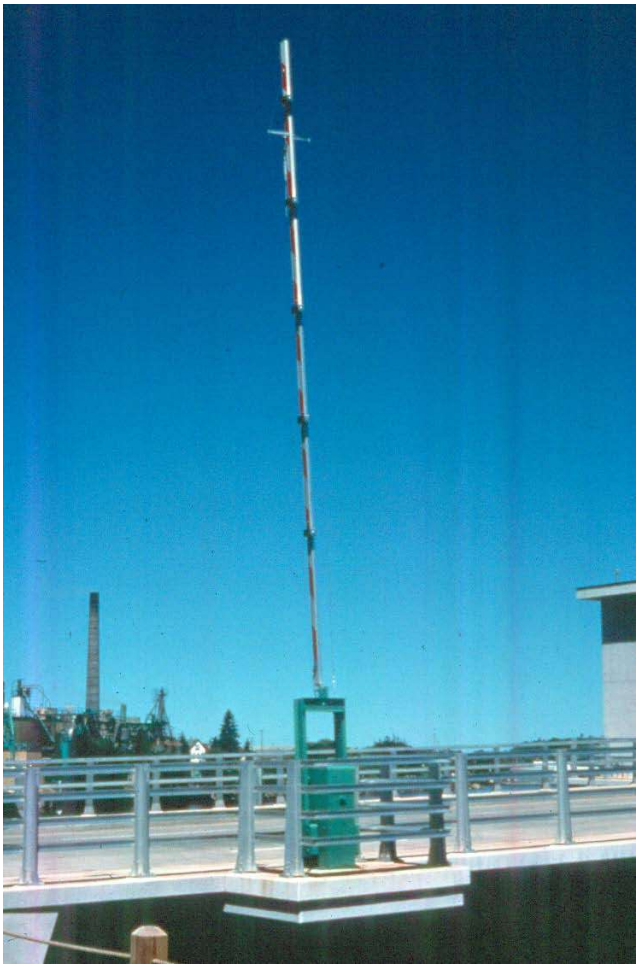


Figure 16.2.54 Traffic Control Gate

Navigational Safety

Navigational safety considerations include compliance with minimum channel width with any restriction on vertical clearance when span is open for navigation. Minimum underclearance designated on the permit drawing are to be provided. Inspect underclearance gauges for closed bridges for accuracy, visibility, and legibility.

See that all navigation lights have a relay for backup light, and red span lights do not change to green until both leaves are fully open (see Figure 16.2.55). Check navigation lights for broken lenses, deteriorated insulation of wiring and cable, and dry and clean interior, as these lights are very important to navigational safety.

Check that the marine radio communication equipment is functional (see Figure 16.2.56). Verify that the Operator can automatically sound the emergency signal to navigation vessels if bridge cannot be opened.

Figure 16.2.55 Navigational Light

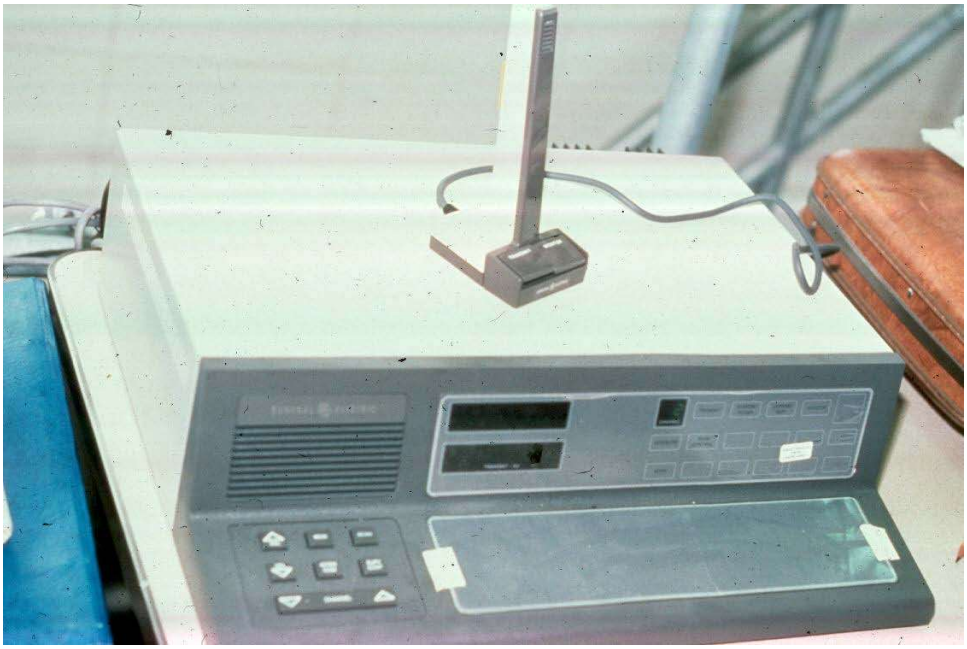


Figure 16.2.56 Marine Two-Way Radio Console

Structure Safety

Structure safety considerations include the structural ability to carry the anticipated loads. Pressure relief valves on hydraulic power units are used to limit hydraulic forces applied to machinery and structure. Horsepower applied to machinery and structure are to be kept within design limits by limiting speed.

Dependable Operation

Operate the movable bridge in both normal and emergency modes to check all interrelated interlocks and to verify every component is operating correctly.

16.2.11 Inspection Locations and Methods of Movable Bridge Opening and Closing Sequences

Movable bridges are considered to be complex according to the NBIS regulations. The NBIS requires identification of specialized inspection methods, and additional inspector training and experience required to inspect these complex bridges. The bridges are then to be inspected according to these methods.

Interlocking for Normal Operation

During normal operation, verify that each interlock functions properly and can be bypassed (when provided). Verify the controls for the traffic signals, traffic gates, center or rear locks, emergency brakes, and the bridge operation are interlocked so that they can only be operated in the following sequences.

Opening Sequence

The bridge opening sequence:

1. Activate traffic signals.
2. Lower oncoming gates and, when traffic has cleared, lower off-going gates. “All gates down” interlocked for withdrawing locks (bypass provided).
3. Press "raise" button if automatic operation is provided or, if manual operation is provided, proceed as follows:

a. Withdraw locks – "Locks Withdrawn." Interlocked for bridge operation (no bypass).

b. Release emergency brakes - no interlock provided. Warning buzzer sounds if brakes are not released when power is applied to motors to move bridge.

c. Accelerate leaves to full speed.

d. When advanced to nearly open position, decelerate leaves to slow speed and stop at nearly open position.

e. At nearly open position, with reduced power, lower leaves to stop at fully open position.

f. Set emergency brakes.

Closing Sequence The bridge closing sequence:

1. Press "lower" button if automatic operation is provided or, if manual operation is provided, proceed as follows:

   a. Release emergency brakes.

   b. Accelerate leaves to full speed.

   c. For all types of bridges with lock bars:

      (1) At advanced nearly closed position, decelerate leaves to slow speed. Leaves stop at nearly closed position by action of the bridge limit switch.

      (2) At nearly closed position with reduced power, lower leaves to stop at fully closed position.

      (3) With machinery wound up (bascule bridges and counterweight heavy vertical lift bridges) or when span is fully closed (swing bridges and span heavy vertical lift bridges), set the brakes and drive lock bars.

   d. For rolling lift bridges having jaw and diagram shear locks with no moving parts:

      (1) At advanced nearly closed position, decelerate to slow speed. The jaw leaf stops at the "locking position" (within the "window" to receive the diaphragms) by action of the bridge limit switch.

      (2) At advance nearly closed position, decelerate to slow speed. The diaphragm leaf stops in the "clear position" (where the lower jaw will clear the diaphragm) by action of the bridge limit switch.

      (3) Depress foot switch to provide reduced power from this point until both leaves are closed.

      (4) Lower the diaphragm leaf to make "soft" contact with lower jaw.

      (5) Close both leaves together with diaphragm castings against lower jaws.

      (6) When leaves are fully closed, drive the rear locks. "Fully closed" interlock provided for rear lock operation (no

bypass).

(7) Set emergency brakes with reduced power applied to motors to hold machinery wound up.

2. Deactivate automatic traffic control, or manually raise gates:

a. All gates raise, off-going gates start up before oncoming gates raise.

b. Warning signals and red lights do not turn off until all gates are raised, even if the power switch is turned "off" (bypass is provided), after which the green traffic lights are turned "on".

Bypass Note: All bypass switches have handles that are spring returned to "off". When the switch is turned to bypass momentarily, a holding relay holds the bypass activated until power is removed from the controls or the switch is turned to cancel bypass. Verify these circuits are provided in order to prevent inadvertent use of any bypass. Until a malfunction is corrected, the operator is required to initiate the use of any bypass switch that is needed every time the bridge is operated.

16.2.12 Inspection Locations and Methods for the Control House

Inspection of the control house is necessary to assure the safety of a movable bridge. The operator is responsible for public and navigational safety during operation and, together with maintenance personnel, is usually the most familiar with any known structural or operational issues. Operational and maintenance log books are to be kept in the control house for reference. The resources within the control house can therefore provide a great deal of general information, through the knowledge of its personnel and the records stored there. The position of the control house provides the best general view of the bridge itself.

Consult with the bridge operators to ascertain whether there are any changes from the normal operation of the bridge. Note whether all Coast Guard, Corps of Engineers, and local instructional bulletins are posted. Check for obvious hazardous operating conditions involving the safety of the operator and maintenance personnel.

Note where the control panel is located in relation to roadway and waterway, and also whether the bridge operator has a good view of approaching boats, vehicles, and pedestrians (see Figure 16.2.57). Check operation of all closed circuit TV equipment, and evaluate its position for safe operation. If controls are in more than one location, note description of the other locations and include their condition as well as the information about the control house. Note whether alternate warning devices such as bullhorns, lanterns, flasher lights, or flags are available.

Note whether the structure shows cracks, and determine whether it is windproof and insulated. Check for any accumulations of debris, which may be readily combustible. Check controllers while bridge is opening and closing. Look for excess play and for sparking during operation. Note whether the submarine cables are kinked, hooked, or deteriorated, especially at the exposed area above or below the water. In tidal areas, check for marine and plant growth. Note if the ends of the cable have been protected from moisture.

Figure 16.2.57 Control Panel

16.2.13 Inspection Locations and Methods for Structural Members

Deficiencies

During the inspection of any type of movable structures, be sure to note any deficiencies that are detrimental to all steel and concrete structures. Most of the bridge structure deficiencies are listed in Chapter 6: Materials, as potential problems apply to movable spans also.

Fatigue

Fatigue can be a problem with movable bridges due to the reversal or the fluctuation of stresses as the spans open and close (see Figure 16.2.58). Carefully inspect any member or connection subject to such stress variations for signs of fatigue.

Figure 16.2.58 Stress Reversals in Members

Counterweights and Attachments

Inspect the counterweights to determine if they are sound and are properly affixed to the structure. Also check temporary supports for the counterweights that are to be used during bridge repair and determine their availability in the event such an occasion arises. Determine whether the counterweight pockets are properly drained. On vertical lift bridges, be sure that the sheaves and their supports are well drained. Examine every portion of the bridge where water can collect. All pockets that are exposed to rain and snow are to have a removable cover. Check for debris, birds, animals, and insect nests in the counterweight pockets.

Where steel members pass through or are embedded in the concrete, check for any corrosion of the steel member and for rust stains on the concrete. Look for cracks and spalls in the concrete.

Where lift span counterweight ropes are balanced by chains (or other means), make sure the links hang freely, and check these devices along with slides, housings, and storage devices for deficiencies and for adequacy of lubrication, where applicable.

Determine whether the bridge is balanced and whether extra balance blocks are available. A variation in the power demands on the motor, according to the span's position, is an indication of an unbalanced leaf or span. If the controls provide a “drift” position, use this to test the balance. Several coats of paint can increase the structure dead load. Otherwise, the counterweights will eventually be inadequate due to excess paint dead load.

Piers

Take notice of any rocking of the piers when the leaf is lifted. This is an indicator of a serious deficiency or critical finding and is to be reported at once. Survey the spans including towers to check both horizontal and vertical displacements. This will help to identify any foundation movements that have occurred.

Check the braces, bearings, and all housings for cracks, especially where stress risers would tend to occur. Inspect the concrete for cracks in areas where machinery bearing plates or braces are attached (see Figure 16.2.59). Note the tightness of bolts and the tightness of other fastening devices used.

Check the pier protection system (see Figure 16.2.60).

Figure 16.2.59 Concrete Bearing Areas

Figure 16.2.60 Pier Protection Systems – Dolphins and Fenders

Steel Grid Decks

Verify that structural welds are sound and the grid decks have adequate skid resistance. Check the roadway surface for evenness of grade and for adequate clearance at the joints where the movable span meets the fixed span. For more information on steel grid decks, see Topic 7.4.

Concrete Decks

A solid concrete deck is used over the pier areas (pivot or bascule pier) to keep water and debris from falling through onto the piers and mechanical devices. Since the machinery room is usually under the concrete deck, check the ceiling for leaks or areas that allow debris and rust to fall on the machinery. For more information of concrete decks, see Topic 7.2.

Other Structural Considerations

Other structural considerations include:

- Examine the live load bearings and wedges located under the trusses or girders at the pivot pier for proper fit alignment and amount of lift.
- Inspect the fully open bumper blocks and the attaching bolts for cracks in the concrete bases.
- Examine the counterweight pit for water. Check the condition of the sump pump, the concrete for cracks, and the entire area for debris.
- See if the shear locks are worn. Measure the exterior dimensions of the lock bars or diaphragm casting and the interior dimensions of sockets or space between jaws to determine the amount of clearance (wear). Report excessive movement and investigate further.
- On swing bridges, check the wedges and the outer bearings at the rest piers for alignment and amount of lift. This can be recognized by excessive vibration of span or uplift when load comes upon the other span.
- On double-leafed bascule bridges, measure the differential vertical movement at the joint between the two leaves under heavy loads. On other types, check for this type of movement at deck joints (breaks in floor) between movable and fixed portions of the structure. This can indicate excessive wear on lock bars or shear lock members.
- Inspect the joint between the two leaves on double-leaf bascule bridges, or the joints between fixed and movable portions of the structure for adequate longitudinal clearance for change in temperature (thermal expansion).
- On bascule bridges, see if the front live load bearings fit snugly. Also observe the fit of tail locks at rear arm and of supports at outer end of single-leaf bridges.
- On rolling lift bascule bridges, check the segmental and track castings and their respective supporting track girders (if used) for wear on sides of track teeth due to movement of sockets on segmental castings. Compare all wear patterns for indications of movement of the leaves. Check for cracking at the fillet of the angles forming the flanges of the segmental and track girders, cracking in the flanges opposite joints in the castings, and cracking of the concrete under the track. Inspect rack support for lateral movement when bridge is in motion.
- On multi-trunnion (Strauss) bascule bridges, check the strut connecting the counterweight trunnion to the counterweight for fatigue cracks. On several bridges, cracking has been noted in the web and lower flanges near the

gusset connection at the end nearer the counterweights. The crack would be most noticeable when the span is opened.

16.2.14 Inspection Locations and Methods for Machinery Members

Mechanical, electrical, and hydraulic equipment includes specialized areas, which are beyond the scope of this reference manual. Since operating equipment is the heart of the movable bridge, it is recommended that expert assistance be obtained when conducting an inspection of movable spans. In many cases, the owners of these movable bridges follow excellent programs of inspection, maintenance, and repair. However, there is always the possibility that some important feature may have been overlooked. Any problems noted during the inspection are reported to the owner.

Trial Openings

Conduct trial openings as necessary to insure proper operational functioning and that the movable span is properly balanced. Trial openings are specifically for inspection. During the trial openings, the safety of the inspection personnel, traveling public and boat operators is a primary concern.

Machinery Inspection Considerations

On all movable structures, the machinery is so important that considerable time is to be devoted to its inspection. The items covered and termed as machinery include all motors, brakes, gears, tracks, shafts, couplings, bearings, locks, linkages, over-speed controls, and any other integral part that transmits the necessary mechanical power to operate the movable portion of the bridge. Inspect machinery not only for its current condition, but also for operational and maintenance methods and analysis of the characteristics of operation. The items listed below and items similar to them are to be inspected and analyzed by a machinery or movable bridge specialist. Refer to FHWA-IP-77-10, *Bridge Inspector's Manual for Movable Bridges* and the *AASHTO Movable Bridge Inspection, Evaluation and Maintenance Manual*, *Manual for Bridge Evaluation* for further information on inspecting these items. The FHWA-IP-77-10 manual is published by the Federal Highway Administration (FHWA), but is currently out of print.

Operation and General System Condition

Observe the general condition of the machinery as a whole, and its performance during operation. Check for smoothness of operation, and note any abnormal performance of components. Note any noise or vibration and the source determined. Document any unsafe or detrimental methods followed by the operator to prevent injury to the public or to personnel, or deficiencies to the equipment. Also note the condition of the paint system.

Maintenance Methods

Perform an evaluation of maintenance methods in light of design details for the equipment. Check application methods and frequency of lubrication in the maintenance logbook, if available. Note general appearance of existing applied lubricant.

Open Gearing

Check open gearing for tooth condition and alignment including over- and under-engagement. Verify that the pitch lines match. Note excessive or abnormal wear. Inspect the teeth, spokes, and hub for cracks. Observe and note the general appearance of the applied lubricants on open gearing. If the lubricant has been contaminated, especially with sand or other gritty material, remove the old lubricant and have new lubricant applied. If there is a way to prevent future contamination, recommend this appropriate procedure as part of the inspector's

comments in the report. Check the teeth of all gears for wear, cleanliness, corrosion, and for proper alignment.

Speed Reducers Including Differentials

Examine the exterior of the housing and mountings for cracks and deficiencies (see Figure 16.2.61 and 16.2.62). Check bolts for tightness and note any corrosion. Inspect the interior of the housing for condensation and corrosion. Check the condition of gears. Watch for abnormal shaft movement during operation, indicating bearing and seal wear. Periodically check oil levels and condition of lubricant. Check that circulating pumps and lubricating lines are properly operating. Any abnormal noise is to be documented. Leaking oil may indicate the presence of a crack.

Figure 16.2.61 Cracked Speed Reducer Housing

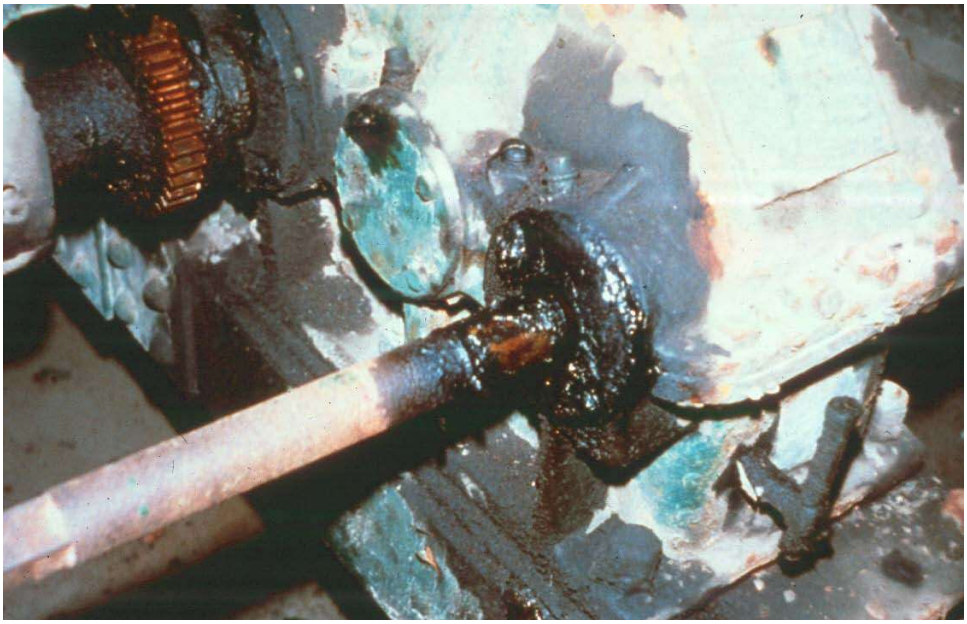


Figure 16.2.62 Leaking Speed Reducer

Shafts and Couplings

Examine shafts damage, twisting, and strain. Cracks, if suspected, may be detected using non-destructive evaluations (NDE) such as magnetic particle or dye penetrant (see Figure 16.2.63). Various advanced inspection methods for steel members are presented in Topic 15.3. Cracks in mechanical components may be determined to be a critical finding. Note misalignment with other parts of the machinery system. Document cracks in shafts and record the exact location. Examine other shafts in the same locations as they were probably made from the same material and fabricated to the same details. They have also been exposed to the same magnitude and frequency of loading. Check coupling hubs, housings, and bolts for condition. Inspect seals and gaskets for leaks. Internal inspection of couplings is warranted if problems are suspected and can be used to determine tooth wear in gear couplings.

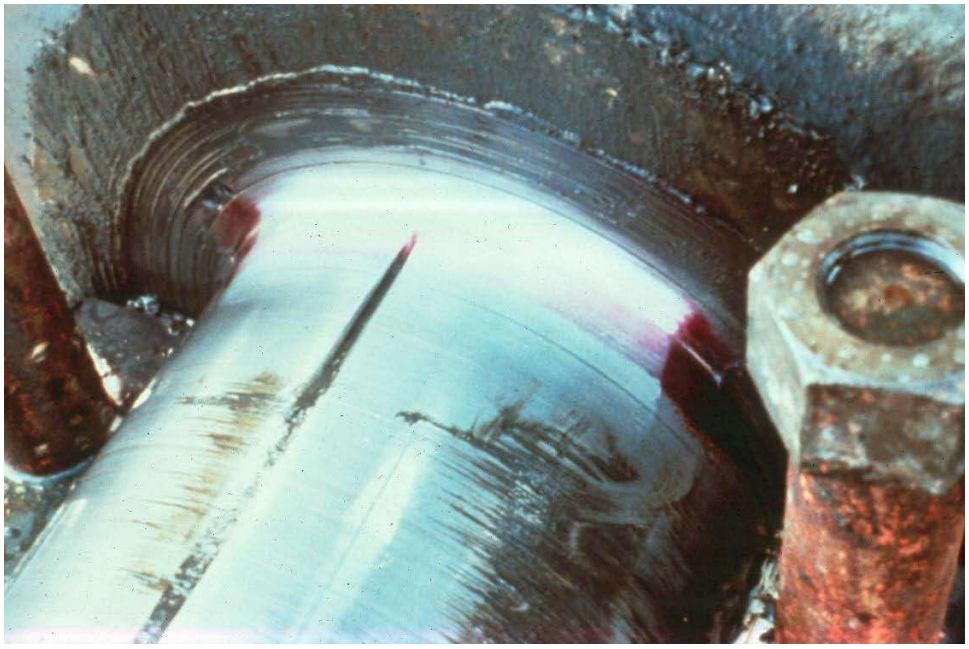


Figure 16.2.63 Hairline Crack Revealed on Shaft from Dye Penetrant Test

Bearings

Examine bearing housings, pedestals, and supports for external condition, noting any cracks. Check bolts in housings and those used for anchors for tightness, damage, and corrosion, noting apparent lubrication characteristics. Grinding noises can be caused the lack of lubricant (see Figure 16.2.64). In sleeve bearings, inspect the bushings for damage and excessive wear. Note evidence of seal damage in anti-friction bearings. Investigate any unusual noise. Check the trunnion bearings for excessive wear, lateral slip, and loose bolts.

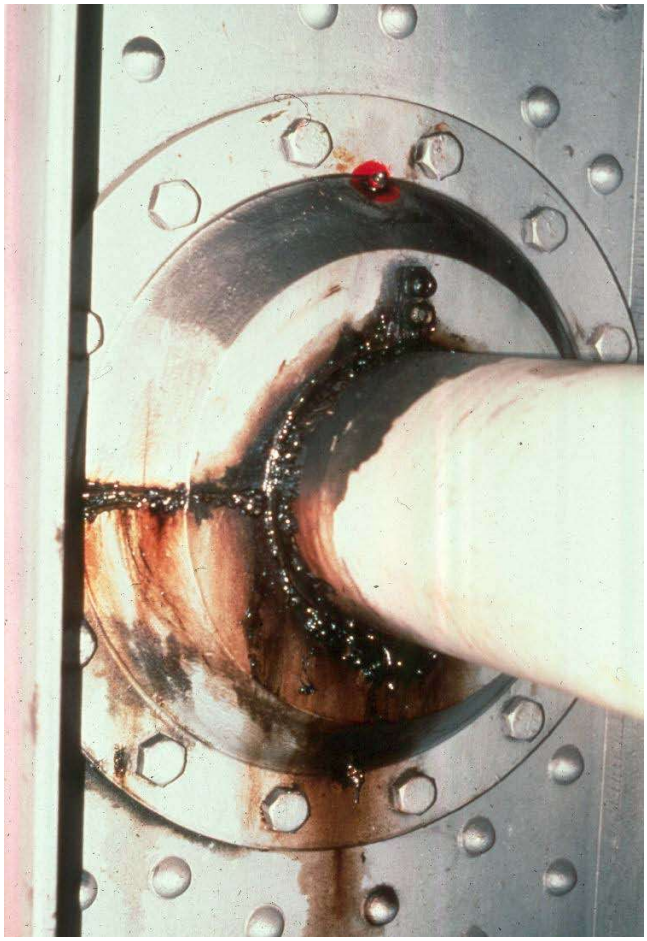


Figure 16.2.64 Leaking Bearing

Brakes

Inspect all braking devices for proper setting of braking torque and for complete release of the brakes when actuated. On shoe brakes, check drums and shoes for wear, damage, and corrosion, for misalignment of shoes with drums, and for clearance when released. Determine if worn linings need replaced. Check for proper actuation without leakage by actuators. Verify that linkages and hand releases are free but not sloppy. On enclosed hydraulic disc brakes, make certain there is proper actuation without leakage at connections or seals. Check the brakes, limit switches, and stops (cylinders and others) for excessive wear and slip movement. Note whether the cushion cylinder ram sticks or inserts too easily. Inspect the brake limit switches for proper setting. Observe the surface of the brake drum for indications of contact with the brake shoes. Check the pressure developed by each disc brake power unit to be sure the brakes are releasing. Also check the manual release on all of the brakes.

Drives - Electric Motors

Check the housing and mountings for damage, corrosion, and fastener condition. Inspect bearings for lubrication and note indications of wear (movement) and seal leakage at shaft extensions.

Drives - Hydraulic Equipment

Look for any leakage at connections and seals. Note any corrosion on the cylinder rods. Listen to motors and pumps, and note any unusual noise. Check power units to make sure all components are functioning and that pressures are properly adjusted. Sample fluid periodically and examine for contamination and wear metal. Check all main hydraulic power units for charge pressure setting and maximum pressure that can be developed by the unit. Check all filters routinely and replace as needed. Also check the level of fluid in the vertical reservoir.

Auxiliary Drives

Check emergency generators for operation and readiness, verifying that there are no oil leaks or abnormal noises. Mechanical service specialists and electrical inspectors are required for more thorough inspections. Auxiliary motors and hand operators, with their clutches and other transmission components, are to be checked for adjustment and readiness to perform when called upon.

Drives - Internal Combustion Engines

Detailed inspections of internal combustion engines are made by mechanical engine specialists. The inspection may include but is not limited to checking of the following conditions:

- If a belt drive is used, look for any wear or slippage. Note the condition of all belts and the need for replacement, if any.
- If a friction drive is used, check that all bracing and bearings are tight.
- If a liquid coupling is used, make sure that the proper quantity of fluid is used. Look for leaks.

Locks

Examine the center locks and tail locks (if used) on double-leafed bascule spans, and the end locks on single-leaf bascule bridges, swing bridges, and vertical lift bridges. Note whether there is excessive deflection at these joints or vibration on the bridge. Inspect the locks for fit and for movement of the span or leaf (or leaves). Check lubrication and for loose bolts. Verify that the lock housing and its braces have no noticeable movement or misalignment. The paint adjacent to the locks will have signs of paint loss or wear if there is movement. Check lock bars, movable posts, linkages, sockets, bushings, and supports for damage, cracks, wear, and corrosion.

Check all rear locks in the withdrawn position for clearance from the path of the moving leaf as it opens and for full engagement when the leaf is closed. Measure the gap, if any, between the lock plate and the moving leaf bearing plate. Check each rear lock hydraulic drive unit for leakage of oil and operation for correct length of movement of the lock.

On bascule bridges, see if the front live load bearings fit snugly. Also observe the fit of tail locks at the rear arm and of supports at the outer end of single-leaf bridges.

Examine actuators for operational characteristics, including leakage if hydraulic. Note both the quantity and quality of the lubricant. Check for alignment, and analyze the type of wear that is occurring. Note condition of movable operators.

Live Load Shoes and Strike Plates

Inspect the fasteners and structure for deficiencies and corrosion. Note contact surface conditions. Check for alignment and movement under load.

Air Buffer Cylinders and Shock Absorbers

Note indications of lack of pressure or stickiness during operation. Check piston rod alignment with strike plate. Note the condition of the rod and housing, and verify if hydraulic leakage is present. Check the air filter and function of any pressure reading or adjusting devices and the operating pressure, if possible. Verify that the air buffers have freedom of movement and development of pressure when closing. Inspect the fully open bumper blocks and the attaching bolts for cracks in the concrete bases.

Machinery Frames, Supports, and Foundations

Check that there is no cracking in the steel or concrete. Note corrosion and damage. Check for deflection and movement under load. Ensure that the linkages and pin connections have the proper adjustment and are in functional condition. Check motor mounting brackets to ensure secure mounting.

Fasteners

Inspect the fasteners for corrosion, loss of section, and tightness.

Wedges

Check the wedges and the outer bearings at the rest piers for alignment and amount of lift. This can be recognized by excessive vibration of span or uplift when load comes upon the other span.

Examine the live load bearings and wedges located under the trusses or girders at the pivot pier for proper fit alignment and amount of lift.

Special Machinery for Swing Bridges

Check center bearings for proper and adequate lubrication, oil leaks, and noise. Examine the housing for cracking, pitting, fit of joints, and note indications of span translation (irregular rotation) at racks and track. Measure for proper clearance of balance wheels above track. Verify that the tracks and balance wheels are free of wear, pitting, and cracking. Check for proper and adequate lubrication at all lubrication points.

Note balance characteristics as indicated by loads taken by balance wheels, and by drag on the rest pier rail.

Check the rim bearing for wear on tracks and rollers, particularly at rest positions where the bridge is carrying traffic. Examine the center pivots and guide rings for proper fit, and for wear, pitting, and cracking. Check for proper and adequate lubrication at all lubrication points.

Examine the center (live load) wedges located under the trusses or girders at the pivot pier for proper fit (no lifting) and alignment. Check end wedges and bearings at the rest piers for alignment and amount of lift. This can be recognized by excessive vibration of the span or uplift when live load crosses the other span. Inspect the end lift jacks, shoes, and all linkages for wear, proper bearing under load, and proper adjustment.

Note the condition of end latches, including any modification that adversely affects their functional design.

Special Machinery for Bascule Bridges

On rolling lift bascule bridges, check the segmental and track castings and their respective supporting track girders (if used) for wear on the sides of track teeth due to movement of sockets on segmental castings. Inspect the trunnion assemblies for deflection, buckling, lateral slip, and loose bolts. Examine the trunnions for any signs of corrosion, pitting, or cracking, particularly at stress risers. Laser leveling may be used during the inspection of trunnions. Check the balance of each leaf. Compare all wear patterns for indications of movement of the leaves. Check for cracking at the fillet of the angles forming the flanges of the segmental and track girders, cracking in the flanges opposite joints in the castings, and cracking of the concrete under the track. Inspect rack support for lateral movement when bridge is in motion.

Check trunnion bearings for lubrication of the full width of the bearing. Verify that extreme pressure (EP) lubrication oil of the proper grade is used.

Special Machinery for Vertical Lift Bridges

The condition of wire ropes and sockets, including wire rope lubrication, is important. Look for flattening or fraying of the strands and deficiencies between them. This is reason for replacement. Similarly, check the up-haul and down-haul ropes to see if they are winding and unwinding properly on the drums. Note any need for tension adjustments in up-haul and down-haul ropes. Determine whether ropes have freedom of movement and are running properly in sheave grooves. Look for any obstructions to prevent movement of the ropes through the pulley system, and check the supports on span drive type bridges. Check rope guides for alignment, proper fit, free movement, wear, and structural integrity of the longitudinal and transverse grooved guide castings. Inspect the grooved guide castings closely for wear in the grooves. Examine the cable hold-downs, turnbuckles, cleats, guides, clamps, splay castings, and the travel rollers and their guides.

Check that balance chains hang freely, that span leveling devices are functioning, and that span and counterweight balance closely. Observe if span becomes "out of level" during lifting operation. Inspect spring tension, brackets, braces, and connectors of power cable reels.

Check for damage, including cracking, at drums and sheaves. Note the condition and alignment of span guides.

16.2.15 Electrical Inspection Considerations

An available electrical specialist is required for the inspection of the electrical equipment. For this inspection, use current AASHTO guidance on inspection of movable bridges. Observe the functional operation of the bridge and look for abnormal performance of the equipment. Check the operational methods and safety features provided. Evaluate the maintenance methods being followed and check the frequency of services performed.

Power Supplies

Examine the normal power supply, standby power supply, and standby generator set (for emergency operation of bridge and service lighting) and note the following:

- Take megger readings on the cable insulation values, noting the weather conditions, namely temperature and humidity.
- Make sure all cable connections are properly tightened.
- Measure the voltage and the current to the motors at regular intervals during the operation of the bridge.
- Check the collector rings and windings on the generator set.
- Test starting circuitry for automatic starting and manual starting.
- See if the unit is vibrating while running under load.

If the power cable has been repaired with a splice, note the condition of the splice box seal.

If no standby power supply has been provided, determine whether a portable generator could be used. A manual transfer switch would be a convenient way of connecting it.

Motors

Examine span drive motors, lock motors, brake thrustor motors, and brake solenoids for the same items as given for power supplies.

Transformers

Check dry transformer coil housings, terminals, and insulators, including their temperature under load. Observe the frames and supports for rigidity to prevent vibration. Check the liquid filled transformer in the same way, along with checking the oil level while looking for leakage. Examine oil insulation test records.

Circuit Breakers

Check circuit breakers (e.g., air, molded case, and oil) and fuses, including the arc chute, contact surfaces, overload trip settings, insulation, and terminal connections. Examine oil insulation test records, and observe the closing and tripping operation. Record all fuse types and sizes being used.

Wires and Cables

Examine the wiring and cables for both power and control. Note whether the submarine cables are kinked, hooked, or deteriorated, especially at the exposed area above and below the water. In tidal areas, look for marine and plant growth. Note if the ends of the cable have been protected from moisture. Record the insulation value of each wire as measured by megger. Look for cracking, overheating, and deterioration of the insulation. Check for wear against surfaces and especially sharp edges. Check the adequacy of supports and that dirt and debris do not accumulate against the conduit and supports. Check terminal connections, clamps, and securing clips for tightness, corrosion, and verify that there are wire numbers on the end of each wire. The weight of the wires or cables will be carried by the clamps and not by the wire connections at the terminal strips.

Cabinets

Examine the programmable logic controller (PLC) cabinets, control consoles and stations, switchboards (see Figure 16.2.65), relay cabinets, motor control centers (MCC), and all enclosures for deficiencies, debris inside, drainage, operations of heater to prevent condensation, and their ability to protect the equipment inside. Check the operation of all traffic signals, traffic gates, traffic barriers, and navigation lights. Verify that the bridge is open to provide the clearance shown on the permit drawing before the green span light turns on. Check the traffic warning equipment and control circuits, including the advanced warning signals (if used), traffic lights/signals, gates, barriers, and the public address and communication equipment.

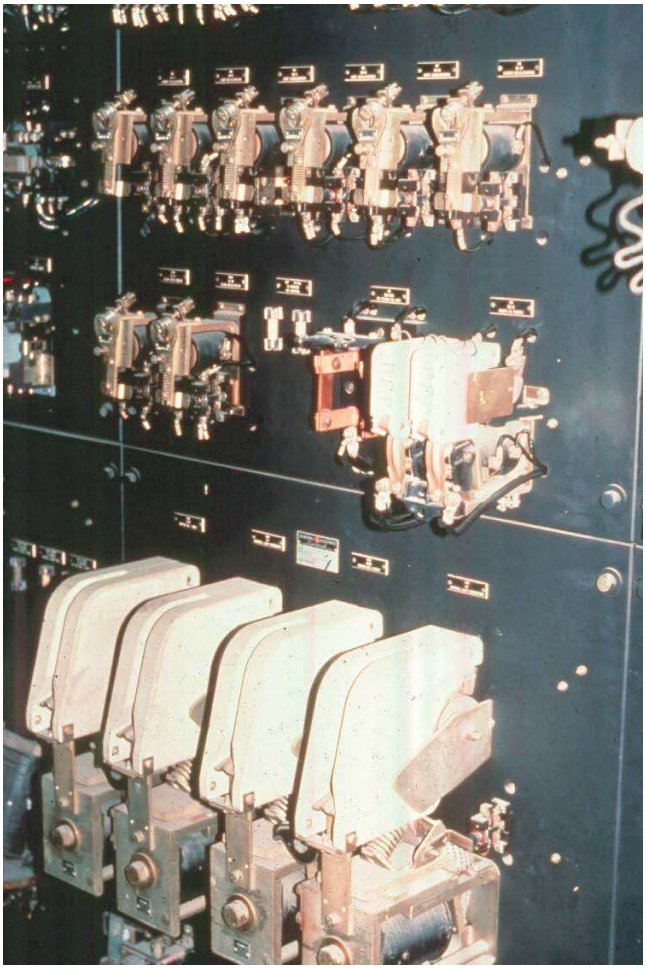


Figure 16.2.65 Open Switchboard

Conduit

See if conduit is far enough away from all surfaces to avoid debris from collecting against it. Note if it is adequately supported and pitched to drain away from junction boxes and pull boxes, so that water is not trapped within. Also, note if all conduits have covers with seals. Report deteriorated conduit so that it can be replaced with new conduit. Seal and re-coat the connectors at the ends of all PVC coated conduit after all fittings are installed.

Junction Boxes	Examine the covers on all junction boxes (JBs) for an effective seal, dry interior, functioning breather-drains, heaters having enough power to prevent condensation inside, and terminal strips all secured to the bottom of horizontal JBs or to the back of vertical JBs.
Meters	Observe if all voltmeters, ammeters, and watt meters are freely fluctuating with a change in load. Check that all switches and meters are operable.
Control Starters and Contactors/Relays	Check the operation of this equipment under load, and watch for arcing between contacts, snap action of contacts, deterioration of any surfaces, and drainage of any moisture. Look for signs of corrosion and overheating.
Limit Switches	Set all limit switches so they do not operate until they are intended to stop the equipment or complete an interlock. Verify that the interior is clean and dry, with all springs active.
Selsyn Transmitters and Receivers	Check for power to the field and signal being sent from the transmitter to the receiver. Observe the receiver tracking the rotation of the bridge as it operates. Observe the mechanical coupling between the driving shaft and the transmitter, checking for damage and misalignment.
Service Light and Outlet	Check to see if power is going to each light and outlet. Note if there is a shield or bar for protecting each bulb and socket. It is desirable to have service lights available when power is removed from all movable bridge controls and equipment.

16.2.16 Hydraulic Inspection Considerations

A hydraulic power specialist is required for the inspection of the hydraulic equipment (see Figure 16.2.66). Observe the functional operation of the bridge and look for abnormal performance of the equipment. Check the safety features provided and evaluate the maintenance methods being followed, checking the frequency of services performed. Due to the inter-related function of components, the requirements for fluid cleanliness, and the need for personnel safety, do not open the reservoir or hydraulic lines. In addition, do not shut off or adjust any component or part of the power circuit without complete understanding of their function and knowledge of the effect such action will have upon the system. Items which are checked during a hydraulic inspection include the following:

- Note leakage anywhere in the system. Significant leakage is immediately brought to the attention of the bridge authority.
- Check for corrosion of reservoir, piping, and connections.
- Inspect sight gauges for proper fluid level in reservoir. Note gauges with low fluid levels or gauges which cannot be read.
- Note unusual noises from any part of the system.
- Check filter indicators to make sure filters are clean.
- Collect a sample of the hydraulic fluid for analysis by a testing laboratory during periodic inspections.

Figure 16.2.66 Hydraulic Power Specialists

16.2.17 Recordkeeping and Documentation

General

The owner of a movable bridge keeps a complete file available for the engineer who is responsible for the operation and maintenance of the bridge. See Topic 4.4 for general record keeping and documentation. The file includes (if applicable), but not be limited to, the following:

- Copy of the latest approved permit drawing
- Complete set of design plans and special provisions
- "As-built" shop plans for the structural steel, architectural, mechanical, electrical, and hydraulic
- Machinery Maintenance Manual
- Electrical Maintenance Manual
- Hydraulic Maintenance Manual
- Copy of maintenance methods being followed
- Copy of the latest Operator's Instruction being followed
- Copies of all inspection reports
- Copy of all maintenance reports
- Copy of all repair plans
- Up-to-date running log on all spare parts that are available, on order, or out of stock

Review inspection and maintenance reports with preventative maintenance measures in mind. An example would be the "megger" readings on wiring insulation; especially those taken on damp rainy days when moisture could influence (reduce) the values. An acceptable minimum reading is usually 1 megaohm. If the value on a wire is decreasing on progressive reports, preventative maintenance may save a "short" that could burn out equipment and put the bridge out of operation.

Inspection and Maintenance Data

Examples of inspection and maintenance records are shown in Figures 16.2.67 through 16.2.73.

South Tower — Differential Assembly GEARS - General — 1.

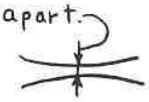
Gear	General Condition	Lubrication	Keys	Alignment		
				Center Distance	Axial	Parallel
Pinion P5	Very Good. Tooth profiles show normal wear	Very Good	Good	Good. Pitch Lines Tangent	Good	Good
Gear I5	Very Good. Tooth profiles normal.	Very Good	Good	No Pitch Line on G5. Looks good. Measured backlash.		
Gear G5	Very Good. Tooth profiles normal	Very Good	Good			
Pinion P4	Very Good. Tooth profiles normal.	Very Good	Integral with shaft	No pitch line on P4. Center distance looks. Looks good. Measured backlash.	Good	Good
Gear G4	Very Good. Tooth profiles normal.	Very Good	Not keyed to shaft. Clutch locks G4 to shaft.			
Bevel Gears BG3 (2)	Very Good. Tooth profiles normal.	Very Good	Integral with sleeves.	Good. Pitch Lines 1/16" to 1/8" apart. 	Good	Good
Bevel Pinions BP3 (2)	Very Good. Tooth profiles normal.	Very Good	Integral with shafts.			

Figure 16.2.67 Example of Notes on Operating Machinery (Gears-General)

South Tower Differential Assembly GEARS - Teeth 2.

Gear	Chordal Thickness		Backlash		Condition of Teeth					
					Normal	Pitting	Rolling-Peening	Abnormal		
	Original	Measured	Original	Measured				Scoring	Interference	Rust & Corr.
Pinion P5	.625"	Did not measure	.011" min to .020" max.	Did not measure. Pitch lines indicate good backlash.	✓					
Gear I5	.625"		.011" min		✓					
Gear G5	.625"		to .020" max.	.0135" Good.	✓					
Pinion P4	.625"		.011" min to	.020" Good	✓					
Gear G4	.625"		.020" max		✓					
Bevel Gears BG3 (2)	.875" at large end of teeth		.015" min to	Did not	✓					
Bevel Pinions BP3 (2)	.875" at large end of teeth		.029" max	measure. Pitch lines indicate good backlash.	✓					

Figure 16.2.68 Example of Notes on Operating Machinery (Gears-Teeth)

South Tower Differential Assembly — BEARINGS — 3

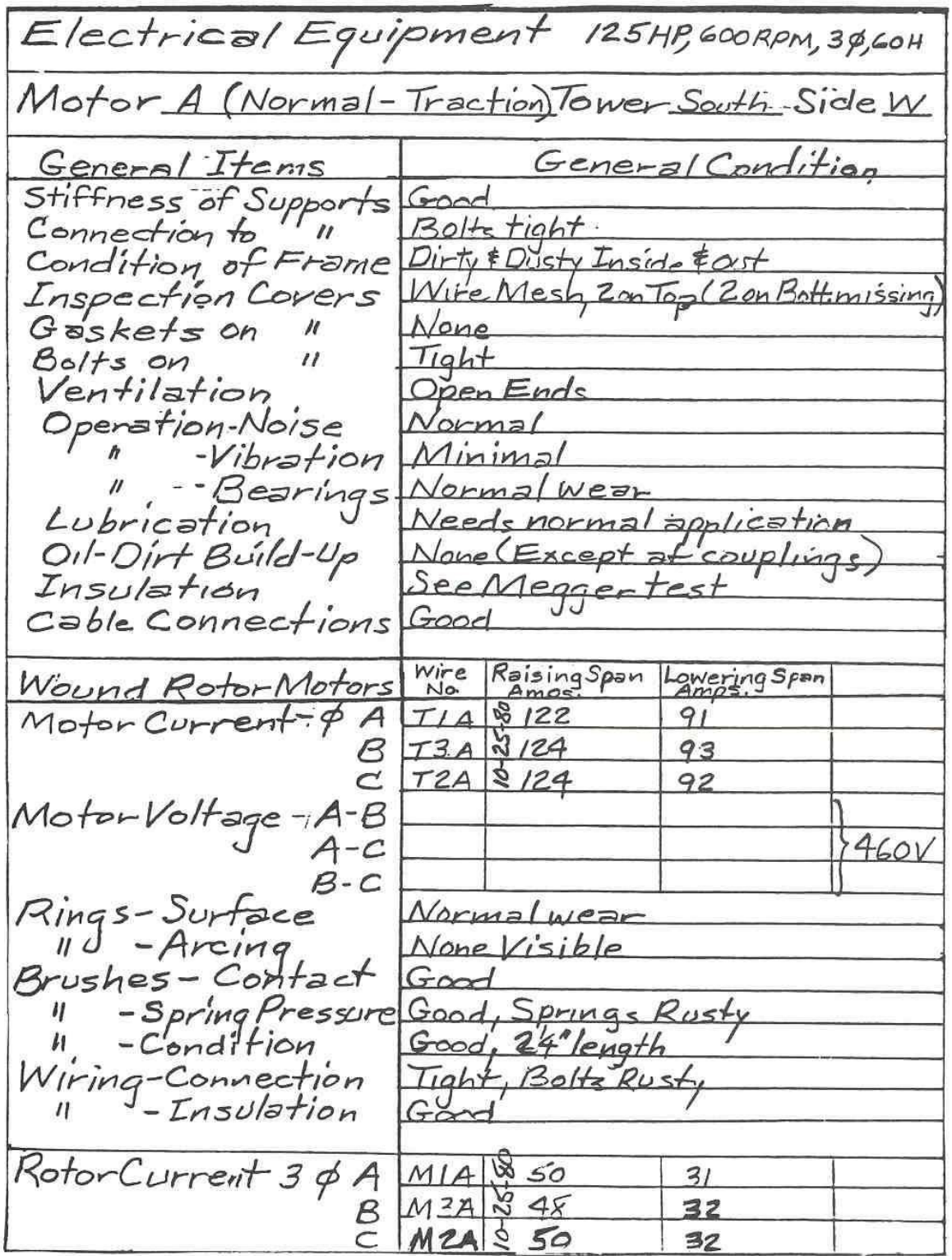
Bearing	General Condition	Clearance		Bolts	Lubrication
		Original	Measured		
West end Emer. Motor Shaft	Good. Fairly clean, paint good. Bearing has 45° angle lube fitting w/dust cap.	.0025" min. to .0073" max.	.006" Good	Good. Nuts tight. Clean, paint good.	Good.
East end Emer. Motor Shaft		.0025" min, to .0073" max.	.006" Good		
West end Intermediate Shaft		.0025" min. to .0073" max.	.007" Good		
East end Intermediate Shaft		.0025" min. to .0073" max.	.005" Good		
West end Normal Motor Shaft		.0025" min. to .0073" max.	.007" Good		
East end Normal Motor Shaft		.0025" min to .0073" max	.009" Fair		

Figure 16.2.69 Example of Notes on Operating Machinery (Bearings)

South Tower Differential Assembly MECHANICAL COMPONENTS 4.

Item	General Condition
Housing Cover	Very good condition. Cover has four hinged maintenance panels, secured with studs and wingnuts. Cover bolted to lower supports with 20 bolts.
Normal (Main) Drive Clutch Cone	Very good condition. No slippage during span operation, starting or stopping. Clutch cone is inside differential assembly and impossible to inspect without disassembly of differential.
Emergency Drive Clutch Cone Assembly	Very good condition. Design plans show cone type clutch. Actually have jaw type clutch.
Differential Clutch Operating Linkage	Very good condition. Well lubricated. Linkage operates smooth and quiet.
Emergency Drive Clutch Operating Linkage	Very good condition. Well lubricated. Linkage operates smooth and quiet.
Gear Motor for operation of Differential Clutch	Good condition. Operates smoothly. Operated with hand crank, turned fairly easy. GE AC Gearmotor, Model KY3AC2345, Motor 1800 rpm, 1/8 HP, 250:1 ratio
Support for above Gear Motor	Good. Some debris and oil on support.
Gear Motor for operation of Emer. Drive Clutch	Good. Operates smoothly. Turned easily with hand crank. Same gearmotor as at differential clutch
Support for above Gear Motor	Good. Some debris and oil on support.
Housing Support	Good condition. Some debris and oil on support and floor. Paint good. 2 lights attached to supports inside

Figure 16.2.70 Example of Notes on Operating Machinery (Mechanical Components)



Electrical Equipment 125HP, 600RPM, 3φ, 60H

Motor A (Normal - Traction) Tower South - Side W

General Items	General Condition
Stiffness of Supports	Good
Connection to "	Bolts tight
Condition of Frame	Dirty & Dusty Inside & Out
Inspection Covers	Wire Mesh, 2 on Top (2 on Bottom missing)
Gaskets on "	None
Bolts on "	Tight
Ventilation	Open Ends
Operation-Noise	Normal
" -Vibration	Minimal
" --Bearings	Normal wear
Lubrication	Needs normal application
Oil-Dirt Build-Up	None (Except at couplings)
Insulation	See Megger test
Cable Connections	Good

Wound Rotor Motors	Wire No.	Raising Span Amps.	Lowering Span Amps.	
Motor Current - φ A	T1A	122	91	
B	T3A	124	93	
C	T2A	124	92	
Motor Voltage - A-B				460V
A-C				
B-C				
Rings - Surface	Normal wear			
" - Arcing	None Visible			
Brushes - Contact	Good			
" - Spring Pressure	Good, Springs Rusty			
" - Condition	Good, 2¼" length			
Wiring - Connection	Tight, Bolts Rusty			
" - Insulation	Good			
Rotor Current 3 φ A	M1A	50	31	
B	M3A	48	32	
C	M2A	50	32	

Figure 16.2.71 Example of Notes on Electrical Equipment (Motors)

Megger Insulation Test Temp 60's Weather Dry.

Rotating Cam - Normal Height Limit Switch.
Contacts shown for Bridge Closed. Tower South Side W

Bottom Connection			Gear Drive End North	Top Connection ..		
Remarks	500V MΩ to Ground	Wire No. Taged U.N.		Wire No.	500V MΩ to Ground	Remarks
	0.2	1084	1	1081	10.	
	0.2	1085	2			
	16.	No Tag 1083	3	1003	8.	
	18.	1105	4	1010.	0.2	
	20.	No Tag 1110	5			
	18.	1117	6			
	18.	1125	7			
	0.2	2051	8	2022	0.2	
	0.2	2052	9			
Spare		No Wires	10			

Contacts

Remarks: Cover has probably been left OFF for a period of time. No gaskets, clips on some switches not hooked. Connection screws inside all rusty on the bottom. Springs rusty but still springy. Contacts are clean with fair contact alignment.

Figure 16.2.72 Example of Notes on Electrical Equipment (Limit Switch)

Megger Insulation Test of the Submarine Cables — Temp 50°s Weather Dry

Equipment Being Controlled	Wire No. on Plans	Emergency Cables			Normal Cables		
		No. in Cable	500V MΩ	Remarks	No. in Cable	500V MΩ	Remarks
North Tower Elev.	261	1	6		2	500	
	261	3	6		4	500	
	263	5	1.5		6	<.2	>20KΩ
	263	7	1.5		8	.1	
	262	9	.9		10	.1	
	262	11	.9		12	.1	
Service Brake C	447	13	2.0		14	1000	
	446	15	40.		16	1000	
	448	17	15.		18	1000	
Service Brake D	467	19	2.		20	1000	
	466	21	25.		22	1000	
	468	23	5.		24	1000	
Drag Brake L	519	25	20.		26	1000	
	516	27	35.		28	1000	
	520	29	5.		30	1000	
Drag Brake M	529	31	4.		32	1000	
516	526	33	5.		34	1000	
	535	35	1.		36	1000	
North Locks Motor	617	37	0.8		38	1000	
	616	39	10.		40	1000	
	618	41	0.2		42	1000	
North Barrier Gate Motor	647	43	12.		44	1000	
	646	45	.7		46	1000	
	648	47	90		48	∞	
N.W. Traffic Gate Motor	687	49	.2		50	1000	
	686	51	35.		52	∞	
	688	52	100.		54	∞	
N.E. Traffic Gate Motor	697	55	9.		56	1000	
	696	57	6.		58	1000	
	698	59	3.		60	1000	

Figure 16.2.73 Example of Notes on Electrical Equipment (Megger Insulation Test of the Submarine Cables)

16.2.18 Evaluation

State and Federal rating guideline systems have been developed to aid in the inspection of movable bridges. The two major rating guideline systems currently in use are the FHWA's *Recording and Coding Guide for the Structural Inventory and Appraisal of the Nation's Bridges* used for the National Bridge Inventory (NBI) component condition rating method and the AASHTO *Guide Manual for Bridge Element Inspection* for element level condition state assessment.

NBI Component Condition Rating Guidelines

Using the NBI component condition rating guidelines, a one-digit code on the Federal Structure Inventory and Appraisal (SI&A) sheet indicates the condition of the superstructure. Component condition rating codes range from 9 to 0 where 9 is the best rating possible. See Topic 4.2 (Item 59) for additional details about NBI component condition rating guidelines.

Consider previous inspection data along with current inspection findings to determine the correct component condition rating.

Element Level Condition State Assessment

In an element level condition state assessment of a movable bridge, possible AASHTO National Bridge Element (NBEs) and Bridge Management Elements (BMEs) are:

NBE No.	Description
Superstructure	
	Box Girder
102	Steel Closed Web/Box Girder
	Floor System
107	Steel Open Girder/Beam
113	Steel Stringer (Stringer-Floorbeam System)
152	Steel Floorbeam (Stringer-Floorbeam System)
	Steel Truss
120	Steel Truss
162	Steel Gusset Plate
	Steel Arch
141	Steel Arch
	Cable
147	Steel Main Cable (not embedded in concrete)
148	Steel Secondary Cable (not embedded in concrete)

BME No.	Description
Wearing Surfaces and Protection Systems	
515	Steel Protective Coating

The unit quantity for the superstructure elements is feet. The total length is distributed among the four available condition states depending on the extent and severity of the deficiency. The unit quantity for gusset plates is each, with each gusset plate element placed in one of the four available condition states depending on the extent and severity of the deficiency. The unit quantity for protective coating is square feet, and the total area is distributed among the four available condition states depending on the extent and severity of the deficiency. The sum

of all condition states equals the total quantity of the National Bridge Element or Bridge Management Element. Condition State 1 is the best possible rating. See the *AASHTO Guide Manual for Bridge Element Inspection* for condition state descriptions.

For mechanical, electrical, and hydraulic movable bridge members, individual bridge owners may choose to create their own Agency Developed Elements (ADEs).

The following Defect Flags are applicable in the evaluation of movable bridges:

Defect Flag No.	**Description**
356	Steel Cracking/Fatigue
357	Pack Rust
362	Superstructure Traffic Impact (load capacity)
363	Steel Section Loss
364	Steel out-of-plane (compression members)

See the AASHTO *Guide Manual for Bridge Element Inspection* for the application of Defect Flags.

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Complex Bridges

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Topic 16.3 Floating Bridges

16.3.1 Introduction

Although uncommon, some states have floating bridges that are not supported by a substructure. Instead, they are supported by, or float on the water. The bridge elevation will change as the water level fluctuates (see Figure 16.3.1).

Floating bridges are cost-effective solutions for crossing large bodies of very deep water with a very soft bottom where conventional piers are impractical. For a site with a 100- to 200-foot deep water and a very soft bottom extending another 100 to 200 feet, a floating bridge is estimated to cost three to five time less than a conventional multi-span fixed bridge or a tunnel.

Floating bridges perform well in areas subjected to high winds, moderate currents and moderate waves. They also have low environmental impact and perform well in seismic events.

Washington State is known for its floating bridges with four of the longest and heaviest floating bridges. They are the SR 520 Evergreen Point Bridge, the I-90 Lacey V. Murrow Bridge, the I-90 Homer M. Hadley Bridge, and the SR 104 Hood Canal Bridge.

Figure 16.3.1 Floating Bridge, SR 520 Evergreen Point Bridge, Seattle, WA During Stormy Weather

16.3.2 Design Characteristics

Floating bridges take advantage of the natural law of buoyancy of water to support the loads. This is achieved through the use of giant pontoons secured into place by an anchoring system. Conventional piers and foundations are not used.

Since a floating bridge "sits" on the water, the bridge itself creates an obstacle to vessels attempting to cross the waterway. For this reason, many floating bridges employ a movable bridge section for vessels to pass through, or an elevated span for vessels to pass under (see Figures 16.3.2 and 16.3.3).

Figure 16.3.2 Movable Bridge Section of Evergreen Point Bridge, Seattle, WA

Figure 16.3.3 Elevated Section of Evergreen Point Bridge, Seattle, WA

Pontoons

Floating bridges may be constructed of wood (see Figure 16.3.4), concrete, steel, or a combination of materials depending on the design requirements although concrete pontoons are generally used in the newer bridges.

The pontoons are large water-tight chambers constructed off site and floated into place (see Figures 16.3.5 and 16.3.6). Despite their heavy concrete composition, the weight of the water displaced by the pontoons is equal to the weight of the structure (including all traffic), which allows the bridge to float. They may be prestressed concrete or reinforced concrete and are classified as either continuous pontoon type or separate pontoon type. The pontoons are held into place by huge steel cables anchored deep in the soil below water.

Figure 16.3.4 Brookfield, Vermont, Floating Bridge Constructed from Timber

Figure 16.3.5 Concrete Pontoons Under Construction

Figure 16.3.6 Concrete Pontoons Transported for Hood Canal Project

To control water leaking into the interior of the pontoons and ultimately sinking the bridges, each pontoon contains several water tight cells. This confines any flooding to a small area of the bridge. Access doors to the interior cells are watertight. Each cell may be equipped with water sensors for early detection of any leaks in the pontoons and a bilge pumping system to pump out water.

Bridge pontoons are designed to safely withstand wind and wave forces, major storms and vessel collisions.

Continuous Pontoons

Continuous pontoon bridges are made of individual pontoons, longitudinally connected to each other. The top of the pontoons may be the roadway or a superstructure may be built on top of the pontoons. The size of each pontoon is determined by design requirements as well as constraints imposed by the constructions facilities and the transportation route to the bridge site.

The floating bridges in use today in Washington State are of the continuous type (see Figure 16.3.7).

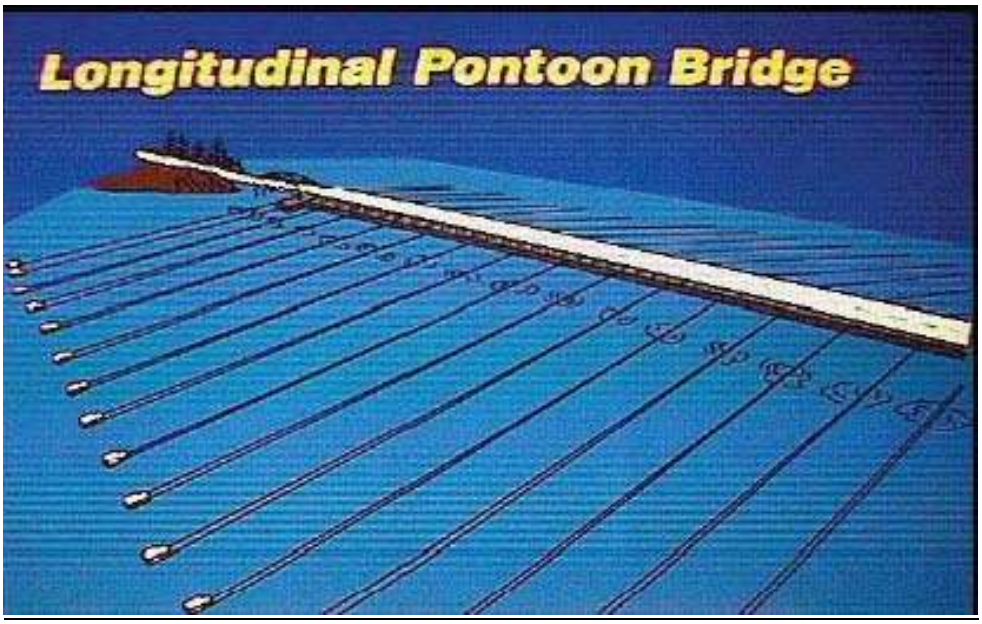


Figure 16.3.7 Continuous Pontoon-Type Structure

Separate Pontoons

A separate pontoon type of floating bridge consists of individual pontoons. These pontoons are placed transversely to the structure and are spanned by a steel or concrete superstructure (see Figures 16.3.8 and 16.3.9). The superstructure needs to be strong enough and rigid enough to maintain the position of the separated pontoons. A series of cables are attached to each pontoon and are anchored deep in the soil below water.

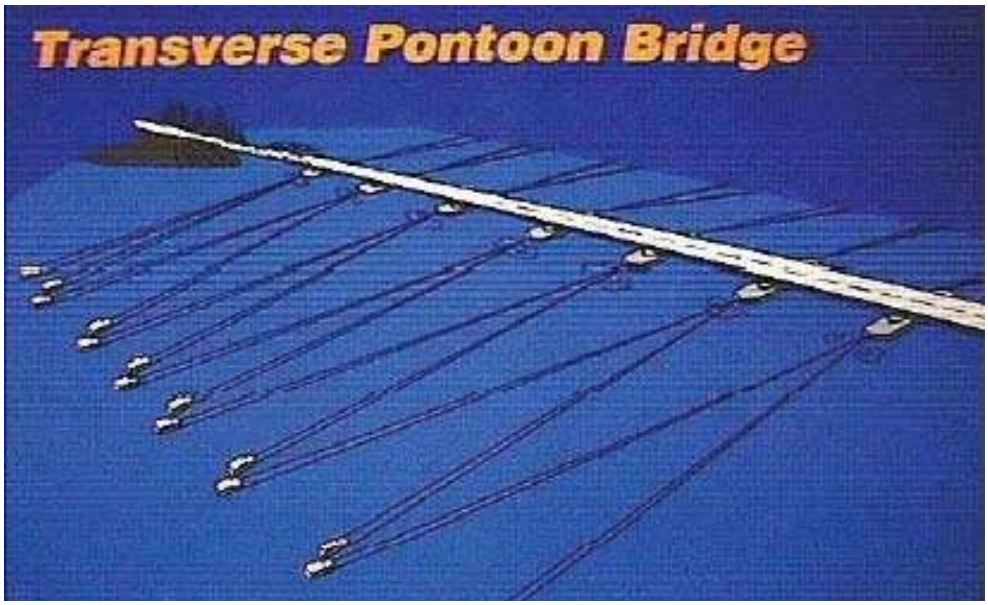


Figure 16.3.8 Separate Pontoon Type Structure

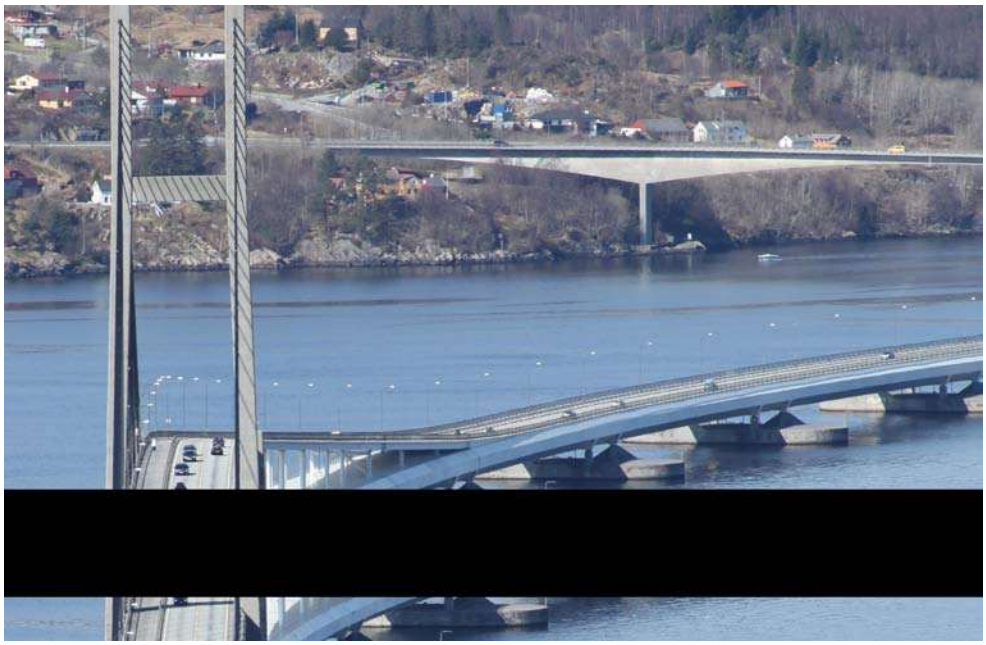


Figure 16.3.9 Bridge Constructed with Separate Pontoons

Anchoring Systems

Floating bridges are held in place in various ways such as a system of piles, caissons, cables, anchors and fixed guide structures. The most common type of system consists of cables and anchors. Anchor cables are normally two and one half inches in diameter and consist of dozens of individual steel strands (see Figure 16.3.10).

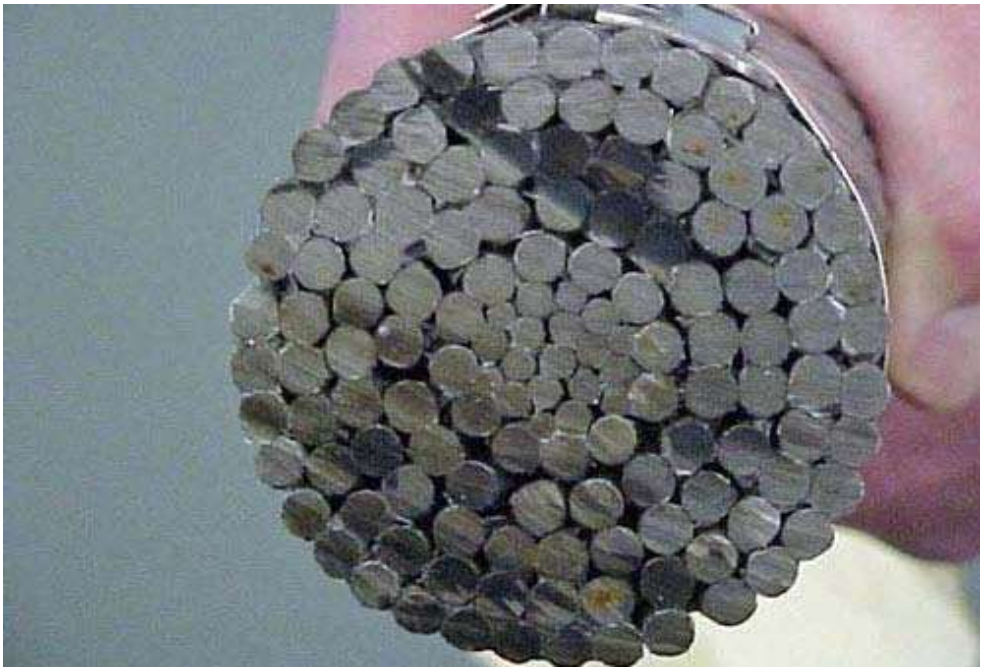


Figure 16.3.10 Cross-Section of Anchor Cable

Anchor cable saddles are used within the pontoon to guide and hold the cable in place (see Figure 16.3.11). Hydraulic jacks inside the pontoon tighten or release the pressure on the cables as the water level fluctuates under the bridge.

Figure 16.3.11 Anchor Cable Saddle

Types of Anchoring Systems

Depending on the depth of the water and the soil conditions, there are four primary types of anchoring systems used on the floating bridges: precast concrete fluke style anchor, pile anchor, open-cell gravity block anchor, and solid gravity slab anchor (stackable).

Precast Concrete Fluke Style Anchor

Precast concrete fluke style anchors are used in deep water with very soft soil conditions. Anchors weighing 60 to 86 tons are lowered to the soil below water. Water jets are turned on allowing the anchors to sink to the proper depth (see Figure 16.3.12).

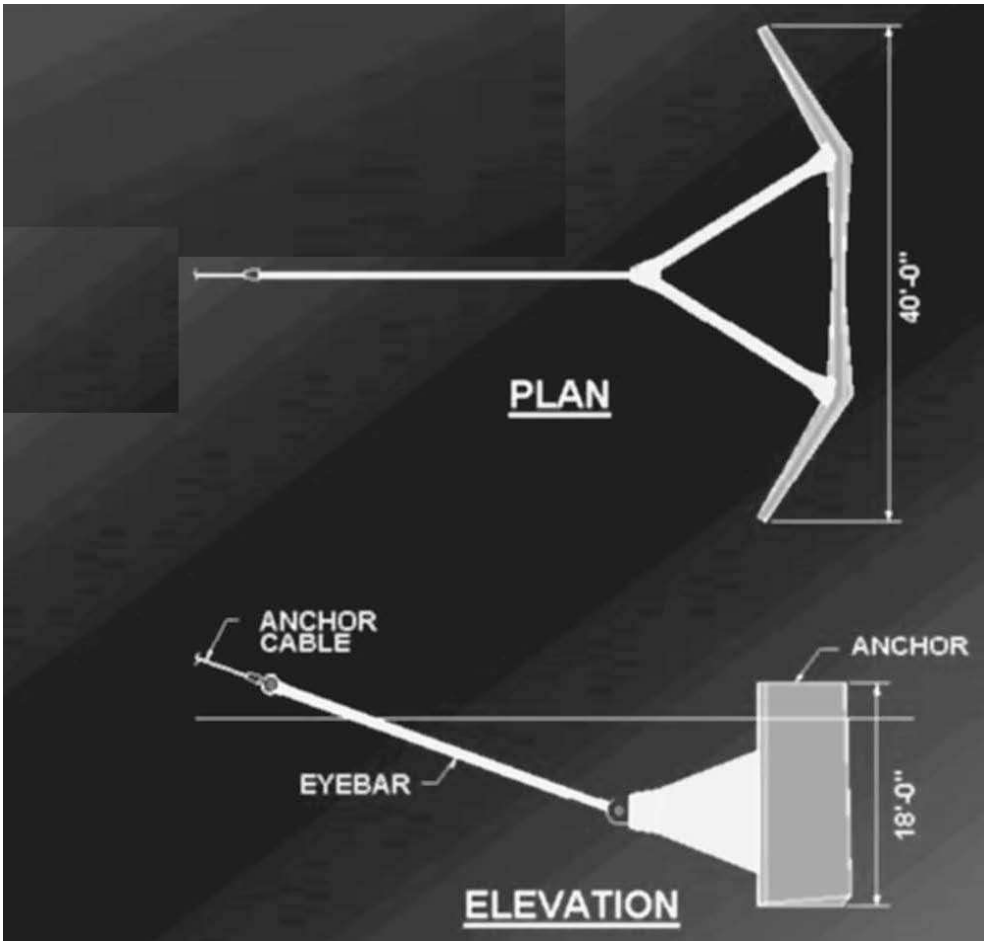


Figure 16.3.12 Precast Concrete Fluke Style Anchor

Pile Anchor

Pile anchors are designed for use in water depths less than 88 feet and with hard soil. Piles are driven into the surface to a specified depth and tied together to increase capacity (see Figure 16.3.13).

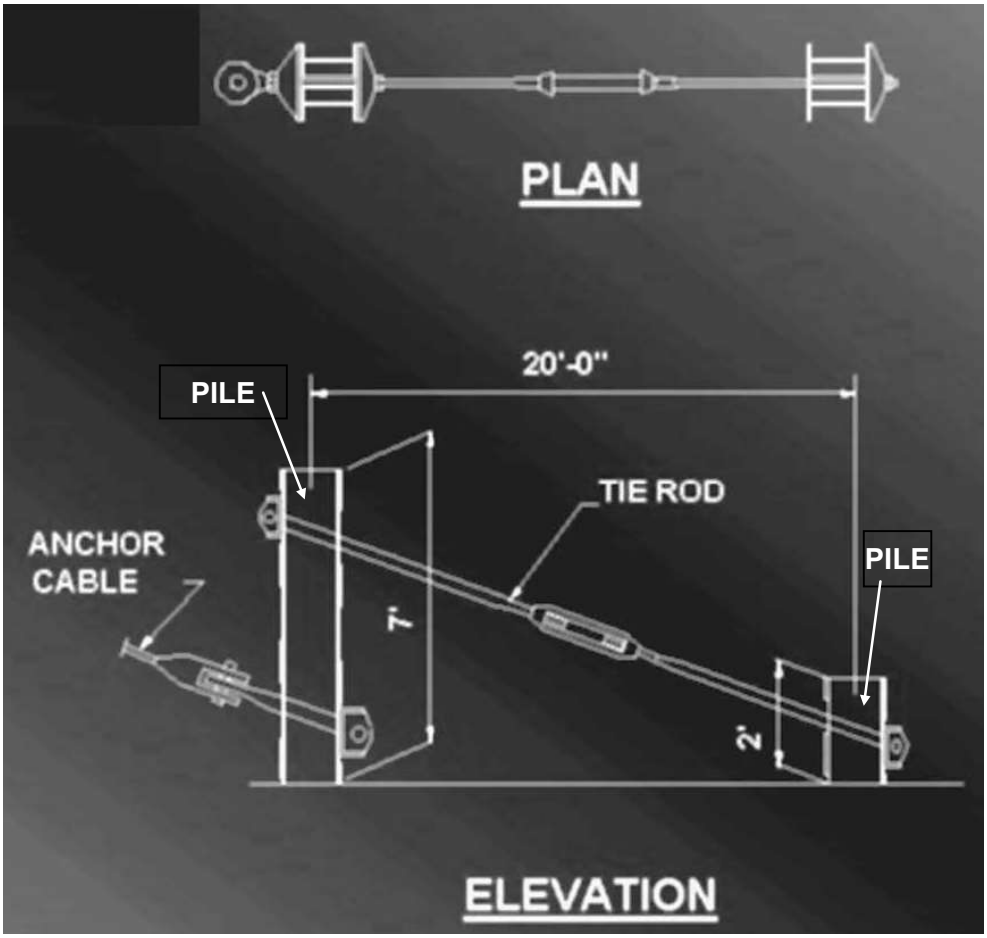


Figure 16.3.13 Pile Anchor

Open-Cell Gravity Block Anchor

Open-cell gravity block anchors are a gravity type of anchor. They are reinforced concrete boxes with an open top that are lowered into position and filled with gravel to a predetermined weight. This type or anchor is used in deep water where the soil is hard (see Figure 16.3.14).

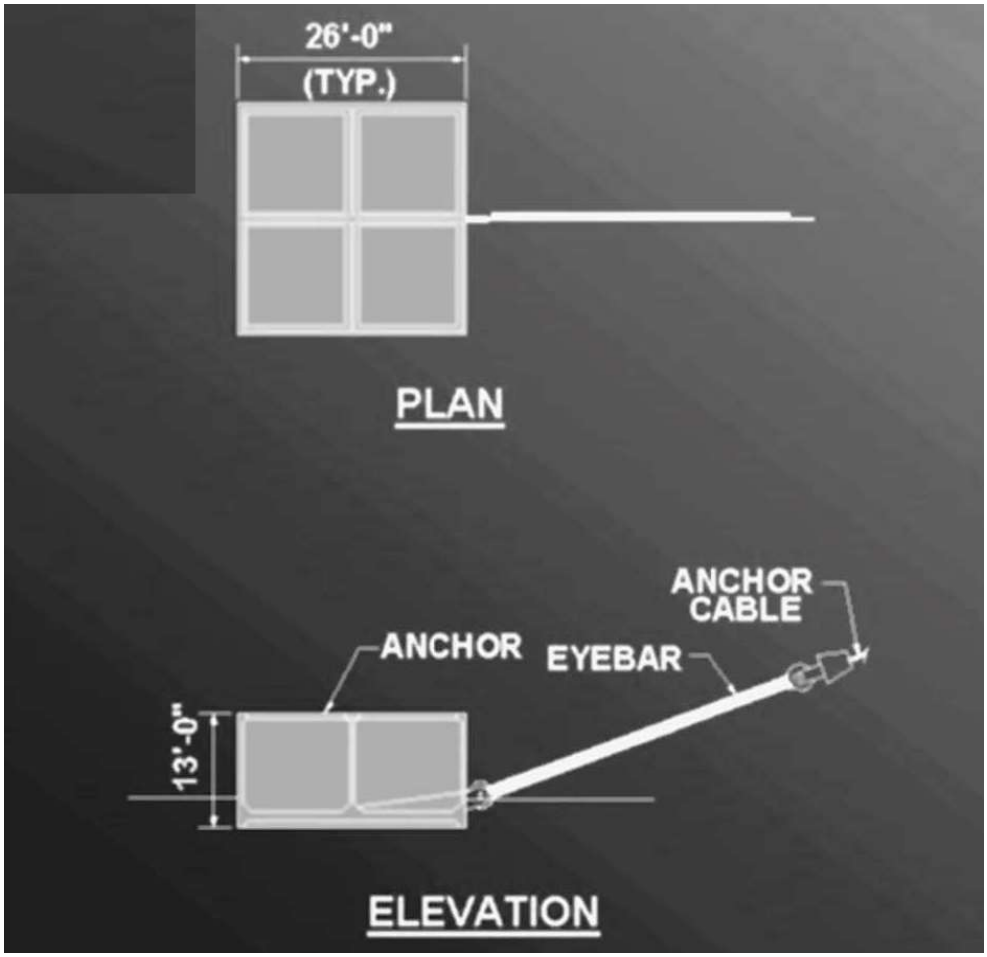


Figure 16.3.14 Open-Cell Gravity Block Anchor

Solid Gravity Slab Anchor (Stackable)

Solid gravity slab anchors are a gravity type of anchor. They can be used in either shallow or deep water where the soil is hard. These anchors are solid reinforced concrete slabs weighing up to 270 tons each. The first slab is lowered into position, and then additional slabs are added until the required anchoring capacity has been reached. Solid gravity slab anchors are the preferred anchor type because they are easy to cast and can be placed quickly (see Figure 16.3.15).

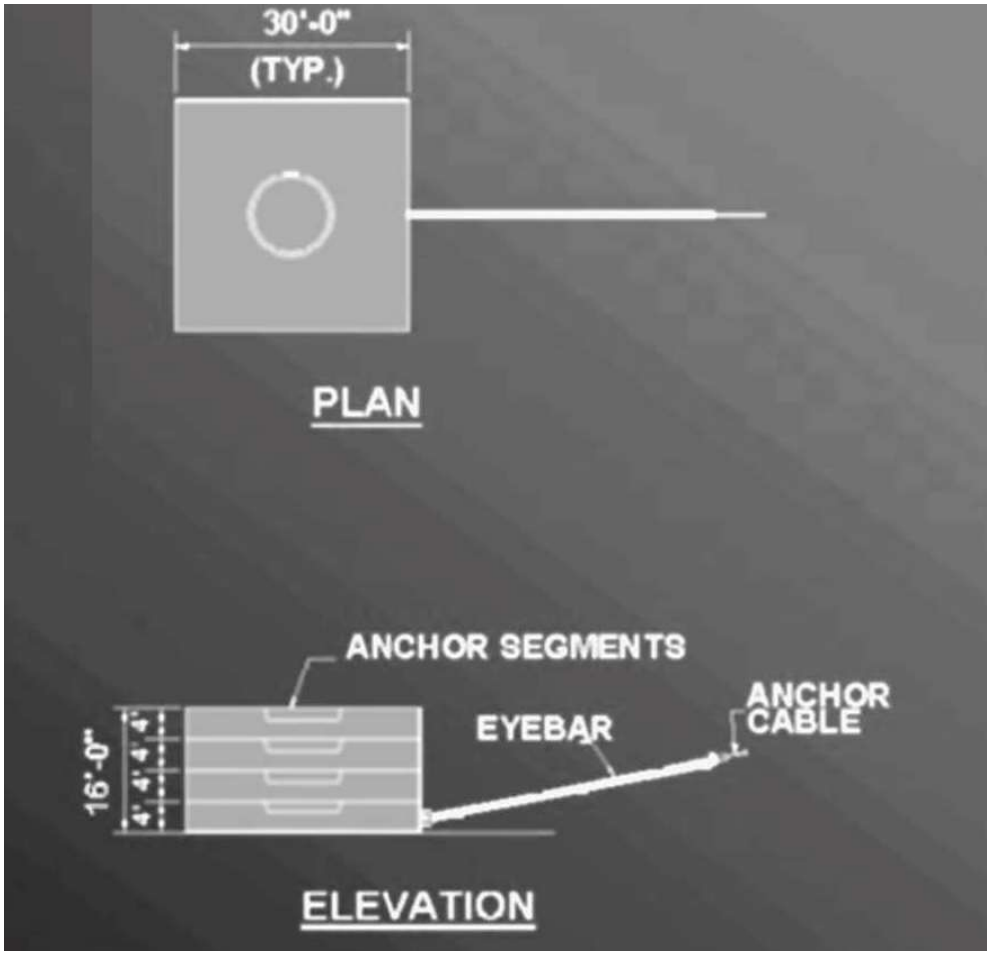


Figure 16.3.15 Solid Gravity Slab Anchor

16.3.3 Overview of Common Deficiencies

Common deficiencies that occur on floating bridges are:

- Corrosion of anchor cables
- Fatigue cracking
- Overloads
- Collision damage
- Water infiltration

Floating bridges may be constructed from steel, concrete or timber. Therefore, deficiencies will depend on the material used to construct the bridge. See Topics 6.1 (Timber), 6.2 (Concrete), and 6.3 (Steel) for specific information regarding deficiencies of each material type.

16.3.4 Inspection Locations and Methods

Because of their uniqueness and depending on the material used, floating bridges can prove challenging to an inspector. Floating bridges can be constructed of steel, concrete or timber, therefore a variety of inspection methods are utilized to thoroughly inspect the bridge. Additionally, since many floating bridges include an elevated conventional bridge structure or a moveable bridge section, those inspection methods and locations are to be considered by the inspection team.

See Chapter 6 for detailed description of anticipated modes of deterioration for common bridge materials. See Chapters 8 through 12 for the inspection and evaluation of timber superstructures, concrete superstructures, steel superstructures, bearings and substructures. See Topic 16.2 for detailed information about movable bridges.

Methods

Visual

Visual inspection of each pontoon cell will reveal any cracks or leaks. Pontoons have access hatches to allow for maintenance and inspection (see Figure 16.3.16).

Visually inspect concrete pontoons for the following deficiencies:

- Cracking
- Spalling
- Delamination
- Overload damage
- Collision damage
- Abrasion
- Loss of watertight seals on access doors and hatches
- Damaged cable connections

Visually inspect steel pontoons for the following deficiencies:

- Cracking
- Overload damage
- Collision damage
- Loss of watertight seals on access doors and hatches
- Coating failure
- Corrosion and section loss
- Damaged cable connections

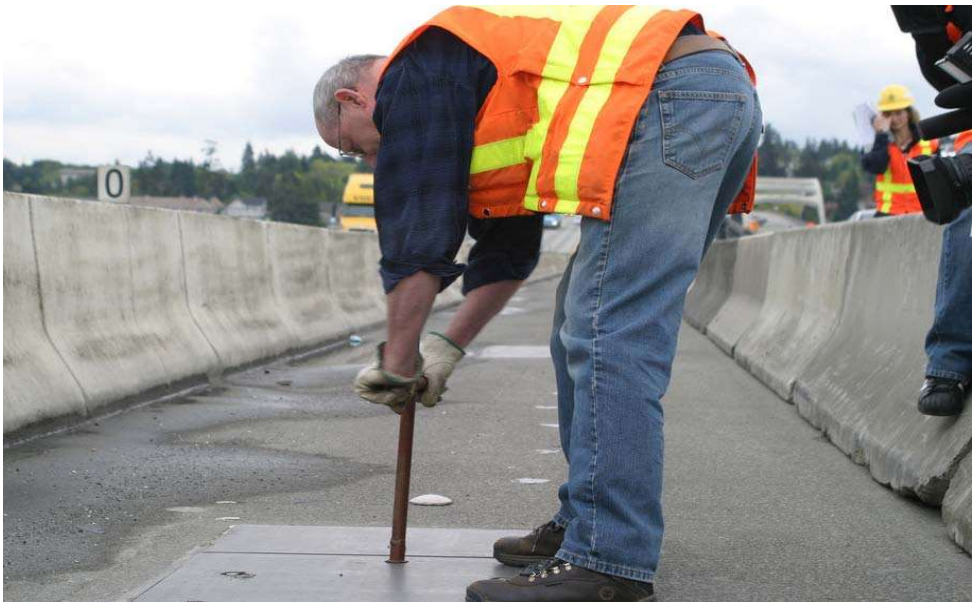


Figure 16.3.16 Inspector Opening Pontoon Access Hatch

Physical

Measure and record the depth of any water found in each cell. The length, location and width of cracks found are to be accurately measured and recorded (see Figure 16.3.17). For steel pontoons and cables, remove corrosion and rust down to bare metal. With calipers or a D-meter, measure and record remaining section thickness. Use a hammer to check for delaminated areas in concrete pontoons.

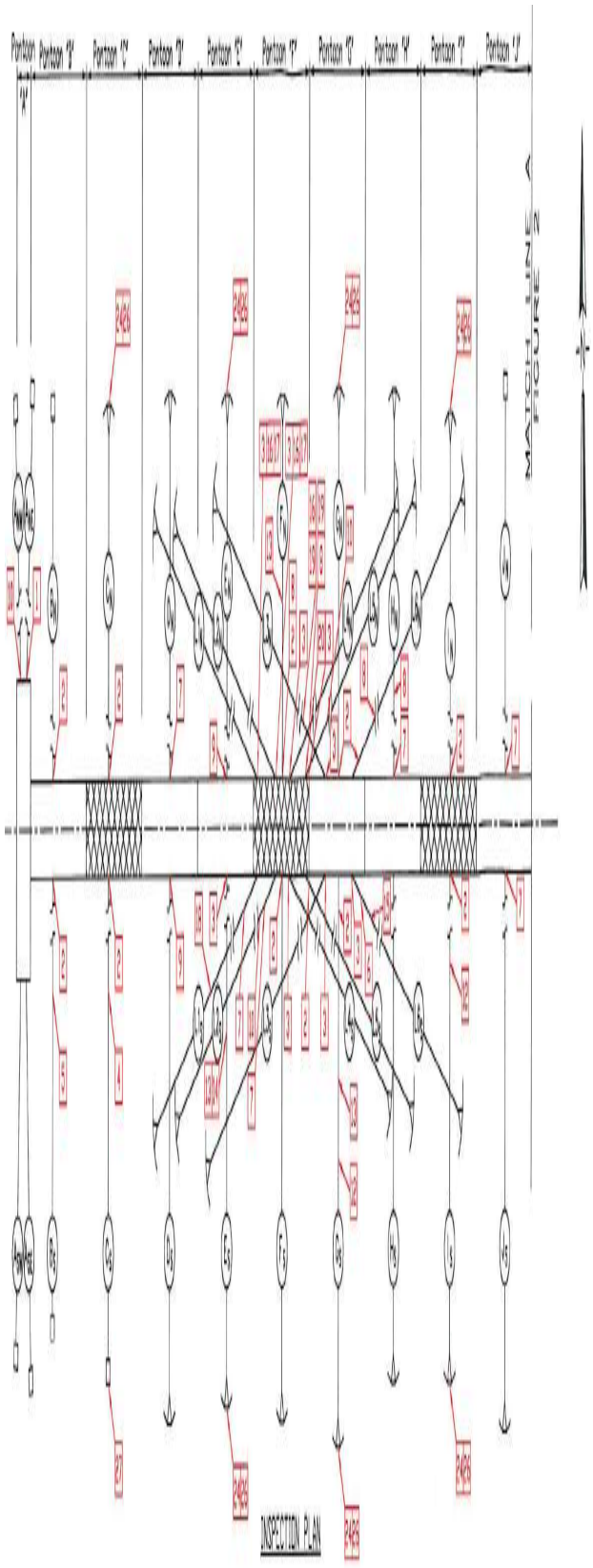


Figure 16.3.17 Sample Pontoon Inspection Plan

Advanced Inspection Methods

Many of the advanced inspection tools used above water have been adopted for underwater use. See Chapter 15 for the advanced inspection methods of timber, steel and concrete.

Anchors may be embedded 100 or more feet below the water surface. Inspection of the anchors will require underwater divers and equipment with the ability to detect any deficiencies present. See Topic 13.3, Underwater Inspection. Underwater cameras, sonar and other specialized equipment can provide access to cables and anchors.

Locations

Pontoons

Examine the floor of each pontoon cell for standing water. Examine pontoon walls and surfaces for cracks. Examine access doors, locks and hatches verifying that they are water tight and in proper working condition. Check the bilge pumping system and verify that it is in working order. Convey any noted problems with the pumping system to specialized maintenance personnel responsible for the system.

Examine the cable ends and anchor cable saddle inside the pontoon. Look at the connections in the pontoons for frayed or broken strands. Verify the presence and functioning of any cathodic protection system on the anchor cables.

Joints

When continuous pontoons are used, inspect the joint between the pontoons. Typically a rubber membrane or grout is used between the pontoons. Examine the alignment of the pontoons across the structure looking for signs of differential movement or distortion. This may indicate water leaking into one of the pontoons or some type of ballast balancing problem within the structure.

Cables

Examine the cable ends at the pontoon portals and check for cable misalignment and fraying. Check for broken wires that may indicate undue stress on the cable securing the pontoon (see Figure 6.3.18). Also check cables for heavy corrosion or section loss (see Figure 6.3.19).

Figure 16.3.18 Frayed Cables Removed from a Floating Bridge

Figure 16.3.19 Typical View of Heavy Corrosion within Pontoon Port

Anchors

Floating bridges are subjected to wind, tides and wave forces that are unpredictable and always changing. This exerts high levels of strain and stress on the cables and the anchors. Inspection of the anchors is not easily accomplished. Underwater remote equipment can provide information on each anchor. Look for any indication of anchor movement, misalignment or undermining of the anchor. Check the ballast on open-cell gravity block anchors to verify if there is enough material to keep the anchors in place.

16.3.5 Evaluation

State and Federal rating guideline systems have been developed to aid in the inspection of floating bridges. The two major rating guideline systems currently in use are the FHWA's *Recording and Coding Guide for the Structural Inventory and Appraisal of the Nation's Bridges* used for the National Bridge Inventory (NBI) component condition rating method and the AASHTO *Guide Manual for Bridge Element Inspection* for element level condition state assessment.

NBI Component Condition Rating Guidelines

Using the NBI component condition rating guidelines, a one-digit code on the Federal Structure Inventory and Appraisal (SI&A) sheet indicates the condition of the superstructure. Component condition rating codes range from 9 to 0 where 9 is the best rating possible. See Topic 4.2 (Item 59) for additional details about NBI component condition rating guidelines.

Consider previous inspection data along with current inspection findings to determine the correct component condition rating.

Element Level Condition State Assessment

In an element level condition state assessment of a floating bridge, possible AASHTO National Bridge Elements (NBEs) and Bridge Management Elements (BMEs) are:

NBE No.	Description
Superstructure	
107	Steel Girder/Beam
102	Steel Closed Web/Box Girder
113	Steel Stringer
152	Steel Floorbeam
147	Steel Cables
109	Prestressed Concrete Girder/Beam
104	Prestressed Concrete Closed Web/Box Girder
115	Prestressed Concrete Stringer
154	Prestressed Concrete Floorbeam
110	Reinforced Concrete Girder/Beam
105	Reinforced Concrete Closed Web/Box Girder
116	Reinforced Concrete Stringer
155	Reinforced Concrete Floorbeam
111	Timber Girder/Beam
117	Timber Stringer
156	Timber Floorbeam
Substructure	
310	Elastomeric Bearing
311	Moveable Bearing (roller, sliding, etc)
312	Enclosed/Concealed Bearing
313	Fixed Bearing
314	Pot Bearing
315	Disk Bearing

BME No.	Description
Wearing Surfaces and Protection Systems	
510	Wearing Surfaces
515	Steel Protective Coating
525	Concrete Protective Coating

The unit quantity for the superstructure elements is feet. The total length is distributed among the four available condition states depending on the extent and severity of the deficiency. The unit of quantity for bearings is each, with each bearing element placed in one of the four available condition states depending on the extent and severity of the deficiency. The unit quantity for wearing surfaces and protective coatings is area, and the total area is distributed among the four available condition states depending on the extent and severity of the deficiency. The sum of all condition states equals the total quantity of the National Bridge Element or Bridge Management Element. Condition State 1 is the best possible rating. See the *AASHTO Guide Manual for Bridge Element Inspection* for condition state descriptions.

The following Defect Flags are applicable in the evaluation of floating bridges:

Defect Flag No.	Description
356	Steel Cracking/Fatigue
357	Pack Rust
358	Concrete Cracking
359	Concrete Efflorescence
360	Settlement
361	Scour
362	Superstructure Traffic Impact (load capacity)
363	Steel Section Loss
364	Steel out-of-plane (Compression Member)

See the AASHTO *Guide Manual for Bridge Element Inspection* for the application of Defect Flags.

Appendix A

Sample Inspection Report

PORT AUTHORITY OF ALLEGHENY COUNTY
PITTSBURGH, PENNSYLVANIA

REPORT ON THE
NBIS INSPECTION
OF
CHARTIERS CREEK BRIDGE

BMS No. 02 7421 0000 9061

Submitted By:

Michael Baker Jr., Inc.
100 Airside Drive
Coraopolis, Pennsylvania
15108

September, 2011

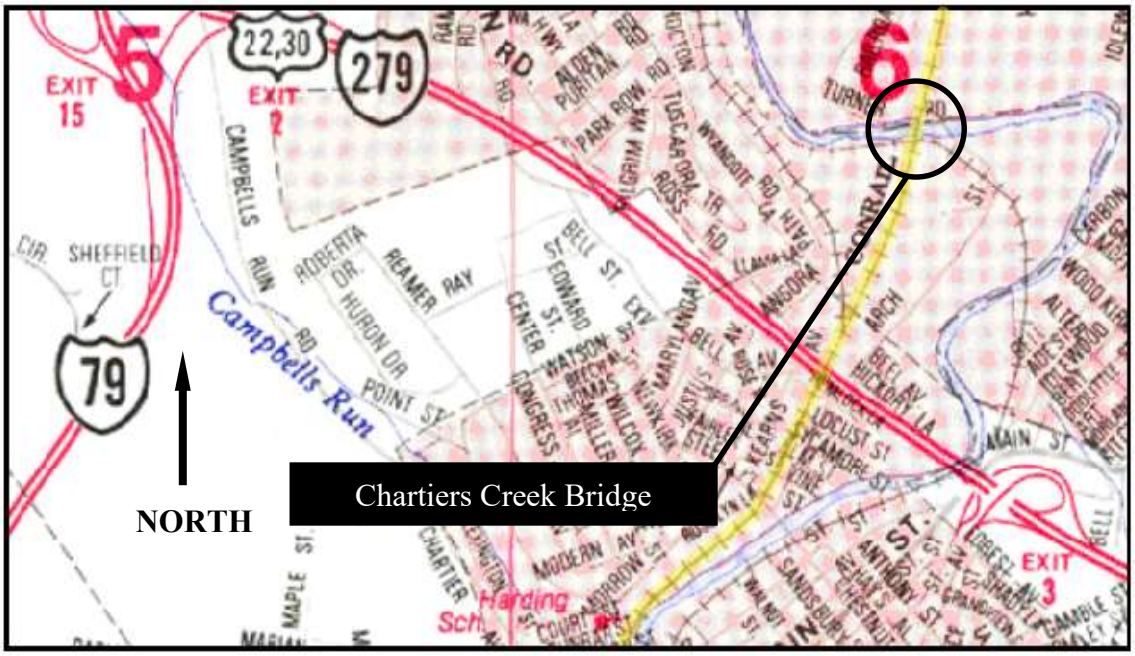
STRUCTURE B.M.S. NUMBER:	02 7421 0000 9061
BRIDGE NAME:	Chartiers Creek Bridge
LOCATION:	Crafton, Pennsylvania
INSPECTION DATE:	June 23, 2011
INSPECTED BY:	Michael Baker Jr., Inc. Patrick A. Leach, P.E. Charles L. Molnar
PREPARED FOR:	Port Authority of Allegheny County
PREPARED BY:	Michael Baker Jr., Inc. Written By: Joseph E. Salvadori, E.I.T. Reviewed By: Raymond A. Hartle, P.E.
PORT AUTHORITY AGREEMENT NUMBER:	11-08
OWNER OF BRIDGE:	Port Authority of Allegheny County

COST INFORMATION:

Inspection & Report	$4,662.00
Rigging	$2,340.00
Traffic Control	$ 0
Railroad	$ 0
Insurance	$ 0

DATE SUBMITTED: (Seal removed for BIRM)

TABLE OF CONTENTS



Location Map

(No Scale)

REPORT ON THE INITIAL NBIS INSPECTION
OF
CHARTIERS CREEK BRIDGE

PORT AUTHORITY OF ALLEGHENY COUNTY

II. INTRODUCTION:

- Location

  Located in the Borough of Crafton, the Chartiers Creek Bridge carries two (2) lanes of the Port Authority of Allegheny County's West Busway over Chartiers Creek, and the Pittsburgh Industrial Railroad, Inc.

- Year Built

  The approximate date of the original construction of the Chartiers Creek Bridge is 1948. The structure was built by the Pennsylvania Railroad Company. Rehabilitation was completed in July 1997.

- Load Posting

  None required.

- Description

  The Chartiers Creek Bridge is a three (3) span, non-composite, riveted and bolted built-up plate girder bridge with a total length of 253'- 11" (see photo no. 1). The 3 spans consist of one (1) main simple span 124'-0", one (1) simple south end span 55'-3", and one (1) simple north end span 68'-3" long. The span lengths are measured between centerline of bearings. The skew angle measured between the centerline of the abutment and West Busway is 90^0. There are AT&T conduits mounted under the deck, and light poles mounted on top of the concrete parapets (see photo no.'s 8 & 2, respectively).

The superstructure consists of four girders spaced at 7'-0" – 6'-0" – 7'-0" on centers, are laterally restrained with angle cross framing, and support an 8 1/2" reinforced concrete deck. The deck thickness includes a 1/2" integral-wearing surface. The deck measures 28'-0" between the reinforced concrete parapets present on both sides of the structure. Galvanized stay-in-place deck forms are present on the underside of the deck (see photo no. 8).

Span 1 girders are made up of a 5'-11" deep by 1/2" thick web plates, and 18" wide by 3/4" thick top and bottom flange plates (see photo no. 8). The main span consists of a 10'- 4 1/2" deep by 1/2" thick web plate, and top and bottom flange plates varying from 20" wide by 7/8" thick, to 20" wide by 1" thick (see photo no. 9). Span 3 girders are made up of a 6'- 10 1/2" deep by 1/2" thick web plate, and 18" wide by 3/4" and 7/8" thick top and bottom flange plates (see photo no. 10). New knee brackets, bolted to the fascia girders, measure 4'-9" wide, from the centerline of existing fascia girders to the centerline of the new W24x55 fascia stringers, with 1/2" thick web plates, and 6" wide by 1/2" thick top and bottom flange plates (see photo no. 4). Lateral bracing and diaphragms consist of angles, and angle x-bracing, respectively. Laminated elastomeric bearing pads are present at the girder ends.

The main span vertical underclearance, from the existing concrete channel bottom, at the centerline of the railroad measures 60'-9" and 36'-7" in span 1.

Gravity type substructures consist of a combination of original stone construction with newly constructed reinforced concrete abutment backwalls and pier caps (see photo no.'s 4 to 7).

III. INSPECTION FINDINGS:

Michael Baker Jr., Inc. performed this initial inspection, which follows NBIS procedures, on June 23, 2011, via a UB-40 underbridge inspection crane. In general, the structure was in good condition with a few minor problems. Several conduits at the south abutment and in span 1 have severely buckled segments, and broken couplers and/or adapters (see photo no.'s 12 & 13). In addition, a conduit in span 3 is split and leaking water (see photo no. 14). These problems are due to the junction boxes being allowed to fill with rainwater during construction.

Approach

The north and south approach roadway and slabs are newly constructed with no deficiencies noted.

Deck

No deficiencies noted – new construction (see photo no. 11). All PennDOT Type 1 scuppers are in excellent condition. A few scuppers exhibit minor debris accumulation but are fully functional (see photo no. 15). Random hairline (< 0.01") shrinkage cracks along the length of the concrete parapets are present (see photo no. 16). Deck expansion joints consist of strip seals in good condition with minor debris accumulation (see photo no. 17).

Superstructure

The superstructure has no visible structural deficiencies. Girders, fascia stringers, knee brackets, and lateral bracing are newly painted. The paint shows no visual defects, but the girders and bracing exhibit evidence of prior minor section loss and member pitting. Fascia stringers and knee brackets are in new condition with no deficiencies noted (see photo no. 4). Diaphragms are in good condition, but show areas of freckled surface rust under the broken

conduit in span 1. Approximately 50% of lateral bracing connections between girders 3 & 4, in span 2, were not painted with final paint coat (see photo no. 18). Laminated elastomeric bearing pads are functioning properly with no problems noted.

Substructure

The north and south abutments are in good condition, with a few minor problems noted. Both abutments have newly constructed reinforced concrete backwalls, bridge seats, and wingwalls with no visual deficiencies noted (see photo no.'s 4 & 5). The stem tops consist of new reinforced concrete construction, also with no visual deficiencies noted, and are attached to the existing stone masonry bases. Some locations of the stone masonry show minor cracking and loosening of mortar.

Piers 1 & 2 are in good condition with minor cracking and loosening of mortar on the existing stone masonry portion of the stems. The bridge seats, caps, and stem tops are newly constructed reinforced concrete with no visual deficiencies noted (see photo no.'s 6 & 7).

Photo No. 1 General Elevation (Upstream)

Photo No.2 South Approach (near)

Photo No.3 North Approach (far)

Photo No.4 South Abutment (near) - Elevation

Photo No.5 North Abutment (far) - Elevation

Photo No.6 Pier 1 - North Face (Looking South)

Photo No.7 Pier 2 - North Face (Looking South), note electrical lines

Photo No.8 General Underside View – Span 1

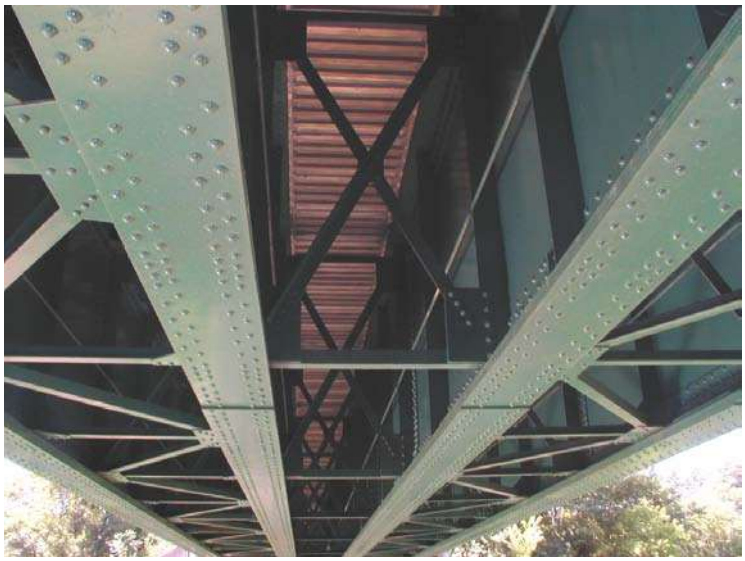


Photo No.9 General Underside View – Span 2

Photo No. 10 General Underside View – Span 3

Photo No. 11 General Deck View

Photo No. 12 Conduit, Span 1 – note longitudinal crack/split

Photo No. 13 Conduit and Couplers, Span 1 – note bend in conduit, and coupler separation

Photo No.14 Conduit , Span 3 – note conduit is split and leaking water

Photo No. 15 Typical PennDOT Type 1 Scupper

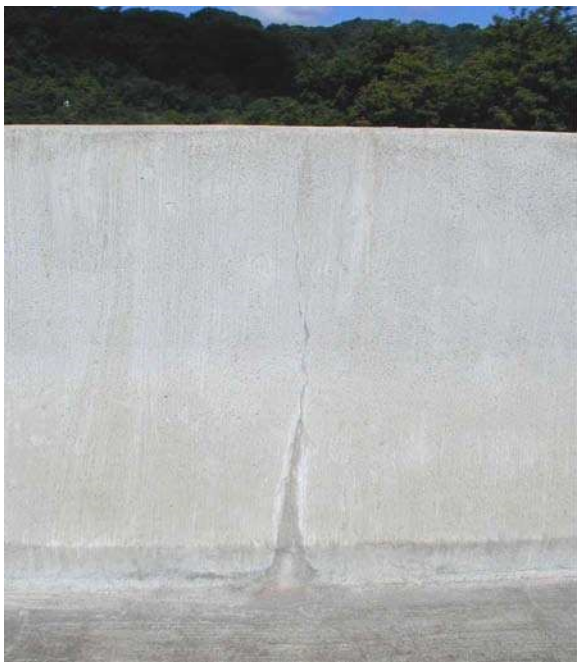


Photo No.16 Typical parapet crack

Photo No. 17 Strip Seal at North Abutment (typ.) – note minor debris accumulation

Photo No.18 Lateral bracing connection between beam #3 and #4, in span 2 – note no final paint coat, and rust freckles

IV. STRUCTURAL ANALYSIS:

Bridge Load Ratings (Tons)

LOAD FACTOR	H	HS	ML	P
Inventory w/o F.W.S	115	159	152	---
Inventory w/ F.W.S	112	155	148	---
Operating w/o F.W.S	191	265	253	346
Operating w/ F.W.S	187	259	247	338

Note: 1) Critical rating is for a beam controlled by shear in span 3
2) Due to no analysis being performed as part of the inspection, the above table is reproduced from contract drawings.

V. RECOMMENDATIONS AND COST ESTIMATE:

Repairs

Item	Estimated Quantity	Unit Cost	Total Cost
Drain junction boxes, and conduits filled with water. Repair bent conduits, and broken couplers/adapters.	N/A	Lump Sum	$7,500.00
Paint locations requiring final paint coat between girders 3 & 4 in span 2.	20 SF	Lump Sum	$1,500.00

TOTAL COST $9,000.00

Note: The above costs are only for the items listed and do not include additional costs which would be incurred when the work is performed, such as mobilization, maintenance and traffic protection, engineering, etc.

PDT Form D-450A (DEC 1996)

Site Data

BRIDGE MANAGEMENT SYSTEM
BRIDGE INSPECTION REPORT

BMS Updated by _____ Date _____

A01: 027421 0000 9061

C05 Structure Type (Dept.): Main — STL. RIVETED I-BEAM — 19110

CHARTIERS CREEK BRIDGE Over CHARTIERS CREEK Approach

Inspection Date E06: 062300

Name of Consultant and/or Inspectors E12: MICHAEL BAKER JR., INC.

Inspection Type E07: 1

Inspected by E08: 8

Hired by E13: 8

Time started: 7:30 A.M.

Weather Conditions: MOSTLY SUNNY Temp: 84

CRAFTON

Time completed: 4:30 P.M.

☐ City ☒ Borough ☐ Township

Optional Reminder: Check boxes if Maintenance Activities are needed --> X

Bridge Signing Verification

BMS Item	Type of Sign	Required Sign	SIGNING IN FIELD: Near Advance	Bridge Site: Near	Bridge Site: Far	Far Advance	Comments
D15	Bridge Weight Limit	N/A T					NONE POSTED
D15	Except Combination	N/A T					
D14	One Truck at a Time	Yes /(No)					
B22/B23	Vert. Clearance - On	N/A					See Sketch
B22/B23	Vert. Clearance - Und	N/A					See Sketch
	One Lane Bridge	Yes /(No)	(Opt)			(Opt)	
	Narrow Bridge	Yes /(No)	(Opt)			(Opt)	
	Hazard Clearance	Yes /(No)					
	Other						
(Opt)	Other						

Key --> OK: Signs properly installed M: Signs missing D: Signs damaged / incorrect New Wearing Surface Under Bridge: YES ☐ NO ☐

Notes

Vert. Clear. Sign **On Feature:** B01 = ___ B31 = ___ **Under Feature:** B01 = ___ B31 = ___

E26 Underclearance Appraisal: 5 Controlling: Lateral 12'-2" Vertical 36'-7"

E28-A Traffic Safety Features (Subfields shown vertically) Posted Speed Limit ___ mph

6 Bridge Railing: PARAPET - JERSEY BARRIER. (GOOD CONDITION - MINOR CRACKING THROUGHOUT)

8 Transition: PARAPET EXTENSIONS.

8 Approach Guiderail: ON RIGHT - CONTINUOUS NJ BARRIER - GOOD. W-BEAM AND STL. POSTS ON NEAR LT. AND FAR LT.

6 Approach Rail Ends: FLARED AND TURNED DOWN W-BEAM ON NEAR LT. AND FAR LT.

E28 Approach Alignment: 8 NO SPEED REDUCTION. GOOD SIGHT DISTANCE.

E15 Approach Roadway: 8 NEW PAVEMENT GOOD CONDITION.

Pavement: GOOD

Drainage: GOOD (ALL NEW CONSTRUCTION)

Shoulders: GOOD

E14 Approach Slab: 8 NEW CONSTRUCTION.

Bump at Bridge Yes ☐ No ☒

C19 Relief Joint: 1

PDT Form D-450B (DEC 1996)

Bridge 1 Data

A01 | 0 2 | 7 4 2 1 | 0 0 0 0 | 9 0 6 1 | Inspection Date E06 | 0 6 2 3 1 1

For Non-State Roadways

B01 Ref	B27 ADT	B28 ADT YR	B30A ADTT %

For State highways, data from RMS will be used.

E25 Deck Geometry | 6 | Table ____ | Controlling Values: B27 / B34 / B22 ____ | A31 / A31 / B18 ____

Design Exception granted ? ____

E16 Deck Wearing Surface | 9 | NEW CONSTRUCTION (CONCRETE INTEGRAL)

C10 Wearing Surface Type | 1 0 1 | C10A Wearing Surface Thickness | 0 5

E17 Deck | 9 | Estimated Spall or Delamination ____ % | Est. Chloride Content ____

Top EXCELLENT CONDITION - NEW CONSTRUCTION.

Underside STAY IN PLACE FORMS (NO RUSTING NOTED) GALVANIZED AND IN GOOD CONDITION.

Exp Joint No. 4 | C22 Exp Jt Types | M | B | G

GOOD CONDITION - SOME MINOR DIRT BUILD UP. (STRIP SEALS)

Deck Drainage GOOD - SOME SCUPPERS HAVE DEBRIS BUT NOT IN THE DOWNSPOUT.

E18 Superstructure | 7 | See Sheet ____ for Additional Details. | Form 491-J attached for FCM details Yes/No ☐

Girders / Beams GOOD CONDITION - SUPERSTRUCTURE HAS BEEN RECONSTRUCTED FOR NEW BUSWAY BRIDGE. NEW PAINT/COATING OVER PREVIOUS PITTING/MORE SECTION LOSS. ALSO, SOME AREAS OVER LIGHT SURFACE RUST ON BOTTOM FLANGE. (THROUGHOUT)

Floorbeams N/A

Stringers NEW (FASCIA STRINGERS) W24 X 55 EXCELLENT CONDITION.

Diaphrams GOOD CONDITION. FEW AREAS OF FRECKLED SURFACE RUST UNDER BROKEN CONDUIT IN SPAN 1.

Truss Members N/A

Portals / Bracing FEW AREAS OF FRECKLED SURFACE RUST UNDER BROKEN CONDUIT IN SPAN 1. SEVERAL AREAS BETWEEN G3 AND G4 IN SPAN 2 WERE NOT PAINTED WITH FINAL COAT.

Bearings GOOD CONDITION. (LAMINATED ELASTOMERIC)

Drainage System (Below Deck) EXCELLENT CONDITION. (TYPE 1 SCUPPERS)

PDT Form D-450C (DEC 1996)

Abutment Data

A01 | 0 2 | 7 4 2 1 | 0 0 0 0 | 9 0 6 1 | E06 Inspection Date | 0 6 2 3 1 1

E20 Substructure | 7 Details on Sheet

NAB - Near Abutment (Use same notation as W09)

Backwall: GOOD CONDITION - NEW CONSTRUCTION.

Bridge Seats: GOOD CONDITION - NEW CONSTRUCTION. VERY MINOR DEBRIS.

Cheekwalls:

Stem: GOOD CONDITION - NEW CONCRETE CONSTRUCTION AT TOP ON EXISTING STONE MASONRY BASE. SOME LOCATIONS HAVE MINOR CRACKING AND LOOSENING OF MORTAR.

Wings: GOOD CONDITION - NEW CONSTRUCTION.

Footing: NOT VISIBLE.

Piles: NOT VISIBLE.

Scour / Undermine: Yes [ ] No [X] See Details on Form: Sheet:

ABUTMENT IS NOT IN CHANNEL. ALSO, CHANNEL IS CONCRETE LINED.

Settlement: NONE NOTED.

Embank-Slope-Wall: GOOD CONDITION - HEAVY VEGETATION.

Wall Drainage:

FAB - Far Abutment (Use same notation as W09)

Backwall: GOOD CONDITION - NEW CONSTRUCTION.

Bridge Seats: GOOD CONDITION - NEW CONSTRUCTION. MINOR DEBRIS.

Cheekwalls:

Stem: GOOD CONDITION - SAME AS NEAR ABUTMENT.

Wings: GOOD CONDITION - NEW CONSTRUCTION.

Footing: NOT VISIBLE.

Piles: NOT VISIBLE.

Scour / Undermine: Yes [ ] No [X] See Details on Form: Sheet:

ABUTMENT IS NOT IN THE CHANNEL.

Settlement: NONE NOTED.

Embank-Slope-Wall: HEAVY VEGETATION.

Wall Drainage:

PDT Form D-450D (DEC 1996)

Pier Data

A01	0 2	7 4 2 1	0 0 0 0	9 0 6 1	E06	0 6 2 3 1 1

Inspection Date

Substructure (Cont.)

Pier / Bent Number 1 (Use same notation as W09)

Bridge Seats GOOD CONDITION - NEW CONSTRUCTION.

Caps GOOD CONDITION - NEW CONSTRUCTION.

Cheekwalls

Columns/Stems GOOD CONDITION - NEW CONSTRUCTION ON TOP OF EXISTING STONE MASONRY BASE. MINOR CRACKING AND LOOSE MORTAR.

Footings NOT VISIBLE.

Piles NOT VISIBLE.

Scour / Undermine Yes [ ] No [X] See Details on Form ____ Sheet ____

NOT IN CHANNEL - CHANNEL IS CONCRETE LINED.

Settlement NONE NOTED.

Pier / Bent Number 2 (Use same notation as W09)

Bridge Seats GOOD CONDITION - NEW CONSTRUCTION.

Caps GOOD CONDITION - NEW CONSTRUCTION.

Cheekwalls

Columns/Stems GOOD CONDITION - SAME AS PIER 1.

Footings NOT VISIBLE.

Piles NOT VISIBLE.

Scour / Undermine Yes [ ] No [X] See Details on Form ____ Sheet ____

CHANNEL IS CONCRETE LINED.

Settlement NONE NOTED.

PDT Form D-450E (DEC 1996) **Waterway 1 Data**

BRIDGE MANAGEMENT SYSTEM
BRIDGE INSPECTION REPORT

BMS Updated by _____ Date _____

A01: 02 7421 0000 9061 — U.W. Inspection Date W01-A: _____

Over _____ Weather Conditions _____

Inspection Type W02: N — U.W. Inspection Type W02-A: _____ — Regular U.W. Insp. Freq. W03: _____ — Interim U.W. Inps. Freq. W04: _____

Time started _____ Time completed _____

Name of Consultant and/or Inspectors W16: _____ — Hired by W17: _____ — Inspection Cost W15: _____

Scour Critical Rating E29A: W06: 9 based on: [X] Observed Scour [ ] Scour Calculation — No. of Units Inspected W14: _____

Streambed Material W07: C 8 _____ (36 SPACES) CONCRET LINED CHANNEL.

E21 Channel/Channel Protection - Cond. Rating: 7 Details on Sheet _____

Channel: CHANNEL IS LINED WITH CONCRETE.

Banks: GOOD CONDITION - HEAVY VEGETATION.

Streambed Movements: NONE NOTED.

Debris, Vegetation: SOME DEBRIS IN CHANNEL.

River (Stream) Control Devices: N/A

Embankment / Streambed Controls: N/A

Drift, Other: NONE NOTED.

E27 Waterway Adequacy: 9

Risk of Overtopping [X] Remote [ ] Slight [ ] Occasional [ ] Frequent

Traffic Delay [X] Insignificant [ ] Significant [ ] Severe **B18 - Functional Class.** _____

High Water Mark: ELEV: _____ DATE (mmyyyy) _____ [ ] New HW Mark [ ] HW since last inspecion

W09 Substructure Unit	W10 Foundation Type	W11 Water Depth	W11-A Observed Scour Rating	W11-B U.W. Insp Performed	W11-C Observed Depth	W11-F Counter-Measures
NAB	P	00	9	E	000	

Findings: ABUTMENT OUT OF FLOOD PLANE.

W09 Substructure Unit	W10 Foundation Type	W11 Water Depth	W11-A Observed Scour Rating	W11-B U.W. Insp Performed	W11-C Observed Depth	W11-F Counter-Measures
P01	P	00	9	E	000	

Findings: _____

Form D-450F
(DEC 1996)

Waterway 2 Data

A01					U.W. Inspection Date W01-A
	0 2	7 4 2 1	0 0 0 0	9 0 6 1	

W09 Substructure Unit	W10 Foundation Type	W11 Water Depth	W11-A Observed Scour Rating	W11-B U.W. Insp Performed	W11-C Observed Depth	W11-F Counter-Measures
P 0 2	P	0 0	9	E	0 0 0	

Findings:

W09 Substructure Unit	W10 Foundation Type	W11 Water Depth	W11-A Observed Scour Rating	W11-B U.W. Insp Performed	W11-C Observed Depth	W11-F Counter-Measures
F A B	P	0 0	9	E	0 0 0	

Findings: ABUTMENT OUT OF FLOOD PLANE.

W09 Substructure Unit	W10 Foundation Type	W11 Water Depth	W11-A Observed Scour Rating	W11-B U.W. Insp Performed	W11-C Observed Depth	W11-F Counter-Measures

Findings:

W09 Substructure Unit	W10 Foundation Type	W11 Water Depth	W11-A Observed Scour Rating	W11-B U.W. Insp Performed	W11-C Observed Depth	W11-F Counter-Measures

Findings:

W09 Substructure Unit	W10 Foundation Type	W11 Water Depth	W11-A Observed Scour Rating	W11-B U.W. Insp Performed	W11-C Observed Depth	W11-F Counter-Measures

Findings:

W09 Substructure Unit	W10 Foundation Type	W11 Water Depth	W11-A Observed Scour Rating	W11-B U.W. Insp Performed	W11-C Observed Depth	W11-F Counter-Measures

Findings:

PDT Form D-450G **Waterway 3 Data**

(DEC 1996)

U.W. Inspection Date

A01	0	2	7	4	2	1	0	0	0	0	9	0	6	1	W01-A						

OBSERVED SCOUR RATING GUIDE

Rating	ITEM NUMBER								Rating
	1	2	3	4	5	6	7	8	
	Change Since Last Inspection	Scour Hole	Debris Potential	Substructure Scourability	Opening Adequacy/ Channel	Sediment	Alignment	Velocity/ Stream Slope	
9	None	None	None	NF/P9/R9	Good	None	Good	Low	9
8	None	Minor	None	P8/C8/R8	Good	Minor	Good	Low	8
7	Minor	Minor	Minor	P7/C7/R7	Fair	Minor	Good	Medium	7
6	Minor	Advanced	Medium*	A6	Fair	Medium	Medium	Medium	6
5	Medium*	Advanced	High*	A5	Fair	High	Medium	High	5
4	Medium	Serious*	High	R4*/A4*	Poor*	High	Poor*+	High	4
3	High*	Serious*	Present*	A3	Overtop*	High	Poor	High	3
2	Bridge is scour critical, IMMEDIATE action is required *								2
1	Bridge is scour critical, bridge is CLOSED *								1
0	Bridge has failed due to scour *								0

NOTES:

Rating considerations given in highest to lowest level of importance from left to right.

* If an item is so marked, it cannot be given a higher ranking.

s founded on competent rock and no problems exist.

C = Effective Countermeasures

P = Pile Supported Substructures

DETERMINATION OF RATING FOR BMS ITEM W11-A

Substructure Unit	1	2	3	4	5	6	7	8	**W11-A**
	Change Since Last Inspection	Scour Hole	Debris Potential	Scourability	Opening Adequacy/ Channel	Sediment	Alignment	Velocity/ Stream Slope	Overall Observed Scour Rating
P02	9	9	8	8	9	7	9	7	9

If Underwater Inspection only

Signatures and Date:

PDT Form D-450K (DEC 1996) **Bridge 2 Data**

A01 | 0 2 | 7 4 2 1 | 0 0 0 0 | 9 0 6 1 | E06 | 0 6 2 3 1 1 | Inspection Date

E19 Paint Condition | 8 8 | New Paint Y / N | If Yes: ☐ Spot ☐ Zone ☒ Full ☐ Revise item G08-G17 ▨

Interior Beam / Girder: VERY GOOD - RECENTLY REPAINTED.

Fascias: VERY GOOD - NEW.

Splash Zone: Truss / Girder:

Truss:

Bearings: VERY GOOD.

Other:

E23 Est. Remaining Life | BMS to Calculate Yes/No | 3 4 | Comments:

Recalculate IR/OR: Yes ☐ Due to: Deterioration ☐ New Wearing Surf. ☐ Other ☐

No ☒ Previous Rating Dated _____ is still valid

	H	HS	ML-80	Other	Other	HS Load Factor
E30 Inventory Rating	1 9 8	2 9 8	8 9 8			2 9 8
E31 Operating Rating	1 9 8	2 9 8	8 9 8			2 9 8

E32 Rate Meth | 2 S | E33 Typ Mem | 1 | AASHTO | E37 Spec | 9 4 | E38 Manual | 9 4

E29 Bridge Post | 9 | CONTROLLING: H _____ HS _____ ML80 X Engineering Judgement _____

E24 Structural Condition Appraisal | 7 | Based upon ☐ Table 1 B27-ADT _____ B30-IR _____

or E18-Super 7 E20-Sub 7 , E22-Culvert _____ ,

E01 Next Insp. Freq. | 2 4 | E03 Equip. Next Insp. | B | SNOOPER TRUCK (UB-40)

E04 Spec. Insp. Type | | E05 By Date | |

Is bridge over water? ☒ Yes. E22 = N Complete Forms D-450E through G

☐ No. E22 = N E21 = N E27 = N E29A = N

Notes: ONE SPAN IS OVER WATER AND ONE SPAN IS OVER RAILROAD.
HAD RAILROAD REPRESENTITIVE ON SITE. CREW WAS OUT OF SPAN 1 (RR LOCATION) BY TIME REQUIRED. (9 A.M.)
INSPECTION WAS FIRST ON NEWLY CONSTRUCTED BUSWAY BRIDGE.WHICH USED AN EXISTING RR BRIDGE.
CONDUITS ON BRIDGE WERE BUSTED AT ADAPTERS AT ABUTMENT 1. ALSO, ONE EXPANSION COUPLER WAS BROKEN AND NEEDED REPLACED. SEVERAL CONDUIT SEGMENTS IN SPAN 1 WERE SEVERELY BUCKLED AND NEEDED REPLACED.

Signatures and Date: PATRICK LEACH, P.E. - 6/23/11
CHARLES MOLNAR - 6/23/11

PDT Form D-450M **Maintenance Needs Data**

(DEC 1996)

A01	0	2	7	4	2	1	0	0	0	0	9	0	6	1

Inspection Date: E06 | 0 | 6 | 2 | 3 | 1 | 1 |

	H01 Item #	H03 Location		H05 Quantity	H08 PR	H09 D/C
Approach Roadway Work						
Pavement (Patch/Raise)	RDPAVMT	L N R L F R	SY			
Pavement Relief Jt (Rep/Repl)	RDRLFJT	L N R L F R	SY			
Shoulders (Repair/Reconstr)	RDSHLDR	L N R L F R	SY			
Drainage-Off Bridge (Improve)	RDDRAIN	L N R L F R	EA			
GR/Trans/End (Rep/Repl/Imp)	RDGDERL	L N R L F R	EA			
Load Limit Signs (Replace)	RDLDSGN	L N R L F R	EA			
Clearance Signs (Replace)	RDCLSGN	L N R L F R	EA			
Cut Brush to Clear Signs	RDBRUSH	L N R L F R	EA			
Approach Slab (Replace)	A744201	L N R L F R	SY			
Cleaning - Flushing						
Deck	A743101	-- --	EB			
Scupper/Down Spouting	B743101	1 2 3 4 5 O	EB			
Bearing/Bearing Seat	C743102	1 2 3 4 5 O	EB			
Steel-Horizontal Surfaces	D743102	1 2 3 4 5 O	EB			
Deck						
Bitum Deck W Surf (Rep/Repl)	BITWRGS	1 2 3 4 5 O	SY			
Timber Deck (Rep/Repl)	B744301	1 2 3 4 5 O	SY			
Open Steel Grid (Rep/Repl)	C744302	1 2 3 4 5 O	SY			
Concrete Deck (Repair)	D744303	1 2 3 4 5 O	SY			
Concrete Sidewalk (Repair)	E744303	1 2 3 4 5 O	SY			
Concrete Curb/Parapet (Rep)	F744303	1 2 3 4 5 O	SY			
Deck Joints - Expansion Joints						
Reseal	A743301	N 1 2 3 O F	LF			
Repair/Reseal	A744101	N 1 2 3 O F	LF			
Compression Seal (Rep/Rehab)	B744102	N 1 2 3 O F	LF			
Modular Dam (Rep/Rehab)	C744102	N 1 2 3 O F	LF			
Steel Dams (Rep/Rehab)	D744102	N 1 2 3 O F	LF			
Other Types (Rep/Rehab)	E744102	N 1 2 3 O F	LF			
Bridge Railings - Parapets						
Bridge Parapet (Rep/Repl)	RLGBRPR	N 1 2 3 O F	LF			
Struct Mount GR (Rep/Repl)	RLGSTRM	N 1 2 3 O F	LF			
Pedestrian (Rep/Repl)	RLGPEDN	N 1 2 3 O F	LF			
Median Barrier (Rep/Repl)	RLGMEDB	1 2 3 4 5 O	LF			
Deck Drainage						
Scupper Grate (Replace)	DRNGRAT	1 2 3 4 5 O	EA			
Drain/Scupper (Install)	B744401	1 2 3 4 5 O	EA			
Downspouting (Rep/Repl)	C744402	N 1 2 3 O F	EA			
Bearings						
Lubricate	A743501	N 1 2 3 O F	EA			
Steel (Rep/Rehab)	A744501	N 1 2 3 O F	EA			
Steel (Replace)	B744501	N 1 2 3 O F	EA			
Expansion (Reset)	C744502	N 1 2 3 O F	EA			
Pedestal/Seat (Reconstruct)	D744503	N 1 2 3 O F	EA			
Timber						
Stringer (Rep/Repl)	A744601	1 2 3 4 5 O	EA			
Other Members (Rep/Repl)	B744601	1 2 3 4 5 O	EA			

	H01 Item #	H03 Location		H05 Quantity	H08 PR	H09 D/C
Steel						
Stringer (Rep/Repl)	A744602	1 2 3 4 5 O	EA			
Floorbeam (Rep/Repl)	B744602	1 2 3 4 5 O	EA			
Girder (Repair)	C744602	1 2 3 4 5 O	EA			
Diaph/Lat. Bracing (Rep/Repl)	D744602	1 2 3 4 5 O	EA			
Reinforced, PS, PC, and PT Concrete						
Stringer (Rep/Repl)	A744603	1 2 3 4 5 O	EA			
Diaphragm (Rep/Repl)	B744603	1 2 3 4 5 O	EA			
Other Members (Rep/Repl)	C744603	1 2 3 4 5 O	EA			
Truss						
Members (Strengthen/Rep/Repl)	A744701	1 2 3 4 5 O	EA			
Portal (Modify)	B744701	1 2 3 4 5 O	EA			
Members(Tighten/Flameshorten)	C744702	1 2 3 4 5 O	EA			
Painting						
Superstructure - Spot	A743201	1 (2) 3 4 5 O	EB	1	4	
Substructure - Spot	B743201	N 1 2 3 O F	EB			
Superstructure - Full	C743201	1 2 3 4 5 O	EB			
Substructure - Full	D743201	N 1 2 3 O F	EB			
Abutment - Wings - Piers						
Backwall (Rep/Repl)	A744801	L N R L F R	CY			
Abutments (Repair)	B744802	L N R L F R	CY			
Wing (Rep/Repl)	C744802	L N R L F R	CY			
Piers (Repair)	D744802	1 2 3 4 5 O	CY			
Footing (Underpin)	E744803	N 1 2 3 O F	CY			
Masonry (Repoint)	F744804	N 1 2 3 O F	LF			
Abut Slopewall (Rep/Repl)	A745101	L N R L F R	SY			
Abut Slopewall (Construct New)	B745102	L N R L F R	CY			
Pile Repair	A745901	N 1 2 3 O F	EA			
Scour - Erosion Control						
Streambed Paving (Rep/Constr)	A745301	UP UN DN	CY			
Rock Protection	B745301	UP UN DN	CY			
Scour Hole (Backfill)	C745301	UP UN DN	CY			
Stream Deflector (Rep/Constr)	D745302	UP UN DN	CY			
Vegetation/Debris (Remove)	ECREMVG	UP UN DN	CY			
Deposition (Remove)	ECREMDP	UP UN DN	CY			
Culvert						
Headwall/Wings (Rep/Repl)	A745201	IN OUT	SY			
Apron/Cutoff Wall (Rep/Repl)	B745202	IN OUT	SY			
Barrel (Repair)	C745203	-- --	SY			
FOR COMPLETION BY REVIEW ENGINEER						
Apply Protective Coating						
Deck/Parapet/Sidewalk	A743401	DK PARA SW	SY			
Substructure	B743401	N 1 2 3 O F	SY			
Construct Temporary						
Support Pier	A745401	N 1 2 3 O F	EA			
Pipe/Culvert Crossing	B745401	LT CL RT	EB			
Bridge	C745401	LT CL RT	EB			

REP..... Repair REPL..... Replace IMP..... Improve
N..... Near UP..... Upstream LNR..... Near Left/Right
F..... Far DN..... Downstream LFR..... Far Left/Right
O..... Other UN..... Under 1,2,3, etc..... Span/Pier No.
IN..... Inlet OUT ..... Outlet EB..... Each Bridge (site)

PR - PRIORITY CODE

0 - Prompt action required. (Inform Bridge Engineer before updating BMS)
1 - High Priority, as soon as work can be scheduled.
2 - Priority, review work plan, adjust schedule if needed.
3 - Add to scheduled work.
4 - Routine structural, can be delayed until funds are available.
5 - Routine non-structural, can be delayed until programmed,

MAJOR IMPROVEMENT NEEDS

F01 **Year Needed** F04 **Improvement Length**

F02 **Type Work** F06 **Bridge Width**

F10 **Future ADT** F11 **Future ADT Year**

Reviewed On: .....

By: .....

Note: The Appendix section for this report is not included here. The BMS 491 Forms for PENNDOT are that state's version of the FHWA SI&A sheet with additional state items. The documents included in the report are typically red marked revisions to the file copy and reflect changes identified during the inspection.

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Appendix B

National Bridge Inspection Standards

Subpart C

National Bridge Inspection Standards

Source: 69 FR 74436, Dec. 14, 2004, unless otherwise noted.

§ 650.301 Purpose.

This subpart sets the national standards for the proper safety inspection and evaluation of all highway bridges in accordance with 23 U.S.C. 151.

§ 650.303 Applicability.

The National Bridge Inspection Standards (NBIS) in this subpart apply to all structures defined as highway bridges located on all public roads.

§ 650.305 Definitions.

Terms used in this subpart are defined as follows:

American Association of State Highway and Transportation Officials (AASHTO) Manual . "The Manual for Bridge Evaluation," First Edition, 2008, published by the American Association of State Highway and Transportation Officials (incorporated by reference, *see* §650.317).

Bridge. A structure including supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between undercopings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening.

Bridge inspection experience. Active participation in bridge inspections in accordance with the NBIS, in either a field inspection, supervisory, or management role. A combination of bridge design, bridge maintenance, bridge construction and bridge inspection experience, with the predominant amount in bridge inspection, is acceptable.

Bridge inspection refresher training. The National Highway Institute "Bridge Inspection Refresher Training Course"[1] or other State, local, or federally developed instruction aimed to improve quality of inspections, introduce new techniques, and maintain the consistency of the inspection program. [1] The National Highway Institute training may be found at the following URL: *http://www.nhi.fhwa.dot.gov./*

Bridge Inspector's Reference Manual (BIRM). A comprehensive FHWA manual on programs, procedures and techniques for inspecting and evaluating a variety of in-service highway bridges. This manual may be purchased from the U.S. Government Printing Office, Washington, DC 20402 and from National Technical Information Service, Springfield, Virginia 22161, and is available at the following URL: *http://www.fhwa.dot.gov/bridge/bripub.htm.*

Complex bridge . Movable, suspension, cable stayed, and other bridges with unusual characteristics.

Comprehensive bridge inspection training. Training that covers all aspects of bridge inspection and enables inspectors to relate conditions observed on a bridge to established criteria (see the

Bridge Inspector's Reference Manual for the recommended material to be covered in a comprehensive training course).

Critical finding. A structural or safety related deficiency that requires immediate follow-up inspection or action.

Damage inspection. This is an unscheduled inspection to assess structural damage resulting from environmental factors or human actions.

Fracture critical member (FCM). A steel member in tension, or with a tension element, whose failure would probably cause a portion of or the entire bridge to collapse.

Fracture critical member inspection. A hands-on inspection of a fracture critical member or member components that may include visual and other nondestructive evaluation.

Hands-on. Inspection within arms length of the component. Inspection uses visual techniques that may be supplemented by nondestructive testing.

Highway. The term "highway" is defined in 23 U.S.C. 101(a)(11).

In-depth inspection. A close-up, inspection of one or more members above or below the water level to identify any deficiencies not readily detectable using routine inspection procedures; hands-on inspection may be necessary at some locations.

Initial inspection. The first inspection of a bridge as it becomes a part of the bridge file to provide all Structure Inventory and Appraisal (SI&A) data and other relevant data and to determine baseline structural conditions.

Legal load. The maximum legal load for each vehicle configuration permitted by law for the State in which the bridge is located.

Load rating. The determination of the live load carrying capacity of a bridge using bridge plans and supplemented by information gathered from a field inspection.

National Institute for Certification in Engineering Technologies (NICET). The NICET provides nationally applicable voluntary certification programs covering several broad engineering technology fields and a number of specialized subfields. For information on the NICET program certification contact: National Institute for Certification in Engineering Technologies, 1420 King Street, Alexandria, VA 22314–2794.

Operating rating. The maximum permissible live load to which the structure may be subjected for the load configuration used in the rating.

Professional engineer (PE). An individual, who has fulfilled education and experience requirements and passed rigorous exams that, under State licensure laws, permits them to offer engineering services directly to the public. Engineering licensure laws vary from State to State, but, in general, to become a PE an individual must be a graduate of an engineering program accredited by the Accreditation Board for Engineering and Technology, pass the Fundamentals of Engineering exam, gain four years of experience working under a PE, and pass the Principles of Practice of Engineering exam.

Program manager. The individual in charge of the program, that has been assigned or delegated the duties and responsibilities for bridge inspection, reporting, and inventory. The program manager provides overall leadership and is available to inspection team leaders to provide guidance.

Public road. The term “public road” is defined in 23 U.S.C. 101(a)(27).

Quality assurance (QA). The use of sampling and other measures to assure the adequacy of quality control procedures in order to verify or measure the quality level of the entire bridge inspection and load rating program.

Quality control (QC). Procedures that are intended to maintain the quality of a bridge inspection and load rating at or above a specified level.

Routine inspection. Regularly scheduled inspection consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, to identify any changes from initial or previously recorded conditions, and to ensure that the structure continues to satisfy present service requirements.

Routine permit load. A live load, which has a gross weight, axle weight or distance between axles not conforming with State statutes for legally configured vehicles, authorized for unlimited trips over an extended period of time to move alongside other heavy vehicles on a regular basis.

Scour. Erosion of streambed or bank material due to flowing water; often considered as being localized around piers and abutments of bridges.

Scour critical bridge. A bridge with a foundation element that has been determined to be unstable for the observed or evaluated scour condition.

Special inspection. An inspection scheduled at the discretion of the bridge owner, used to monitor a particular known or suspected deficiency.

State transportation department. The term “State transportation department” is defined in 23 U.S.C. 101(a)(34).

Team leader. Individual in charge of an inspection team responsible for planning, preparing, and performing field inspection of the bridge.

Underwater diver bridge inspection training. Training that covers all aspects of underwater bridge inspection and enables inspectors to relate the conditions of underwater bridge elements to established criteria (see the Bridge Inspector's Reference Manual section on underwater inspection for the recommended material to be covered in an underwater diver bridge inspection training course).

Underwater inspection. Inspection of the underwater portion of a bridge substructure and the surrounding channel, which cannot be inspected visually at low water by wading or probing, generally requiring diving or other appropriate techniques.

[69 FR 74436, Dec. 14, 2004, as amended at 74 FR 68379, Dec. 24, 2009]

§ 650.307 Bridge inspection organization.

(a) Each State transportation department must inspect, or cause to be inspected, all highway bridges located on public roads that are fully or partially located within the State's boundaries, except for bridges that are owned by Federal agencies.

(b) Federal agencies must inspect, or cause to be inspected, all highway bridges located on public roads that are fully or partially located within the respective agency responsibility or jurisdiction.

(c) Each State transportation department or Federal agency must include a bridge inspection organization that is responsible for the following:

(1) Statewide or Federal agency wide bridge inspection policies and procedures, quality assurance and quality control, and preparation and maintenance of a bridge inventory.

(2) Bridge inspections, reports, load ratings and other requirements of these standards.

(d) Functions identified in paragraphs (c)(1) and (2) of this section may be delegated, but such delegation does not relieve the State transportation department or Federal agency of any of its responsibilities under this subpart.

(e) The State transportation department or Federal agency bridge inspection organization must have a program manager with the qualifications defined in §650.309(a), who has been delegated responsibility for paragraphs (c)(1) and (2) of this section.

§ 650.309 Qualifications of personnel.

(a) A program manager must, at a minimum:

(1) Be a registered professional engineer, or have ten years bridge inspection experience; and

(2) Successfully complete a Federal Highway Administration (FHWA) approved comprehensive bridge inspection training course.

(b) There are five ways to qualify as a team leader. A team leader must, at a minimum:

(1) Have the qualifications specified in paragraph (a) of this section; or

(2) Have five years bridge inspection experience and have successfully completed an FHWA approved comprehensive bridge inspection training course; or

(3) Be certified as a Level III or IV Bridge Safety Inspector under the National Society of Professional Engineer's program for National Certification in Engineering Technologies (NICET) and have successfully completed an FHWA approved comprehensive bridge inspection training course, or

(4) Have all of the following:

(i) A bachelor's degree in engineering from a college or university accredited by or determined as substantially equivalent by the Accreditation Board for Engineering and Technology;

(ii) Successfully passed the National Council of Examiners for Engineering and Surveying Fundamentals of Engineering examination;

(iii) Two years of bridge inspection experience; and

(iv) Successfully completed an FHWA approved comprehensive bridge inspection training course, or

(5) Have all of the following:

(i) An associate's degree in engineering or engineering technology from a college or university accredited by or determined as substantially equivalent by the Accreditation Board for Engineering and Technology;

(ii) Four years of bridge inspection experience; and

(iii) Successfully completed an FHWA approved comprehensive bridge inspection training course.

(c) The individual charged with the overall responsibility for load rating bridges must be a registered professional engineer.

(d) An underwater bridge inspection diver must complete an FHWA approved comprehensive bridge inspection training course or other FHWA approved underwater diver bridge inspection training course.

§ 650.311 Inspection frequency.

(a) *Routine inspections.* (1) Inspect each bridge at regular intervals not to exceed twenty-four months.

(2) Certain bridges require inspection at less than twenty-four-month intervals. Establish criteria to determine the level and frequency to which these bridges are inspected considering such factors as age, traffic characteristics, and known deficiencies.

(3) Certain bridges may be inspected at greater than twenty-four month intervals, not to exceed forty-eight-months, with written FHWA approval. This may be appropriate when past inspection findings and analysis justifies the increased inspection interval.

(b) *Underwater inspections.* (1) Inspect underwater structural elements at regular intervals not to exceed sixty months.

(2) Certain underwater structural elements require inspection at less than sixty-month intervals. Establish criteria to determine the level and frequency to which these members are inspected considering such factors as construction material, environment, age, scour characteristics, condition rating from past inspections and known deficiencies.

(3) Certain underwater structural elements may be inspected at greater than sixty-month intervals, not to exceed seventy-two months, with written FHWA approval. This may be appropriate when past inspection findings and analysis justifies the increased inspection interval.

(c) *Fracture critical member (FCM) inspections.* (1) Inspect FCMs at intervals not to exceed twenty-four months.

(2) Certain FCMs require inspection at less than twenty-four-month intervals. Establish criteria to determine the level and frequency to which these members are inspected considering such factors as age, traffic characteristics, and known deficiencies.

(d) Damage, in-depth, and special inspections. Establish criteria to determine the level and frequency of these inspections.

§ 650.313 Inspection procedures.

(a) Inspect each bridge in accordance with the inspection procedures in the AASHTO Manual (incorporated by reference, *see* §650.317).

(b) Provide at least one team leader, who meets the minimum qualifications stated in §650.309, at the bridge at all times during each initial, routine, in-depth, fracture critical member and underwater inspection.

(c) Rate each bridge as to its safe load-carrying capacity in accordance with the AASHTO Manual (incorporated by reference, *see* §650.317). Post or restrict the bridge in accordance with

the AASHTO Manual or in accordance with State law, when the maximum unrestricted legal loads or State routine permit loads exceed that allowed under the operating rating or equivalent rating factor.

(d) Prepare bridge files as described in the AASHTO Manual (incorporated by reference, *see* §650.317). Maintain reports on the results of bridge inspections together with notations of any action taken to address the findings of such inspections. Maintain relevant maintenance and inspection data to allow assessment of current bridge condition. Record the findings and results of bridge inspections on standard State or Federal agency forms.

(e) Identify bridges with FCMs, bridges requiring underwater inspection, and bridges that are scour critical.

(1) Bridges with fracture critical members. In the inspection records, identify the location of FCMs and describe the FCM inspection frequency and procedures. Inspect FCMs according to these procedures.

(2) Bridges requiring underwater inspections. Identify the location of underwater elements and include a description of the underwater elements, the inspection frequency and the procedures in the inspection records for each bridge requiring underwater inspection. Inspect those elements requiring underwater inspections according to these procedures.

(3) Bridges that are scour critical. Prepare a plan of action to monitor known and potential deficiencies and to address critical findings. Monitor bridges that are scour critical in accordance with the plan.

(f) *Complex bridges.* Identify specialized inspection procedures, and additional inspector training and experience required to inspect complex bridges. Inspect complex bridges according to those procedures.

(g) *Quality control and quality assurance.* Assure systematic quality control (QC) and quality assurance (QA) procedures are used to maintain a high degree of accuracy and consistency in the inspection program. Include periodic field review of inspection teams, periodic bridge inspection refresher training for program managers and team leaders, and independent review of inspection reports and computations.

(h) *Follow-up on critical findings.* Establish a statewide or Federal agency wide procedure to assure that critical findings are addressed in a timely manner. Periodically notify the FHWA of the actions taken to resolve or monitor critical findings.

§ 650.315 Inventory.

(a) Each State or Federal agency must prepare and maintain an inventory of all bridges subject to the NBIS. Certain Structure Inventory and Appraisal (SI&A) data must be collected and retained by the State or Federal agency for collection by the FHWA as requested. A tabulation of this data is contained in the SI&A sheet distributed by the FHWA as part of the "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges," (December 1995) together with subsequent interim changes or the most recent version. Report the data using FHWA established procedures as outlined in the "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges."

(b) For routine, in-depth, fracture critical member, underwater, damage and special inspections enter the SI&A data into the State or Federal agency inventory within 90 days of the date of

inspection for State or Federal agency bridges and within 180 days of the date of inspection for all other bridges.

(c) For existing bridge modifications that alter previously recorded data and for new bridges, enter the SI&A data into the State or Federal agency inventory within 90 days after the completion of the work for State or Federal agency bridges and within 180 days after the completion of the work for all other bridges.

(d) For changes in load restriction or closure status, enter the SI&A data into the State or Federal agency inventory within 90 days after the change in status of the structure for State or Federal agency bridges and within 180 days after the change in status of the structure for all other bridges.

§ 650.317 Reference manuals.

(a) The materials listed in this subpart are incorporated by reference in the corresponding sections noted. These incorporations by reference were approved by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. These materials are incorporated as they exist on the date of the approval, and notice of any change in these documents will be published in the Federal Register. The materials are available for purchase at the address listed below, and are available for inspection at the National Archives and Records Administration (NARA). These materials may also be reviewed at the Department of Transportation Library, 1200 New Jersey Avenue, SE., Washington, DC 20590, (202) 366–0761. For information on the availability of these materials at NARA call (202) 741–6030, or go to the following URL: *http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.htm* . In the event there is a conflict between the standards in this subpart and any of these materials, the standards in this subpart will apply.

(b) The following materials are available for purchase from the American Association of State Highway and Transportation Officials, Suite 249, 444 N. Capitol Street, NW., Washington, DC 20001, (202) 624–5800. The materials may also be ordered via the AASHTO bookstore located at the following URL: *http://www.transportation.org* .

(1) The Manual for Bridge Evaluation, First Edition, 2008, AASHTO, incorporation by reference approved for §§650.305 and 650.313.

(2) [Reserved]

[74 FR 68379, Dec. 24, 2009]

Glossary

GLOSSARY

A

AASHTO - American Association of State Highway and Transportation Officials, name changed from AASHO (American Association of State Highway Officials) in 1973

American Association of State Highway and Transportation Officials (AASHTO) Manual - "Manual for Condition Evaluation of Bridges," second edition, published by the American Association of State Highway and Transportation Officials (incorporated by reference into 23 CFR 650)

abrasion - wearing or grinding away of material by friction; usually caused by sand, gravel, or stones, carried by wind or water

absorption - the process of a liquid being taken into a permeable solid (e.g., the wetting of concrete)

abutment - part of bridge substructure at either end of bridge which transfers loads from superstructure to foundation and provides lateral support for the approach roadway embankment

ADT - Average Daily Traffic

ADTT - Average Daily Truck Traffic

admixture - an ingredient added to concrete other than cement, aggregate or water (e.g., air entraining agent)

aggradation - progressive raising of a streambed by deposition of sediment

aggregate - hard inert material such as sand, gravel, or crushed rock that may be combined with a cementing material to form mortar or concrete

air entrainment - the addition of air into a concrete mixture in order to increase the durability and resist thermal forces

alkali silica reactivity (ASR) - an expansive reaction that results in swelling and expansion of concrete.

alignment - the relative horizontal and vertical positioning between components, such as the bridge and its approaches

alignment bearing - a bearing embedded in a bridge seat to prevent lateral movements (see BEARING)

alligator cracking - cracks initiated by inadequate base support or drainage that form on the surface of a road in adjacent, rectangular shapes (like the skin of an alligator)

alloy - two or more metals, or metal and non-metal, intimately combined, usually by dissolving together in a molten state to form a new base metal

anchorage - the complete assemblage of members and parts, embedded in concrete, rock or other fixed material, designed to hold a portion of a structure in correct position

anchor bolt - a metal rod or bar commonly threaded and fitted with a nut and washer at one end only, used to secure in a fixed position upon the substructure the bearings of a bridge, the base of a column, a pedestal, shoe, or other member of a structure

anchor span - the span that counterbalances and holds in equilibrium the cantilevered portion of an adjacent span; also called the back span; see CANTILEVER BEAM, GIRDER, or TRUSS

angle - a basic member shape, usually steel, in the form of an "L"

anisotropy - the property of certain materials, such as crystals, that exhibits different strengths in different directions

anode - the positively charged pole of a corrosion cell at which oxidation occurs

anti-friction bearing - a ball or roller-type bearing; a bearing that reduces transfer of horizontal loads between components

appraisal rating - a judgment of a bridge component's adequacy in comparison to current standards

approach - the part of the roadway immediately before and after the bridge structure

approach pavement - an approach which has a cross section that is either the same as or slightly wider than the bridge deck width

approach slab - a reinforced concrete slab placed on the approach embankment adjacent to and usually resting upon the abutment back wall; the function of the approach slab is to carry wheel loads on the approaches directly to the abutment, thereby transitioning any approach roadway misalignment due to approach embankment settlement

appurtenance - an element that contributes to the general functionality of the bridge site (e.g., lighting, signing)

apron - a form of scour (erosion) protection consisting of timber, concrete, riprap, paving, or other construction material placed adjacent to abutments and piers to prevent undermining

arch - a curved structure element primarily in compression that transfers vertical loads through inclined reactions to its end supports

arch barrel - a single arch member that extends the width of the structure

arch rib - the main support element used in open spandrel arch construction; also known as arch ring

armor - a secondary steel member installed to protect a vulnerable part of another member, e.g., steel angles placed over the edges of a joint; also scour protection such as rip rap

armoring countermeasures - devices that resist erosive forces caused by the flow, but do not alter the flow direction.

as-built plans - plans made after the construction of a project, showing all field changes to the final design plans (i.e.. showing how the bridge was actually built)

asphalt - a brown to black bituminous substance that is found in natural beds and is also obtained as a residue in petroleum refining and that consists chiefly of hydrocarbons; an asphaltic composition used for pavements and as a waterproof cement

ASTM - American Society for Testing and Materials

auger - a drill with a spiral channel used for boring

axial - in line with the longitudinal axis of a member

axial force - the force that acts through the longitudinal axis of a member.

axle load - the load borne by one axle of a traffic vehicle, a movable bridge, or other motive equipment or device and transmitted through a wheel or wheels

B

back - see EXTRADOS

backfill - material, usually soil or coarse aggregate, used to fill the unoccupied portion of a substructure excavation such as behind an abutment stem and backwall

backstay - cable or chain attached at the top of a tower and extending to and secured upon the anchorage to resist overturning stresses exerted upon the tower by a suspended span

backwall - the topmost portion of an abutment above the elevation of the bridge seat, functioning primarily as a retaining wall with a live load surcharge; it may serve also as a support for the extreme end of the bridge deck and the approach slab

backwater - the back up of water in a stream due to a downstream obstruction or constriction

bank - sloped sides of a waterway channel or approach roadway, short for embankment

bascule bridge - a bridge over a waterway with one or two leaves which rotate from a horizontal to a near-vertical position, providing unlimited overhead clearance

base course - a layer of compacted material found just below the wearing course that supports the pavement

base metal - the surface metal of a steel element to be incorporated in a welded joint; also known as structure metal, parent metal

base plate - steel plate, whether cast, rolled or forged, connected to a column, bearing or other member to transmit and distribute its load to the substructure

batten plate - a plate with two or more fasteners at each end used in lieu of lacing to tie together the shapes comprising a built-up member

batter - the inclination of a surface in relation to a horizontal or a vertical plane; commonly designated on bridge detail plans as a ratio (e.g., 1:3, H:V); see RAKE

battered pile - a pile driven in an inclined position to resist horizontal forces as well as vertical forces

bay - the area of a bridge floor system between adjacent multi-beams or between adjacent floor beams

beam - a linear structural member designed to span from one support to another and support vertical loads

bearing - a support element transferring loads from superstructure to substructure while permitting limited movement capability

bearing capacity - the load per unit area which a structural material, rock, or soil can safely carry

bearing failure - crushing of material under extreme compressive load

bearing pile - a pile which provides support through the tip (or lower end) of the pile

bearing plate - a steel plate, which transfers loads from the superstructure to the substructure

bearing pressure - the bearing load divided by the area to which it is applied

bearing seat - a prepared horizontal surface at or near the top of a substructure unit upon which the bearings are placed

bearing stiffener - a vertical web stiffener at the bearing location

bearing stress - see BEARING PRESSURE

bedding - the soil or backfill material used to support pipe culverts

bedrock - the undisturbed rock layer below the surface soil

bench mark - an established reference point with known elevation and coordinates, used to document dimensions, elevations or position movement

bending moment - a combination of tension and compression forces developed when an external load is applied transversely to a bridge member, causing it to bend

bent - a substructure unit made up of two or more column or column-like members connected at their top-most ends by a cap, strut, or other member holding them in their correct positions

berm - the line that defines the location where the top surface of an approach embankment or causeway is intersected by the surface of the side slope

beveled washer - a wedge-shaped washer used in connections incorporating members with sloped flange legs, e.g., channels and S-beams

bitumen - a black sticky mixture of hydrocarbons obtained from natural deposits or from distilling petroleum; tar

bituminous concrete - a mixture of aggregate and liquid asphalt or bitumen, which is compacted into a dense mass

blanket - a streambed protection against scour placed adjacent to abutments and piers

BMS - Bridge Management System

bolt -a mechanical fastener with machine threads at one end to receive a nut, and an integral head at the other end

bolster - a block-like member used to support a bearing on top of a pier cap or abutment bridge seat; see PEDESTAL

bond - in reinforced concrete, the grip of the concrete on the reinforcing bars, which prevents slippage of the bars relative to the concrete mass

bond stress - a term commonly applied in reinforced concrete construction to the stress developed by a force tending to produce movement or slippage at the interface between the concrete and the reinforcement bars

bowstring truss - a general term applied to a truss of any type having a polygonal arrangement of its top chord members conforming to or nearly conforming to the arrangement required for a parabolic truss; a truss with a curved top chord

box beam - a hollow structural beam with a square, rectangular, or trapezoidal cross-section that supports vertical loads and provides torsional rigidity

box culvert - a culvert of rectangular or square cross-section

box girder - a hollow, rectangular or trapezoidal shaped girder, a primary member along the longitudinal axis of the bridge, which provides good torsional rigidity

bracing - a system of secondary members that maintains the geometric configuration of primary members

bracket - a projecting support fixed upon two intersecting members to strengthen and provide rigidity to the connection

breastwall - the portion of an abutment between the wings and beneath the bridge seat; the breast wall supports the superstructure loads, and retains the approach fill; see STEM

bridge - a structure including supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between undercopings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening

bridge deficiency - a defect in a bridge component or member that makes the bridge less capable or less desirable for use

bridge elements - structural elements that are commonly used in highway bridge construction and are encountered on bridge safety inspections

bridge inspection experience - active participation in bridge inspections in accordance with the NBIS, in either a field inspection, supervisory, or management role. A combination of bridge design, bridge maintenance, bridge construction and bridge inspection experience, with the predominant amount in bridge inspection, is acceptable.

bridge inspection refresher training - the National Highway Institute "Bridge Inspection Refresher Training Course" [1] or other State, local, or federally developed instruction aimed to improve quality of inspections, introduce new techniques, and maintain the consistency of the inspection program.

[1] The National Highway Institute training may be found at the following URL: *http://www.nhi.fhwa.dot.gov./*

***Bridge Inspector's Reference Manual (BIRM)* -** a comprehensive FHWA manual on programs, procedures and techniques for inspecting and evaluating a variety of in-service highway bridges. This manual may be purchased from the U.S. Government Printing Office, Washington, DC 20402 and from National Technical Information Service, Springfield, Virginia 22161, and is available at the following URL: *http://www.fhwa.dot.gov/bridge/bripub.htm.*

bridge pad - the raised, leveled area upon which the pedestal, masonry plate or other corresponding element of the superstructure bears on the substructure; also called bridge seat bearing area

bridge seat - the top surface of an abutment or pier upon which the superstructure span is placed and supported; for an abutment it is the surface forming the support for the superstructure and from which the backwall rises; for a pier it is the entire top surface

bridge site - the position or location of a bridge and its surrounding area

bridging - a carpentry term applied to the cross̃bracing fastened between timber beams to increase the rigidity of the floor construction, limit differential deflection and minimize the effects of impact and vibration

brittle fracture - the failure of a steel member occurring without warning, prior to plastic deformation

brittleness - the ability of a material to break while exhibiting little to no plastic deformation

brush curb - a narrow curb, 9 inches or less in width, which prevents a vehicle from brushing against the railing or parapet

buckle - to fail by an inelastic change in alignment (deflection) as a result of compression in axial loaded members

buckle plate - an obsolete style of steel deck using dished steel plates as structural members

built-up member - a column or beam composed of plates and angles or other structural shapes united by bolting, riveting or welding to enhance section properties

bulb t-girder - a t-shaped concrete girder with a bulb shape at the bottom of the girder cross section

bulkhead - a retaining wall-like structure commonly composed of driven sheet piles or a barrier of wooden timbers or reinforced concrete members

buoyancy - upward pressure exerted by the fluid in which an object is immersed

butt joint - a joint between two pieces of metal that have been connected in the same plane

buttress - a bracket-like wall, of full or partial height, projecting from another wall; the buttress strengthens and stiffens the wall against overturning forces; all parts of a buttress act in compression

buttressed wall - a retaining wall designed with projecting buttresses to provide strength and stability

butt weld - a weld joining two plates or shapes end to end; also splice weld

C

cable - a tension member comprised of numerous individual steel wires or strands twisted and wrapped in such a fashion to form a rope of steel; see SUSPENSION BRIDGE

cable band - a steel casting with clamp bolts which fixes a floor system suspender cable to the catenary cable of a suspension bridge

cable-stayed bridge - a bridge in which the superstructure is directly supported by cables, or stays, passing over or attached to towers located at the main piers

caddisfly - a winged insect closely related to the moth and butterfly whose aquatic larvae seek shelter by digging small shallow holes into submerged timber elements

caisson - a rectangular or cylindrical chamber for keeping water or soft ground from flowing into an excavation

camber - the slightly arched or convex curvature provided in beams to compensate for dead load deflection; in general, a structure built with perfectly straight lines appears slightly sagged

cantilever - a structural member that has a free end projecting beyond a support; length of span overhanging the support

cantilever abutment - an abutment that resists lateral earth pressure through the opposing cantilever action of a vertical stem and horizontal footing

cantilever bridge - a general term applying to a bridge having a superstructure incorporating cantilever design

cantilever span - a superstructure span composed of two cantilever arms, or of a suspended span supported by one or two cantilever arms

cap - the topmost portion of a pier or a pile bent serving to distribute the loads upon the columns or piles and to hold them in their proper relative positions; see PIER CAP, PILE CAP

cap beam - the top member in a bent that ties together the supporting members

capstone - the topmost stone of a masonry pillar, column or other structure requiring the use of a single capping element

carbon steel - steel (iron with dissolved carbon) owing its properties principally to its carbon content; ordinary, unalloyed steel

cast-in-place (C.I.P.) - the act of placing and curing concrete within formwork to construct a concrete element in its final position

cast iron - relatively pure iron, smelted from iron ore, containing 1.8 to 4.5% free carbon and cast to shape

catch basin - a receptacle, commonly box shaped and fitted with a grilled inlet and a pipe outlet drain, designed to collect the rainwater and floating debris from the roadway surface and retain the solid material so that it may be periodically removed

catchment area - see DRAINAGE AREA

catenary - the curve obtained by suspending a uniformly loaded rope or cable between two points

cathode - the negatively charged pole of a corrosion cell that accepts electrons and does not corrode

cathodic protection - a means of preventing metal from corroding by making it a cathode through the use of impressed direct current or by attaching a sacrificial anode

catwalk - a narrow walkway for access to some part of a structure

causeway - an elevated roadway crossing a body of water

cellular abutment - an abutment in which the space between wings, abutment stem, approach slab, and footings is hollow. Also known as a vaulted abutment

cement mortar - a mixture of sand and cement with enough water to make it plastic

cement paste - the plastic combination of cement and water that supplies the cementing action in concrete

centerline of bearings - a horizontal line that passes through the centers of the bearings, used in abutment/pier layout and beam erection

center of gravity - the point at which the entire mass of a body acts; the balancing point of an object

centroid - that point about which the static moment of all the elements of area is equal to zero

chain drag - a chain or a series of short medium weight chains attached to a T-shaped handle; used as a preliminary technique for sounding a large deck area for delamination

chamfer - an angled edge or corner, typically formed in concrete

channel - a waterway connecting two bodies of water or containing moving water; a rolled steel member having a C-shaped cross section

channel lining - rigid concrete pavement or flexible protective revetment mats placed on the bottom of a streambed

channel profile - a longitudinal section of a channel along its centerline

checks - a crack in wood occurring parallel with the grain and through the rings of annual growth

cheek wall - see KNEE WALL

chipping hammer - hammer such as a geologist's pick or masonry hammer used to remove corrosion from steel members and to sound concrete for delamination; a welder's tool for cleaning slag from steel after welding

chloride - an ingredient in deicing agents that can damage concrete and steel bridge elements

chloride contamination - the presence of recrystalized soluble salts, which causes accelerated corrosion of the steel reinforcement

chord - a generally horizontal member of a truss

circular arch - an arch in which the intrados surface has a constant radius

clearance - the unobstructed vertical or horizontal space provided between two objects

clear headroom - the vertical clearance beneath a bridge structure available for navigational use

clear span - the unobstructed space or distance between support elements of a bridge or bridge member

clip angle - see CONNECTION ANGLE

closed spandrel arch - a stone, brick or reinforced concrete arch span having spandrel walls to retain the spandrel fill or to support either entirely or in part the floor system of the structure when the spandrel is not

filled

coarse aggregate - aggregate that stays on a sieve of 5 mm (¼") square opening

coating - a material that provides a continuous film over a surface in order to protect or seal it; a film formed by the material

coefficient of thermal expansion - the unit change in dimension produced in a material by a change of one degree in temperature

cofferdam - a temporary dam-like structure constructed around an excavation to exclude water; see SHEET PILE COFFERDAM

cold chisel - short bar with a sharp end used for cold-cutting soft metals when struck with a hammer

collision damage - a special case of overload that occurs when any vehicle, railroad car, marine traffic or flowing ice strikes a bridge member, railing or column

column - a general term applying to a vertical member resisting compressive stresses and having, in general, a considerable length in comparison with its transverse dimensions

column bent - a bent shaped pier that uses columns incorporated with a cap beam

compaction - the process by which a sufficient amount of energy (compressive pressure) is applied to soil or other material to increase its density

complex bridge - movable, suspension, cable stayed, and other bridges with unusual characteristics

component - a general term reserved to define a bridge deck, superstructure or substructure

composite action - the contribution of a concrete deck to the moment resisting capacity of the superstructure beam when the superstructure beams are not the same material as the deck

composite construction - a method of construction whereby a cast-in-place concrete deck is mechanically attached to superstructure members by shear connectors

comprehensive bridge inspection training - training that covers all aspects of bridge inspection and enables inspectors to relate conditions observed on a bridge to established criteria (see the Bridge Inspector's Reference Manual for the recommended material to be covered in a comprehensive training course).

compression - a type of stress involving pressing together; tends to shorten a member; opposite of tension

compression failure - buckling, crushing, or collapse caused by compression stress

compression flange - the part of a beam that is compressed due to a bending moment

compression seal joint - a joint consisting of a neoprene elastic seal squeezed into the joint opening

concentrated load - a force applied over a small contact area; also known as point load

concrete - a stone-like mass made from a mixture of aggregates and cementing material, which is moldable prior to hardening; see BITUMINOUS CONCRETE and PORTLAND CEMENT CONCRETE

concrete beam - a structural member of reinforced concrete designed to carry bending loads

concrete pile - a pile constructed of reinforced concrete either precast and driven into the ground or cast-in-place in a hole bored into the ground

concrete tee team - "T" shaped section of reinforced concrete; cast-in-place monolithic deck and beam system

condition rating - a judgment of a bridge component condition in comparison to its original as-built condition

conductor - a material that is suitable for carrying electric current

connection angle - a piece of angle serving to connect two elements of a member or two members of a structure; also known as clip angle

consolidation - the time dependent change in volume of a soil mass under compressive load caused by water slowly escaping from the pores or voids of the soil

construction joint - a pair of adjacent surfaces in reinforced concrete where two pours have met, reinforcement steel extends through this joint

continuous beam - a general term applied to a beam that spans uninterrupted over one or more intermediate supports

continuous bridge - a bridge designed to extend without joints over one or more interior supports

continuous footing - a common footing that is underneath a wall, or columns

continuous span - spans designed to extend without joints over one or more intermediate supports

continuous truss - a truss without hinges having its chord and web members arranged to continue uninterrupted over one or more intermediate points of support

continuous weld - a weld extending throughout the entire length of a connection

contraction - the thermal action of the shrinking of an object when cooled; opposite of expansion

contraction scour - the removal of the material under the structure only

coping - a course of stone laid with a projection beyond the general surface of the masonry below it and forming the topmost portion of a wall; a course of stone capping the curved or V-shaped extremity of a pier,

providing a transition to the pier head proper, when so used it is commonly termed the "starling coping," "nose coping," the "cutwater coping" or the "pier extension coping"

corbel - a piece constructed to project from the surface of a wall, column or other portion of a structure to serve as a support for another member

core - a cylindrical sample of concrete or timber removed from a bridge component for the purpose of destructive testing to determine the condition of the component

corrosion - the general disintegration of metal through oxidation

corrugated - an element with alternating ridges and valleys

counter - a truss web member that undergoes stress reversal and resists only live load tension; see WEB MEMBERS

counterfort - a bracket-like wall connecting a retaining wall stem to its footing on the side of the retained material to stabilize the wall against overturning; a counterfort, as opposed to a buttress, acts entirely in tension

counterforted abutment - an abutment that develops resistance to bending moment in the stem by use of counterforts. This permits the breast wall to be designed as a horizontal beam or slab spanning between counterforts, rather than as a vertical cantilever slab

counterforted wall - a retraining wall designed with projecting counterforts to provide strength and stability

counterweight - a weight which is used to balance the weight of a movable member; in bridge applications counterweights are used to balance a movable span so that it rotates or lifts with minimum resistance. Also sometimes used in continuous structures to prevent uplift

couplant - a viscous fluid material used with ultrasonic gages to enhance transmission of sound waves

couple - two forces that are equal in magnitude, opposite in direction, and parallel with respect to each other

coupon - a sample of steel taken from an element in order to test material properties

course - a horizontal layer of bricks or stone

cover - the clear thickness of concrete between a reinforcing bar and the surface of the concrete; the depth of backfill over the top of a pipe or culvert

covered bridge - an indefinite term applied to a wooden bridge having its roadway protected by a roof and enclosing sides

cover plate - a plate used in conjunction with a flange or other structural shapes to increase flange section properties in a beam, column, or similar member

crack - a break without complete separation of parts; a fissure

crack comparator card - A crack comparator card can be used to measure the width of cracks. This type of crack width measuring device is a transparent card about the size of an identification card. The card has lines on it that represent crack widths. The line on the card that best matches the width of the crack lets the inspector know the measured width of the crack.

cracking (reflection) - visible cracks in an overlay indicating cracks in the concrete underneath

crack initiation - the beginning of a crack usually at some microscopic defect

crack propagation - the growth of a crack due to energy supplied by repeated stress cycles

creep - an inelastic deformation that occurs under a constant load, below the yield point, and increases with time

creosote - an oily liquid obtained by the distillation of coal or wood tar and used as a wood preservative

crevice corrosion - occurs between adjacent surfaces but the rust may not expand, even though significant section loss may have occurred

crib - a structure consisting of a foundation grillage combined with a superimposed framework providing compartments or coffers which are filled with gravel, concrete or other material satisfactory for supporting the structure to be placed thereon

cribbing - a construction consisting of wooden, metal or reinforced concrete units so assembled as to form an open cellular-like structure for supporting a superimposed load or for resisting horizontal or overturning forces acting against it.

cribwork - large timber cells that are submerged full of concrete to make an underwater foundation

critical finding - a structural or safety related deficiency that requires immediate follow-up inspection or action

cross - transverse bracings between two main longitudinal members; see DIAPHRAGM, BRACING

cross frame - steel elements placed in "X" shaped patterns to act as stiffeners between the main carrying superstructure members

cross girders - transverse girders, supported by bearings, which support longitudinal beams or girders

cross-section - the shape of an object cut transversely to its length

cross-sectional area - the area of a cross-section

crown - the highest point of the transverse cross section of a roadway, pipe or arch; also known as soffit or vertex

crown of roadway - the vertical dimension describing the total amount the surface is convexed or raised from

gutter to centerline; this is sometimes termed the cross fall or cross slope of roadway

crushing - occurs perpendicular to the grain, usually at support points

culvert - a drainage structure beneath an embankment (e.g., corrugated metal pipe, concrete box culvert)

curb - a low barrier at the side limit of the roadway used to guide the movement of vehicles

curb inlet - see SCUPPER

curtain wall - a term commonly applied to a thin wall between main columns designed to withstand only secondary loads. Also the wall portion of a buttress or counterfort abutment that spans between the buttresses or counterforts

curvature - the degree of curving of a line or surface

curved girder - a girder that is curved in the horizontal plane in order to adjust to the horizontal alignment of the bridge

cutoff wall - vertical wall at the end of an apron or slab to prevent scour undermining

cutwater - a sharp-edged structure, facing the water channel current, built around a bridge pier to protect if from the flow of water and debris in the water

cyclic stress - stress that varies with the passage of live loads; see STRESS RANGE

D

damage inspection - this is an unscheduled inspection to assess structural damage resulting from environmental factors or human actions

dead load - a static load due to the weight of the structure itself

debris - material including floating wood, trash, suspended sediment or bed load moved by a flowing stream

decay - the result of fungi feeding on the cell walls of the wood

deck - that portion of a bridge which provides direct support for vehicular and pedestrian traffic, supported by a superstructure

deck arch - an arch bridge with the deck above the top of the arch

deck bridge - a bridge in which the supporting members are all beneath the roadway

decking - bridge flooring installed in panels, e.g., timber planks

deck joint - a gap allowing for rotation or horizontal movement between two spans or an approach and a span

deficiency - see BRIDGE DEFICIENCY

deflection - elastic movement of a structural member under a load

deformation - distortion of a loaded structural member; may be elastic or inelastic

deformed bars - concrete reinforcement consisting of steel bars with projections or indentations (deformations) to increase the mechanical bond between the steel and concrete

degradation - general progressive lowering of a stream channel by scour

delamination - surface separation of concrete into layers; separation of glulaminated timber plies

design load - the force for which a structure is designed; the most severe combination of loads

distributed loads - loads that are applied along a significant length of a structure

deterioration - decline in quality over a period of time due to chemical or physical degradation

diagonal - a sloping structural member of a truss or bracing system

diagonal stay - a cable support in a suspension bridge extending diagonally from the tower to the roadway to add stiffness to the structure and diminish the deformations and undulations resulting from traffic service

diagonal tension - the tensile force due to horizontal and vertical shear in a beam

diaphragm - a transverse member placed within a member or superstructure system to distribute stresses and improves strength and rigidity; see BRACING

diaphragm wall - a wall built transversely to the longitudinal centerline of a spandrel arch serving to tie together and reinforce the spandrel walls, together with providing a support for the floor system in conjunction with the spandrel walls; also known as cross wall

differential settlement - uneven settlement of individual or independent elements of a substructure; tilting in the longitudinal or transverse direction due to deformation or loss of foundation material

dike - an earthen embankment constructed to retain or redirect water; when used in conjunction with a bridge, it prevents stream erosion and localized scour and/or so directs the stream current such that debris does not accumulate; see SPUR

discharge - the volume of fluid per unit of time flowing along a pipe or channel

displacement induced stress - stresses caused by differential deflection of adjacent parts

distributed load - a load uniformly applied along the length of an element or component of a bridge

ditch - a trough-like excavation made to collect water

diver - a specially trained individual who inspects the underwater portion of a bridge substructure and the surrounding channel

dolphin - a group of piles driven close together or a caisson placed to protect portions of a bridge exposed to possible damage by collision with river or marine traffic

double movable bridge - a bridge in which the clear span over the navigation channel is produced by joining the arms of two adjacent swing spans or the leaves of two adjacent bascule spans at or near the center of the navigable channel; see MOVABLE BRIDGE

dowel - a length of bar embedded in two parts of a structure to hold the parts in place and to transfer stress

drainage - a system designed to remove water from a structure

drainage area - an area in which surface run-off collects and from which it is carried by a drainage system; also known as catchment area

drain hole - hole in a box shaped member or a wall to provide means for the exit of accumulated water or other liquid; also known as drip hole; see WEEP HOLE

drain pipes - pipes that carry storm water

drawbridge - a general term applied to a bridge over a navigable body of water having a movable superstructure span of any type

drift bolt - a short length of metal bar used to connect and hold in position wooden members placed in contact; similar to a dowel

drift pin - tapered steel rod used by ironworkers to align bolt holes

drip notch - a recess cast on the underside of an overhang that prevents water from following the concrete surface onto the supporting beams

drop inlet - a type of inlet structure that conveys the water from a higher elevation to a lower outlet elevation smoothly without a free fall at the discharge

duct - the hollow space where a prestressing tendon is placed in a post-tensioned prestressed concrete girder

ductile - capable of being molded or shaped without breaking; plastic

ductile fracture - a fracture characterized by plastic deformation

ductility - the ability to withstand nonelastic deformation without rupture

dumbbell pier - a pier consisting of two cylindrical or rectangular shaped piers joined by an integral web

dummy member - truss member that carries no primary loads; may be included for bracing or for appearance

E

E - modulus of elasticity of a material; Young's modulus; the stiffness of a material

efflorescence - a deposit on concrete or brick caused by crystallization of carbonates brought to the surface by moisture in the masonry or concrete

elastic - capable of sustaining deformation without permanent loss of shape

elastic strain - the reversible distortion of a material

elastic deformation - non-permanent deformation; when the stress is removed, the material returns to its original shape

elasticity - the property whereby a material changes its shape under the action of loads but recovers its original shape when the loads are removed

elastomer - a natural or synthetic rubber-like material

elastomeric pad - a synthetic rubber pad used in bearings that compresses under loads and accommodates horizontal movement by deforming

electrolyte - a medium of air, soil, or liquid carrying ionic current between two metal surfaces, the anode and the cathode

electrolytic cell - a device for producing electrolysis consisting of the electrolyte and the electrodes

electrolytic corrosion - corrosion of a metal associated with the flow of electric current in an electrolyte

elevation view - a drawing of the side view of a structure

elliptic arch - an arch in which the intrados surface is a full half of the surface of an elliptical cylinder; this terminology is sometimes incorrectly applied to a multicentered arch

elongation - the elastic or plastic extension of a member

embankment - a mound of earth constructed above the natural ground surface to carry a road or to prevent water from passing beyond desirable limits; also known as bank

end block - in a prestressed concrete I-beam, the widened beam web at the end to provide adequate anchorage bearing for the post tensioning steel and to resist high shear stresses; similarly, the solid end diaphragm of a box beam

end post - the end compression member of a truss, either vertical or inclined in position and extending from top chord to bottom chord

end rotation - Occurs when a structure deflects

end section - a concrete or steel appurtenance attached to the end of a culvert for the purpose of hydraulic efficiency, embankment retention or anchorage

end span - a span adjacent to an abutment

epoxy - a synthetic resin which cures or hardens by chemical reaction between components which are mixed together shortly before use

epoxy coated reinforcement - reinforcement steel coated with epoxy; used to prevent corrosion

equilibrium - in statics, the condition in which the forces acting upon a body are such that no external effect (or movement) is produced

equivalent uniform load - a load having a constant intensity per unit of its length producing an effect equal to that of a live load consisting of vehicle axle or wheel concentrations spaced at varying distances

erosion - wearing away of soil by flowing water not associated with a channel; see SCOUR

expansion - an increase in size or volume

expansion bearing - a bearing designed to permit longitudinal or lateral movements resulting from temperature changes and superimposed loads with minimal transmission of horizontal force to the substructure; see BEARING

expansion dam - the part of an expansion joint serving as an end form for the placing of concrete at a joint; also applied to the expansion joint device itself; see EXPANSION JOINT

expansion joint - a joint designed to permit expansion and contraction movements produced by temperature changes, loadings or other forces

expansion rocker - a bearing device at the expansion end of a beam or truss that allows the longitudinal movements resulting from temperature changes and superimposed loads through a tilting motion

expansion roller - a cylinder so mounted that by revolution it facilitates expansion, contraction or other movements resulting from temperature changes, loadings or other forces

expansion shoe - expansion bearing, generally of all metal construction

exterior girder - an outermost girder supporting the bridge floor

extrados - the curve defining the exterior (upper) surface of an arch; also known as back

eyebar - a member consisting of a rectangular bar with enlarged forged ends having holes for engaging connecting pins

F

failure - a condition at which a structure reaches a limit state such as cracking or deflection where it is no longer able to perform its usual function; collapse; fracture

falsework - a temporary wooden or metal framework built to support the weight of a structure during the period of its construction and until it becomes self-supporting

fascia - an outside, covering member designed on the basis of architectural effect rather than strength and rigidity, although its function may involve both

fascia girder - an exposed outermost girder of a span sometimes treated architecturally or otherwise to provide an attractive appearance

fatigue - the tendency of a member to fail at a stress below the yield point when subjected to repetitive loading

fatigue crack - any crack caused by repeated cyclic loading at a stress below the yield point

fatigue damage - member damage (crack formation) due to cyclic loading

fatigue life - the length of service of a member subject to fatigue, based on the number of cycles it can undergo

fender - a structure that acts as a buffer to protect the portions of a bridge exposed to floating debris and water-borne traffic from collision damage; sometimes called an ice guard in regions with ice floes

fender pier - a pier-like structure which performs the same service as a fender but is generally more substantially built; see GUARD PIER

field coat - a coat of paint applied after the structure is assembled and its joints completely connected; quite commonly a part of the field erection procedure; field painting

fill - material, usually earth, used to change the surface contour of an area, or to construct an embankment

filler - a piece used primarily to fill a space beneath a batten, splice plate, gusset, connection angle, stiffener or other element; also known as filler plate

filler metal - metal prepared in wire, rod, electrode or other form to be fused with the structure metal in the formation of a weld

filler plate - see FILLER

fillet - a curved portion forming a junction of two surfaces that would otherwise intersect at an angle

fillet weld - a weld of triangular or fillet shaped crosssection between two pieces at right angles

filling - see FILL

fine aggregate - sand or grit for concrete or mortar that passes a No. 4 sieve (4.75 mm)

finger dam - expansion joint in which the opening is spanned by meshing steel fingers or teeth

fish belly - a term applied to a girder or a truss having its bottom flange or its bottom chord constructed either haunched or bowshaped with the convexity downward; see LENTICULAR TRUSS

fixed beam - a beam with a fixed end

fixed bearing - a bearing that allows only rotational movement; see BEARING

fixed bridge - a bridge having constant position, i.e., without provision for movement to create increased navigation clearance

fixed end - movement is restrained

fixed-ended arch - see VOUSSOIR ARCH

fixed span - a superstructure span having its position practically immovable, as compared to a movable span

fixed support - a support that will allow rotation only, no longitudinal movement

flange - the (usually) horizontal parts of a rolled I-shaped beam or of a built-up girder extending transversely across the top and bottom of the web

flange angle - an angle used to form a flange element of a built-up girder, column, strut or similar member

floating bridge - see PONTOON BRIDGE

floating foundation - used to describe a soil-supported raft or mat foundation with low bearing pressures; sometimes applied to a "foundation raft" or "foundation grillage"

flood frequency - the average time interval in years in which a flow of a given magnitude will recur

flood plain - area adjacent to a stream or river subject to flooding

floor - see DECK

floorbeam - a primary horizontal member located transversely to the general bridge alignment

floor system - the complete framework of members supporting the bridge deck and the traffic loading

flow capacity - maximum flow rate that a channel, conduit, or culvert structure is hydraulically capable of carrying

flux - a material that protects the weld from oxidation during the fusion process

footbridge - a bridge designed and constructed to provide means of traverse for pedestrian traffic only; also known as pedestrian bridge

footing - the enlarged, lower portion of a substructure, which distributes the structure load either to the earth or to supporting piles; the most common footing is the concrete slab; footer is a colloquial term for footing

footing aprons - protective layers of material surrounding the footing of a substructure unit

foot wall - see TOE WALL

force - an influence that tends to accelerate a body or to change its movement

forms - the molds that hold concrete in place while it is hardening; also known as form work, shuttering; see LAGGING, STAY-IN-PLACE FORMS

form work - see FORMS

foundation - the supporting material upon which the substructure portion of a bridge is placed

foundation excavation - the excavation made to accommodate a footing for a structure; also known as foundation pit

foundation failure - failure of a foundation by differential settlement or by shear failure of the soil

foundation grillage - a construction consisting of steel, timber, or concrete members placed in layers; each layer is perpendicular to those above and below it and the members within a layer are generally parallel, producing a crib or grid-like effect. Grillages are usually placed under very heavy concentrated loads

foundation load - the load resulting from traffic, superstructure, substructure, approach embankment, approach causeway, or other incidental load increment imposed upon a given foundation area

foundation pile - see PILE

foundation pit - see FOUNDATION EXCAVATION

foundation seal - a mass of concrete placed underwater within a cofferdam for the base portion of structure to close or seal the cofferdam against incoming water; see TREMIE

fracture - see BRITTLE FRACTURE

fracture critical member (FCM) - a steel member in tension, or with a tension element, whose failure would probably cause a portion of or the entire bridge to collapse

fracture critical member inspection - a hands-on inspection of a fracture critical member or member components that may include visual and other nondestructive evaluation

frame - a structure which transmits bending moments from the horizontal beam member through rigid joints to vertical or inclined supporting members

framing - the arrangement and connection of the component members of a bridge superstructure

freeboard - the vertical distance between the design flood water surface and the lowest point of the structure to account for waves, surges, drift and other contingencies

free end - movement is not restrained

freeze-thaw - freezing of water within the capillaries and pores of cement paste and aggregate resulting in internal overstressing of the concrete, which leads to deterioration including cracking, scaling, and crumbling.

fretting corrosion - occurs in elements in close contact that are subject to vibrations such as intersecting truss diagonals

friction pile - a pile that provides support through friction resistance between the pile and the surrounding earth along the lateral surface of the pile

friction roller - a roller placed between members intended to facilitate change in their relative positions by reducing the frictional resistance to translation movement

frost heave - the upward movement of, or force exerted by, soil due to freezing of retained moisture

frost line - the depth to which soil may be frozen

functionally obsolete – a bridge that has deck geometry, load carrying capacity, clearance or approach roadway alignment that no longer meets the criteria for the system of which the bridge is a part

G

gabion - rock filled wire baskets used to retain earth and provide erosion control

galvanic action - electrical current between two unlike metals

galvanize - to coat with zinc

gauge - the distance between parallel lines of rails, rivet holes, etc; a measure of thickness of sheet metal or wire; also known as gage

general scour - the lowering of a streambed across the waterway at the bridge, which may or may not be uniform

geometry - shape or form; relationship between lines or points

girder - a horizontal flexural member that is the main or primary support for a structure; any large beam, especially if built up

girder bridge - a bridge whose superstructure consists of two or more girders supporting a separate floor

system as differentiated from a multi-beam bridge or a slab bridge

girder span - a span in which the major longitudinal supporting members are girders

glue laminated - a member created by gluing together two or more pieces of lumber

grade - the fall or rise per unit horizontal length; see GRADIENT

grade crossing - a term applicable to an intersection of two highways, two railroads or a railroad and a highway at a common grade or elevation; now commonly accepted as meaning the last of these combinations

grade intersection - the location where two roadway slopes meet in profile; to provide a smooth transition from one to the other they are connected by a vertical curve and the resulting profile is a sag or a crest

grade separation - roadways crossing each other at different elevations; see OVERPASS, UNDERPASS

gradient - the rate of inclination of the roadway and˜ or sidewalk surface(s) from the horizontal, applying to a bridge and its approaches; it is commonly expressed as a percentage relation (ratio) of horizontal to vertical dimensions

gravity abutment - a thick abutment that resists horizontal earth pressure through its own dead weight

gravity wall - a retaining wall that is prevented from overturning or sliding by its own dead weight

grid flooring - a steel floor system comprising a lattice pattern that may or may not be filled with concrete

grillage - assembly of parallel beams, usually steel or concrete, placed side by side, often in layers with alternating directions; see FOUNDATION GRILLAGE

groin - a wall built out from a river bank to check scour

grout - mortar having a sufficient water content to render it free-flowing, used for filling (grouting) the joints in masonry, for fixing anchor bolts and for filling cored spaces; usually a thin mix of cement, water and sometimes sand or admixtures

grouting - the process of filling in voids with grout

guard pier - a pier-like structure built to protect a swing span in its open position from collision with passing vessels or water-borne debris; may be equipped with a rest pier upon which the swing span in its open position may be latched; see FENDER PIER

guardrail - a safety feature element intended to redirect an errant vehicle

guide banks - dikes that extend upstream from the approach embankment at either or both sides of the bridge opening to direct flow through the opening

guide rail - see GUARDRAIL

gunite - the process of blowing Portland cement mortar or concrete onto a surface using compressed air

gusset plate - a plate that connects the members of a structure and holds them in correct position at a joint

gutter - a paved ditch; area adjacent to a roadway curb used for drainage

guy - a cable member used to anchor a structure in a desired position

H

H Loading - a combination of loads used to represent a two-axle truck developed by AASHTO

hairline cracks - very narrow cracks that form in the surface of concrete due to tension caused by loading

hammer - hand tool used for sounding and surface inspection

hammerhead pier - a pier with a single cylindrical or rectangular shaft and a relatively long, transverse cap; also known as a tee pier or cantilever pier

hand hole - hole provided in component plate of built-up box section to permit access to the interior for construction and maintenance purposes

hand rail - commonly applies only to sidewalk railing presenting a latticed, barred, balustered or other open web construction

hands-on - inspection within arms length of the component. Inspection uses visual techniques that may be supplemented by nondestructive testing

hands-on access - close enough to the member or component so that it can be touched with the hands and inspected visually

hanger - a tension member serving to suspend an attached member; allows for expansion between a cantilevered and suspended span

haunch - an increase in the depth of a member usually at points of support; the outside areas of a pipe between the spring line and the bottom of the pipe

haunched girder - a horizontal beam whose cross sectional depth varies along its length

H-beam - a rolled steel member having an H-shaped cross-section (flange width equals beam depth) commonly used for piling; also H-pile

head - a measure of water pressure expressed in terms of an equivalent weight or pressure exerted by a column of water; the height of the equivalent column of water is the head

head loss - the loss of energy between two points along the path of a flowing fluid due to fluid friction; reported in feet of head

headwall - a concrete structure at the ends of a culvert to retain the embankment slopes, anchor the culvert, and prevent undercutting

headwater - the source or the upstream waters of a stream

heat treatment - any of a number of various operations involving controlled heating and cooling that are used to impart specific properties to metals; examples are tempering, quenching, and annealing

heave - the upward motion of soil caused by outside forces such as excavation, pile driving, moisture or soil expansion; see FROST HEAVE

heel - the portion of a footing behind the stem

helical - having the form of a spiral

high carbon steel - carbon steel containing 0.5 to 1.5% dissolved carbon

high strength bolt - bolt and nut made of high strength steel, usually A325 or A490

highway - the term 'highway' includes:

A) a road, street, and parkway;
B) a right-of-way, bridge, railroad-highway crossing, tunnel, drainage structure, sign, guardrail, and protective structure, in connection with a highway; and
C) a portion of any interstate or international bridge or tunnel and the approaches thereto, the cost of which is assumed by a State transportation department, including such facilities as may be required by the United States Customs and Immigration Services in connection with the operation of an international bridge or tunnel

hinge - a point in a structure at which a member is free to rotate

hinged joint - a joint constructed with a pin, cylinder segment, spherical segment or other device permitting rotational movement

honeycomb - an area in concrete where mortar has separated and left spaces between the coarse aggregate, usually caused by improper vibration during concrete construction

horizontal alignment - a roadway's centerline or baseline alignment in the horizontal plane

horizontal curve - a roadway baseline or centerline alignment defined by a radius in the horizontal plane

horizontal shear splits - separations of the wood fibers parallel to the grain due to excessive loading

Howe truss - a truss of the parallel chord type with a web system composed of vertical (tension) rods at the panel points with an X pattern of diagonals

HS Loading - a combination of loads developed by AASHTO used to represent a truck and trailer

hybrid girder - a girder whose flanges and web are made from steel of different grades

hydraulic countermeasures - man-made or man-placed devices designed to direct streamflow and to protect against lateral migration and scour

hydraulics - the mechanics of fluids

hydrology - study of the accumulation and flow of water from watershed areas

hydroplaning - loss of contact between a tire and the roadway surface when the tire planes or glides on a film of water

I

I-beam - a structural member with a crosssectional shape similar to the capital letter "I"

ice guard - see FENDER

impact - A factor that describes the effect on live load due to dynamic and vibratory effects of a moving load; in bridge design, a load based on a percentage of live load to include dynamic and vibratory effects; in fracture mechanics, a rapidly applied load, such as a collision or explosion

incomplete fusion - a weld flaw where the weld metal has not combined metallurgically with the base metal

in-depth inspection - a close-up, inspection of one or more members above or below the water level to identify any deficiencies not readily detectable using routine inspection procedures; hands-on inspection may be necessary at some locations

indeterminate stress - stress in a structural member which cannot be calculated directly; it is computed by the iterative application of mathematical equations, usually with an electronic computer; indeterminate stresses arise in continuous span and frame type structures

individual column footing - footing supporting one column

inelastic compression - compression beyond the yield point

initial inspection - the first inspection of a bridge as it becomes a part of the bridge file to provide all Structure Inventory and Appraisal (SI&A) data and other relevant data and to determine baseline structural conditions.

inlet - an opening in the floor of a bridge leading to a drain; roadway drainage structure which collects surface water and transfers it to pipes

inspection frequency - the frequency with which the bridge is inspected -- normally every two years

integral abutment - an abutment cast monolithically with the end diaphragm of the deck; such abutments usually encase the ends of the deck beams and are pile supported

integral deck - a deck which is monolithic with the superstructure; concrete tee beam bridges have integral decks

intercepting ditch - a ditch constructed to prevent surface water from flowing in contact with the toe of an embankment or causeway or down the slope of a cut

interior girder - any girder between exterior or fascia girders

interior span - a span of which both supports are intermediate substructure units

intermittent weld - a noncontinuous weld commonly composed of a series of short welds separated by spaces of equal length

internal redundancy - a bridge member having several elements that are mechanically fastened together

internal steel corrosion - occurs due to the elimination of the protection of steel caused by chlorides

intrados - the curve defining the interior (lower) surface of the arch; also known as soffit

inventory item - data contained in the structure file pertaining to bridge identification, structure type and material, age and service, geometric data, navigational data, classification, load rating and posting, proposed improvements, and inspections

inventory rating - the capacity of a bridge to withstand loads under normal service conditions based on 55% of yield strength

invert elevation - the bottom or lowest point of the internal surface of the transverse cross section of a pipe or culvert

iron - a metallic element used in cast iron, wrought iron and steel

isotropic - having the same material properties in all directions, e.g., steel

J

jack arch - a deck support system comprised of a brick or concrete arch springing from the bottom flanges of adjacent rolled steel beams

jacking - the lifting of elements using a type of jack (e.g., hydraulic), sometimes acts as a temporary support system

jack stringer - the outermost stringer supporting the bridge floor in a panel or bay

jacket - a protective shell surrounding a pile made of fabric, concrete or other material

jersey barrier - a concrete barrier with sloping front face that was developed by the New Jersey Department of Transportation

joint - in masonry, the space between individual stones or bricks; in concrete, a division in continuity of the concrete; in a truss, point at which members of a truss are joined

K

keeper plate - a plate, which is connected to a sole plate, designed to prohibit a beam from becoming dislodged from the bearing

key - a raised portion of concrete on one face of a joint that fits into a depression on the adjacent face

keystone - the symmetrically shaped, wedge˜like stone located in a head ring course at the crown of an arch; the final stone placed, thereby closing the arch

king-post - the vertical member in a "king-post" type truss; also known as king rod

king-post truss - two triangular panels with a common center vertical; the simplest of triangular system trusses

kip - a kilo pound (1000 lb.); convenient unit for structural calculations

knee brace - a short member engaging at its ends two other members that are joined to form a right angle or a near-right angle to strengthen and stiffen the connecting joint

knee wall - a return of the abutment backwall at its ends to enclose the bridge seat on three of its sides; also called cheek wall

knife edge - a condition in which corrosion of a steel member has caused a sharp edge

knuckle - an appliance forming a part of the anchorage of a suspension bridge main suspension member permitting movement of the anchorage chain

knots - separations of the wood fibers due to the trunk growing around an embedded limb

K-truss - a truss having a web system wherein the diagonal members intersect the vertical members at or near the mid-height; the assembly in each panel forms a letter "K"

L

L-abutment - a cantilever abutment with the stem flush with the toe of the footing, forming an "L" in cross section

laced column - a riveted, steel built-up column of usually four angles or two channels tied together laterally with lacing

lacing - small flat plates, usually with one rivet at each end, used to tie individual sections of built up members; see LATTICE

lagging - horizontal members spanning between piles to form a wall; forms used to produce curved surfaces; see FORMS

lamellar tear - incipient cracking parallel to the face of a steel member

laminated timber - timber planks glued together face to face to form a larger member; see GLUE LAMINATED

lane loading - a design loading which represents a line of trucks crossing over a bridge

lap joint - a joint between two members in which the end of one member overlaps the end of the other

lateral - a member placed approximately perpendicular to a primary member

lateral bracing - the bracing assemblage engaging a member perpendicular to the plane of the member; intended to resist transverse movement and deformation; also keeps primary parallel elements in truss bridges and girder bridges aligned; see BRACING

lateral stream migration - the relocation of the channel due to lateral streambank erosion

lattice - a crisscross assemblage of diagonal bars, channels, or angles on a truss; also known as latticing, lacing

lattice truss - in general, a truss having its web members inclined but more commonly the term is applied to a truss having two or more web systems composed entirely of diagonal members at any interval and crossing each other without reference to vertical members

leaching - the action of removing substances from a material by passing water through it

lead line - a weighted cord incrementally marked, used to determine the depth of a body of water; also known as sounding line

leaf - the movable portion of a bascule bridge that forms the span of the structure

legal load - the maximum legal load for each vehicle configuration permitted by law for the State in which the bridge is located

lenticular truss - a truss having parabolic top and bottom chords curved in opposite directions with their ends

meeting at a common joint; also known as a fish belly truss

levee - an embankment built to prevent flooding of low-lying land

leveling course - a layer of bituminous concrete placed to smooth an irregular surface

light-weight concrete - concrete of less than standard unit weight; may be no-fines concrete, aerated concrete, or concrete made with lightweight aggregate

link - a hanger plate in a pin and hanger assembly whose shape is similar to an eyebar, e.g., the head (at the pinhole) is wider than the shank

link and roller - a movable bridge element consisting of a hinged strut̃like link fitted with a roller at its bottom end, supported upon a shoe plate or pedestal and operated by a thrust strut serving to force it into a vertical position and to withdraw it therefrom; when installed at each outermost end of the girders or the trusses of a swing span their major function is to lift them to an extent that their camber or droop will be removed and the arms rendered free to act as simple spans; when the links are withdrawn to an inclined position fixed by the operating mechanism the span is free to be moved to an open position

live load - a temporary dynamic load such as vehicular traffic that is applied to a structure; also accompanied by vibration or movement affecting its intensity

load - a force carried by a structure component

load factor design - a design method used by AASHTO, based on limit states of material and arbitrarily increased loads

load indicating washer - a washer with small projections on one side, which compress as the bolt is tightened; gives a direct indication of the bolt tension that has been achieved

load path redundancy - a bridge having three or more main load-carrying members

load rating - the determination of the live load carrying capacity of a bridge using bridge plans and supplemented by information gathered from a field inspection

load and resistance factor design (LRFD) - design method used by AASHTO, based on limit states of material with increased loads and reduced member capacity based on statistical probabilities

local buckling - localized buckling of a beam's plate element, can lead to failure of member

local scour - the removal of streambed material adjacent to an obstruction in a waterway, that has been placed within the stream (such as a pier or abutment), and causes the acceleration of the flow induced by the obstruction

longitudinal bracing - bracing that runs lengthwise with a bridge and provides resistance against longitudinal movement and deformation of transverse members

loss of prestress - loss of prestressing force due to a variety of factors, including shrinkage and creep of the

concrete, creep of the prestressing tendons, and loss of bond

low-carbon steel - steel with 0.04 to 0.25% dissolved carbon; also called mild steel

lower chord - the bottom horizontal member of a truss

luminaire - a lighting fixture

M

macadam - roadway pavement made with crushed stone aggregate, of coarse open gradation, compacted in place; asphaltic macadam included asphalt as a binder

main beam - a horizontal structural member which supports the span and bears directly on a column or wall

maintenance - basic repairs performed on a facility to keep it at an adequate level of service

maintenance and protection of traffic - the management of vehicular and pedestrian traffic through a construction zone to ensure the safety of the public and the construction workforce; MPT; TRAFFIC PROTECTION

marine borers - mollusks and crustaceans that live in water and destroy wood by digesting it

masonry - that portion of a structure composed of stone, brick or concrete block placed in courses and usually cemented with mortar

masonry cement - Portland cement and lime used to make mortar for masonry construction

masonry plate - a steel plate placed on the substructure to support a superstructure bearing and to distribute the load to the masonry beneath

mattress - a flexible scour protection blanket composed of interconnected timber, gabions, or concrete units.

meander - a twisting, winding action from side to side; characterizes the serpentine curvature of a narrow, slow flowing stream in a wide flood plain

median - separation between opposing lanes of highway traffic; also known as median strip

member - an individual angle, beam, plate, or built component piece intended ultimately to become an integral part of an assembled frame or structure

metal corrosion - oxidation of metal by electro-galvanic action involving an electrolyte (moisture), an anode (the metallic surface where oxidation occurs), a cathode (the metallic surface that accepts electrons and does not corrode), and a conductor (the metal piece itself)

midspan - a reference point halfway between the supports of a beam or span

mild steel - steel containing from 0.04 to 0.25% dissolved carbon; see LOW CARBON STEEL

military loading - a loading pattern used to simulate heavy military vehicles passing over a bridge

mill scale - dense iron oxide on iron or steel that forms on the surface of metal that has been forged or hot worked

modular joint - a bridge joint designed to handle large movements consisting of an assembly of several strip or compression seals

modulus of elasticity - the ratio between the stress applied and the resulting elastic strain

moisture content - the amount of water in a material expressed as a percent by weight

moment - the couple effect of forces about a given point; see BENDING MOMENT

monolithic - forming a single mass without joints

mortar - a paste of portland cement, sand, and water laid between bricks, stones or blocks

movable bridge - a bridge having one or more spans capable of being raised, turned, lifted, or slid from its normal service location to provide a clear navigation passage; see BASCULE BRIDGE, VERTICAL LIFT BRIDGE, PONTOON BRIDGE, RETRACTILE DRAW BRIDGE, ROLLING LIFT BRIDGE, and SWING BRIDGE

movable span - a general term applied to a superstructure span designed to be swung, lifted or otherwise moved longitudinally, horizontally or vertically, usually to provide increased navigational clearance

moving load - a live load which is moving, for example, vehicular traffic

MPT - see MAINTENANCE AND PROTECTION OF TRAFFIC

MSE - mechanically stabilized earth; see REINFORCED EARTH

multi-centered arch - an arch in which the intrados surface is outlined by two or more arcs symmetrically arranged and having different radii that intersect tangentially

N

nail laminated - a laminated member produced by nailing two or more pieces of timber together face to face

National Bridge Inspection Standards NBIS - National Bridge Inspection Standards, first established in 1971 to set national policy regarding bridge inspection frequency, inspector qualifications, report formats, and inspection and rating procedures

National Bridge Inventory (NBI) - A database of Structure Inventory and Appraisal data collected by each state or Federal bridge-owning agency to fulfill the requirements of the NBIS

NCHRP - National Cooperative Highway Research Program

NICET - National Institute for Certification in Engineering Technologies, the NICET provides nationally applicable voluntary certification programs covering several broad engineering technology fields and a number of specialized subfields. For information on the NICET program certification contact: National Institute for Certification in Engineering Technologies, 1420 King Street, Alexandria, VA 22314–2794.

NDE - nondestructive evaluation

NDT - nondestructive testing; any testing method of checking structural quality of materials that does not damage them

necking - the elongation and contraction in area that occurs when a ductile material is stressed

negative bending - bending of a member that causes tension in the surface adjacent to the load, e.g., moment at interior supports of a span or at the joints of a frame

negative moment - bending moment in a member such that tension stresses are produced in the top portions of the member; typically occurs in continuous beams and spans over the intermediate supports

neoprene - a synthetic rubber-like material used in expansion joints and elastomeric bearings

neutral axis - the internal axis of a member in bending along which the strain is zero; on one side of the neutral axis the fibers are in tension, on the other side the fibers are in compression

Non-homogeneous -

nose - a projection acting as a cut water on the upstream end of a pier; see STARLING

notch effect - stress concentration caused by an abrupt discontinuity or change in section

O

offset - a horizontal distance measured at right angles to a survey line to locate a point off the line

on center - a description of a typical dimension between the centers of the objects being measured

open spandrel arch - a bridge that has open spaces between the deck and the arch members allowing "open" visibility through the bridge

open spandrel ribbed arch - a structure in which two or more comparatively narrow arch rings, called ribs, function in the place of an arch barrel; the ribs are rigidly secured in position by arch rib struts located at intervals along the length of the arch; the arch ribs carry a column type open spandrel construction which supports the floor system and its loads

operating rating - the capacity of a bridge to withstand loads based on 75% of yield strength; the maximum

permissible live load to which the structure may be subjected for the load configuration used in the rating

operator's house - the building containing control devices required for opening and closing a movable bridge span

orthotropic - having different properties in two or more directions at right angles to each other (e.g., wood); see ANISOTROPY

outlet - in hydraulics, the discharge end of drains, sewers, or culverts

out-of-plane distortion - distortion of a member in a plane other than that which the member was designed to resist

overlay - see WEARING SURFACE

overload - a weight greater than the structure is designed to carry

overload damage - occurs when concrete members are sufficiently overstressed

overpass - bridge over a roadway or railroad

overturning - tipping over; rotational movement

oxidation - the chemical breakdown of a substance due to its reaction with oxygen from the air

oxidized steel - rust

P

pack - a steel plate inserted between two others to fill a gap and fit them tightly together; also known as packing; fill; filler plate

pack rust - rust forming between adjacent steel surfaces in contact which tends to force the surfaces apart due to the increase in material volume

paddleboard - striped, paddle-shaped signs or boards placed on the roadside in front of a narrow bridge as a warning of reduced roadway width

panel -the portion of a truss span between adjacent points of intersection of web and chord members

panel point - the point of intersection of primary web and chord members of a truss

parabolic arch - an arch in which the intrados surface is a segment of a symmetrical parabolic surface (suited to concrete arches)

parabolic truss - a polygonal truss having its top chord and end post vertices coincident with the arc of a parabola, its bottom chord straight and its web system either triangular or quadrangular; also known as a parabolic arched truss

parapet - a low wall along the outmost edge of the roadway of a bridge to protect vehicles and pedestrians

pedestal - concrete or built-up metal member constructed on top of a bridge seat for the purpose of providing a specific bearing seat elevation

pedestal pier - one or more piers built in block-like form that may be connected by an integrally built web between them; when composed of a single, wide blocklike form, it is called a wall or solid pier

pedestrian bridge - see FOOT BRIDGE

penetration - when applied to creosoted lumber, the depth to which the surface wood is permeated by the creosote oil; when applied to pile driving; the depth a pile tip is driven into the ground

permanent loads - loads that are constant for the life of the structure

physical testing - the testing of bridge members in the field or laboratory

pier - a substructure unit that supports the spans of a multi-span superstructure at an intermediate location between its abutments

pier cap - the topmost horizontal portion of a pier that distributes loads from the superstructure to the vertical pier elements

pile - a shaft-like linear member which carries loads to underlying rock or soil strata

pile bent - a row of driven or placed piles extending above the ground surface supporting a pile cap; see BENT

pile bridge - a bridge carried on piles or pile bents

pile cap - a slab or beam which acts to secure the piles in position laterally and provides a bridge seat to receive and distribute superstructure loads

pile foundation - a foundation supported by piles in sufficient number and to a depth adequate to develop the bearing resistance required to support the substructure load

pile pier - see PILE BENT

piling - collective term applied to group of piles in a construction; see PILE, SHEET PILES

pin - a cylindrical bar used to connect elements of a structure

pin-connected truss - a general term applied to a truss of any type having its chord and web members connected at each panel point by a single pin

pin and hanger - a hinged connection detail designed to allow for expansion and rotation between a cantilevered and suspended span at a point between supports.

pin joint - a joint in a truss or other frame in which the members are assembled upon a single cylindrical pin

pin packing - arrangement of truss members on a pin at a pinned joint

pin plate - a plate rigidly attached upon the end of a member to develop the desired bearing upon a pin or pin-like bearing, and secure additional strength and rigidity in the member; doubler plate

pintle - a relatively small steel pin engaging the rocker of an expansion bearing, in a sole plate or masonry plate, thereby preventing sliding of the rocker

pipe - a hollow cylinder used for the conveyance of water, gas, steam etc.

piping - removal of fine particles from within a soil mass by flowing water

plain concrete - concrete with no structural reinforcement except, possibly, light steel to reduce shrinkage and temperature cracking

plan and profile - a drawing that shows both the roadway plan view and profile view in the same scale; see PLAN VIEW, PROFILE

plan view - drawing that represents the top view of the road or a structure

plastic deformation - permanent deformation of material beyond the elastic range

plastic strain - the irreversible or permanent distortion of a material

plate - a flat sheet of metal which is relatively thick; see SHEET STEEL

plate girder - a large I-shaped beam composed of a solid web plate with flange plates attached to the web plate by flange angles or fillet welds

plug weld - a weld joining two members produced by depositing weld metal within holes cut through one or more of the members; also known as slot weld

plumb bob - a weight hanging on a cord used to provide a true vertical reference

plumb line - a true vertical reference line established using a plumb bob

pneumatic caisson - an underwater caisson in which the working chamber is kept free of water by compressed air at a pressure nearly equal to the water pressure outside it

point loads - loads that are applied to a localized area

pointing - the compacting of the mortar into the outermost portion of a joint and the troweling of its exposed surface to secure water tightness or desired architectural effect; replacing deteriorated mortar

ponding - accumulation of water

pontoon bridge - a bridge supported by floating on pontoons moored to the riverbed; a portion may be removable to facilitate navigation

pony truss - a through truss without top chord lateral bracing

pop-out - conical fragment broken out of a concrete surface by pressure from reactive aggregate particles

portable bridge - a bridge that may be readily erected for a temporary communication-transport service and disassembled and reassembled at another location

portal - the clear unobstructed space of a through truss bridge forming the entrance to the structure

portal bracing - a system of sway bracing placed in the plane of the end posts of the trusses

portland cement - a fine dry powder made by grinding limestone clinker made by heating limestone in a kiln; this material reacts chemically with water to produce a solid mass

portland cement concrete - a mixture of aggregate, portland cement, water, and usually chemical admixtures

positive moment - a force applied over a distance that causes compression in the top fiber of a beam and tension in the bottom fiber

post - a member resisting compressive stresses, located vertical to the bottom chord of a truss and common to two truss panels; sometimes used synonymously for vertical; see COLUMN

posting - a limiting dimension, speed, or loading indicating larger dimensions, higher speeds, or greater loads cannot be safely taken by the bridge

post-stressing - see POSTTENSIONING

posttensioning - a method of prestressing concrete in which the tendons are stressed after the concrete has been cast and hardens

pot bearing - a bearing type that allows for multi-dimensional rotation by using a piston supported on an elastomer contained on a cylinder ("pot"), or spherical bearing element

pot holes - irregular shaped, disintegrated areas of bridge deck or roadway pavement caused by the failure of the surface material

Pratt truss - a truss with parallel chords and a web system composed of vertical posts with diagonal ties inclined outward and upward from the bottom chord panel points toward the ends of the truss; also known as N-truss

precast concrete - concrete members that are cast and cured before being placed into their final positions on a construction site

prestressed concrete - concrete with strands, tendons, or bars that are stressed before the live load is applied

prestressing - applying forces to a structure to deform it in such a way that it will withstand its working loads more effectively; see POSTTENSIONING, PRETENSIONING

pretensioning - a method of prestressing concrete in which the strands are stressed before the concrete is placed; strands are released after the concrete has hardened, inducing internal compression into the concrete

primary member - a member designed to resist flexure and distribute primary live loads and dead loads

priming coat - the first coat of paint applied to the metal or other material of a bridge; also known as base coat, or primer

probing - investigating the location and condition of submerged foundation material using a rod or shaft of appropriate length; checking the surface condition of a timber member for decay using a pointed tool, e.g., an ice pick

Professional engineer (PE) - an individual, who has fulfilled education and experience requirements and passed rigorous exams that, under State licensure laws, permits them to offer engineering services directly to the public. Engineering licensure laws vary from State to State, but, in general, to become a PE an individual must be a graduate of an engineering program accredited by the Accreditation Board for Engineering and Technology, pass the Fundamentals of Engineering exam, gain four years of experience working under a PE, and pass the Principles of Practice of Engineering exam

profile - a section cut vertically along the center line of a roadway or waterway to show the original and final ground levels

program manager - the individual in charge of the program, that has been assigned or delegated the duties and responsibilities for bridge inspection, reporting, and inventory. The program manager provides overall leadership and is available to inspection team leaders to provide guidance

programmed repair - those repairs that may be performed in a scheduled program

protective system - a system used to protect bridges from environmental forces that cause steel and concrete to deteriorate and timber to decay, typically a coating system

PS&E - Plans, Specifications, and Estimate; the final submission of the designers to the owner

public road. - the term ``public road'' means any road or street under the jurisdiction of and maintained by a public authority and open to public travel

punching shear - shear stress in a slab due to the application of a concentrated load

Q

quality assurance (QA) - the use of sampling and other measures to assure the adequacy of quality control procedures in order to verify or measure the quality level of the entire bridge inspection and load rating program

quality control (QC) - procedures that are intended to maintain the quality of a bridge inspection and load rating at or above a specified level

queen-post truss - a parallel chord type of truss having three panels with the top chord occupying only the length of the center panel

R

railing - a fence-like construction built at the outermost edge of the roadway or the sidewalk portion of a bridge to protect pedestrians and vehicles; see HANDRAIL

rake - an angle of inclination of a surface in relation to a vertical plane; also known as batter

ramp - an inclined traffic-way leading from one elevation to another

range of stress - the algebraic difference between the minimum and maximum stresses in a member

raveling - the consistent loss of aggregate from a pavement resulting in a poor riding surface

reaction - the resistance of a support to a load

rebar - see REINFORCING BAR

redundancy - the structural condition where there are more elements of support than are necessary for stability.

redundant member - a member in a bridge which renders it a statically indeterminate structure; the structure would be stable without the redundant member whose primary purpose is to reduce the stresses carried by the determinate structure

rehabilitation - significant repair work to a structure

reinforced concrete - concrete with steel reinforcing bars embedded in it to supply increased tensile strength and durability

reinforced concrete pipe - pipe manufactured of concrete reinforced with steel bars or welded wire fabric

Reinforced Earth - proprietary retaining structure made of earth and steel strips connected to concrete facing; the steel strips are embedded in backfill and interlock with the facing; see MSE

reinforcement - rods or mesh embedded in concrete to strengthen it

reinforcing bar - a steel bar, plain or with a deformed surface, which bonds to the concrete and supplies tensile strength to the concrete

relaxation - a decrease in stress caused by creep

residual stress - a stress that is trapped in a member after it is formed into its final shape

resistivity of soil - an electrical measurement in ohm-cm that estimates the corrosion activity potential of a given soil

resurfacing - a layer of wearing surface material that is put over the approach or deck surface in order to create a more uniform riding surface

Retained Earth - proprietary retaining structure made of weld wire fabric strips connected to concrete facing; see MSE

retaining wall - a structure designed to restrain and hold back a mass of earth

retractile draw bridge - a bridge with a superstructure designed to move horizontally, either longitudinally or diagonally, from "closed" to "open" position, the portion acting in cantilever being counterweighted by that supported on rollers; also known as traverse draw bridge

rib - curved structural member supporting a curved shape or panel

rigger - an individual who erects and maintains scaffolding or other access equipment such as that used for bridge inspection

rigid frame - a structural frame in which bending moment is transferred between horizontal and vertical or inclined members by joints

rigid frame bridge - a bridge with moment resisting joints between the horizontal portion of the superstructure and vertical or inclined legs

rigid frame pier - a pier with two or more columns and a horizontal beam on top constructed monolithically to act like a frame

rip-rap - stones, blocks of concrete or other objects placed upon river and stream beds and banks, lake, tidal or other shores to prevent scour by water flow or wave action

river training structures - devices that alter the flow of the river

rivet - a one-piece metal fastener held in place by forged heads at each end

riveted joint - a joint in which the assembled members are fastened by rivets

roadway - the portion of the road intended for the use of vehicular traffic

roadway shoulder - drivable area immediately adjoining the traveled roadway

rocker bearing - a bridge support that accommodates expansion and contraction of the superstructure through a tilting action

rocker bent - a bent hinged or otherwise articulated at one or both ends to provide the longitudinal movements resulting from temperature changes and superimposed loads

rolled shape - forms of rolled steel having "I", "H", "C", "Z" or other cross sectional shapes

rolled-steel section - any hot-rolled steel section including wide flange shapes, channels, angles, etc.

roller - a steel cylinder intended to provide longitudinal movements by rolling contact

roller bearing - a single roller or a group of rollers so installed as to permit longitudinal movement of a structure

roller nest - a group of steel cylinders used to facilitate the longitudinal movements resulting from temperature changes and superimposed loads

rolling lift bridge - a bridge of bascule type devised to roll backward and forward upon supporting girders when operated through an "open and closed" cycle

routine inspection - regularly scheduled inspection consisting of observations and/or measurements needed to determine the physical and functional condition of the bridge, to identify any changes from initial or previously recorded conditions, and to ensure that the structure continues to satisfy present service requirements.

routine permit load - a live load, which has a gross weight, axle weight or distance between axles not conforming with State statutes for legally configured vehicles, authorized for unlimited trips over an extended period of time to move alongside other heavy vehicles on a regular basis.

rubble - irregularly shaped pieces of stone in the undressed condition obtained from a quarry and varying in size

runoff - the quantity of precipitation that flows from a catchment area past a given point over a certain period

S

sacrificial anode - the anode in a cathodic protection system

sacrificial coating - a coating over the base material to provide protection to the base material; examples include galvanizing on steel and aluclading on aluminum

sacrificial protection - see CATHODIC PROTECTION

sacrificial thickness - additional material thickness provided for extra service life of a member in an aggressive environment

saddle - a member located upon the topmost portion of the tower of a suspension bridge which acts as a bearing surface for the catenary cable passing over it

safe load - the maximum load that a structure can support with an appropriate factor of safety

safety belt - a belt worn in conjunction with a safety line to prevent falling a long distance when working at heights; no longer acceptable as fall protection under OSHA rules

safety curb - a curb between 9 inches and 24 inches wide serving as a limited use refuge or walkway for pedestrians crossing a bridge

safety factor - the difference between the ultimate strength of a member and the maximum load it is expected to carry

safety harness - harness with shoulder, leg, and waist straps of approved OSHA design used as personal fall protection in conjunction with appropriate lanyards and tie off devices

sag - to sink or bend downward due to weight or pressure

scab - a plank bolted over the joint between two timber members to hold them in correct alignment and strengthen the joint; a short piece of Ĩbeam or other structural shape attached to the flange or web of a metal pile to increase its resistance to penetration; also known as scab piece

scaling - the gradual disintegration of a concrete surface due to the failure of the cement paste caused by chemical attack or freeze˜thaw cycles

scour - removal of a streambed or bank area by stream flow; erosion of streambed or bank material due to flowing water; often considered as being localized around piers and abutments of bridges

scour critical bridge - a bridge with a foundation element that has been determined to be unstable for the observed or evaluated scour condition.

scour protection - protection of submerged material by steel sheet piling, rip rap, concrete lining, or combination thereof

scuba - self-contained underwater breathing apparatus; a portable breathing device for free swimming divers

scupper - an opening in the deck of a bridge to provide means for water accumulated upon the roadway surface to drain

seam weld - a weld joining the edges of two members placed in contact; in general, it is not a stress-carrying weld

seat - a base on which an object or member is placed

seat angle - a piece of angle attached to the side of a member to provide support for a connecting member either temporarily during its erection or permanently; also known as a shelf angle

secondary member - a member that does not carry calculated live loads; bracing members

section loss - loss of a member's cross sectional area usually by corrosion or decay

section view - an internal representation of a structure element as if a slice was made through the element

seepage - the slow movement of water through a material

segmental - constructed of individual pieces or segments which are collectively joined to form the whole

segmental arch - a circular arch in which the intrados is less than a semi-circle

segregation - in concrete construction, the separation of large aggregate from the paste during placement

seismic - a term referring to earthquakes (e.g., seismic forces)

semi-stub abutment - cantilever abutment founded part way up the slope, intermediate in size between a full height abutment and a stub abutment

service load design - AASHTO's description for Working Stress Design

settlement - the movement of substructure elements due to changes in the soil properties

shadow vehicle - vehicle used to prevent vehicles from entering the work zone if the motorist drifts into the lane closure

shakes -separations of the wood fibers parallel to the grain between the annual growth rings

shear - the load acting across a beam near its support

shear connectors - devices that extend from the top flange of a beam and are embedded in the above concrete slab, forcing the beam and the concrete to act as a single unit

shear force - equal but opposite forces that tend to slide one section of a member past the adjacent section

shear spiral - a coil-shaped component welded to the top flange of a beam, as a shear connector

shear stress - the shear force per unit of crosssectional area; also referred to as diagonal tensile stress

shear stud - a type of shear connector in the form of a road with a head that is attached to a beam with an automatic stud-welding gun

sheet pile cofferdam - a wall-like barrier composed of driven piling constructed to surround the area to be occupied by a structure and permit dewatering of the enclosure so that the excavation may be performed in the open air

sheet piles - flattened Z-shaped interlocking piles driven into the ground to keep earth or water out of an excavation or to protect an embankment

sheet piling - a general or collective term used to describe a number of sheet piles installed to form a crib, cofferdam, bulkhead, etc.; also known as sheeting

sheet steel - steel in the form of a relatively thin sheet or plate; for flat rolled steel, specific thicknesses vs. widths are classified by AISI as bar, strip, sheet or plate

shelf angle - see SEAT ANGLE

shim - a thin plate inserted between two elements to fix their relative position and to transmit bearing stress

shoe - a steel or iron member, usually a casting or weldment, beneath the superstructure bearing that transmits and distributes loads to the substructure bearing area

shop - a factory or workshop

shop drawings - detailed drawings developed from the more general design drawings used in the manufacture or fabrication of bridge components

shoring - a strut or prop placed against or beneath a structure to restrain movement; temporary soil retaining structure

shoulder abutment - a cantilever abutment extending from the grade line of the road below to that of the road overhead, usually set just off the shoulder; see FULL HEIGHT ABUTMENT

shoulder area - see ROADWAY SHOULDER

shrinkage – a reduction in volume caused by moisture loss in concrete or timber while drying

sidewalk - the portion of the bridge floor area serving pedestrian traffic only

sidewalk bracket - frame attached to and projecting from the outside of a girder to serve as a support for the sidewalk stringers, floor and railing or parapet

sight distance - the length of roadway ahead that is easily visible to the driver; required sight distances are defined by AASHTO's "A Policy on Geometric Design of Highways and Streets"

silt - very finely divided siliceous or other hard rock material removed from its mother rock through erosive action rather than chemical decomposition

simple span - beam or truss with two unrestraining supports near its ends

S-I-P forms - see STAY-IN-PLACE FORMS, FORMS

skew angle - the angle produced when the longitudinal members of a bridge are not perpendicular to the substructure; the skew angle is the acute angle between the alignment of the bridge and a line perpendicular to the centerline of the substructure units

skewback - the inclined support at each end of an arch

skewback shoe - the member transmitting the thrust of an arch to the skewback course or cushion course of an abutment or piers; also known as skewback pedestal

slab - a wide beam, usually of reinforced concrete, which supports load by flexure

slab bridge - a bridge having a superstructure composed of a reinforced concrete slab constructed either as a single unit or as a series of narrow slabs placed parallel with the roadway alignment and spanning the space between the supporting substructure units

slide - movement on a slope because of an increase in load or a removal of support at the toe; also known as landslide

slip form - to form concrete by advancing a mold

slope - the inclination of a surface expressed as a ratio of one unit of rise or fall for so many horizontal units

slope protection - a thin surfacing of stone, concrete or other material deposited upon a sloped surface to prevent its disintegration by rain, wind or other erosive action; also known as slope pavement

slot weld - see PLUG WELD

slump - a measurement taken to determine the stiffness of concrete; the measurement is the loss in height after a cone-shaped mold is lifted

soffit - underside of a bridge deck; also see INTRADOS

soldier beam - a steel pile driven into the earth with its projecting butt end used as a cantilever beam

soldier pile wall - a series of soldier beams supporting horizontal lagging to retain an excavated surface; commonly used in limited right-of-way applications

soil interaction structure - a subsurface structure that incorporates both the strength properties of a flexible structure and the support properties of the soil surrounding the structure

sole plate - a plate attached to the bottom flange of a beam that distributes the reaction of the bearing to the beam

solid sawn beam – a section of tree cut to the desired size at a saw mill

sounding - determining the depth of water by an echo-sounder or lead line; tapping a surface to detect delaminations (concrete) or decay (timber)

spall - depression in concrete caused by a separation of a portion of the surface concrete, revealing a fracture parallel with or slightly inclined to the surface

span - the distance between the supports of a beam; the distance between the faces of the substructure elements; the complete superstructure of a single span bridge or a corresponding integral unit of a multiple span structure; see CLEAR SPAN

spandrel - the space bounded by the arch extrados and the horizontal member above it

spandrel column - a column constructed on the rib of an arch span and serving as a support for the deck construction of an open spandrel arch; see OPEN SPANDREL ARCH

spandrel fill - the fill material placed within the spandrel space of a closed spandrel arch

spandrel tie - a wall or a beam-like member connecting the spandrel walls of an arch and securing them against bulging and other deformation; in stone masonry arches the spandrel tie walls served to some extent as counterforts

spandrel wall - a wall built on the extrados of an arch filling the space below the deck; see TIE WALLS

special inspection - an inspection scheduled at the discretion of the bridge owner, used to monitor a particular known or suspected deficiency

specifications - a detailed description of requirements, materials, tolerances, etc., for construction which are not shown on the drawings; also known as specs

spider - inspection access equipment consisting of a bucket or basket which moves vertically on wire rope, driven by an electric or compressed air motor

spillway - a channel used to carry water away from the top of a slope to an adjoining outlet

splice - a structural joint between members to extend their effective length

splits - advanced checks that extended completely through the piece of wood

spread footing - a foundation, usually a reinforced concrete slab, which distributes load to the earth or rock below the structure

spring line - the horizontal line along the face of an abutment or pier at which the intrados of an arch begins

spurs - a projecting jetty-like construction placed adjacent to an abutment or embankment to prevent scour

stage - inspection access equipment consisting of a flat platform supported by horizontal wire-rope cables; the stage is then slid along the cables to the desired position; a stage is typically 20 inches wide, with a variety of lengths available

staged construction - construction performed in phases, usually to permit the flow of traffic through the site

state transportation department - the term “state transportation department” means that department, commission, board, or official of any State charged by its laws with the responsibility for highway construction

statics - the study of forces and bodies at rest

station - 100 feet (U.S. customary); 100 meters (metric)

stationing - a system of measuring distance along a baseline

stay-in-place forms - a corrugated metal sheet for forming deck concrete that will remain in place after the concrete has set; the forms do not contribute to deck structural capacity after the deck has cured; see FORMS, S.I.P FORMS

stay plate - a tie plate or diagonal brace to prevent movement

steel - an alloy of iron, carbon, and various other elements

stem - the vertical wall portion of an abutment retaining wall, or solid pier; see BREASTWALL

stiffener - a small member attached to another member to transfer stress and to prevent buckling

stiffening girder - a girder incorporated in a suspension bridge to distribute the traffic loads uniformly among the suspenders and reduce local deflections

stiffening truss - a truss incorporated in a suspension bridge to distribute the traffic loads uniformly among the suspenders and reduce local deflections

stirrup - U-shaped bar used as a connection device in timber and metal bridges; U-shaped bar placed in concrete to resist diagonal tension (shear) stresses

stone masonry - the portion of a structure composed of stone, generally placed in courses with mortar

straight abutment - an abutment whose stem and wings are in the same plane or whose stem is included within a length of retaining wall

strain - the change in length of a body produced by the application of external forces, measured in units of length; this is the proportional relation of the amount of change in length divided by the original length

strain hardening - the effect of increased yield strength when a material has been plastically deformed

strand - a number of wires grouped together usually by twisting

streambanks - the sloped sides of the channel

streambed - the bottom of the channel

streamflow - the water, suspended sediment and any debris moving through the channel

strengthening - adding to the capacity of a structural member

stress - the force acting across a unit area in a solid material

stress concentration - local increases in stress caused by a sudden change of cross section in a member

stress corrosion – occurs in metals with high tensile forces such as prestressed reinforcement exposed to contaminants such as chlorides

stress range - the variation in stress at a point with the passage of live load, from initial dead load value to the maximum additional live load value and back

stress raiser - a detail that causes stress concentration

stress reversal - change of stress type from tension (+) to compression (−) or vice versa

stress sheet - a drawing showing all computed stresses resulting from the application of a system of loads together with the design composition of the individual members resulting from the application of assumed unit stresses for the material to be used in the structure

stress-laminated timber – consists of multiple planks mechanically clamped together to perform as one unit

stringer - a longitudinal beam spanning between transverse floorbeams and supporting a bridge deck

strip seal joint - a joint using a relatively thin neoprene seal fitted into the joint opening

structural analysis - engineering computation to determine the carrying capacity of a structure

structural member - an individual piece, such as a beam or strut, which is an integral part of a structure

structural redundancy - the ability of an interior continuous span to resist total collapse by cantilever action in the event of a fracture

structural shapes - the various types of rolled iron and steel having flat, round, angle, channel, "I", "H", "Z" and other cross-sectional shapes adapted to heavy construction

structural stability - the ability of a structure to maintain its normal configuration, not collapse or tip in any way, under existing and expected loads

structural tee - a tee-shaped rolled member formed by cutting a wide flange longitudinally along the centerline of web

structurally deficient – bridges where 1) significant load carrying elements are found to be in poor or worse condition due to deterioration and/or damage or, 2) the adequacy of the waterway opening provided by the bridge is determined to be extremely insufficient to the point of causing intolerable traffic interruptions

structure - something, such as a bridge, that is designed and built to sustain a load

strut - a member acting to resist axial compressive stress; usually a secondary member

stub abutment - an abutment within the topmost portion of an embankment or slope having a relatively small vertical height and usually pile supported; stub abutments may also be founded on spread footings

subbase - a layer of material placed between the base course and the subgrade within a flexible pavement structure

subgrade - natural earth below the roadway pavement structure

sub-panel - a truss panel divided into two parts by an intermediate web member, generally a subdiagonal or a hanger

substructure - the abutments and piers built to support the span of a bridge superstructure

superelevation - the difference in elevation between the inside and outside edges of a roadway in a horizontal curve; required to counteract the effects of centrifugal force

superimposed dead load - dead load that is applied to a compositely designed bridge after the concrete deck has cured; for example, the weight of parapets or railings placed after the concrete deck has cured

superstructure - the entire portion of a bridge structure that primarily receives and supports traffic loads and in turn transfers these loads to the bridge substructure

surface breakdown - see scaling

surface corrosion - rust that has not yet caused measurable section loss

suspended span - a simple span supported from the free ends of cantilevers

suspender - a vertical wire cable, metal rod, or bar connecting the catenary cable of a suspension bridge or an arch rib to the bridge floor system, transferring loads from the deck to the main members

suspension bridge - a bridge in which the floor system is supported by catenary cables that are supported upon towers and are anchored at their extreme ends

suspension cable - a catenary cable which is one of the main members upon which the floor system of a suspension bridge is supported; a cable spanning between towers

swale - a drainage ditch with moderately sloping sides

sway anchorage - a guy, stay cable or chain attached to the floor system of a suspension bridge and anchored upon an abutment or pier to increase the resistance of the suspension span to lateral movement; also known as sway cable

sway bracing - diagonal brace located at the top of a through truss, transverse to the truss and usually in a vertical plane, to resist transverse horizontal forces

sway frame - a complete panel or frame of sway bracing

swedged anchor bolt - anchor bolt with deformations to increase bond in concrete; see ANCHOR BOLT

swing span bridge - a movable bridge in which the span rotates in a horizontal plane on a pivot pier, to permit passage of marine traffic

T

tack welds - small welds used to hold member elements in place during fabrication or erection

tail water - water ponded below the outlet of a waterway, thereby reducing the amount of flow through the waterway; see HEADWATER

tape measure - a long, flexible strip of metal or fabric marked at regular intervals for measuring

team leader - individual in charge of an inspection team responsible for planning, preparing, and performing field inspection of the bridge

tee beam - a rolled steel section shaped like a "T"; reinforced concrete beam shaped like the letter "T"

temperature steel - reinforcement in a concrete member to prevent cracks due to stresses caused by temperature changes

temporary bridge - a structure built for emergency or interim use, intended to be removed in a relatively short time

tendon - a prestressing cable, strand, or bar

tensile force - a force caused by pulling at the ends of a member; see TENSION

tensile strength - the maximum tensile stress at which a material fails

tension - stress that tends to pull apart material

thalweg elevation – lowest elevation of the streambed

thermal movement - contraction and expansion of a structure due to a change in temperature

three-hinged arch - an arch that is hinged at each support and at the crown

through arch - an arch bridge in which the deck passes between the arches

through girder bridge - normally a two-girder bridge where the deck is between the supporting girders

tie - a member carrying tension

tie plate - relatively short, flat member carrying tension forces across a transverse member; for example, the plate connecting a floor beam cantilever to the main floor beam on the opposite side of a longitudinal girder; see STAY PLATE

tie rod - a rod-like member in a frame functioning to transmit tensile stress; also known as tie bar

tie walls - one of the walls built at intervals above an arch ring connecting and supporting the spandrel walls; any wall designed to serve as a restraining member to prevent bulging and distortion of two other walls connected thereby; see DIAPHRAGM WALL

timber - wood suitable for construction purposes

toe - the front portion of a footing from the intersection of the front face of the wall or abutment to the front edge of the footing; the line where the side slope of an embankment meets the existing ground

toe of slope - the location defined by the intersection of the embankment with the surface existing at a lower elevation; also known as toe

toe wall - a relatively low retaining wall placed near the "toe of slope" location of an embankment to protect against scour or to prevent the accumulation of stream debris; also known as footwall

ton - a unit of weight equal to 2,000 pounds

torque - the angular force causing rotation

torque wrench - a hand or power tool used to turn a nut on a bolt that can be adjusted to deliver a predetermined amount of torque

torsion - twisting about the longitudinal axis of a member

torsional force - an external moment that tends to rotate or twist a member about its longitudinal axis

torsional rigidity - a beam's capacity to resist a twisting force along the longitudinal axis

toughness - a measure of the energy required to break a material

tower - a pier or frame supporting the catenary cables of a suspension bridge

traffic control - modification of normal traffic patterns by signs, cones, flagmen, etc.

transducer - a device that converts one form of energy into another form, usually electrical into mechanical or the reverse; the part of ultrasonic testing device which transmits and receives sound waves\

transient loads - temporary loads that change over time

transverse bracing - the bracing assemblage engaging the columns of bents and towers in planes transverse to the bridge alignment that resists the transverse forces tending to produce lateral movement and deformation of the columns

transverse girder - see CROSS GIRDER

travel way - the roadway

tremie - a piece of construction equipment (e.g., pipe or funnel) used to place concrete underwater

trestle - a bridge structure consisting of spans supported on braced towers or frame bents

truck loading - a combination of loads used to simulate a single truck passing over a bridge

truss - a jointed structure made up of individual members primarily carrying axial loads arranged and connected in triangular panels

truss bridge - a bridge having a pair of trusses for a superstructure

trussed beam - a beam stiffened to reduce its deflection by a steel tie-rod that is held at a short distance from the beam by struts

truss panel - see PANEL

tubular sections - structural steel tubes, rectangular, square or circular; also known as hollow sections

tubular truss - a truss whose chords and struts are composed of pipes or cylindrical tubes

tunnel - an underground passage, open to daylight at both ends

turnbuckle - a long, cylindrical, internally threaded nut with opposite hand threads at either end used to connect the elements of adjustable rod and bar members

two-hinged arch - a rigid frame that may be arch-shaped or rectangular with hinges at both supports

U

U-bolt - a bar bent in the shape of the letter "U" and fitted with threads and nuts at its ends

ultimate strength - the highest stress that a material can withstand before breaking

ultrasonic thickness gage - an instrument used to measure the thickness of a steel element using a probe which emits and receives sound waves

ultrasonic testing - nondestructive testing of a material's integrity using sound waves

undermining - the scouring away of stream and supporting foundation material from beneath the substructure footing

underpass - the lowermost feature of a grade separated crossing; see OVERPASS

underwater diver bridge inspection training - training that covers all aspects of underwater bridge inspection and enables inspectors to relate the conditions of underwater bridge elements to established criteria (see the Bridge Inspector's Reference Manual section on underwater inspection for the recommended material to be covered in an underwater diver bridge inspection training course).

underwater inspection - inspection of the underwater portion of a bridge substructure and the surrounding channel, which cannot be inspected visually at low water by wading or probing, generally requiring diving or other appropriate techniques.

uniform load - a load of constant magnitude along the length of a member

unit stress - the force per unit of surface or crosssectional area

uplift - a negative reaction or a force tending to lift a beam, truss, pile, or any other bridge element upwards

upper chord - the top longitudinal member of a truss

V

vertical - describes the axis of a bridge perpendicular to the underpass surface

vertical alignment - a roadway's centerline or baseline alignment in the vertical plane

vertical clearance - the distance between the structure and the underpass

vertical curve - a sag or crest in the profile of a roadway, usually in the form of a parabola, to transition between grades

vertical lift bridge - a bridge in which the span moves up and down while remaining parallel to the roadway

viaduct - a series of spans carried on piers at short intervals

vibration - the act of vibrating concrete to compact it

Vierendeel truss - a truss with only chords and verticals joined with rigid connections designed to transfer moment

voided slab - a precast concrete deck unit cast with cylindrical voids to reduce dead load

voids - an empty or unfilled space in concrete

Voussoir - one of the truncated wedge-shaped stones composing a ring course in a stone arch; also known as ring stone

voussoir arch - an arrangement of wedge shaped blocks set to form an arched bridge

W

wale, waler - horizontal bracing running along the inside walls of a sheeted pit or cofferdam

Warren truss - a triangular truss consisting of sloping members between the top and bottom chords and no verticals; members form the letter W

washer - a small metal ring used beneath the nut or the head of a bolt to distribute the load or reduce galling during tightening

watercement ratio - the weight of water divided by the weight of portland cement in concrete; this ratio is a major factor in the strength of concrete

waterproofing membrane - an impervious layer placed between the wearing surface and the concrete deck, used to protect the deck from water and corrosive chemicals that could damage it

waterway area - the entire area beneath the bridge which is available to pass flood flows

waterway opening - the available width for the passage of water beneath a bridge

wear - gradual removal of surface mortar due to friction

wearing surface - the topmost layer of material applied upon a roadway to receive the traffic loads and to resist the resulting disintegrating action; also known as wearing course

web - the portion of a beam located between and connected to the flanges; the stem of a dumbbell type pier

web crippling - damage caused by high compressive stresses resulting from concentrated loads

web members - the intermediate members of a truss, not including the end posts, usually vertical or inclined

web plate - the plate forming the web element of a plate girder, built-up beam or column

web stiffener - a small member welded to a beam web to prevent buckling of the web

weephole - a hole in a concrete retaining wall to provide drainage of the water in the retained soil

weld - a joint between pieces of metal at faces that have been made plastic and caused to flow together by heat or pressure

weldability - the degree to which steel can be welded without using special techniques, such as pre-heating

welded bridge structure - a structure whose metal elements are connected by welds

welded joint - a joint in which the assembled elements and members are connected by welds

welding - the process of making a welded joint

weld layer - a single thickness of weld metal composed of beads (runs) laid in contact to form a pad weld or a portion of a weld made up of superimposed beads

weld metal - fused filler metal added to the fused structure metal to produce a welded joint or a weld layer

weld penetration - the depth beneath the original surface to which the structure metal has been fused in the making of a fusion weld; see PENETRATION

weld sequence - the order of succession required for making the welds of a built-up piece or the joints of a structure, to minimize distortion and residual stresses

weld toe - particularly in a filet weld, the thin end of the taper furthest from the center of the weld cross section

wheel guard - a raised curb along the outside edge of traffic lanes to safeguard constructions outside the roadway limit from collision with vehicles

wheel load - the load carried by and transmitted to the supporting structure by one wheel of a traffic vehicle, a movable bridge, or other motive equipment or device; see AXLE LOAD

weep hole - a hole in a concrete element (abutment backwall or retaining wall) used to drain water from behind the element; any small hole installed for drainage

Whipple truss - a double-intersecting through Pratt truss where the diagonals extend across two panels

wide flange - a rolled I-shaped member having flange plates of rectangular cross section, differentiated from an S-beam (American Standard) in that the flanges are not tapered

wind bracing - the bracing systems that function to resist the stresses induced by wind forces

wind lock - a lateral restraining device found on steel girder and truss bridges

wingwall - the retaining wall extension of an abutment intended to restrain and hold in place the side slope material of an approach roadway embankment

wire mesh reinforcement - a mesh made of steel wires welded together at their intersections used to reinforce concrete; welded wire fabric

wire rope - steel cable of multiple strands which are composed of steel wires twisted together

working stress - the unit stress in a member under service or design load

working stress design - a method of design using the yield stress of a material and a factor of safety that determine the maximum allowable stresses

wrought iron - cast iron that has been mechanically worked to remove slag and undissolved carbon

wythe - a single layer of brick or stone in the thickness direction

X

X-ray testing - nondestructive testing technique used for detecting internal flaws by passing X-rays through a material to film or other detector

Y

yield - permanent deformation (permanent set) which a metal piece takes when it is stressed beyond the elastic limit

yield point - see YIELD STRESS

yield stress - the stress at which noticeable, suddenly increased deformation occurs under slowly increasing load

yield strength - the stress level at which plastic deformation begins

Z

zee - steel member shaped like a modified "Z" in cross section

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