

SECTION 9
BEARINGS

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SECTION 9 **BEARINGS**

9.1 GENERAL (REV. 12/19)

Bearings are structural devices that transmit loads from the superstructure to the substructure. Bearings may also be required to allow for horizontal movement due to temperature and time dependent causes, allow rotation due to loads on the superstructure, and transmit seismic forces from the superstructure to the substructure. The selection and layout of bearings shall be consistent with the proper functioning of the bridge.

Bearings may be fixed or movable as required for the bridge design. Movable bearings may include guides to control the direction of translation. Fixed and guided bearings shall be designed to resist all loads and restrain unwanted translation. Keeper blocks may also be used to restrain some of these loads. When anchor bolts are required at bearings, stainless steel bolts shall not be used.

Combinations of bearing types should not be used at the same line of bearing. Differing deflection and rotational characteristics may result in damage to the bearings or structure.

Several bearing types are recommended below for different situations. Other bearing devices may be used, provided that they have been approved by the **CTDOT**.

9.1.1 Skew Effects

Provisions shall be made in the bearing design for both lateral and longitudinal movement based on the geometry of the deck, the layout of the deck expansion joints and keeper assemblies. For bridges with complicated deck configurations, a thermal expansion analysis of the deck should be done in order to determine the thermal movements relative to the bridge bearings. The geometry of the deck, not the structural framing, should be the basis for the expansion analysis. For narrow bridges where the effects are minimal, transverse expansion may be neglected.

9.1.2 Curvature Effects

For curved superstructures, provisions shall be made in the alignment of bearing guides and keeper blocks for both lateral and longitudinal movement based on the geometry of the deck and the layout of the deck expansion joints. Generally, the direction of movement of the superstructure may be assumed to be parallel to the chord of the deck centerline taken from the joint to the neutral point of the superstructure. The neutral point is defined as the point where no thermal movement occurs.

9.1.3 Temperature Range

The temperature range used for the calculation of thermal movement at bearings shall be 120°F. This temperature range is based on a mean low temperature of -10°F and a mean high temperature of +110°F. The median temperature for design of bearings shall be +50°F.

9.1.4 Coefficient of Thermal Expansion

For the design of bearings, a coefficient of thermal expansion (α) shall be taken as 6.4×10^{-6} inches per °F. This equates to approximately 2.75-inch total movement for a 300 foot long bridge.

9.1.5 Seismic

If the bridge is designed for seismic events, the bearings may be designed to transmit seismic forces from the superstructure to the substructure. The movement due to seismic forces shall be accommodated in the design of the bearings. It is important that the bearing remain stable under the maximum anticipated bridge displacement during the seismic event. For requirements for the design of seismic isolation bearings, see **BDM** [3].

Rocker type bearings should not be used due to the high susceptibility of overturning during seismic events.

9.1.6 Single Span Bridges

The design of single span bridges may be based on providing elastomeric expansion bearings at both ends of the superstructure if the grade of the roadway is less than 5%. The designer should incorporate keeper assemblies in order to maintain alignment of the superstructure. Designs of this nature will reduce the amount of expansion at the bearings and deck joints. For simple span bridges, with a fixed and an expansion bearing, the fixed bearing should be located at the low end of the structure.

9.1.7 Multi-Span Bridges

The design and layout of bearings in multi-span bridges should be based on the design of the deck expansion joints, the capacity of the bearings to accommodate the anticipated loads and movement, and the seismic design of the substructure where applicable.

9.2 BEARING SPECIFIC DESIGN REQUIREMENTS

9.2.1 Steel Reinforced Elastomeric Bearings (Rev. 12/19)

Steel reinforced elastomeric bearings shall be the first bearing of choice for any bridge bearing due to the low initial cost and the low future maintenance costs. These bearings should be considered for low to moderate load situations.

Steel reinforced elastomeric bearings may be designed as either rectangular or round. Round elastomeric bearings should be considered where significant movement occurs in both the longitudinal and transverse direction.

If the shearing force in the bearing is less than 20% of the minimum vertical load on the bearing, the interface of the bearing and the concrete bearing seat should not be attached or bonded. For cases where the shearing force is greater, the following possibilities should be investigated:

- a. The bearing should be redesigned to attempt to reduce the shearing force.
- b. The bearing should be shop vulcanized under heat and pressure to a bottom steel plate that is anchored to the substructure.
- c. A PTFE slider type bearing can be considered.

Steel reinforced elastomeric bridge bearings shall only be designed with virgin neoprene not natural rubber.

Elastomeric bearings shall be unanchored to the substructure. When anchor bolts are required, holes for anchor bolts shall not pass through the elastomeric bearing. If anchor bolts are required, then the bolts shall be located outside the limits of the bearing.

9.2.1.1 Steel Bridge Beams

For the design of steel bridge beams, the top of the bearing should be vulcanized under heat and pressure to a steel top plate to facilitate installation. The top plate should be bolted to a beveled sole plate. Field welding should be avoided due to the possibility of damage to the elastomer during welding.

9.2.1.2 Prestressed Concrete Bridge Beams

For prestressed concrete bridge beams without steel sole plates, if the grade of the roadway is less than 5% the bearings may be manufactured with a sloping top surface provided that the internal steel reinforcement plates are parallel and level.

9.2.2 Cotton Duck Reinforced Bearings with PTFE Slider

Cotton Duck fabric reinforced elastomeric bearings should be considered for locations with low to moderate loads combined with moderate to high movement.

The movement due to expansion is accommodated between the PTFE and the slider plate. The PTFE material should be bonded to the top surface of the bearing. The slider plate shall be welded to a top plate or the beveled sole plate.

9.2.3 High Load Multi-Rotation Bearings

High Load Multi-Rotational bearings should be considered for locations with moderate to high loads combined to moderate to high movement. The designer should not completely design high load multi-rotational bearings for each location; however, a preliminary design should be done to determine the rough overall dimensions of the bearing. The specifications for high load multi-rotational bearings require that the Contractor or his Fabricator design the specific bearings based on the type of bearing that is supplied.

The sealing rings used to secure the elastomer disc within the pot shall be round in cross section. Flat rings will not be allowed due to problems with leakage of the elastomer.

9.2.4 Steel Fixed Bearings

Steel bearings may be used where no movement is necessary and where the only rotation is in the transverse axis of the bridge. A 0.125-inch thick, 90 durometer random fabric pad should be used to seat the steel masonry plate on the concrete substructure bearing pad. For steel bridge beams, the anchor bolts for the bearing should not pass through the flange of the beam.

9.3 EXISTING BEARING REPLACEMENT AND REHABILITATION (REV. 02/24)

The replacement or rehabilitation of existing bearings on a bridge being rehabilitated shall consider the bearing's type, age (remaining service life), material, condition, and location relative to a deck joint, condition of the existing member ends (to remain in place), and the scope of the structural work on the bridge.

For bridge rehabilitation alternatives proposing a superstructure replacement, all the existing bearings, regardless of bearing type, age, material, or condition, shall be replaced.

For bridge rehabilitation alternatives proposing a deck replacement, existing all-metal expansion bearings, all-metal fixed bearings, and high-load multi-rotational (HLMR) bearings, regardless of age or condition, shall be replaced. Existing elastomeric bearings, including isolation bearings, may remain provided:

1. the elastomer is uncracked, free of tears, has uniform and equal deformations and bulges (both vertically and laterally) compared to all bearings in the line
2. the exposed steel components do not have any heavy, laminated, or impacted rust and
3. the bearings do not have any conditions that will impact the function of the bearings for all loading conditions and load effects for the remaining service life of the structure without replacement

Commentary: All-metal expansion bearings include high-profile steel rocker bearings and bearings with steel and other metals, such as low-profile self-lubricating bronze plate steel bearings. All-metal fixed bearings include high-profile steel fixed pin bearings and low-profile steel fixed pin bearings with a radiused sole plate and a masonry plate. HLMR bearings include pot, spherical and disc bearings.

Per AASHTO Guide Specification for the Service Life of Highway Bridges, since the service life of all metal bearings and HLMR bearings is approximately 75 years or less, these types of bearings shall be replaced when the deck is being replaced. Elastomeric bearings are estimated to have a service life of 75-100 years.

Conditions that may impact the function of elastomeric bearings include the bearings' location relative to the centerline of bearing (indicating the bearing is "walking"), or bearings with less than 100% contact with the member it supports or the supporting surface of the concrete bearing pad.

The term "load effects" refers to not only forces, but also translational and rotational movements.

If an evaluation of the bearings for load conditions and load effects result in excessive deformation of the bearing, the bearings would not meet the existing elastomeric bearing criteria and should be replaced.

For bridge rehabilitation alternatives proposing a bridge widening, the bearings shall be addressed as follows:

1. existing all-metal expansion bearings, regardless of age or condition, shall be replaced.
2. existing all-metal fixed bearings may remain provided:
 - a. the bearing components do not have any heavy, laminated, or impacted rust and
 - b. the bearing components do not have any conditions, such as section loss, loss of bearing area, or loss of restraint, that will impact the function of the bearings for all loading conditions and load effects for the remaining service life of the structure without replacement
3. existing elastomeric bearings may remain provided:
 - a. the elastomer is uncracked, free of tears, has uniform and equal deformations and bulges (both vertically and laterally) compared to all bearings in the line
 - b. the exposed steel components do not have any heavy, laminated, or impacted rust and
 - c. the bearings do not have any conditions that will impact the function of the bearings for all loading conditions and load effects for the remaining service life of the structure without replacement

For all other bridge rehabilitation alternatives, bearings shall be considered for replacement if:

1. the elastomer has cracks or tears, and does not uniformly and equally deform both vertically and laterally compared to all bearings in the line
2. the exposed steel components of the bearings have section loss or heavy, laminated, or impacted rust
3. the bearings do not function appropriately for all proposed loading conditions and load effects for the remaining service life of the structure without replacement.
4. the bearings have been modified from their original construction, such as self-lubricating bronze plate bearings that had the anchor bolts through the flange and bearing cut short and replaced with keeper plates

Commentary: Since the “other bridge rehabilitation alternatives” is not a defined scope of work, the direction “bearings shall be considered for replacement” has been given. The designer shall determine whether the bearings should be replaced or rehabilitated based on the criteria provided and structural scope of work.

On existing bridges undergoing bearing replacement, the condition of the member ends must be adequate to support and connect the replacement bearings. If the member ends have existing deficiencies, such as section loss, that cannot be corrected, the replacement of the bearings may not be feasible.

Commentary: Steel section loss at member ends may result in a tapered bottom flange edge that no longer has sufficient edge thickness (i.e.. “knife edge”) for a weld to connect a replacement sole plate to the flange.

The replacement bearings and sole plates shall be sized to avoid conflicts with full length cover plates unless the cover plates will be modified.

Existing concrete bearing pads shall only be reused if they are in good condition. Existing concrete bearing pads with cracks and spalls shall be replaced.

Commentary: At locations undergoing bearing replacement, since the structure will be raised, concrete bearing pads with cracks and spalls shall be replaced to better ensure a longer service life of the component.

Where existing concrete bearing pads will be reused, the reuse of existing anchor bolts is not permitted. The existing anchor bolts shall be cut off and removed to below the top surface of the pad, the exposed anchor bolt shall be coated with 2 coats of brush applied cold galvanizing compound (The use of aerosol spray is not permitted), the void filled with cementitious patching material and the entire pad shall be coated with “Penetrating Sealer Protective Compound.” Designs shall meet bearing anchorage requirements. Designers shall ensure that the installation of replacement anchor bolts is feasible.

Commentary: Where bearings are being replaced, the structural resistance and remaining service life of existing anchor bolts shall be assumed to be inadequate so that the anchor bolts cannot be reused. The anchorage that they provide must be addressed at the time of the bearing replacement.

Designers should understand that installation of anchor bolts for bearings below an existing structure can be difficult because existing structure components may limit worker, equipment, and material access. Designers shall ensure the constructability of the replacement anchor bolts.

At bearing replacement locations, existing concrete bearing pads shall be replaced if the pad height along with the height of the replacement bearing will adversely impact the portion of the structure to remain in place or if the pad bearing area provides less than 100 percent of the bearing area required by the replacement bearing.

Commentary: The edges of concrete bearing pads are beveled reducing the area available to support bearings.

On existing bridges undergoing elastomeric bearing replacement that have abutments with a slab over backwall condition, the bearing shall be designed and detailed to prevent the slab from resting on the top of the backwall after all bearing deflection has taken place. The joint between the underside of the slab and the top of the backwall shall be filled with a combination of 2 sealants to prevent the backfill from migrating into the joint and the intrusion of water onto the bridge seat. Once the bridge is resting on the replacement bearings, and after the joint has been cleaned with compressed air, from the underside of the bridge, install expanding spray applied open cell foam from the rear face of the back wall (end of deck) to within 1 inch of the front face of the backwall. Complete the sealant installation, by installing a non-sagging elastomeric joint sealant in the remaining 1 inch depth of the joint.

Rehabilitation of existing bearings is limited to cleaning and painting the exposed steel surfaces of the bearing. All cleaning and painting of the exposed steel portions of existing bearings shall conform to the CTDOT special provisions for paint removal and field painting. The cleaning and painting of rocker bearings or fixed bearings with a radiused sole plate that have heavy, laminated, or impacted rust between the bearing radius and the masonry plate is not permitted. The rehabilitation of bearings by removing, disassembling, cleaning, re-lubricating and reinstalling the bearing is not permitted.

Commentary: Abrasively blast cleaning rocker bearings or fixed bearings with heavy, laminated or impacted rust between the radiused bearing surface and the surface of the masonry plate typically reveals section loss on each surface leaving nonuniform "gaps" between the surfaces and a "flattening" of the bearing radius. Since the resulting condition impacts the functionality of the bearing and will adversely impact the condition rating of the bridge element, bearing replacement should be considered provided bearing replacement is included in the structural scope of work for the project. Designers should be aware of these concerns on projects where the structural scope of work is limited to the abrasive blast cleaning and field painting of an existing structure.

The rehabilitation of self-lubricating bronze bearings by removing, disassembling, cleaning, re-lubricating and reinstalling the bearing was once practiced by CTDOT. This method of rehabilitation was determined to be ineffective and is no longer permitted.