



American Railway Engineering and
Maintenance-of-Way Association

CHAPTER 19

BRIDGE BEARINGS^{1,2}

Current until revision of next edition

FOREWORD

Part 1, Design and Part 2, Construction formulate specific and detailed rules for the design and construction of bearings for nonmovable railway bridges. Part 3 is a commentary, including bibliography, for explanation of various articles in the preceding parts.

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¹ References, Vol. 96, p. 92.

² The material in this and other chapters in the AREMA *Manual for Railway Engineering* is published as recommended practice to railroads and others concerned with the engineering, design and construction of railroad fixed properties (except signals and communications), and allied services and facilities. For the purpose of this Manual, RECOMMENDED PRACTICE is defined as a material, device, design, plan, specification, principle or practice recommended to the railways for use as required, either exactly as presented or with such modifications as may be necessary or desirable to meet the needs of individual railways, but in either event, with a view to promoting efficiency and economy in the location, construction, operation or maintenance of railways. It is not intended to imply that other practices may not be equally acceptable.

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INTRODUCTION

■ The Chapters of the AREMA Manual are divided into numbered Parts, each comprised of related documents (specifications, recommended practices, plans, etc.). Individual Parts are divided into Sections by centered headings set in capital letters and identified by a Section number. These Sections are subdivided into Articles designated by numbered side headings.

Page Numbers – In the page numbering of the Manual (19-2-1, for example) the first numeral designates the Chapter number, the second denotes the Part number in the Chapter, and the third numeral designates the page number in the Part. Thus, 19-2-1 means Chapter 19, Part 2, page 1.

In the Glossary and Bibliography, the Part number is replaced by either a “G” for Glossary or “B” for Bibliography.

Document Dates – The bold type date (Document Date) at the beginning of each document (Part) applies to the document as a whole and designates the year in which revisions were last made somewhere in the document, unless an attached footnote indicates that the document was adopted, reapproved, or rewritten in that year.

Article Dates – Each Article shows the date (in parenthesis) of the last time that Article was modified.

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■ **Annual Updates** – New manuals will be reprinted and issued yearly, in their entirety.





American Railway Engineering and
Maintenance-of-Way Association



Part 1

Design¹

— 1997 —

Current until revision of next edition

FOREWORD

The purpose of this part is to formulate specific and detailed rules for the design of bearings for nonmovable railway bridges.

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SECTION 1.1 INTRODUCTION

1.1.1 DEFINITION OF TERMS

1.1.1.1 Contractual Terms

- a. The term “Company” means the railway company party to the contract. The term “Engineer” means the chief engineering officer of the Company or his authorized representatives. The term “Inspector” means the inspector representing the Company. The term “Contractor” means the manufacturing, fabricating or erecting contractor party to the contract.
- b. See [Chapter 15, Steel Structures, Section 1.1, Proposals and Drawings](#) for other contractual terms and/or requirements for “Proposals,” “Shop Drawings,” “Drawings to Govern,” “Patented Devices” and “Notice to Engineer.”

1.1.1.2 Bearing Component Terms

- a. The following technical terms are used throughout this Chapter for the various types or components of Bridge Bearings:

Base Plate: A steel plate, whether cast, rolled or forged, usually used to uniformly distribute line bearing loads from a rocker, rocker plate, roller, or roller nest to other bridge bearing components.

Bed Plate: See Masonry Plate or Base Plate.

Bronze or Copper-Alloy Sliding Expansion Bearing: A sliding expansion bearing device consisting of a bronze or copper-alloy plate, frequently with a lubricating material compressed into trepanned recesses in the upper and/or lower surfaces of the plate. The lubricating material is intended to provide permanent lubrication to the sliding interface between the upper and lower bearing elements for heavy loads undergoing slow expansion movements.

Bolster: A block-like member composed of wood, metal, or concrete used to transmit and distribute a bridge bearing load to the top of a pier cap or abutment bridge seat; or to raise a bridge bearing above moisture or debris that may collect on a bridge seat. Metal bolsters frequently consist of voided iron or steel castings, or built up steel weldments.

Disc Bearing: A type of multi-rotational bearing which provides for end rotation of bridge spans by means of a flat, circular shaped, elastomeric disc.

Elastomeric Bearing: A device constructed partially or wholly from elastomer for the purpose of transmitting loads and accommodating movement between a bridge span and its supporting structure.

External Steel Load Plate: A steel plate bonded to the upper and/or lower surfaces of an elastomeric bearing.

Guide Bar: An element of an expansion bearing which protrudes beyond the sliding surface and has its long dimension parallel to the direction of movement. The element is intended to limit the lateral movement of the bearing or span, and thus guide the span's longitudinal movement. A guide bar is usually a steel bar of rectangular or square cross section which is welded to, or machined from the sole plate, base plate, or masonry plate.

Guide Key: An element of a steel expansion bearing consisting of one or more keyways and keys. Keyways are generally of rectangular or square cross section and are machined into the upper and lower bearing elements. The key is usually a steel bar of rectangular or square cross section that fits into the keyways. The fit is tight, to limit lateral movement of the bearing or span, while allowing longitudinal movement. The long dimension of the guide key is parallel to the direction of movement.

Hold Down Device: An assembly which prevents upward vertical movement of the bridge superstructure with respect to the substructure that is added to a bearing with no inherent resistance to vertical uplift.

Lateral Restraint Device: An assembly which prevents lateral movement of the bridge superstructure with respect to the substructure at an expansion bearing with no inherent resistance to lateral movement.

Masonry Plate: A steel plate or plate-shaped member, whether cast, rolled or forged, usually placed upon a masonry pier, abutment or other substructure unit and used to distribute loads from upper components of a bridge bearing uniformly over the masonry bridge seat below.

Multi-Rotational Bearing: A type of bearing or bearing device which has the capability of allowing rotation in any of several directions, typically both transverse and longitudinal directions. Multi-rotational bearings frequently include a circular elastomeric disc or pad, or spherical sliding surface.

Pedestal: A block-like member or assemblage composed of wood, metal, or concrete used to transmit and distribute a load from a bridge bearing or other member or part of a structure to another member or part. Metal pedestals frequently consist of voided iron or steel castings, or built up steel weldments.

Pin: A cylindrical bar, usually steel, used to connect, hold in position, and/or transmit loads from one bridge bearing component to another, while allowing for the rotation of those bridge bearing components relative to each other.

Pintle: A machined steel pin which typically is press fit into a hole in an upper or lower element or base plate of a bearing assembly. A pintle is usually used with bearings utilizing a rocker, rocker plate or roller element. The pintle provides a positive horizontal shear connection between the lower element or base plate and the rocker or roller elements of the bearing allowing for rotation.

Plain Elastomeric Bearing: An elastomeric bearing that consists of elastomer only.

Pot Bearing: A type of bearing which usually consists of an elastomeric disc confined in a steel cylinder, or pot, with a ring sealed steel piston which transmits bridge bearing loads to the elastomeric disc.

Reinforced Elastomeric Bearing: An elastomeric bearing that consists of layers of elastomer restrained at their interfaces by integrally bonded steel reinforcement.

Rocker: A cylindrical sector shaped member attached, frequently by a pin at its axis location, to the expansion end of a girder or truss that will transmit bridge bearing loads in line bearing contact upon its perimetrical surface with a base plate, bolster, pedestal or masonry plate and thus provide for longitudinal movements by a wheel-like translation.

Rocker Plate: A steel plate with one cylindrical surface that will transmit bridge bearing loads in line bearing contact upon its perimetrical surface to other bearing components and allow for longitudinal rotation of the span ends due to span deflection.





Roller: A steel, cylindrical shaped member, frequently forming an element of a roller nest or any other bearing device intended to provide longitudinal movements by rolling contact and that will transmit bridge bearing loads in line bearing contact with both a top plate or sole plate above, and a base plate, bolster, pedestal or masonry plate below.

Roller Nest: A group of two or more steel cylinders forming a part of an expansion bearing at the movable end of a girder or truss intended to provide longitudinal movements by rolling contact and that will transmit bridge bearing loads in line bearing contact with both a top plate or sole plate above, and a base plate, bolster, pedestal or masonry plate below. Commonly, the rollers of a roller nest are assembled in a frame or box.

Seismic Isolation Bearing: A type of bridge bearing which is intended to reduce the dynamic response of a bridge superstructure and thus minimize seismic loads acting on, and damage to, the bridge by providing a compliant connection between the superstructure and substructure through viscous damping, friction or metallic yielding.

Seismic Isolation Device: A device which is intended to reduce the dynamic response of a bridge superstructure and thus minimize seismic loads acting on, and damage to, the bridge by providing a compliant connection between the superstructure and substructure through viscous damping, friction or metallic yielding. A seismic isolation device may be a component of a seismic isolation bearing or may be a device, or one of several devices, independently connected between the bridge superstructure or substructure.

Shoe: A bolster-like or pedestal-like member or plate, typically placed under the end of a plate girder or truss, to transmit and distribute bridge bearing loads to the masonry bridge seat, other bearing components or other substructure members.

Sole Plate: A steel plate bolted, riveted, or welded directly under the bottom flange of a rolled beam or plate girder, bottom chord of a truss, or cast into the bottom of a concrete girder, to uniformly distribute the bridge bearing loads into other bridge bearing components below, such as a roller nest, rocker plate, base plate, pedestal, multi-rotational bearing or masonry plate.

Spherical Bearing: A type of multi-rotational bearing which provides for end rotation of bridge spans by means of a convex spherical surface hinging, rocking or sliding in a mating concave spherical surface. Lubrication of the mating surfaces is usually required and is frequently accomplished by providing a TFE Bearing Surface or a Bronze or Copper-Alloy Sliding Surface.

TFE Bearing Surface: A low-friction sliding surface which utilizes a polytetrafluorethylene (TFE) sheet or woven fiber fabric manufactured from pure virgin unfilled TFE resin, which is bonded to a steel backing substrate and usually slides against a polished stainless steel sheet.

Trepanned Recess: A disk or ring shaped void machined into a metal plate or bushing. The disk or ring shaped void usually has a rectangular or square cross section. Trepanned recesses are generally machined into bronze or copper-alloy bearing elements and are filled with a lubricating material. The lubricating material is intended to provide permanent lubrication to the sliding interface between the bronze or copper-alloy bearing element and the opposing steel bearing elements.

1.1.2 GENERAL REQUIREMENTS

- a. Design of bearings shall be such as to allow for expansion and contraction of the spans resulting from change in temperature at the rate of 25 (1 inch) in 30 000 (100 feet) for Minimum Service Temperature¹ Zone 1 and 30 (1¼ inch) in 30 000 (100 feet) for Minimum Service Temperature Zones 2 and 3. Provisions shall also be made for change in length of the span resulting from live load. In steel spans more than 90 000 (300 feet) long, allowance shall be made for expansion of the floor system. Due consideration shall be given to the effects of lateral thermal movement for structures wider than 12 000 (40 feet).
- b. Bearings and ends of spans shall be securely anchored against lateral and vertical movement. The Engineer may waive the requirement for vertical restraint of concrete spans.
- c. Bearings for spans of less than 15 000 (50 feet) need not have provision to accommodate rotation due to deflection of the span.
- d. Bearings for spans of 15 000 (50 feet) or greater shall have provision to accommodate rotation due to deflection of the span. This requirement can be accommodated by use of a type of bearing employing a hinge, curved bearing plate or rocker plate, elastomeric pad, or pin arrangement.
- e. End bearings subject to both longitudinal and transverse rotation shall consist of elastomeric or multi-rotational bearings.
- f. Due consideration shall be given to bearing stability under seismic loading in the selection of bearing type.
- g. Bearings on masonry preferably shall be raised above the bridge seat by masonry plates, pedestals or bolsters. The Engineer may waive this requirement for elastomeric bearings.
- h. Provision for the replacement of bearings shall be considered in the design.



1.1.3 EXPANSION BEARINGS

- a. The expansion end of spans of 21 000 (70 feet) or less may be designed to accommodate movement through the use of low friction sliding surfaces or elastomeric pads.
- b. The expansion end of spans longer than 21 000 (70 feet) shall be supported by bearings employing rollers, rockers, reinforced elastomeric pads, or low friction sliding surfaces designed to accommodate larger longitudinal movements.

1.1.4 FIXED BEARINGS

- a. The fixed end of spans shall be securely anchored to the substructure to prevent lateral and longitudinal movement.
- b. Span rotation shall be accommodated as stipulated in the provisions of [Article 1.1.2 c, d and e](#).

1.1.5 BEARING SELECTION CRITERIA

(UNDER DEVELOPMENT)

SECTION 1.2 BASIC ALLOWABLE STRESSES

The basic allowable stresses to be used in proportioning the parts of a bridge bearing shall be as specified below.

1.2.1 STRUCTURAL STEEL, BOLTS AND PINS

- a. Except as provided in [paragraph c](#) below, the basic allowable stresses for all steel bearing components, weld metal, bolts or rivets, shall be as specified in [Chapter 15, Steel Structures, Section 1.4, Basic Allowable Stresses](#).
- b. When the allowable stress for steel bearing components is expressed in terms of F_y , F_y = yield point of the material as specified in [Chapter 15, Steel Structures, Table 3-2](#).

MPa (psi)

- c. Bearing on pins

$0.75F_y$

F_y = yield point of the material on which the pin bears, or of the pin material, whichever is less, as specified in [Chapter 15, Steel Structures, Table 3-2](#).

Bearing on milled web members, milled stiffeners and other steel parts in contact, except as specified in this Article

$0.83F_y$

Bearing between rockers and rocker pins

$0.375F_y$

F_y = yield point of the material in the rocker or in the rocker pin, whichever is less, as specified in [Chapter 15, Steel Structures, Table 3-2](#).

Stress in extreme fibers of pins

$0.83F_y$

kN/mm

Pounds per linear inch.

Bearing on rollers, rockers and rocker plates:

For diameters up to 600 (25 inch)

$$\frac{(F_y - 90)d}{33\,000}$$

$$\left(\frac{(F_y - 13,000)600d}{20,000} \right)$$

For diameters from 600 (25 inch) to 3000 (125 inch)

$$\frac{(F_y - 90)\sqrt{d}}{1300}$$

$$\left(\frac{(F_y - 13,000)3,000\sqrt{d}}{20,000} \right)$$

d = diameter of roller, rocker, or rocker plate curved surface; mm (inch)

F_y = yield point of the material in the roller, rocker, or rocker plate; or in the base plate, whichever is less, as specified in [Chapter 15, Steel Structures, Table 3-2](#).

1.2.2 CAST STEEL

For cast steel, the allowable stresses in compression and bearing shall be the same as those allowed for structural steel with the same yield point or yield strength. Other allowable stresses shall be 75 percent of those allowed for structural steel with the same yield point or yield strength.

1.2.3 BRONZE OR COPPER-ALLOY PLATES

For self-lubricating bronze or copper-alloy plates, the allowable stresses in bearing on the net area shall not exceed 14 MPa (2,000 psi).

1.2.4 ELASTOMERIC BEARINGS

For unconfined elastomeric bearings, the allowable average compressive stress shall be as specified in [Article 1.6.3.4](#), but shall not exceed 7 MPa (1,000 psi) for reinforced bearings, or 5.5 MPa (800 psi) for plain bearings.

1.2.5 MASONRY

- a. Except as provided in [paragraph b](#), the basic allowable stresses for all concrete masonry and reinforcing steel shall be as specified in [Chapter 8, Concrete Structures and Foundations](#).
- b. Bearing pressure:

	<u>MPa (psi)</u>
Granite	5.5 (800)
Sandstone and limestone	3 (400)
Concrete	0.25 of the ultimate compressive strength
(When the strength of concrete is unknown, use 17 MPa (2,500 psi) for the design ultimate compressive strength.)	

1.2.6 TIMBER

Allowable bearing stresses and other design stresses for all timber members shall be as specified in [Chapter 7, Timber Structures](#).

SECTION 1.3 STEEL BEARING COMPONENTS

1.3.1 SCOPE

- a. This Section covers the materials for, and the design of, steel bearings or steel bearing components made from rolled steel plates and shapes, steel forgings or cast steel which are used to carry railroad loading. The use of ductile or malleable iron castings is also covered for specific bearing components.
- b. The fabrication and installation of steel bridge bearings or steel bearing components shall be in accordance with the requirements of [Section 2.2, Steel Bearing Components](#) and [Chapter 15, Steel Structures](#).



1.3.2 MATERIALS

Except as provided in [Article 1.3.2.1](#) through [Article 1.3.2.4](#) below, material for all bearing components produced from rolled steel plates or shapes, shall conform to one of the ASTM designations listed in [Chapter 15, Steel Structures, Table 3-1](#).

1.3.2.1 Pins, Rollers, and Rockers

In addition to the designations listed in [Chapter 15, Steel Structures, Table 3-1](#), steel for pins, rollers, and rockers may conform to one of the ASTM A 668M (A 668) classes: Steel Forgings, Carbon and Alloy, for General Industrial Use, listed below in [Table 10-1](#).

Table 10-1. Classes of Steel Forgings Acceptable for Pins, Rollers, and Rockers

ASTM A668M (A668) Class	F _y - Min Yield Point, MPa (psi)	Size Limitation ¹
Class C	230 (33,000)	To 500 (20 inches) in dia.
Class D	260 (37,500)	To 500 (20 inches) in dia.
Class F	345 (50,000)	To 250 (10 inches) in dia.
Class G ²	345 (50,000)	To 250 (10 inches) in dia.

¹Expansion rollers shall be not less than 150 (6 inch) in diameter.

²Rolled material of the same properties may be substituted.

1.3.2.2 Fasteners—Rivets and Bolts

Fasteners may be carbon steel bolts, ASTM A 307, power-driven rivets, ASTM A 502 Grades 1 or 2, or high-strength bolts, ASTM A 325M (A 325) or ASTM A 490M (A 490) in accordance with [Chapter 15, Steel Structures](#).

1.3.2.3 Weld Metal

Weld metal shall conform to the current requirements of AWS D1.5 and [Chapter 15, Steel Structures](#).

1.3.2.4 Cast Steel, Ductile Iron Castings and Malleable Castings

1.3.2.4.1 Cast Steel and Ductile Iron

- Cast steel shall conform to specifications for Steel Castings for Bridges, ASTM A 486; Mild-to-Medium-Strength Carbon-Steel Castings for General Application, ASTM A 27M (A 27); and Corrosion-Resistant Iron-Chromium, Iron-Chromium-Nickel and Nickel-Based Alloy Castings for General Application, ASTM A 743M (A 743).
- Ductile iron castings shall conform to ASTM A 536.

1.3.2.4.2 Malleable Castings

Malleable castings shall conform to specifications for Malleable Iron Castings, ASTM A 47M (A 47), Grade 22010 (32510) {minimum yield point, F_y 220 MPa (32,500 psi)}.

1.3.3 SHOES AND PEDESTALS

- a. Shoes and pedestals shall be designed on the assumption that the vertical load is distributed uniformly over the entire bearing surface. They shall be either made of cast steel or built-up by welding rolled steel and/or cast steel elements together.
- b. Shoes and pedestals preferably shall be made of cast steel or structural steel. No part of a cast steel shoe, and no load carrying part of a welded shoe, shall be less than 25 (1 inch) thick.
- c. In a welded shoe, the vertical load shall be carried directly in bearing between elements. Diaphragms shall be provided between web surfaces to ensure stability of component parts.
- d. The difference in width and length between top and bottom bearing surfaces shall not exceed twice the vertical distance between them. For hinged bearings with pins, the vertical distance shall be measured from the centerline of pin.
- e. Webs and pin holes in the webs shall be arranged to keep any eccentricity to a minimum. The net section through the hole shall provide 140 percent of the net section required for the actual stress transmitted through the pedestal or shoe. Pins shall be of sufficient length to ensure a full bearing. Pins shall be secured in position by appropriate nuts with washers. All portions of shoes and pedestals shall be secured against lateral movement of the pins.

1.3.4 ROCKER PLATES, ROCKERS AND ROLLERS

1.3.4.1 Rocker Plates

- a. Rocker plates shall be used in preference to either rockers or rollers where conditions permit. Rocker plates must be used in conjunction with a base plate. For expansion bearings, the base plate must be supported on a reinforced elastomeric pad or low friction sliding surface designed to accommodate longitudinal movements from both temperature and translations at the span bearing elevation resulting from span rotations due to span deflections. The elastomeric pad or sliding surface should only be placed at the expansion end of the span and must be designed to also accommodate the additive longitudinal movements resulting from fixed end span rotation.
- b. The nominal centerline thickness of the rocker plate shall not be less than 40 (1½ inch) and the curved surface shall be cylindrical.
- c. The rocker plate shall be doweled to the base plate to prevent lateral movement, skewing or creeping of the rocker plate on the base plate.
- d. The effective length of rocker plate, for calculating line bearing stress, shall be the lesser of the actual length of the rocker plate or the least length determined as follows:
 - (1) The length of any bearing surface above or below the rocker plate, such as the bottom flange width or length of sole plate for steel spans, plus the total thickness of all plates between the bearing surface and the line bearing or curved surface of the rocker plate (including the nominal centerline thickness of the rocker plate if between the two surfaces).
 - (2) For steel spans, the distance out-to-out of bearing stiffeners plus the total thickness of all plates between the bottom of bearing stiffener surface and the line bearing or curved surface of the rocker plate (including the bottom flange thickness and the nominal centerline thickness of the rocker plate if between the two surfaces).





- (3) For concrete spans, the length of sole plate cast into the bottom of the span plus the total thickness of all plates between the bottom of sole plate bearing surface and the line bearing or curved surface of the rocker plate (including the nominal centerline thickness of the rocker plate if between the two surfaces).

- e. The effective length of rocker plate, for calculating line bearing stress, shall also be reduced by the diameter of each dowel hole located on the line bearing surface.

1.3.4.2 Rockers

- a. Rockers shall be used in preference to rollers where conditions permit. The upper surface of rockers shall have a pin or cylindrical bearing.
- b. The lower portion of a rocker, at the nominal center line of bearing, shall not be less than 40 (1½ inch) thick and the lower surface shall be cylindrical with its center of rotation at the center of rotation of the upper bearing surface.
- c. The rocker shall be doweled to the base plate to prevent lateral movement, skewing or creeping of the base of the rocker.
- d. The effective length of rocker, for calculating line bearing stress, shall not be greater than the length of the upper bearing surface plus the distance from the lower surface to the upper bearing surface. There shall be sufficient web material between the upper and lower portion of the rocker to ensure uniform distribution of load over the effective length of rocker.
- e. The effective length of rocker, for calculating line bearing stress, shall also be reduced by the diameter of each dowel hole located on the line bearing surface.

1.3.4.3 Rollers

- a. Rollers may be either cylindrical or segmental and shall not be less than 150 (6 inches) in diameter.
- b. Rollers shall be connected by substantial side bars to ensure parallelism and shall be guided by gearing or other effective means to prevent lateral movement, skewing, and creeping.
- c. Rollers and bearing plates shall be protected from dirt and water as far as practicable, and the design shall be such that water will not be retained and the roller nests will be accessible for inspection and cleaning.

1.3.5 SOLE, BASE AND MASONRY PLATES

- a. Base and masonry plates shall be designed on the assumption that the vertical load is distributed uniformly over a bearing area with effective length and width as defined in [paragraph b](#), except for eccentricity from rocker travel.
- b. The effective length of the bearing area shall not be greater than the effective length of the rocker plate or rocker as defined in [Article 1.3.4.1c](#) or [Article 1.3.4.2c](#), or the length of the roller, plus 2 times the thickness of the base plate. The effective width of the bearing area shall not be greater than 4 times the thickness of the base plate for a single roller, rocker plate or rocker, or the distance between multiple rollers plus 4 times the thickness of the base plate for roller nests.