Table of Contents

Chapter 11
Inspection and Evaluation of Bridge Bearings

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Inspection and Evaluation of Bridge Bearings

Topic 11.1 Bridge Bearings

11.1.1 Introduction

A bridge bearing is a superstructure element that provides an interface between the superstructure and the substructure. The three primary functions of a bridge bearing are:

- To transmit loads from the superstructure to the substructure
- To allow rotation caused by permanent (dead load) and transient (live load) deflection.
- To permit horizontal movement of the superstructure due to thermal expansion and contraction (expansion bearings only)

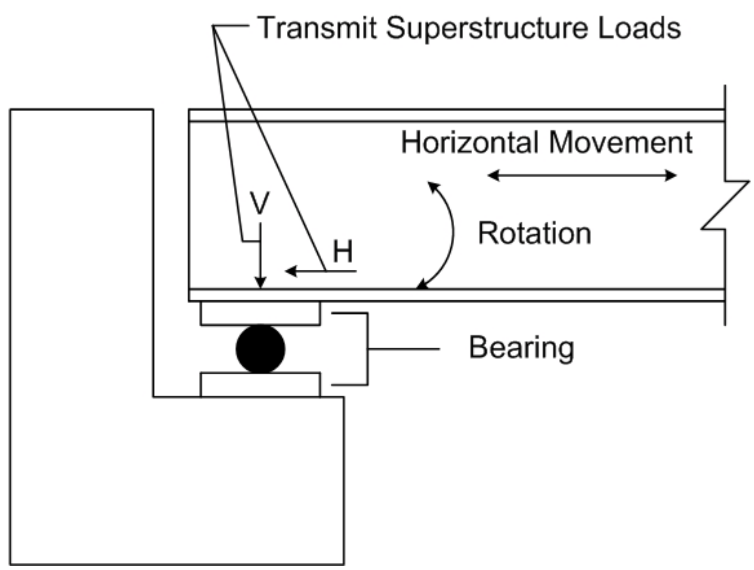

Figure 11.1.1 Three Functions of a Bearing

Fixed and Moveable Bearings

The operation of bridge bearings is critical to the safety and load-carrying capacity of a bridge. When bridge bearings do not operate properly:

- Expansion and contraction movements that are not accommodated by bearings cause internal axial stresses.
- End rotations that are not accommodated by bearings cause internal bending stresses, including high stresses in the substructure.
- Excessive forces may result in damage or instability of the superstructure or substructure.

Bearings that do not allow for horizontal translation or movement of the superstructure are referred to as fixed bearings. Bearings that do allow for horizontal translation or movement of the superstructure are known as moveable bearings. Both fixed and moveable bearings permit rotation that occurs as loads are applied or removed from the bridge (see Figure 11.1.2).

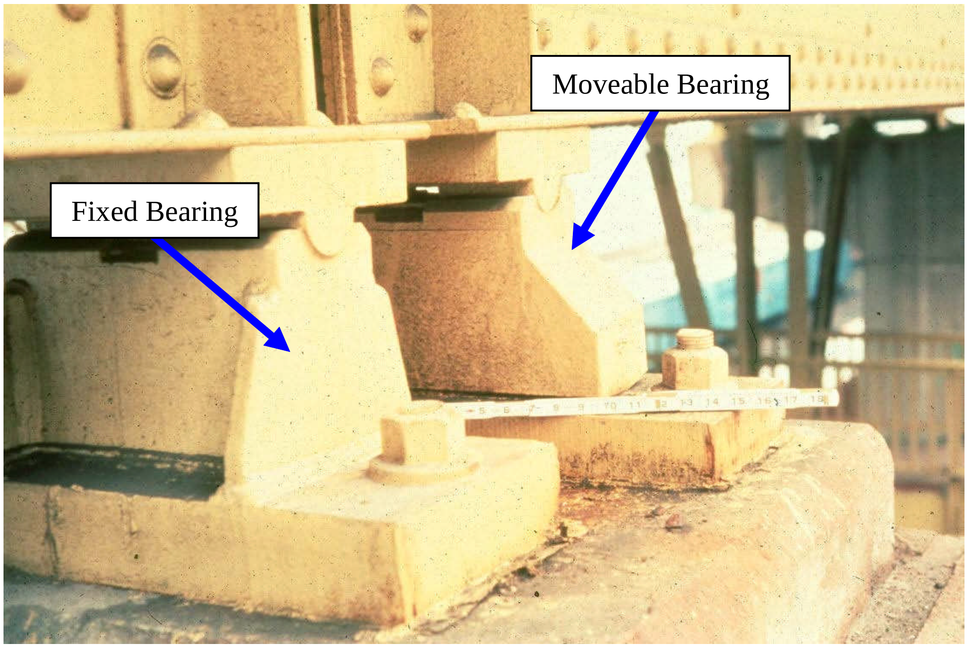

Figure 11.1.2 Fixed and Moveable Bearings

11.1.2 Four Basic Elements of a Bearing

A bridge bearing consists of four basic elements; sole plate, bearing or bearing device, masonry plate and anchor bolts (see Figure 11.1.3).

Sole Plate

The sole plate is responsible for distributing forces from the superstructure to the bearing device. It is a steel plate that is attached to the bottom of girders, beams or truss chords. A sole plate may also be embedded into the bottom flange of a prestressed concrete girder. With concrete beams, girders or slabs, the lower flange or bottom of the section may function as the sole plate.

Bearing or Bearing Device

The bearing or bearing device is secured to the sole plate and masonry plate and provides the function of transmitting the forces from the sole plate to the masonry plate.

Masonry Plate

The masonry plate is a steel plate that is attached to the bearing seat of an abutment or pier. The masonry plate serves to distribute vertical forces from the bearing to the substructure unit.

Anchor Bolts

The anchor bolts connect the bearing to the substructure unit. Anchor bolts are designed to restrain the masonry plate from horizontal translation. The anchor bolts can, however, pass through or alongside the moveable bearing element to provide restraint against transverse movement. The local or governing agency requirements need to be checked to determine the minimum bolt diameter and the minimum embedded length.

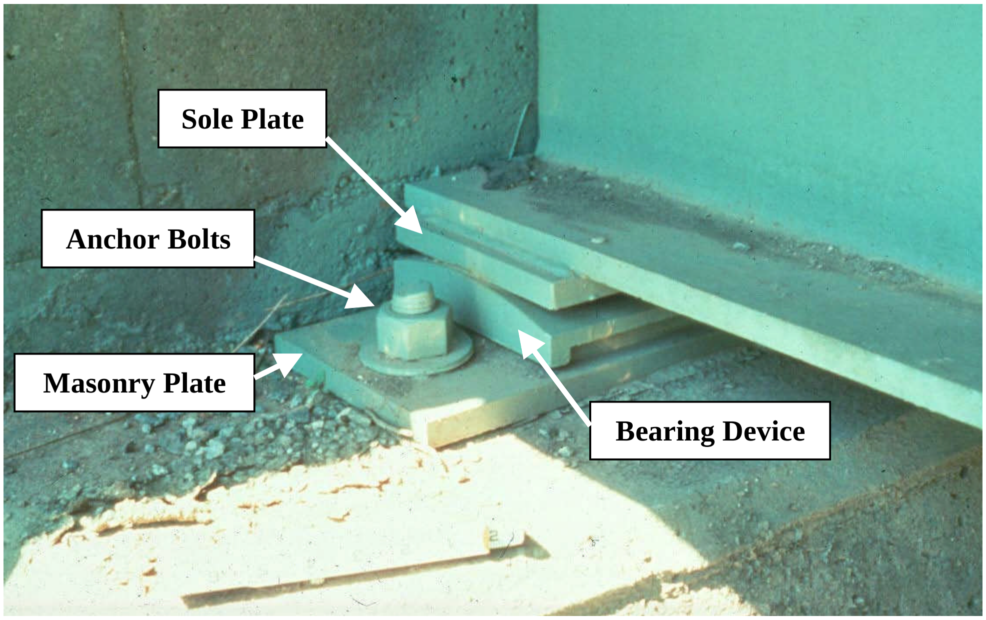

Figure 11.1.3 Elements of a Typical Bridge Bearing

Not every bearing has these specific components. Every bearing does, however, have features that fulfill the function of each of these components.

11.1.3 Bearing Types and Functionality

The American Association of State Highway and Transportation Officials (AASHTO) defines six bearing element types. Each type reflects the overall operation of the bearing.

These six types of bearings are:

- Moveable bearings
- Elastomeric bearings
- Pot bearings
- Disk bearings
- Fixed bearings
- Enclosed or concealed bearings

These bearing types along with "uncommon" bearings are presented in this section.

Moveable Bearings

Various moveable bearing types have evolved out of the need to accommodate superstructure movement, both reliably and efficiently. Seasonal changes impact the maximum and minimum ambient temperatures. Moveable bearings are responsible for allowing movement due to these fluctuations in temperature. Types of moveable bearings include:

- Sliding plate bearings
- Roller bearings
- Rocker bearings

Sliding Plate Bearings

Several types of sliding plate bearings have been used in bridges over the years. They are primarily used on structures with a span length less than 40 feet. Longitudinal movement is provided by one plate sliding upon another. The basic difference between types of sliding plate bearings is the method of lubrication. Among the various types of plates are those presented below.

Lubricated Steel Plates

The first generation of lubricated steel plates consisted of two steel plates with the bearing devices milled smooth (see Figure 11.1.4). Lubrication between the plates consisted of grease, graphite and tallow. Unfortunately, the lubricant typically held dirt, which absorbed moisture and eventually corroded and froze the bearing. “Freezing,” as used to describe bearings, indicates that the bearing movement or rotation is restricted due to corrosion, mechanical binding, dirt buildup, or other interference. The bearing cannot move or rotate as intended.

The next generation of lubricated steel plates consisted of a small plate sliding on a considerably larger one. The theory behind this was that if the contact area were smaller, the forces transmitted overcame the freezing forces. In application, the smaller plate actually wore a groove in the larger one, eventually freezing the bearing anyway.

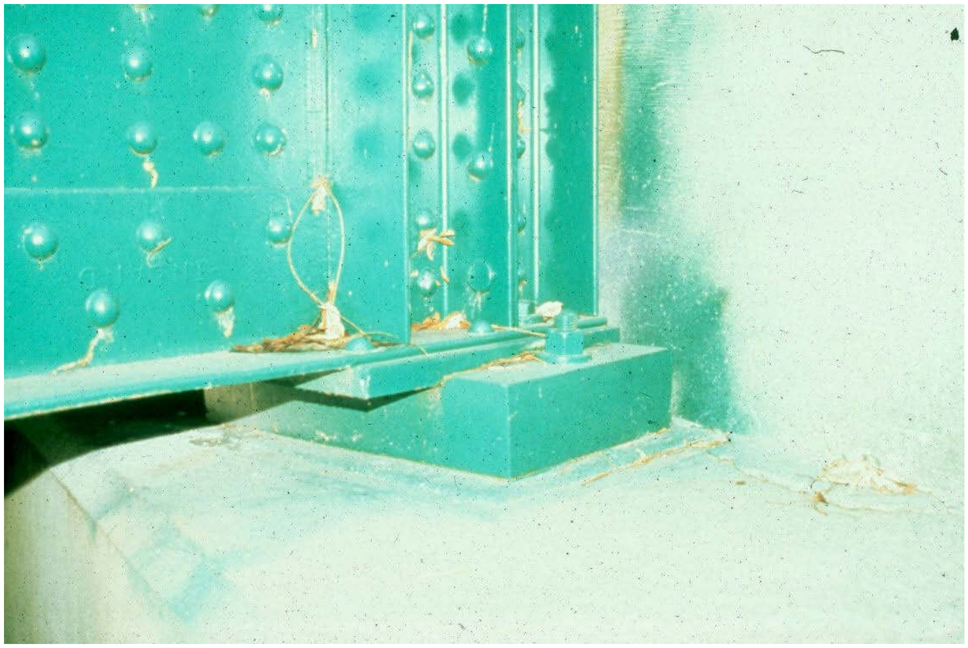

Figure 11.1.4 Lubricated Steel Plate Bearing

Lead Sheets Between Steel Plates

By placing a thin lead sheet between the steel plates, it is possible to keep the plates from freezing together when they corrode. Lead sheets are used to reduce corrosion between the plates, thereby providing more freedom of movement. However, in this type of bearing, the lead has a tendency to work its way out from between the plates.

Bronze Bearing Plates

A bronze bearing plate was introduced to avoid the corrosion problems of steel plates in contact with one another (see Figure 11.1.5). Since bronze does not corrode, it was used to maintain the freedom of movement. Although corrosion is reduced, the bronze, which is soft material, becomes worn due to trapped dirt and the action of expansion and contraction. Eventually, a freezing of the plates may take place.

Figure 11.1.5 Bronze Sliding Plate Bearing

Asbestos Sheet Packing Between Metal Plates

A graphite-impregnated asbestos sheet has been used between steel bearing plates to provide some movement in spans less than 40 feet.

Self-Lubricating Bronze Bearings

The self-lubricating bronze bearing was developed to ensure a graphite lubricant between bearing plates, regardless of their wear. Portions of the face of the bearing were removed and replaced with a graphite compound, which continuously lubricated the bearing surfaces. Some manufacturers claim that these bearings are corrosion resistant and never require any maintenance. The bearings may be maintenance free if they are kept free from dirt and abrasive dust.

These bearings are widely available in many different forms, including plates, plates with one side cut to a radius, and half cylinders. The flat (top) side provides translational movement, while rotational movement is provided by the radius side (bottom) (see Figure 11.1.6).

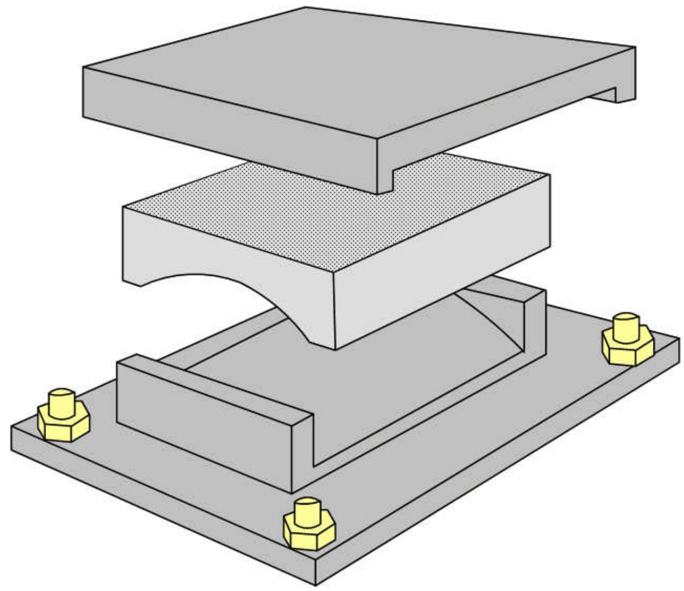

Figure 11.1.6 Self-lubricating Bronze Sliding Plate Bearing

Roofing Felt or Tar Paper

Another type of bearing consists of oil-soaked felt or tar paper that has been lightly coated with graphite. Several layers are placed on the bridge seat with the superstructure placed directly on it. This is a simple but effective bearing that is commonly used on short span concrete slabs and girders that sit on concrete abutments. These bearing types provide limited horizontal movement.

PTFE on Stainless Steel Plates

A compound known as "polytetrafluoroethylene" (PTFE) has the lowest coefficient of friction of any of the commonly available materials, making it quite desirable for use in bridge bearings.

Various types of bearings have been offered to take advantage of PTFE's characteristics. Today, bearings using PTFE have a sheet of stainless steel underneath the sole plate to slide across the PTFE. Pure PTFE has a low compressive strength and a high coefficient of thermal expansion. To make it suitable for use in bridge bearings, PTFE is combined with suitable fillers. These fillers are typically glass fiber and bronze. While giving strength to the PTFE, these fillers do not increase its low coefficient of friction.

Roller Bearings

A roller bearing consists of a cylinder that "rolls" between the sole plate and masonry plate as the superstructure expands and contracts (see Figure 11.1.7). Roller bearings are used in a wide variety of forms including single rollers and roller nests.

Single Roller Bearings

The single roller is one of the most widely used moveable bearings. Rollers can vary in size, with specified diameters ranging from 6 to 15 inches. While the larger rollers are less susceptible to corrosion problems, dirt may get trapped in the contact areas along the top and bottom of the bearing. This enables moisture absorption, eventually deteriorating the bearing surface. However, because only a small portion of the roller actually becomes corroded, the corroded roller can be rotated and another portion of the roller surface can be used. Many single roller bearings are made of corrosion resistant steel.

An unrestrained roller may gradually work itself out from underneath the bridge superstructure. For this reason, pintle pins are used to keep the roller in place. These pins fit tightly into the roller but loosely into the upper and lower plates. The loose fit allows for the necessary structure movement.

Figure 11.1.7 Single Roller Bearing

Roller Nest Bearings

First used in steel bridges in the early 1900's, roller nests consist of a group of rollers, each about 1.5 to 2 inches in diameter. When clean, roller nests work well. However, the small rollers offer many places for dirt and moisture to collect. This results in wear and corrosion of the rollers, and ultimately results in bearing failure. Attempts to seal this bearing require careful maintenance of protective covers and skirts, which are typically unsuccessful (see Figure 11.1.8).

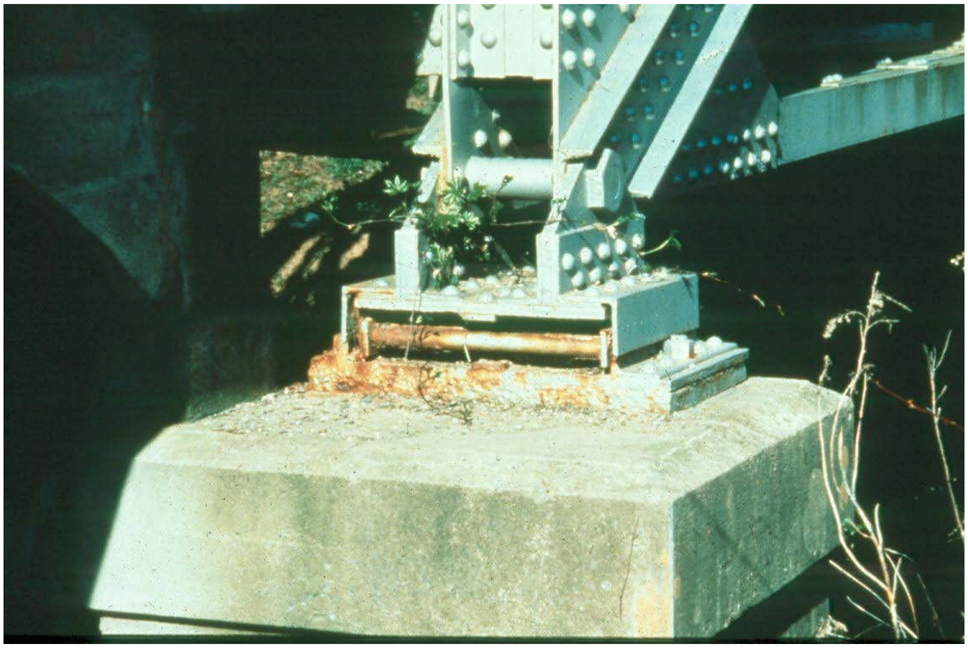

Figure 11.1.8 Roller Nest Bearing

Rocker Bearings

The rocker bearing functions in a similar manner to the roller bearing and is generally used where a substantial amount of longitudinal movement is required (see Figure 11.1.9). As with roller bearings, rocker bearings come in different forms, such as segmental rockers, rocker nests, and pinned rockers.

Figure 11.1.9 Rocker Bearing

Segmental Rocker Bearings

Segmental rocker bearings evolved out of the use of large rollers. When the rollers get up to 20 inches in diameter, they become very heavy and difficult to handle. Since only a small portion of the roller bearing is actually in contact between the sole plate and masonry plate, the unused portion may be cut away and a substantial weight savings obtained (see Figure 11.1.10).

Larger segmental rockers have also been fabricated from rectangular blocks, rounded at both ends, which allow the bearing to roll and the horizontal movement to take place.

Figure 11.1.10 Segmental Rocker Bearing

Rocker Nest Bearings

A group of several rockers forms a rocker nest bearing (see Figure 11.1.11). Similar to roller nests, rocker nests provide many small areas for dirt and moisture to collect. Moisture can lead to corrosion which may result in a bearing failure.

Figure 11.1.11 Segmental Rocker Nest Bearing

Pinned Rocker Bearings

The pinned rocker is the most popular rocker bearing in use today. The top is basically a large pin and helps to keep the bearing aligned correctly. Longitudinal movement is provided by the rotation allowed by the pin and the rolling provided by the rocker (see Figure 11.1.12). When exposed to adverse environmental conditions, however, the pin can corrode and freeze. Pinned rocker bearings can be quite large and are commonly used for relatively long spans and heavy loads. Holes in the radius portion of the bearing may be slotted to accommodate longitudinal movement.

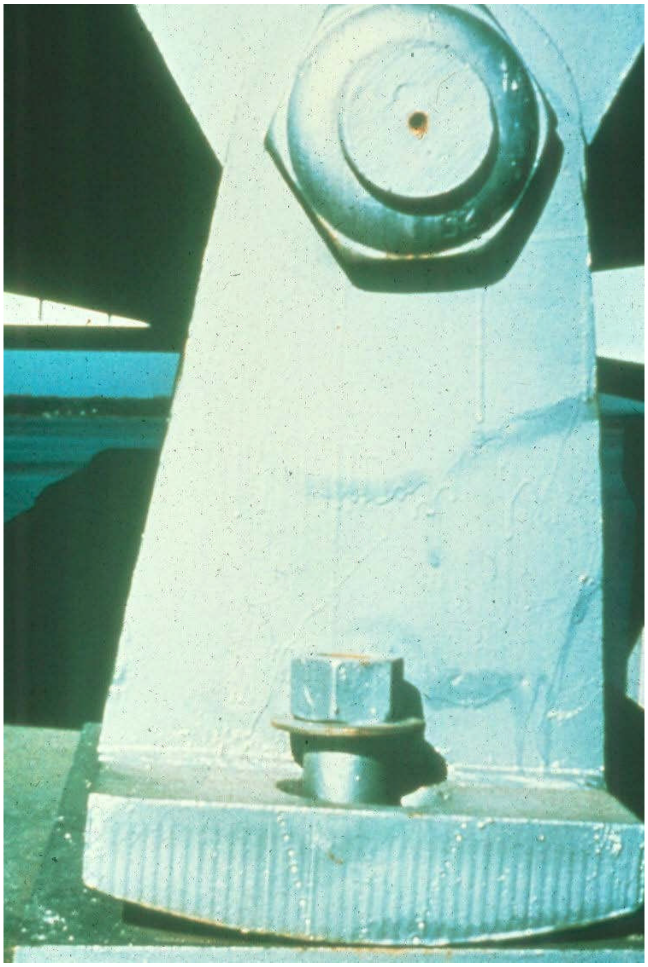

Figure 11.1.12 Pinned Rocker Bearing

Elastomeric Bearings

Elastomeric bearings include both plain and laminated neoprene pads. Neoprene is a heavy rubber-like material that deforms slightly under compression or shear.

Plain Neoprene Pads

A plain neoprene bearing consists of a rectangular or circular pad of pure neoprene and is used primarily on short span, prestressed concrete structures (see Figure 11.1.13). Neoprene bearings are popular for steel beam bridges as well. Expansion and contraction are achieved through a shearing deformation of the neoprene. These bearings are typically of uniform thickness.

Various means are used to prevent the neoprene bearing from "walking" out of position from under a beam. An epoxy compound has been used to bond the pad to the beam and the bridge seat, but it has not always been successful.

Figure 11.1.13 Plain Neoprene Bearing Pad

Laminated Neoprene Pads

A laminated neoprene bearing is simply a stack of neoprene pads with steel or fiberglass plates separating them (see Figure 11.1.14). The plates are not visible if the entire bearing is encased in neoprene. Laminated bearing pads are used on longer structures where the expansion and contraction requirements and the vertical superstructure loads are greater.

Although a single, thicker pad could conceivably do the job of the laminated bearing, excess bulging and wearing of the pad dramatically decreases its useful life. The laminated bearing eliminates this excess bulging and allows expansion and contraction without excessive wear.

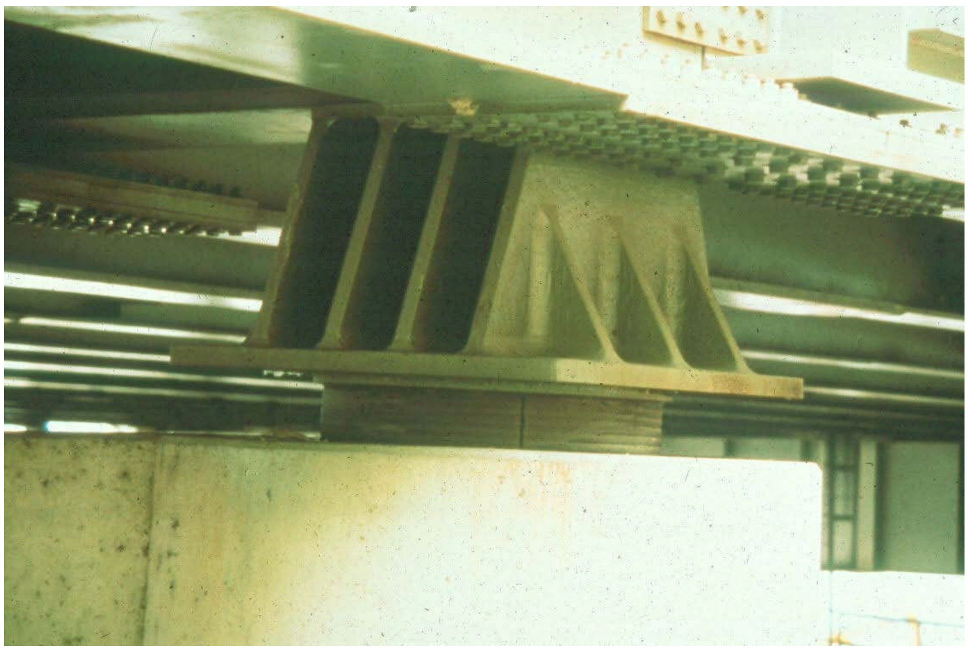

Figure 11.1.14 Laminated Neoprene Bearing Pad

Pot Bearings

Pot bearings allow for the multi-dimensional rotations of a structure.

Neoprene Pot Bearings

A neoprene pot bearing has a stainless steel plate that is attached to the sole plate. This stainless steel plate slides on a polytetrafluoroethylene (PTFE) disk. The PTFE disk is attached to a steel piston, which rests on a neoprene pad, allowing for the rotation of the structure. The pad rests in a shallow steel cylinder that is attached to the masonry plate. This cylinder is referred to as the pot. Guide bars in the pot bearing restrict transverse movement (see Figure 11.1.15).

A fixed bearing version of this configuration does not possess the stainless steel plate or the PTFE disk.

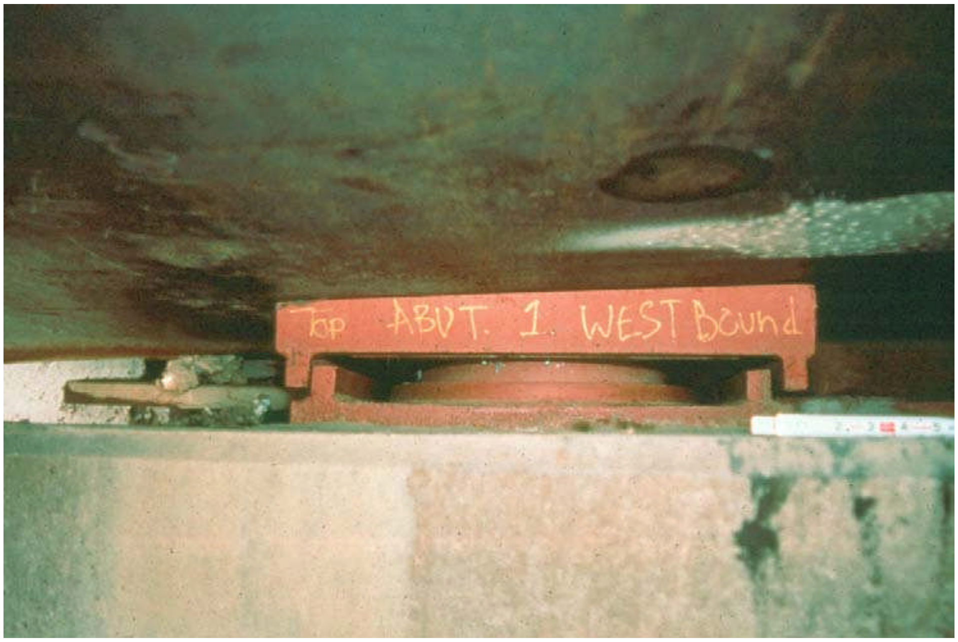

Figure 11.1.15 Neoprene Pot Bearing with Guide Bars

Disk Bearings

Disk bearings typically have a very low profile. As with pot bearings, disk bearings provide a high-capacity solution for bridges. The difference between a pot bearing and a disk bearing is the bearing device. Disk bearings accommodate rotations through the deformation of a hard plastic disk that is typically unconfined (see Figure 11.1.16).

Disk bearings may be configured to restrict translational movement or provide movement in one or more directions through a PTFE surface, stainless steel plates and guide bars (if applicable).

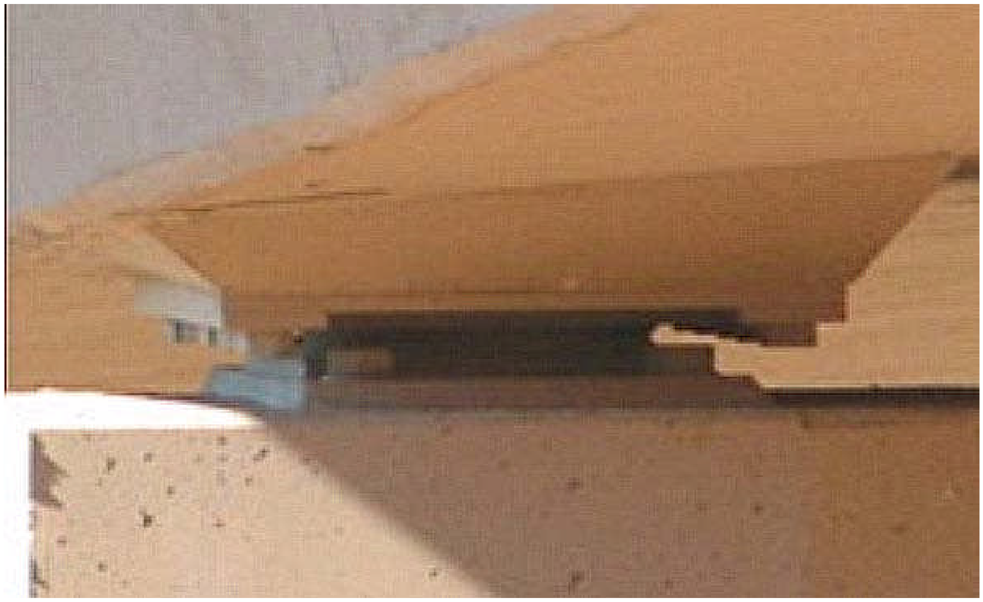

Figure 11.1.16 Disk Bearing

Fixed Bearings

Fixed bearings are classified as only allowing rotational movement. They rely on the rotation around the pins to accommodate end rotation. Fixed bearings also prevent translational (or horizontal) movement.

Figure 11.1.17 shows a fixed bearing. As with the moveable bearing, the vertical superstructure loads are transmitted down to the fixed bearing and then passed down to the substructure. In addition to transmitting vertical loads, a fixed bearing also transmits horizontal loads from the superstructure to the substructure. The fixed bearing also accommodates any rotation resulting from the transient (live load) deflection, but does not provide for any longitudinal movement.

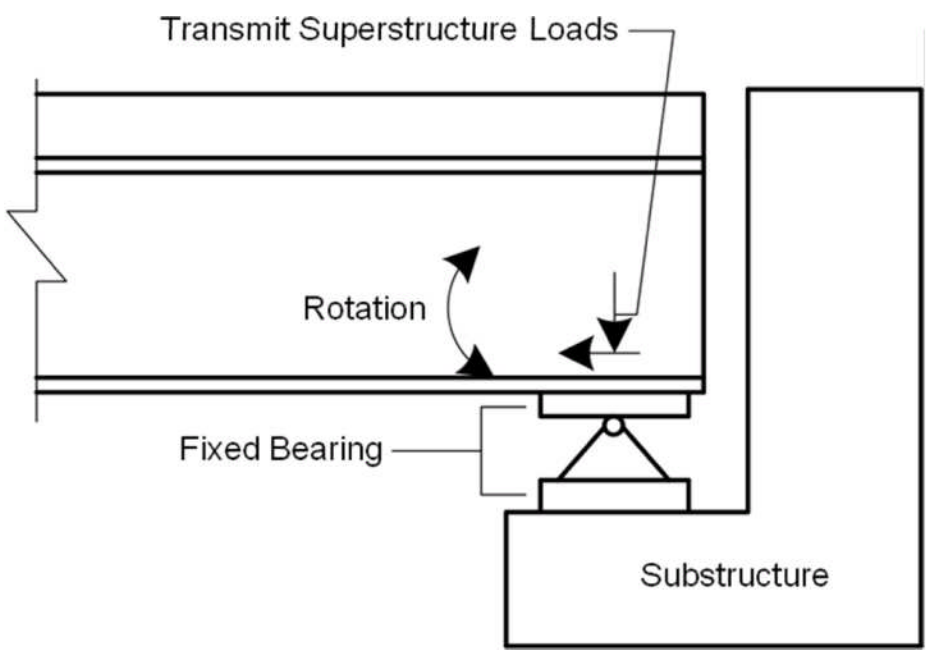

Figure 11.1.17 Fixed Bearing

Enclosed or Concealed Bearings

For some bearings, the line-of-sight between the inspector and the bearing may be compromised. These bearings are said to be enclosed or concealed bearings and cannot be adequately evaluated through a visual inspection (see Figure 11.1.18).

Examples of bearings that may be considered enclosed or concealed include bridges with integral end diaphragms.

It is important to note the difference between a bridge with concealed bearings and a bridge with integral abutments, which has no bearings.

Figure 11.1.18 Enclosed or Concealed Bearing

Uncommon Bearings

Uncommon bearings are not a specific bearing element type defined by AASHTO. Instead, uncommon bearings represent specific types of bearings that are still in service, but are no longer utilized in modern bridge construction.

The AASHTO-defined bearing element types can still be used to inventory these uncommon bearings for element level inspection (moveable, expansion, pot, disk, or fixed bearings, or enclosed/concealed if they cannot be visually inspected), which have been included in parenthesis after the bearing name.

Pin and Link Bearings (Moveable or Enclosed/Concealed Bearings)

The pin and link bearing is typically used on continuous cantilever structures to support the ends of a suspended span. It can also be used as a type of restraining device, which is discussed later in this topic. This bearing type consists of two vertically oriented steel plates pinned at the top and bottom to allow longitudinal movement (see Figure 11.1.19). A disadvantage of this type of bearing is that, as the superstructure expands and contracts, the deck rises and falls (but only slightly). Another disadvantage is that pins can fracture when frozen by corrosion.

Figure 11.1.19 Pin and Link Bearing

Restraining Bearings (Moveable, Pot, Disk, Fixed or Enclosed/Concealed Bearings)

Restraining bearings serve to hold a bridge down in the case of uplift. Uplift usually occurs on cantilever anchor spans. The devices used to resist uplift can be as simple as long bolts running through the bearings on short span bridges or as complex as chains of eyebars on larger structures (see Figure 11.1.20). Lock nuts are used with bolted restraining devices to resist uplift. Pin and link members are also used as restraining devices. The type of restraining device used depends on the magnitude of the uplift force.

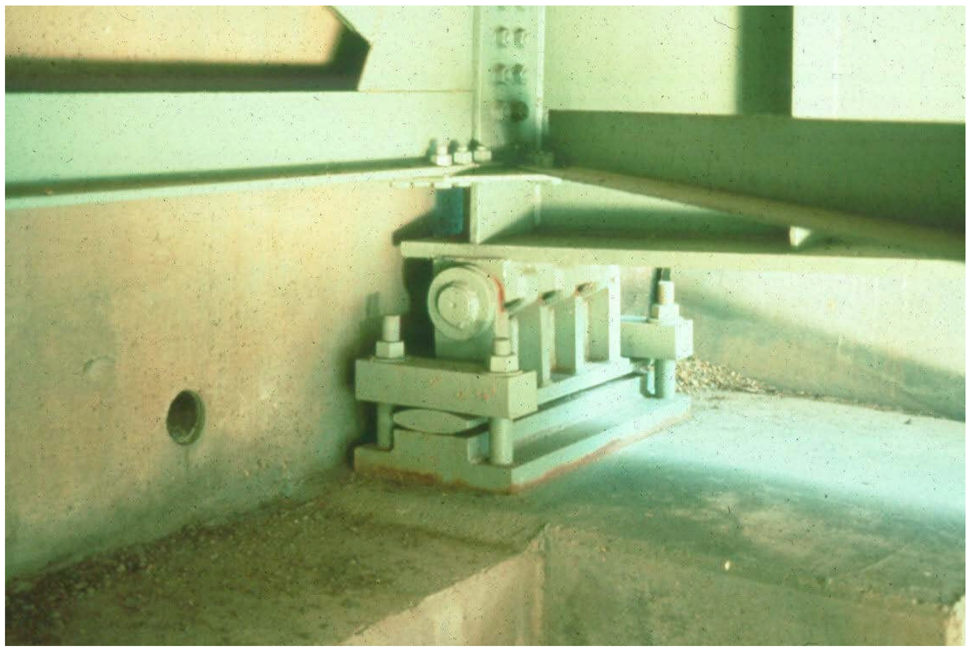

Figure 11.1.20 Restraining Bearing

Isolation Bearings (Moveable, Elastomeric or Pot Bearings)

Isolation bearings were developed to protect structures against extreme horizontal loadings due to earthquakes. Isolation bearings may also be used to accommodate horizontal movements due to large truck loadings. These bearings operate by allowing larger than normal relative movement, which reduces lateral loads applied to the structure.

Types of isolation bearings include lead-core isolation, friction pendulum and high-damping rubber.

Lead Core Bearings (Elastomeric Bearings)

Lead core bearings are a type of isolation bearing. These bearings are similar to laminated neoprene bearings in that they are a sandwich of neoprene and steel plates (see Figures 11.1.21 and 11.1.22). These bearings contain a lead core that stiffens the bearing to help resist the effects of high horizontal bridge loading. During seismic loads, the lead core is designed to yield, thereby making the bearing more flexible and allowing it to isolate the bridge from the effects of earthquake motion. The downside to lead core bearings is the possibility of requiring replacement after a seismic event, since the lead core may have yielded. However, the cost to replace these bearings is favorable considering the damage an earthquake may cause to the bridge structure.

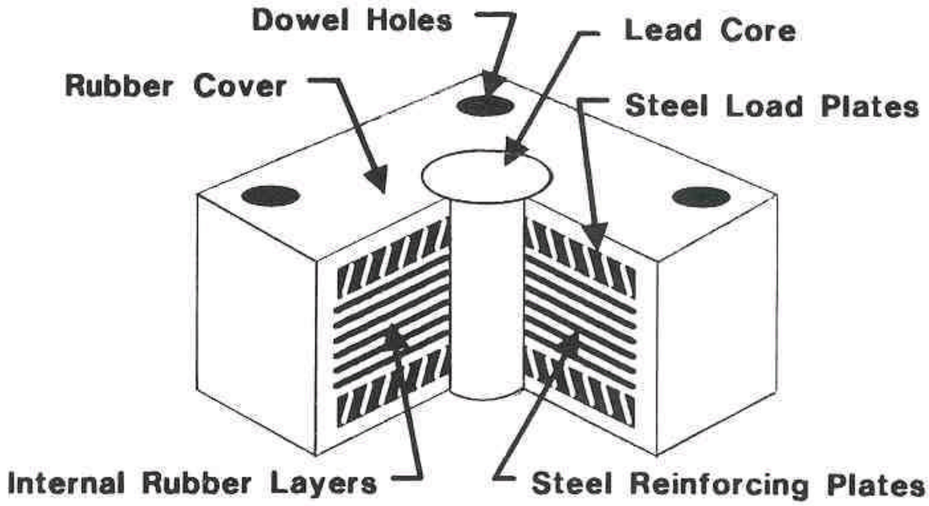

Figure 11.1.21 Sketch of a Lead Core Isolation Bearing

Figure 11.1.22 Lead Core Isolation Bearing

Friction Pendulum Bearings (Moveable or Pot Bearings)

Another bearing type designed to protect against earthquake damage is a friction pendulum bearing. These bearings are designed to reduce lateral loads and shaking movements transmitted to the structure (see Figure 11.1.23). They can protect structures and their contents during strong, high magnitude earthquakes and can operate near fault pulses and deep soil sites.

Friction pendulum bearings incorporate the characteristics of a pendulum to lengthen the natural period of the isolated structure so as to avoid the strongest earthquake forces (see Figure 11.1.24). The period of the bearing is selected by choosing the radius of curvature of the concave surface. It is independent of the loads of the superstructure. Torsion motions of the substructure are minimized because the center of stiffness of the bearings automatically coincides with the center of mass of the superstructure.

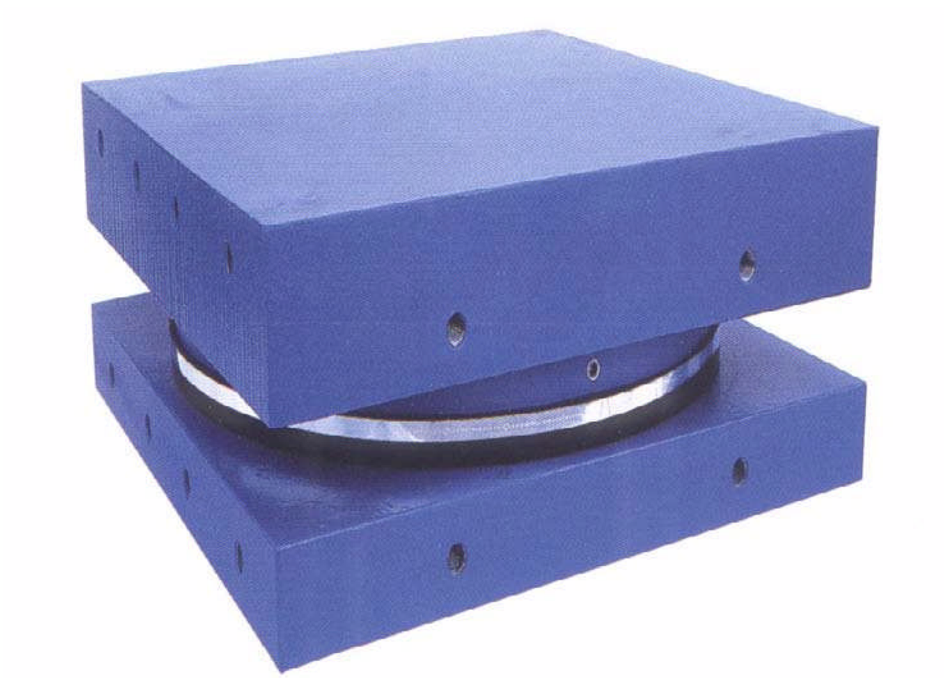

Figure 11.1.23 Friction Pendulum Bearing

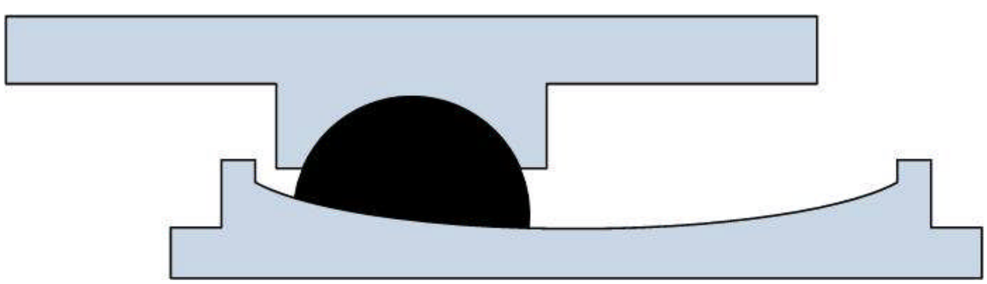

Figure 11.1.24 Sketch of a Friction Pendulum Bearing

High-Damping Rubber Bearings (Elastomeric Bearings)

High-damping rubber bearings were also developed to protect structures from the damage of earthquakes. Under service load conditions, the bearing provides support in a similar fashion to elastomeric bearings. Its rigidity is provided by a high rubber modulus at small shear strains. During an earthquake, a special hysteretic rubber compound in the bearing dissipates the energy of the earthquake. As a result, the structure is isolated from the shaking forces of the earthquake and is less likely to collapse.

Spherical Pot Bearings (Pot Bearings)

Spherical bearings allow for multi-directional rotation. They are similar to neoprene pot bearings, except that the polytetraflouroethylene (or PTFE) disk is bonded to a spherical aluminum casting that rotates within a PTFE-coated pot. The pot is attached to the masonry plate.

Anchorage bolt holes are incorporated on the sliding plate. Directly beneath the sliding plate, a PTFE disk is bonded to a spherical aluminum casting (that serves as the bearing device). This disk allows for multi-directional translation between the sliding plate and bearing device. Rotational movement is then provided by the curved surface of the bearing device and PTFE-coated pot. The pot may be cylindrical (as shown in Figure 11.1.25) or rectangular in shape. Beneath the pot is the masonry plate, which allows for the bearing to be anchored to the substructure unit.

Spherical pot bearings may also incorporate exterior guide bars. These guide bars function similar to those found on pot bearings and disk bearings, limiting or preventing horizontal translation.

A fixed bearing version of this configuration has the upper aluminum casting attached to the sole plate and incorporates edge-guide bars. Fixed spherical bearings also do not utilize stainless steel plates on a PTFE disk.

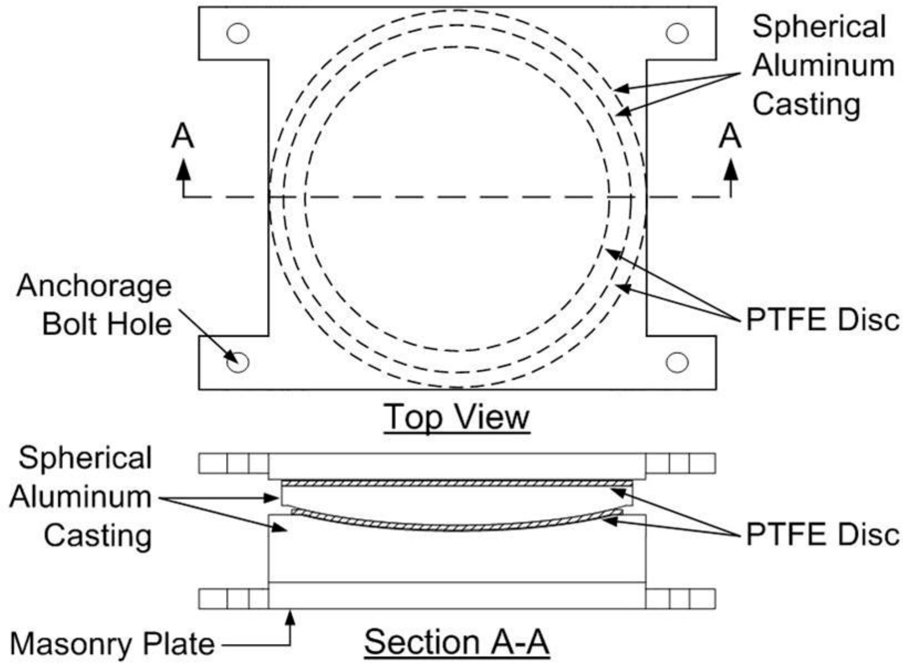

Figure 11.1.25 Spherical Pot Bearing

11.1.4 Inspection Methods and Locations

The inspection of bearings is broken down into three different categories:

- General
- Steel bearings
- Elastomeric bearings

For each of these different categories, the inspection of bearings may utilize one or more of the three inspection methods: visual, physical and advanced.

Most deficiencies are first detected by visual inspection. This inspection method is a hands-on inspection or inspection where the inspector is close enough to touch the area being inspected. More exact visual observations can also be employed using a magnifying unit after cleaning the suspect area.

Physical inspection methods may also be employed into the categories of inspection. These methods include the use of a wire brush, grinder or sand blaster. Degreasing spray may also be used to help remove paint and reveal the deficiency. Measurement of the deficiencies to check to irregular dimensions or section loss is also a physical inspection method.

Several advanced inspection methods are available for steel bearings. Applicable advanced methods for steel bearings are listed below within the Steel Bearings subtopic.

General

When inspecting a bearing, the inspector first determines if the bearing was initially intended to be fixed or moveable. If the bearing was designed to allow for translation or movement of the superstructure, then it is a moveable bearing; if not, then it is a fixed bearing. The inspector refers to the design plans if available. It is critical that the inspector assess whether moveable bearings still allow for translation or horizontal movement.

Check that bearings are properly aligned horizontally and vertically, with the bearing surfaces clean and in full contact with each other. If only partial contact is made, damage can occur to the bearing device, superstructure, or substructure. This damage can occur when a girder has moved horizontally so that the bearing rests on only a portion of the masonry plate. In this situation, the full load of the superstructure is applied to a smaller area on the masonry plate and results in a higher stress that could crush the bridge seat. Also, such redistribution of the load may cause buckling to occur in the girder web of the superstructure above the bearing. Distress in the form of cracking or spalling under the bearings may be an indication that the bearings are not handling the anticipated horizontal movement of the superstructure.

Bearings need to have a suitable support. A distance of several inches needs to exist between the edge of the masonry plate and the edge of the supporting member, abutment, or pier. Note any loss to the supporting member near the bearing (e.g., spalling of a concrete bridge seat) (see Figure 11.1.26).

Bearings and the concrete substructure lateral shear keys on skewed bridges are inspected for binding and damage due to the creep effect of the bridge (i.e., the tendency of the bridge to move laterally along the skew).

Record the temperature during the inspection. Special thermometers with magnets are available to measure the actual temperature of the superstructure and bearing. Measure the movement of the bearings and compare it to the recorded temperature. The bearings need to be in the expanded position for temperatures greater than the design (or average) temperature and in the contracted position for temperatures less than the design (or average) temperature. The design temperature is 68 degrees Fahrenheit unless otherwise noted.

Small maintenance problems with bearings can grow progressively worse if ignored, eventually causing major problems for the bridge. Inoperable bearings can transfer significant overstress to the superstructure or substructure.

Figure 11.1.26 Spalling of Concrete Bridge Seat Due to High Edge Stress

Inspection of Steel Bearings

Various metallic materials have been used in bearings, including steel, bronze, aluminum, lead, and cast iron. However, steel is by far the most prominent and also the most susceptible to deterioration, while most other materials are either non-corrosive or corrosion-resistant. Consequently, the following discussions concentrate the inspection of steel bearings.

Most defects in steel bearings are first detected by a visual assessment. In order for this to occur, a hands-on inspection, or inspection where the inspector is close enough to touch the area being evaluated, is required. Use a wire brush, grinder or hammer to remove any loose or flaked steel. Use appropriate personal protective equipment when disturbing potentially hazardous coatings and materials.

Several advanced methods may be required to evaluate the steel bearing.

Nondestructive methods for steel bearings, described in Topic 15.3.2, include:

- Acoustic emissions testing
- Dye penetrant
- Magnetic particle
- Radiography testing
- Ultrasonic testing (see Figure 11.1.27)
- Eddy current

Figure 11.1.27 Ultrasonic Testing Inspection of a Pin in a Bearing

Corrosive Forces

Check all bearing elements for any pitting, section loss, deterioration and debris build-up, which can cause the bearing to bind up or freeze (see Figure 11.1.28). Evidence of a frozen bearing includes bending, buckling, improper alignment of members, or cracks in the bearing seat. Check for bent, broken or missing anchor bolts.

Figure 11.1.28 Heavy Corrosion on a Steel Rocker Bearing

Looseness

Loose bearings can be identified by noise at the bearing or observing bearing movement when loaded. Loosening may be caused by any of the following (see Figures 11.1.29 through 11.1.31):

- Settlement or movement of the bearing support away from the portion of the bridge being supported
- Excessive rust or corrosion, which results in a loss of material in the bearing itself
- Excessive deflection or vibration in the bridge
- Loose, missing or broken fasteners that are used to attach the bearing to either the superstructure or the substructure
- Worn bearing elements
- Uplift in curved bridge superstructures
- Pavement pressure, which drives the backwall into the beams

Specific inspection items for the various types of steel bearings are detailed following this paragraph.

Figure 11.1.29 Rocker Bearing with Excessive Horizontal Movement

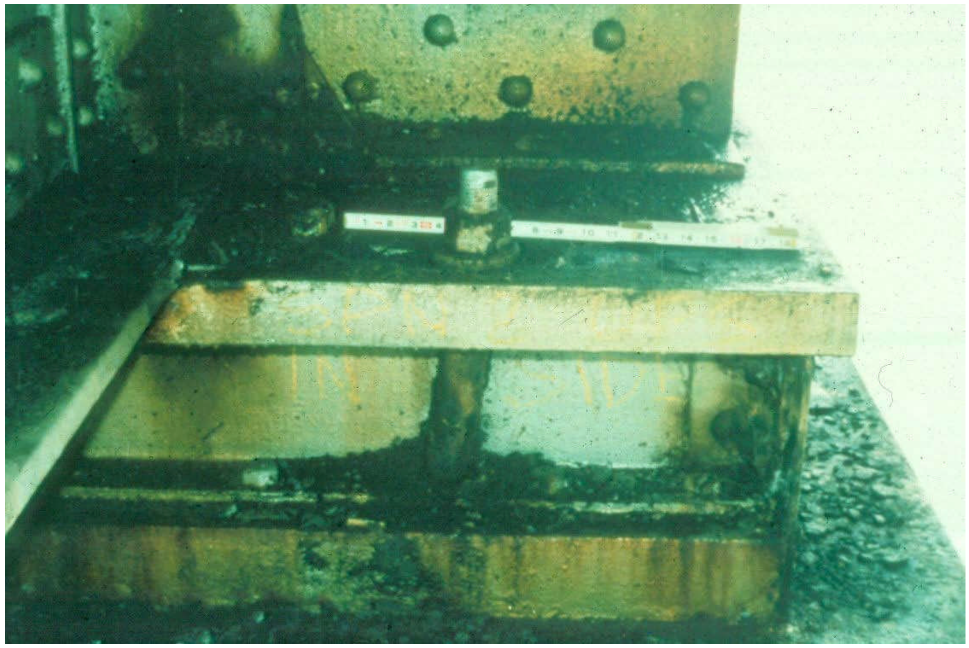

Figure 11.1.30 Bent Anchor Bolt due to Excessive Horizontal Movement

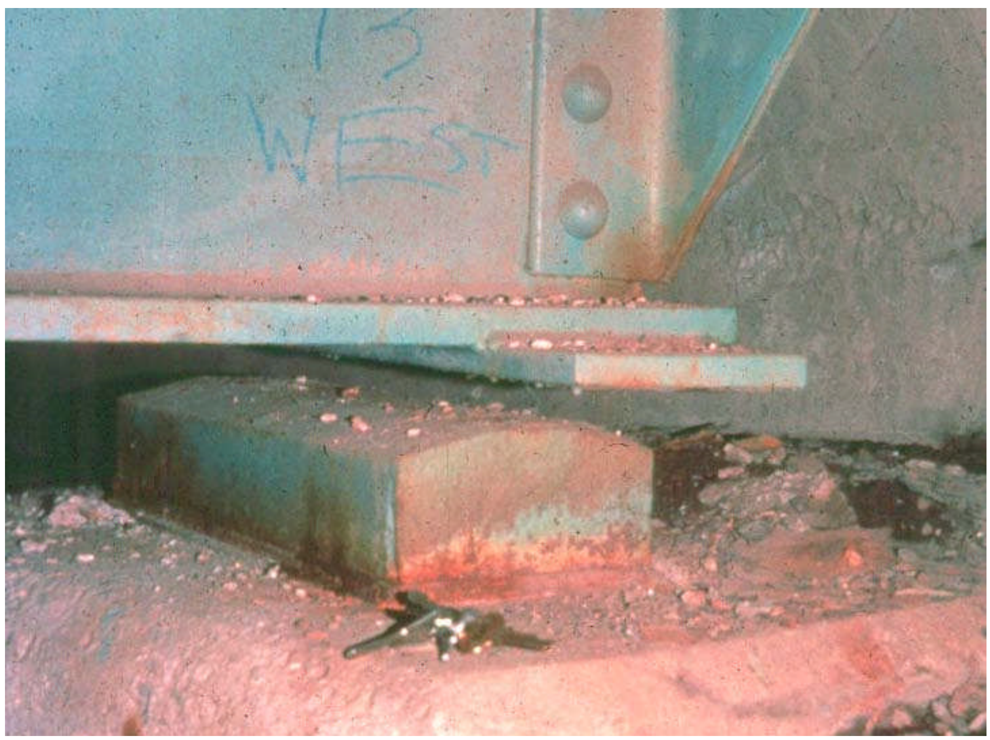

Figure 11.1.31 Uplift at Bridge Bearing

Sliding Plate Bearings

When a bridge is constructed, the upper and lower plates of the sliding plate bearing are placed such that they are centered with respect to each other at a certain temperature, usually 68 degrees Fahrenheit. Any movement of the bearing can be measured based on this initial alignment.

For plates of equal size, the amount of expansion or longitudinal movement that has occurred is the distance from the front or back of the top plate to the front or back of the bottom plate or, alternatively, the distance between the centers of the top and bottom plates (see Figure 11.1.32). For plates of unequal size, the amount of expansion is one half of the difference between the front and back distances between the top and bottom plates. Alternatively, and perhaps easier to measure, the expansion is the distance between the centers of the top and bottom plates. These dimensions need to be measured to the nearest one-eighth inch, in additional to the bridge element temperature at the time of inspection.

Bearings employing bronze sliding plates with steel masonry plates on bridges exposed to a salt air environment need to be examined for signs of electrolytic corrosion between the bronze and steel plates. Galvanic corrosion can also occur between aluminum and steel plates.

See Figure 11.1.33 for a checklist of sliding plate bearing inspection items.

Figure 11.1.32 Longitudinal Misalignment in Bronze Sliding Plate Bearing

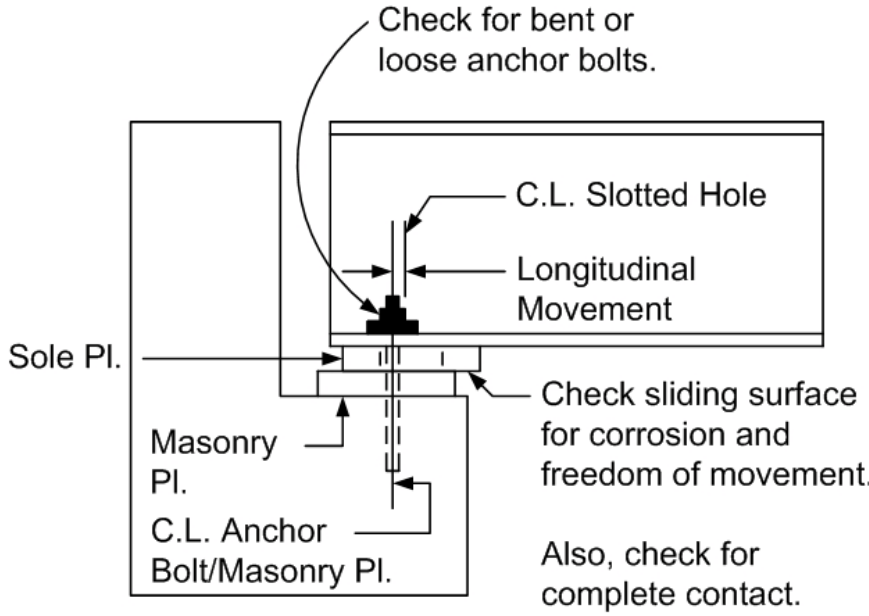

Figure 11.1.33 Sliding Plate Bearing Inspection Checklist Items

Roller Bearings

Roller bearings are similar to sliding plate bearings in that the roller unit needs to be centered on the masonry plate at its design erection temperature. Therefore, the expansion (or contraction) is one half of the difference between the front of plate-to-roller distance and the back of plate-to-roller distance. Alternatively, and perhaps easier to measure, the expansion (or contraction) is also the distance between the center of the roller (where it contacts the masonry plate) and the center of the masonry plate. Again, the temperature at the time of inspection needs to be recorded.

Rollers and masonry plates need to be clean and free of corrosion in order to remain operable. They need to be inspected for signs of wear.

The position of the roller also needs to be examined to see if the pintles are exposed or missing. Such conditions may indicate excessive superstructure expansion or contraction movement or undesirable substructure movement. See Figure 11.1.34 for an example of a damaged roller nest bearing.

Figure 11.1.34 Damaged Roller Nest Bearing

Rocker Bearings

See Figure 11.1.35 for a checklist of rocker bearing inspection items.

Some rocker bearings have markings on the rocker and masonry plates. With no expansion or contraction, these marks need to line up perfectly vertically. The amount of longitudinal movement can be determined by measuring the distance along the masonry plate between the two marks.

If the bearing has no markings, the expansion can be determined by measuring the distance between the current point of contact between the rocker and the masonry plate and the original point of contact, which is assumed to be the midpoint along the rocker's curved surface (see Figure 11.1.36).

Measurements need to be to the nearest one eighth inch, and the inspection temperature needs to be recorded.

Rockers need to be inspected for proper tilt. In warmer temperatures (above 68ºF), the rockers need to be tilted towards the backwall in the expanded direction; in colder temperatures, the rockers need to be tilted backward in the contracted position away from the backwall (see Figure 11.1.35). Also check for the condition of the pintles if they are visible.

Rocker bearings and pins (if present) need to be examined for corrosion, wear and freedom of movement (see Figure 11.1.37).

Check the condition of the anchor bolts and nuts for corrosion and freedom of movement on expansion bearings.

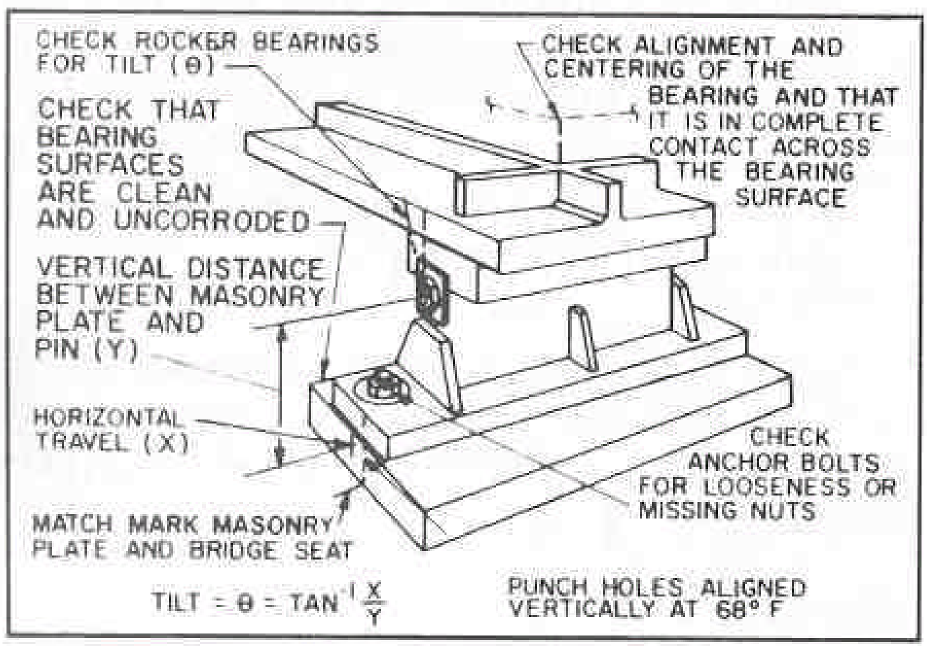

Figure 11.1.35 Rocker Bearing Inspection Checklist Items

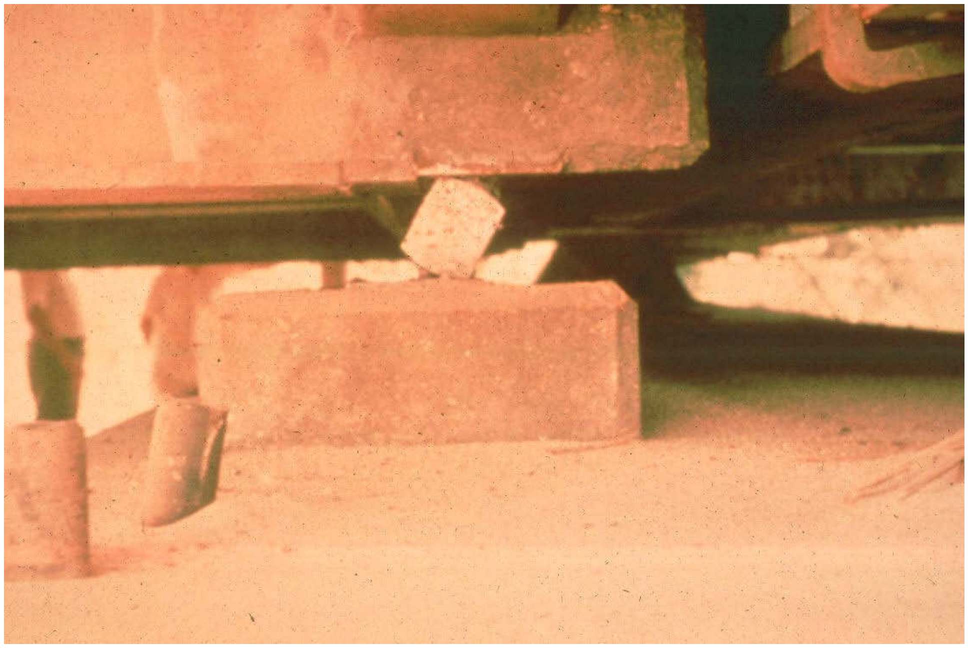

Figure 11.1.36 Excessive Tilt in a Segmental Rocker

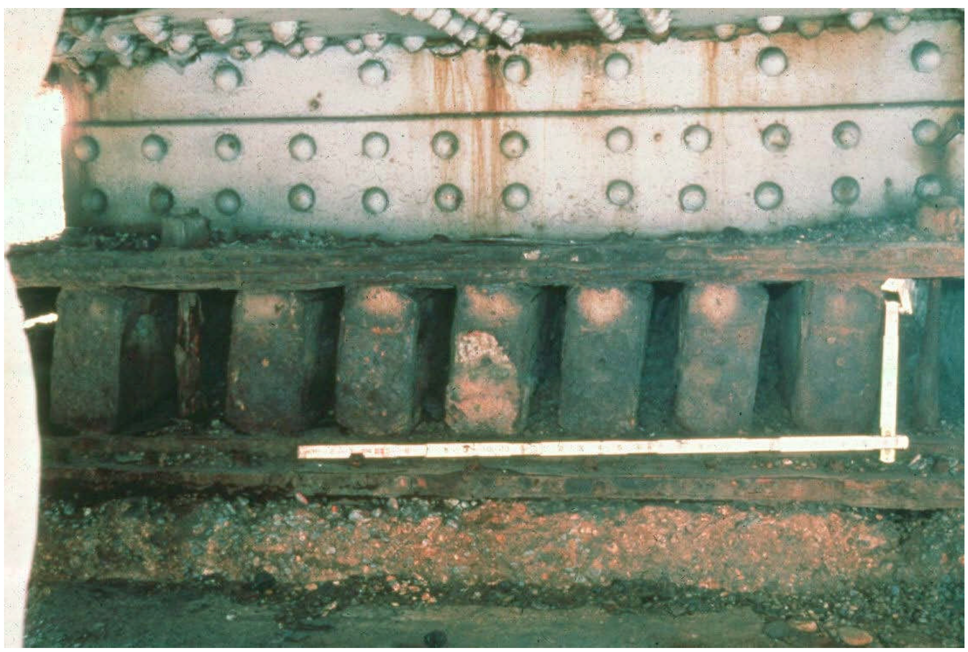

Figure 11.1.37 Frozen Rocker Nest

Pot Bearings

Pot bearing longitudinal movement can be measured in the same way as for a sliding plate bearing. The movement is one half of the difference between the front and back distances of the top and bottom plates. If the pot bearing allows movement in two directions, the inspector needs to investigate transverse movement as well. The inspection temperature at which measurements are taken also needs to be recorded.

Although not normally required, pot bearing rotation also needs to be measured if it appears to be excessive. The top and bottom plates of a pot bearing are usually designed to be parallel if no rotation has taken place. Rotation can therefore be determined by measuring the length of the bottom plate and the distance between the two plates at the front and back of the bearing. The angle of rotation, measured from the horizontal, can be calculated using the following equation and Figure 11.1.38:

$$\text{Rotation (Degrees)} = \tan^{-1} [(\text{Height}_1 - \text{Height}_2)/\text{Plate Length}]$$

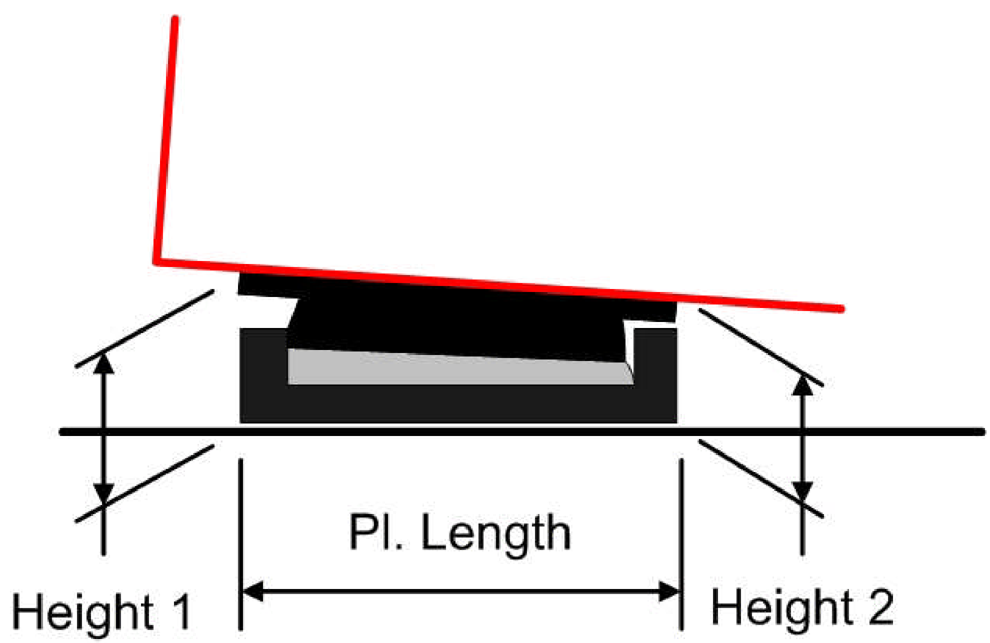

Figure 11.1.38 Frozen Rocker Nest

Since the pot bearing allows multidirectional rotation, the inspector needs to check rotation along both sides of the bearing.

Examine pot bearings for proper seating of the various elements with respect to one another. That is, check to see that the neoprene pad is properly seated within the pot and that the top plate is located properly over the elements below. Determine if the neoprene element is being extruded from the pot. Inspect guide bars for wear, binding, cracking and deterioration.

Investigate welds for cracks, and examine for any separation between the PTFE and the steel surface to which it is bonded. Although they are usually hidden from view, check any exposed portions of the neoprene elements for splitting or tearing. Look for any buildup of dirt and debris in and around the bearing that could affect the smooth operation of the bearing.

Pin and Link Bearings (Uncommon Bearing)

Inspection of pin and link bearings are essentially the same as that described for pins and hangers in Topic 10.9. The amount of corrosion and ability of the connection to move freely is of critical concern, especially for suspended span bridges.

The amount of corrosion on the pin and the interior portion of the link adjacent to it are impossible to detect visually. Ultrasonic testing or disassembly of the connection is required to determine the actual extent of deterioration. For a discussion of ultrasonic testing, refer to Topic 15.3. Since disassembly is impractical during normal periodic bridge inspections, the inspector needs to closely examine exposed portions of the pin and link for signs of corrosion, wear, stress, cracks, bending, and misalignment. If warranted, the inspector needs to recommend further action (i.e., special testing or disassembly of the pin and link).

Also examine the hanger/link for proper amount of tilt using a plumb line or level, record the opening between the ends of the girders, and record the inspection temperature.

Restraining Bearings (Uncommon Bearing)

Inspection of restraining bearings is very similar to that for pin and link bearings in that the condition of the main tension elements (i.e., hanger plates, eyebars, and anchor rods or bolts) and pins is the main concern. Where these elements encompass a normal bridge bearing, the inspection of the bearing assembly itself follows the methods normally used for that particular type of bearing.

The elements that make up the restraining portion of the bearing need to be investigated for deterioration, misalignment, or other defects that could affect the normal operation of the bearing. Anchor bolts may need nondestructive testing to determine their condition.

Inspection of Elastomeric Bearings

Inspection of elastomeric bearings is somewhat simpler than the steel bearings since there are usually fewer elements to inspect. However, certain defects in elastomeric bearings are rather difficult to detect. Elements that are common to both steel bearings and elastomeric bearings are sole plates, masonry plates, and anchor bolts. Only the elastomeric elements or elements specific to elastomeric bearings are discussed here. See Figure 11.1.39 for a checklist of elastomeric bearing inspection items.

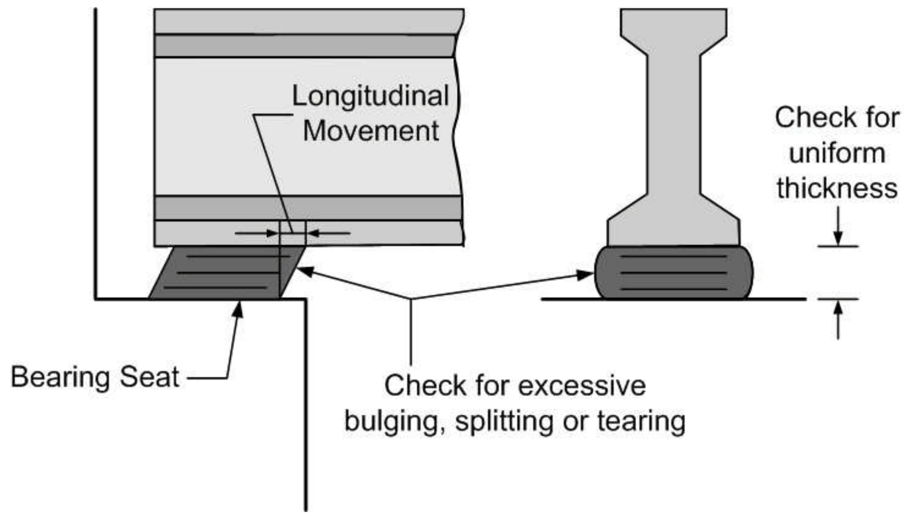

Figure 11.1.39 Elastomeric Bearing Inspection Checklist Items

Neoprene Bearings

Neoprene bearing pads need to be inspected for excessive bulging (approximately greater than 15 percent of thickness) (see Figure 11.1.40). This indicates that the bearing might be too tall for the application and therefore improperly designed. Slight bulging in the sides of the pad can be expected. Whether or not it is excessive may be difficult to determine, but if it appears excessive for the height or thickness of the pad, then it needs to be noted. As expansion and contraction of the structure takes place, the bulge tends to roll on the beam or bridge seat.

The bearing pad needs to be inspected for any splitting or tearing. Close attention needs to be paid to laminated neoprene bearings. Improper manufacturing can sometimes cause a failure in the area where the neoprene and interior steel shims are bonded together.

The pad also needs to be inspected for variable thickness other than that attributable to normal rotation of the bearing.

A plain (unlaminated) pad needs to be examined for any apparent growth in the length of the pad at the masonry plate. This growth indicates excessive strain in the pad. This is not a normal condition and usually indicates a problem with the design or manufacturing of the bearing. If this condition persists, the pad eventually experiences a shearing failure. Pad growth is not usually a problem with laminated bearings.

Close attention needs to be given to the area where the pad is bonded to the sole and masonry plates. This is where a neoprene bearing frequently fails. Therefore, some agencies prohibit bonding of the bearing. Sometimes the pad tends to "walk" out from under the beam or girder. Some agencies prohibit painting of the contact surface between the neoprene and the sole plate for this reason.

The longitudinal movement of a neoprene bearing pad is measured in nearly the same manner as for a sliding plate bearing. The longitudinal movement is the horizontal offset (in the longitudinal direction) between the top edge of the pad and the bottom edge of the pad. Record the temperature at the time of inspection.

The rotation on a neoprene bearing is measured the same way as for a pot bearing. The top and bottom of the pad are normally parallel if no rotation has taken place. The inspector needs to measure the length of the pad and the height of the pad at the front and rear of the bearing. The equation presented in the pot bearing section can then be used to calculate the rotation. If a beveled pad is used to accommodate a bridge on grade, then the original dimensions of the pad needs to be known in order to determine the bearing rotation.

Figure 11.1.40 Neoprene Bearing Pad Excessive Bulging

Isolation Bearings (Uncommon Bearing)

The inspection items for isolation bearings (lead core and high-damping rubber) are essentially the same as those for plain or laminated neoprene bearings. The only elements unique to isolation bearings (lead core) are the lead core and steel dowels, both of which are hidden from view and cannot be inspected (see Figure 11.1.41). The lead core may yield during an earthquake. After a seismic event, the bearing shape and horizontal alignment in both the longitudinal and transverse direction needs to be closely inspected. It may be necessary to replace lead core bearings after an earthquake.

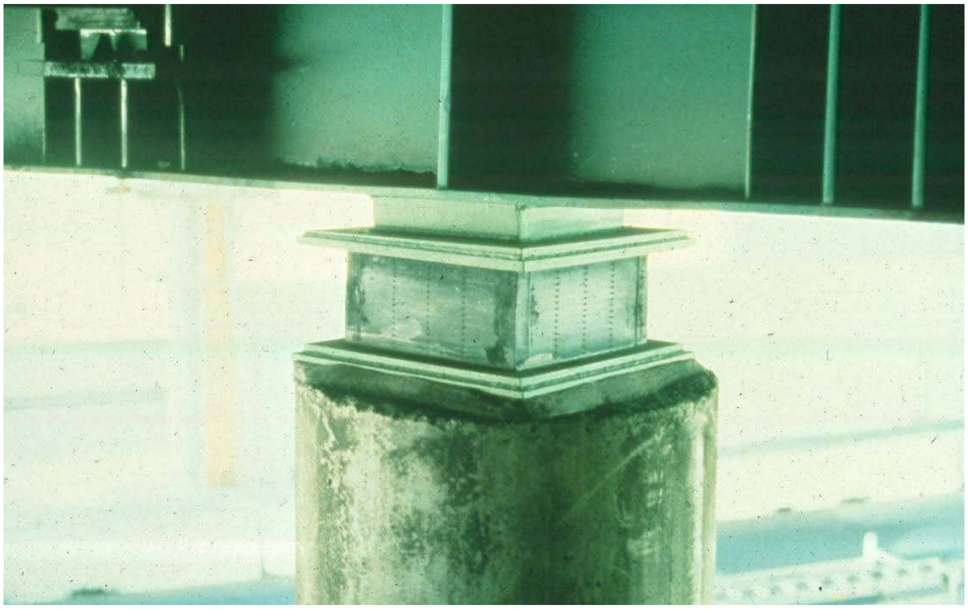

Figure 11.1.41 Lead Core Isolation Bearing

11.1.5 Evaluation

State and Federal rating guideline systems have been developed to aid in the inspection of bearings. 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 NBI component condition rating guidelines, bearings can impact the superstructure component condition rating shown on the Federal Structure Inventory and Appraisal (SI&A) in extreme situations. There is no item for bearings under superstructure in the SI&A.

The bearing type and the condition of the bearing are noted on the inspection form, but no rating is given. Some bridge owners do ask inspectors to provide a condition rating for bearings.

Element Level Condition State Assessment

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

NBE No.	**Description**
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	
515	Steel Protective Coating

The unit quantity for the bearing elements is each. Each bearing element is 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 for bearings. See the *AASHTO Guide Manual for Bridge Element Inspection* for condition state descriptions.

Note that "uncommon bearings" are classified according to one of the six AASHTO bearing designations.

The following Defect Flags are applicable in the evaluation of bearings:

Smart Flag No.	**Description**
356	Steel Cracking/Fatigue
357	Pack Rust
363	Steel Section Loss

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

Serious Bearing Conditions

The superstructure condition rating is affected when serious bearing conditions exist that may cause local failures for the supported primary load-carrying members.

If such a serious condition exists with the bearings, then the bearings have an impact on the superstructure condition rating (see Figures 11.1.42 and 11.1.43). Otherwise, the bearings have no effect in the superstructure rating, though the bearing condition and deficiencies are still noted by the inspector.

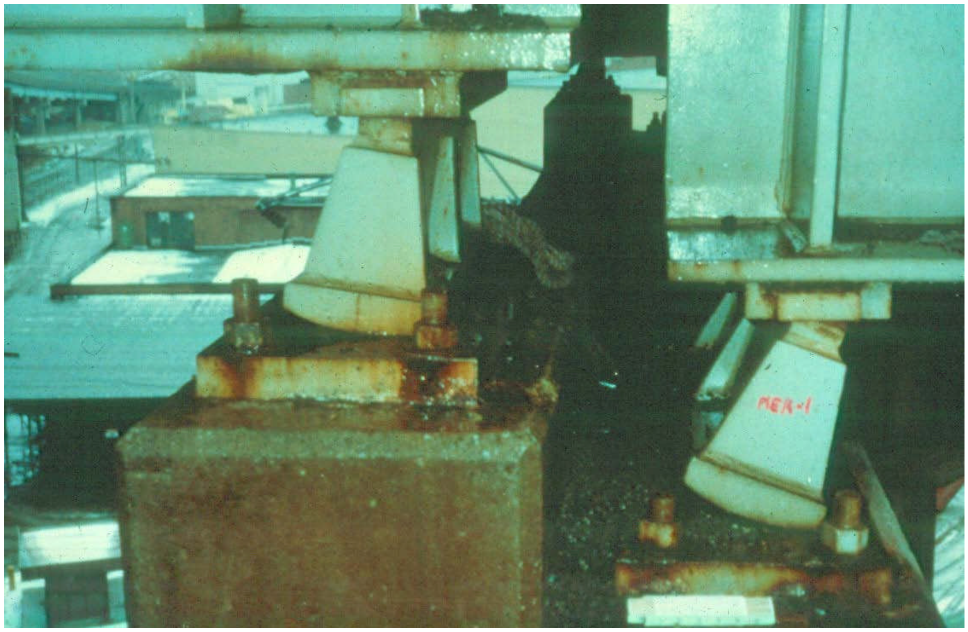

Figure 11.1.42 Serious Bearing Condition

Figure 11.1.43 Broken Pintle on a Bearing

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