Oregon Department of Transportation

# SECTION 1.14
# Bearing & Expansion Joints

Revisions for the current edition are highlighted yellow. Deleted text is not marked.

Past editions of the Bridge Design Manual are available through our website.

1.14.1 Bearings, General

1.14.2 Expansion Joints

# 1.14 Bearings and Expansion Joints

## 1.14.1 Bearings, General

Design bearing for movements due to the following:

- Temperature.
- Time-dependent behavior (creep and shrinkage).
- Seismic activity.
- Vertical loading.
- Elastic shortening due to prestressing, if applicable.
- Traffic loading.
- Construction tolerance.
- Lateral loading.

Design bearings and joints in coordination to ensure the structure behaves as intended under all conditions.

*Table 1.14.1-1* shows bearing types that are allowed for use and their capacities.

## C 1.14.1

Bearings are essential components that transfer loads from the superstructure to the substructure and, ultimately, to the ground. They allow for controlled movements while restricting unwanted displacements.

The compatibility of a bearing's movement capabilities with adjacent expansion joints is critical.

Table 1.14.1-1 Summary of Bearing Types and Capacities

| Bearing Type | Max. Load (Kips) | Max. Translation(inches) | Max. Rotation (degrees) |
|---|---|---|---|
| Plain Neoprene Elastomeric | 100 | 1 | *1°* |
| Steel Reinforced Elastomeric (SRBP) | 800-1000* | 6 | *2°* (approximately 0.03–0.04 rad) |
| PTFE Sliding | 1000 – 2000 (area-dependent) | 12-20 | *0°* (flat PTFE sliders alone do **not** accommodate rotation) |
| Disc Bearing | 2000 (single unit) | 0 (fixed)<br>20 (with PTFE slide) (fixed by itself; expansion versions add a sliding element | *1.5°* (typical design rotation ~0.02 rad; higher rotation risks disc/metal contact) |
| Pot Bearing (not preferred) | 2000 (single unit) | | |
| Isolation (Require a design deviation) | 1500 (typical HDR/LRB/FPS unit **) | >8 (project specific) | *~2°* (on the order of a few degrees; often similar to elastomeric bearing capacity) |

Notes:

All loads are unfactored loads.

* Design to 800 kips is typically economical. If this load exceeds 1000 kips, contact the Structural Materials Engineer to coordinate testing and discuss special provision preparation, as it exceeds testing capabilities of most laboratories.

** HDR (High Damping Rubber): Special elastomeric bearings with higher damping rubber; moderate displacement capacity with energy dissipation.
LRB (Lead Rubber Bearing): Elastomeric bearing with a lead plug; combines flexibility and significant damping (~15–30%); widely used for seismic isolation.
FPS (Friction Pendulum System): Sliding, concave pendulum isolator; accommodates very large displacements (10–20+ in.) with stable restoring force; suited for long spans and high-seismic zones.

## 1.14.1.1 Design Considerations

Provide provisions for future bearing replacement, including temporary jacking and support for all manufactured bridge bearings. See *BDM 1.14.1.4*.

Include consideration of jacking and temporary support in the original design. Consider the potential of bearing replacement during the life of the structure in sizing of crossbeams and bents.

For steel girder bridges, do not add stiffeners or other reinforcement elements in the original design. Ensure that girder ends remain accessible for potential future stiffener additions when required during a bearing replacement.

## C1.14.1.1

There is a potential for bearing failure during the service life of a bridge, requiring provisions for bearing replacement in the design drawings. To accommodate the bearing replacement, generally leave enough vertical clearance for a hydraulic jack and steel bearing plates.

The intent is to incorporate practical and cost-effective design considerations for potential future bearing replacements without adding unnecessary structural elements or excessive initial costs.

Where bearing replacements may not be required within the bridge's lifespan, evaluate whether provisions for jacking and temporary support are necessary. In many cases, integral abutments or direct-bearing seat designs eliminate the need for future bearing replacement.

This approach maintains design flexibility while avoiding unnecessarily high material and fabrication costs.

## 1.14.1.2 Elastomeric Bearing Pads

Use elastomeric bearings to accommodate movements on short to medium-span structures. The two types of pads include:

- Plain pads.
- Laminated pads reinforced with steel plates.

Use plain elastomeric (unreinforced) pads for slabs and box beams construction, when a span length is shorter than or equal to 70 feet. Use the details shown in *Figure A1.11.2.9-4* for end bents or *Figure A1.11.3.2-3* for interior bents. SRBP designed to Method B are also acceptable.

Design all elastomeric bearings using **Method B** per *LRFD 14.7.5*. Specify in the contract drawings that **Method B** was used.

Specify shear modulus as 165 psi at 73º F in the contract drawings, without referencing durometer hardness.

## C1.14.1.2

Plain pads are made from elastomer molded or extruded into large sheets, volcanized and then cut to size. Neoprene or natural rubber elastomeric compound is acceptable.

Steel reinforced bearing pads (SRBP) are made from alternate layers of elastomer and steel plate cut to size and then volcanized. A thin cover layer of elastomer encapsulates the steel plates to prevent corrosion. The exposed edge voids in the pads caused by the steel laminate restraining devices are shop sealed with appropriate caulking material.

Method B offers greater control over design calculations and bearing performance while providing better accommodation for rotational demands compared to Method A. Traditionally, elastomer specifications have been based on durometer hardness; however, shear modulus is the most critical physical property for bearing design. Research indicates that shear modulus can vary significantly among compounds with the same hardness.

Consider horizontal forces induced by restraint of movement at the bearings and reasonable shear modulus of the bearing pads in bearing and substructure design.

Use the following shear moduli for the design:

- 220 psi for Section II and 300 psi for Section III (*BDM 1.3.7*) for substructure design check using service and strength load combinations and for bearing slippage check using service load combinations.
- 165 psi for seismic analysis.

Use the following movements for pad thickness design:

$$ES + LF1 * (CR + SH) + LF2 * (TF \text{ or } TR)$$

Where:

ES = elastic shortening movement

CR = creep movement $CR = (ES) * (CF)$

SH = shrinkage movement

TF = temperature fall movement

TR = temperature rise movement

CF = creep factor

$LF_1$ = from *LRFD 3.4.1*

$LF_2$ = TU, load factor from *LRFD Table 3.4.1-1*

Bearing stiffness affects analysis and design checks in the following situations:

- Slippage check to prevent the bearing pads moving out of place during the service life. Use a coefficient of friction of 0.2 between elastomer and clean concrete or steel.
- Superstructure and substructure capacity check due to horizontal forces induced by the restraint of movement.
- When bearing pads are modeled in seismic analysis, stiffness of bearings affects seismic response of the structure.

Temperature affects the bearing stiffness, i.e. stiffer in low temps. and softer in high temps.

The point of no movement, which is the neutral location on a bridge that does not move horizontally due to temperature changes, should be considered in displacement calculations, accounting for substructure stiffness.

Refer to g-9.1-2022 Steel Bridge Bearing Guidelines Appendix B for calculation of thermal movement for non-standard steel bridges (e.g. curved and skewed).

Use proper signs and the Service Limit State Load Factor that produces the largest movement in each load combination.

The final elastomer thickness is two times the design movement. See *Figure 1.14.1.2-1* for typical configuration of SRBP. The actual finished thickness will vary depending on the type of reinforcement.

Size the nominal pad thickness in multiples of ½ inch, from ½ inch to 6 inches maximum. Use a minimum of 14 gauge steel plate.

Use a creep factor of 1.5 for both prestressed and post-tensioned concrete structures. Calculate shrinkage movement using 0.0004 times the total length of the structure.

For prestressed concrete structures 40 percent of this movement takes place within the first thirty days after manufacture. Therefore, the amount of creep and shrinkage movement for these structures, after placement, can normally be taken as 60 percent of the total.

For elastic shortening of post-tensioned, cast-in-place concrete bridges compare the design values with the field measured values in *BDM 1.5.8.1* and use the more conservative values.

Values for shortening of post-tensioned, cast-in-place concrete bridges have been determined by field measurements by ODOT Bridge Section.

For precast/prestressed concrete girders, set ES equal to zero for the movement calculation.

For precast/prestressed concrete girders, elastic shortening occurs immediately after transfer of prestress during girder manufacturing at the precast producer plant.

Pad thickness called out on detail plans represents the total elastomer thickness, including all internal shims and elastomer layers. When bearing pad elevations are shown, the assumed loaded total pad thickness used in determining those elevations must be listed. See *Figure 1.14.1.2-1* for example.

For designed bearings, the minimum size of elastomeric bearing pads is specified in *Table 1.14.1.2-1*.

Table 1.14.1.2-1 Minimum Bearing Pad Size Requirements

| Type | Wp (inches) | Lp (inches) | Number of Pads |
|---|---|---|---|
| Slabs | 5 | 16 | 2 |
| Box Girders | 6 | 20 | 2 |
| BT48 - BT84 | 7 | 22 | 1 |
| BT90 and BT96 | 7 | 28 | 1 |
| WSDOT Shape WFxxG and WFxxDG | 7 | 28 | 1 |

When details shown in *Figure A1.11.2.9-4* (end bents) or *Figure A1.11.3.2-3* (interior bents) are used, specify 1/2 thick unreinforced bearing pads with the sizes specified in *Table 1.14.1.2-2*.

Table 1.14.1.2-2 - ½ Inch Thick Unreinforced Bearing Pad Size Requirements

| Type | Depth (inches) | Wp (inches) | Lp (inches) |
|---|---|---|---|
| Slabs | 15 | 5 | 16 |
| | 18 | 5 | 18 |
| | 21 | 5 | 20 |
| | 26 | 5.5 | 20 |
| | 30 | 6 | 20 |
| Box Girders | All | 6 | 20 |

See *Figure 1.14.1.2-2* for bearing pad details for slabs and box girders.

Figure 1.14.1.2-1 Typical Steel Laminated Elastomeric Bearing Pad

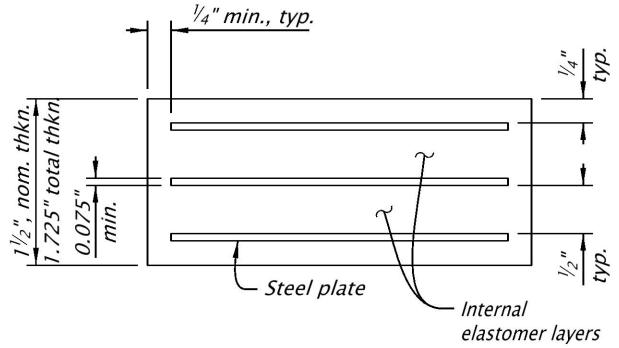



Figure 1.14.1.2-2 Bearing Pad Details for Slabs and Box Girders

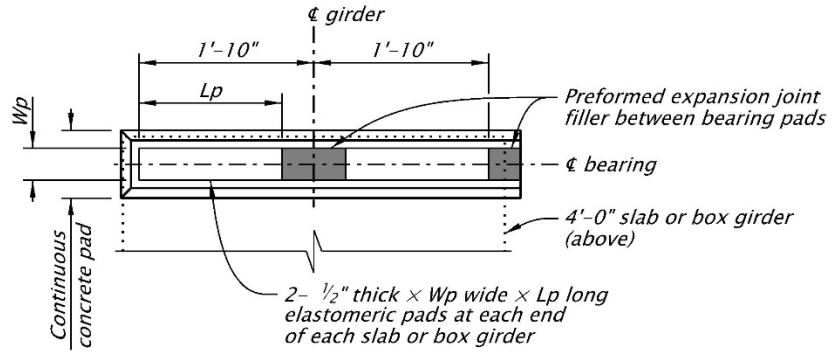
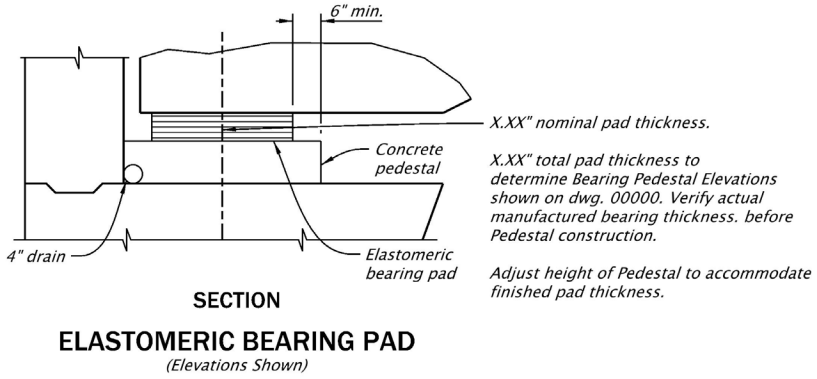



Figure 1.14.1.2-3 Elastomeric Bearing Pad Examples



## 1.14.1.3 Pot, Disc, Sliding and Spherical Bearings

## C1.14.1.3

Use these bearings on long-span and post-tensioned concrete structures where the design movement cannot be accommodated with elastomeric bearings.

Use the following movements for these bearings:

Shortening:

$$ES + LF1 * (CR + SH) + LF2(TF)$$

$$ES + LF1 * (CR + SH) + LF3(EQ)$$

Lengthening:

$$LF2 * (TR)$$

$$ES + LF1 * (CR + SH) + LF3(EQ)$$

Where:

ES = elastic shortening movement

CR = creep movement $CR = (ES) * (CF)$

SH = shrinkage movement

TF = temperature fall movement

TR = temperature rise movement

CF = creep factor

EQ = Maximum design earthquake displacement (movable bearings)

$LF_1$ = from *LRFD 3.4.1*

$LF_2$= TU, Load Factor from *LRFD Table 3.4.1-1*

$LF_3$= Load Factor from *LRFD Table 3.4.1-1*

Use proper signs and the Service Limit State Load Factor that produces the largest movement in each load combination.

Use a creep factor of 1.5 for both prestressed and post-tensioned concrete structures. Calculate shrinkage movement using 0.0004 times the total length of the structure.

For prestressed concrete structures 40 percent of this movement takes place within the first thirty days after manufacture. Therefore, the amount of creep and shrinkage movement for these structures, after placement, can normally be taken as 60 percent of the total.

For post-tensioned concrete, detail the initial position of expansion bearings so that the bearing will behave satisfactorily after the design movement has taken place. See *Figure 1.14.1.3-1*.

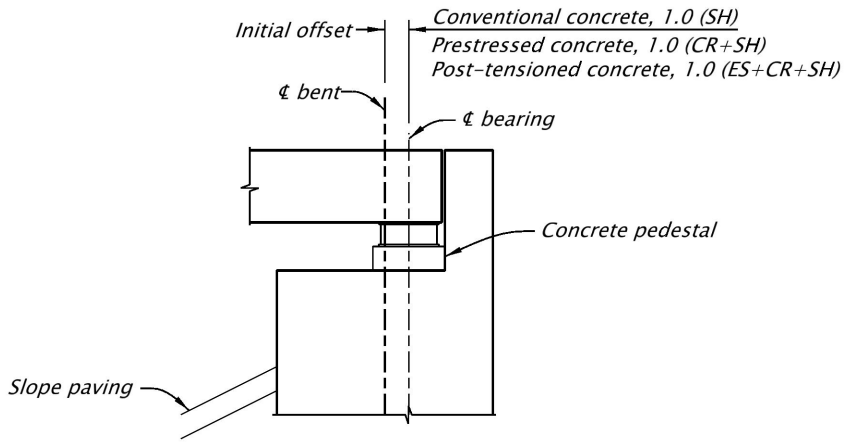
For shortening of post-tensioned, cast-in-place concrete bridges compare the design values with the field measured values in *BDM 1.5.8.1* and use the more conservative values.

Values for shortening of post-tensioned, cast-in-place concrete bridges have been determined by field measurements by ODOT Bridge Section.

For precast/prestressed concrete girders, set ES equal to zero for the movement calculation.

For precast/prestressed concrete girders elastic shortening occurs immediately after transfer of prestress during girder manufacturing at the precast producer plant.

Figure 1.14.1.3-1 Initial Bearing Position to Accommodate Design Movement



Verify the shop drawings, specified test results, and certifications comply with *SP 00582*.

Approved bearings are listed in the *Qualified Products List*.

## SCHEMATIC DRAWING

Include in the contract plans a schematic drawing of the bearing showing the method of attachment of the upper and lower units to the superstructure and substructures, respectively.

## C SCHEMATIC DRAWING

See *Figure 1.14.1.3-2* for an example.

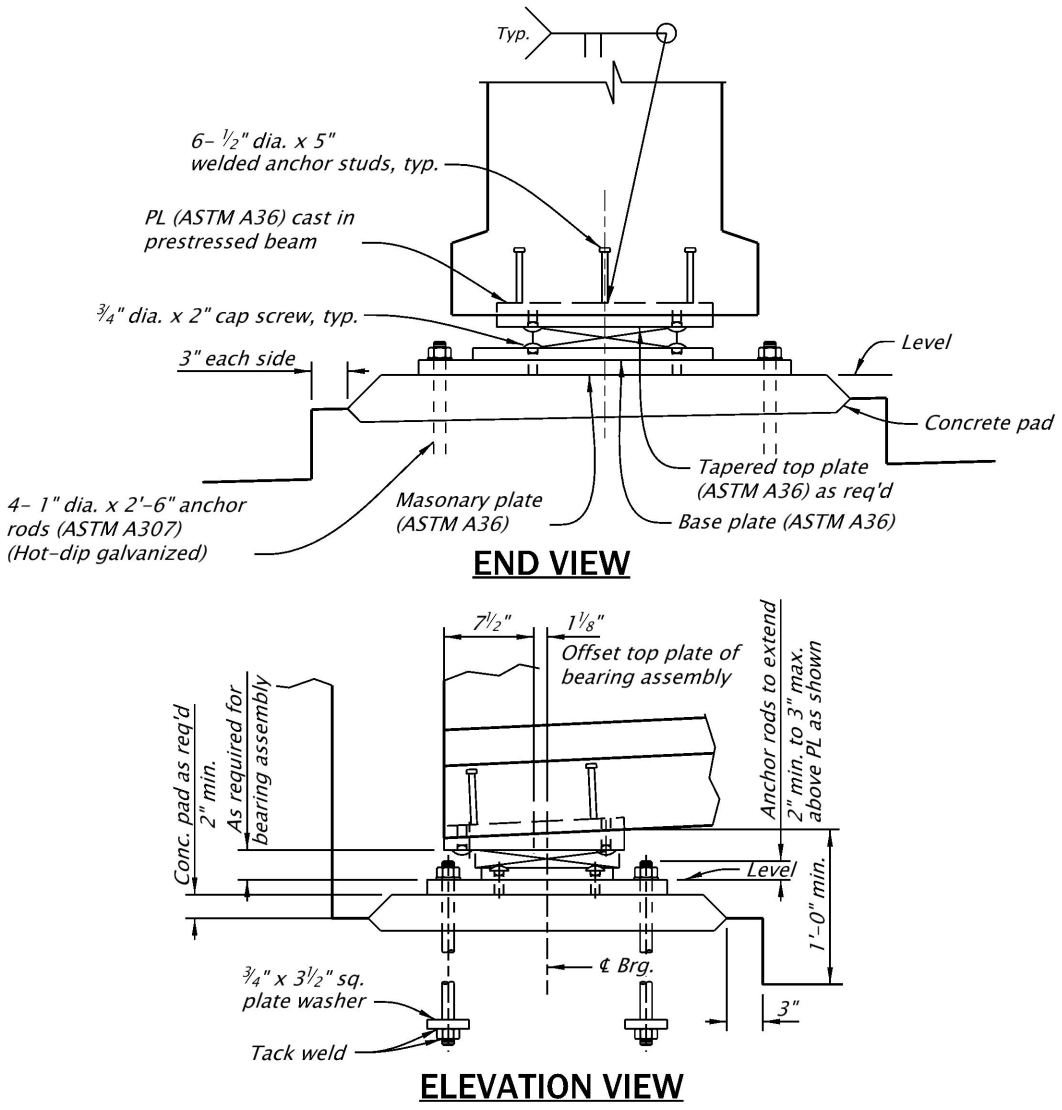
## DESIGN NOTES

In the contract plans, list design notes for:

- Required clearance to edge of concrete support.
- Maximum allowable concrete bearing stress.
- Minimum rotational capacity of bearing (not less than 0.015 radian).
- Any restriction as to type of bearing (e.g. pot, disc or spherical).
- Reference to bearing schedule for load and movement capacity.
- Reference to *Standard Specifications* for painting.
- Reference to the *Qualified Products List* for approved bearings.

## C DESIGN NOTES

Figure 1.14.1.3-2 Example Schematic of Bearing Showing Attachment




Paint all exposed surfaces of the bearing devices except teflon, stainless steel, machine finished or polished bearing surfaces, according to *SP 00594*. Provide a primer coat only for portions to be in contact with concrete and for steel-to-steel contact surfaces.

## 1.14.1.4 Guided Bearing

## C 1.14.1.4

Design each guided bearing to resist the entire horizontal load at any one bent. Use no more than two guided bearings per bent or hinge.

Where more than two guided bearings are required, use non-guided bearings and provide devices independent of the bearings to resist horizontal loads.

Ensure the top bearing plate dimensions are adequate to compensate for the initial bearing offset shown.

Provide additional bolted plates with the top and bottom plates of the bearing assembly to facilitate removal of bearing for repair or replacement and to provide a level surface for the bearing unit.

## 1.14.1.5 Seismic Isolation Bearing

## C 1.14.1.5

Design Seismic Isolation Bearings according to the *4th Edition of AASHTO Guide Specifications for Seismic Isolation Design*.

Provide the envelope for allowable bearing size and the design stiffness or hysteresis loop on the plans.

Refer to *BDM 1.17.7* for design scenarios that justify the use of seismic isolation bearings on new bridges or seismic retrofits.

## 1.14.1.6 Bearing Replacement

Develop one feasible construction method for bearing replacement and show it on the plans. Coordinate the construction method with the overall project construction sequence and structural constraints. Detail or depict on the plans all structural strengthening measures required by the method when applicable. Indicate which elements are to be constructed as shown on the plans and which are to be designed by the contractor. Include analysis of the method and applicable structural capacity checks in the calculation book.

### STRUCTURAL ANALYSIS AND FEASIBILITY VERIFICATION

Perform a global and local structural analysis to evaluate necessary design limit states to verify the adequacy of all affected structural elements and stability of the structure during the bearing replacement and for in-service conditions.

Account for unequal loading scenarios, especially in skewed or complex pier configurations.

Assess the capacity of pier crossbeams subjected to temporary loads.

## C 1.14.1.6

### C STRUCTURAL ANALAYSIS AND FEASIBLITY VERIFICATION

Refer to *BDM 1.3.4* for information on temporary loading, *BDM 1.2.6.1.6* for inspection and maintenance considerations, and *BDM 1.16.3.3* for information on falsework.

For instance, global analysis would include overturning check for the bridge substructure. Local analysis would include crossbeam capacity checks. These examples are provided for specific cases. However, for each situation different checks may be needed, such as stability of the proposed temporary structural system, capacity on relevant structural elements, etc.

Temporary loads refer to the loads applied during the bearing replacement process, which may differ significantly from the structure's normal operational conditions. These include jacking forces, load redistribution (temporary shifts in load paths due to bearing removal and

replacement), construction equipment loads (additional forces from cranes, scaffolding, or other temporary structures), wind and seismic loads, traffic loads (if the bridge remains partially open, live loads from traffic need to be factored in). Permanent loads refer to the forces acting on the structure in its final state after the new bearing is installed.

## JACKING AND TEMPORARY SUPPORT DESIGN

## C JACKING AND TEMPORARY SUPPORT DESIGN

When a bent is accessible (e.g. close to the ground, away from traffic), consider a falsework jacking bent that is supported by its own footing.

Provide provisions for jacking from a bent that is not easily accessible as follows:

- When a space is available and adequate, locate the jacking location on the existing crossbeam.
- When the space on the existing crossbeam is limited, show the jacking location on a support extended from the existing crossbeam. Design concrete anchoring for the support extension and provide details on the plan including drilled hole depth and locations in the existing crossbeam. Show an acceptable limit of jacking locations on the support extension. Indicate that the support extension details are conceptual. The contractor's engineer is responsible for the design of the temporary support extension.

Designers are responsible for locating drilled holes in the existing crossbeam. This is to avoid conflict between the existing reinforcing bars and the required anchor locations. Investigating the as-constructed plans along with a site visit required by *BDM 1.2.3.1* should result in good detailing that can minimize issues during the construction. However, unexpected situations can occur, such as hole drilling encounters reinforcing bars in the existing crossbeam, a drilled hole adjustment plan should be provided by permitting drilled hole relocation up to a certain distance as allowed by the as-constructed details.

Verify the structural capacity of all affected elements, ensuring they can support jacking forces at the assumed location and load redistribution. Strengthening of crossbeams or other structural elements may be required.

Consider differential movement and settlement effects due to loading through temporary support locations.

## PLANS AND SPECIFICATIONS

Show the following details in the plans:

- Conceptual construction sequence and details.
- Jacking location.
- Temporary support details.
- Notes regarding structural verification that are the contractor's responsibility.
- Conceptual extension support, if applicable.
- Structural strengthening, if applicable.

Include specific requirements in the project special provisions for the conceptual details shown in the plans.

Indicate in *SP 00255* that the required global and local structural analysis to verify the adequacy of all affected structural elements and structural system need to be performed if the contractor uses a different bearing replacement method and sequence.

## C PLANS AND SPECIFICATIONS

For most projects, the conceptual details with notes shown in the plans are adequate.

# 1.14.1.7 Reinforced Concrete Bearing Seats

# C 1.14.1.7

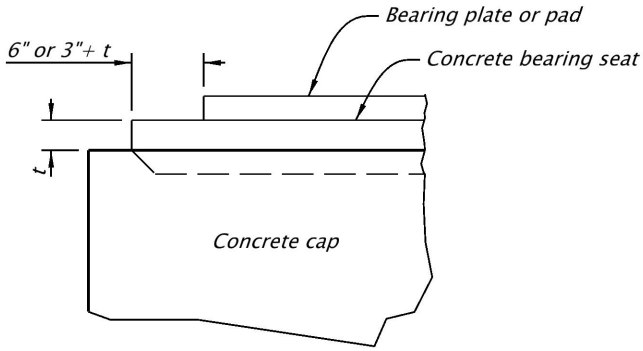
## CLEARANCE

Provide 6 inches, or 3 inches plus the thickness of grout under the bearing, whichever is greater, for the minimum horizontal clearance from the edge of a bearing plate, or 1 inch and thicker elastomeric bearing pad, to the edge of a concrete bearing seat. See *Figure 1.14.1.7-1*.

Where the bearing is skewed with the bent, this dimension may be reduced at the corner of the pad.

Locate anchor rods a minimum of 6 inches clear of the nearest face of concrete.

Figure 1.14.1.7-1 Concrete Bearing Seat Clearance




## C CLEARANCE

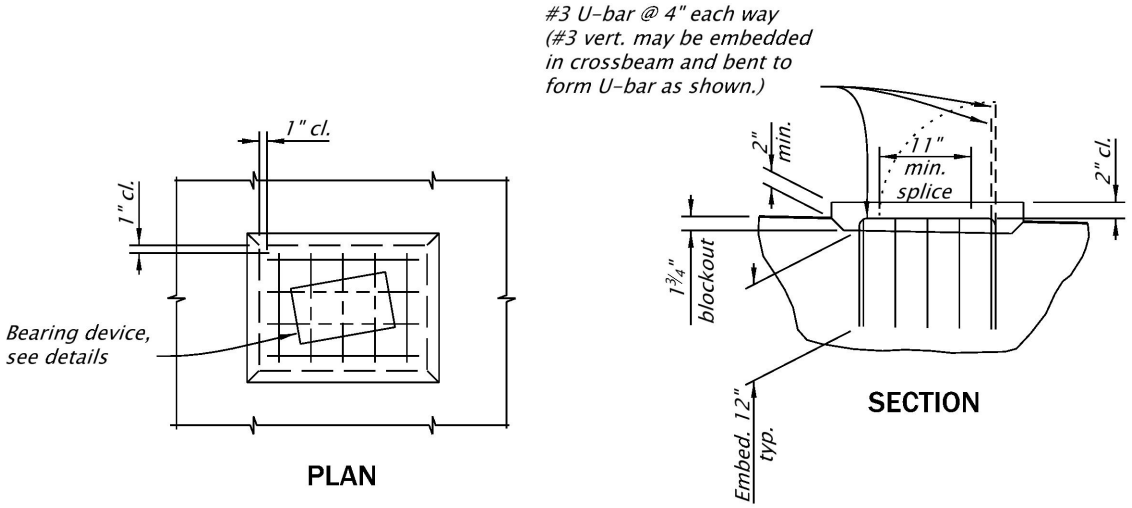
## ADDITIONAL REINFORCEMENT

Detail a reinforced concrete bearing seat under the bearings of all prefabricated beams, except precast slabs and box beams less than or equal to 70 feet in length.

## C ADDITIONAL REINFORCEMENT

Certain bearings may require no concrete buildup but have the bearing surface ground to grade.

Figure 1.14.1.7-2 Typical Reinforced Concrete Bearing Seat Details

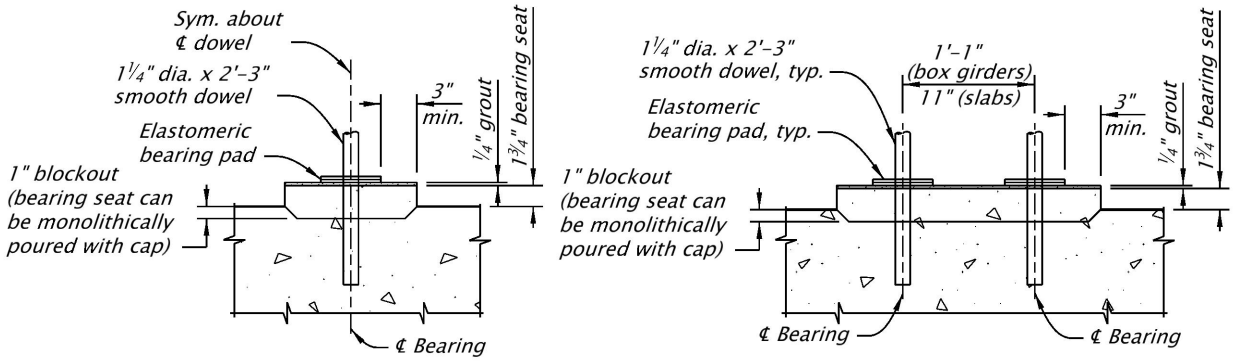


# 1.14.1.8 Unreinforced Bearing Seats (Prestressed Slabs and Boxes)

C1.14.1.8

For prestressed slabs and boxes, provide bearing details as shown in *Figure 1.14.1.8-1*.

Figure 1.14.1.8-1 Unreinforced Bearing Seat Details




*NOTE:*
*Allow bearing seat concrete to cure for three days or until concrete obtains design strength. Place ¼"grout layer on concrete bearing seat. Place elastomeric bearing pads and preformed expansion joint filler on grout layer. Place slab or box girder on bearing pads before the grout layer is fully set to ensure uniform bearing across full width. If uniform bearing is not achieved, lift slab or box girder and repeat the procedure. Remove any excess grout protruding above the bearing pads immediately after placing slab or box girder.*

## 1.14.1.9 Bearing Schedule

## C 1.14.1.9

Include the following items in the bearing schedule:

- Location of bearing (bent number).
- Number of bearings required (number per bent).
- Bearing fixity (fixed, guided or non-guided).
- Unfactored vertical dead load (load/bearing).
- Unfactored vertical live load (load/bearing)
- Factored test loads = Test Loads 1.5 x (DL+LL)

Factored test load according to *Section 02571.30 Short-Duration Compression Test*. If this load exceeds 1000 kips, contact the Structural Materials Engineer to coordinate testing and discuss special provision preparation, as it exceeds testing capabilities of most laboratories.

- Vertical design capacity (dead load + live load + impact, load/bearing).
- Horizontal design capacity of fixed and guided bearings (not less than 10 percent of the vertical design capacity).

Example bearing schedules are shown in *Figure 1.14.1.9-1* for elastomeric bearing pads and *Figure 1.14.1.9-2* for guided elastomeric bearings.

Figure 1.14.1.9-1 Bearing Schedule for Elastomeric Bearing

| BEARING SCHEDULE | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BENT | NUMBER REQUIRED | TYPE | DESIGN LOAD CAPACITIES IN KIPS PER BEARING | | | INITIAL OFFSET | CALCULATED MOVEMENTS | | | MOVEMENT PER 10° F TEMP. CHANGE | MINIMUM MOVEMENT CAPACITY FROM INITIAL POSITION | | | BEARING TESTING TABLE |
| | | | Vertical | Lateral | Longit. | | 30° Temp. Rise | 40° Temp. Fall | Creep, Shrinkage & Elastic Shortening | | Temp. Rise Direction | Temp. Fall Direction | Total | *Factored Test Loads 1.5∗(DL+LL)(kips)* |
| *1 & 5* | *4* | *Guided* | *1000* | **600* | *---* | *3"* | *⅞"* | *1¼"* | *4½"* | *5/16"* | *1½"* | *7½"* | *9"* | *1125* |

**Reduce design load to 200 kips for PTFE surface only.*

Figure 1.14.1.9-2 Bearing Schedule for Guided Elastomeric Bearings

| BEARING SCHEDULE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BENT | NUMBER REQUIRED | DESIGN LOAD CAPACITIES IN KIPS PER BEARING | | | TAPERED DISTRIBUTION PLATE | | DESIGN LOADS – SERVICE 1 LIMIT STATE (kips) | | BEARING TESTING TABLE |
| | | Nominal Thickness, t | Loaded Height (DL) | Diameter, D | Bk. Sta. tBK | Ah. Sta., tAH | Dead Load | Live Load (w/o impact) | *Factored Test Loads 1.5∗(DL+LL)(kips)* |
| *1* | *4* | *3.448"* | *3.418"* | *18"* | *1.06"* | *1.94"* | *168* | *105* | *409.5* |
| *2* | *A* | *4.598"* | *4.547"* | *22"* | *1.08"* | *1.92"* | *436* | *174* | *915* |
| | *B* | | | | *1.11"* | *1.89"* | | | |
| | *C* | | | | *1.14"* | *1.86"* | | | |
| | *D* | | | | *1.16"* | *1.84"* | | | |

## 1.14.1.10 Bearing Anchor Rods

Material for anchor rods should conform to ASTM F1554, and should be either threaded (with nuts) or swedged on the embedded portion of the rod. Specify the design yield strength of this material as 36 ksi, 55 ksi, or 105 ksi, depending on the design. Identify the yield strength in the specifications or on the plans.

Anchor rods, if used, should be investigated for the combined effects of shear and bending. A shear plate may be incorporated into the design to reduce the bending effects in the anchor rods.

## C 1.14.1.10

The nature of this type of bearing requires that the anchorage forces be passed through a plane that is above the bridge seat. If bending forces in the anchor rods are large, then shear blocks should be added (see *g-9.1-2022 Steel Bridge Bearing Guidelines "E" Drawings in Article 2.10*).

# 1.14.2 Expansion Joints

## 1.14.2.1 Definitions

Expansion Joint definitions are in *SP 00585* and are expanded up on in the commentary.

## C 1.14.2.1

Armored Joint - Steel armoring to protect the vertical edges of a joint opening. The armor may be steel shapes.

Asphaltic Plug Joint (APJ) Systems - A closed expansion and contraction joint system composed of aggregate and flexible binder material placed over a steel bridging plate.

Closed Expansion Joint - A joint with seal material placed to prevent water or debris from entering the joint. Includes poured joint seals, compression joint seals, asphaltic plug joint systems, preformed strip seals, and modular bridge joint systems.

Control Joint - A joint created by sawing a groove in a surface and filling it with a poured material, creating a weakened vertical plane that controls the location of cracking developed due to restraint stresses.

Filled Joint - A filled joint using a preformed joint filler placed prior to the concrete pour. Hot applied joint sealant is placed on top of the joint filler.

Hot Applied Joint Sealant - A hot-poured asphaltic material used for sealing cracks and joints from water penetration to prolong pavement and joint life.

Modular Bridge Joint Systems (MBJS) - A closed expansion and contraction joint using a series of continuous preformed strip seals inserted into steel shapes to seal the joint.

Poured Joint Seal - A closed expansion and contraction joint sealed with a rapid-cure poured joint sealant (2 part silicone).

Precompressed Foam Silicone Joint (PFSJ) Seal - A closed expansion and contraction

joint system consisting of a preformed, pre-compressed, silicone-coated, self-expanding foam joint system bonded to joint faces using epoxy adhesive.

Preformed Compression Joint Seal - A closed expansion and contraction joint sealed with a continuous preformed elastomeric compression gland.

Preformed Joint Filler - A preformed expansion joint material having small extrusion and substantial recovery after release from compression.

Preformed Strip Seal System - A closed expansion and contraction joint using a continuous preformed elastomeric gland (strip seal) inserted into an extruded or formed steel retainer bar with steel anchors.

## 1.14.2.2 Design Considerations for Joint Seals and Systems

## C 1.14.2.2

Consider integral abutment or semi-integral abutment wherever criteria in *BDM 1.11.2.5* and *BDM 1.11.2.6* are met. Design expansion joints to provide for the effects of temperature, shrinkage and creep.

Use skew angle a minimum of ±5 degrees different from snow plow angle for all joints except asphaltic plug joints. Consider the effect of skew angles on future widening of the structure.

Normally the angle of attack of snowplows is skewed 30 degrees to the roadway alignment. Snowplow blades can fall into the joint where the skew angle of the joint matches the snowplow's angle, resulting in danger to the snowplow driver or traffic.

### STRIP SEAL SYSTEM

Use preformed single strip systems to seal deck joints with up to 4 inch range of movement (1½ inch minimum installation width). For joints of greater anticipated movement, use a modular bridge joint system.

### C

It is not recommended to use a modular bridge joint system solely to provide for possible seismic movements.

### PREFORMED COMPRESSION SEAL

C

Preformed compression seals can be specified for joints with a design movement of up to 1½ inches. Specify a seal size to ensure that the seal remains in compression throughout the service life.

### POURED JOINT SEAL

C

Poured joint seal can be specified for a design movement up to 1½ inches.

### ASPHALTIC PLUG JOINT SYSTEM

C

Asphaltic plug joint systems may be specified where following conditions are satisfied:

- Maximum range of design movement up to 1 ½ inches (total).
- Maximum bridge skew less than 45 degrees.
- Maximum lateral movement at joint ¼ inch.
- Maximum vertical movement at joint (uplift) ¼ inch.
- Maximum superelevation of 6 percent.

Do not use asphaltic plug joint systems under following conditions:

- Where traffic is accelerating or decelerating, such as intersection with traffic lights or stop signs.
- Bridge with a curved horizontal alignment.
- Longitudinal joint between two structures.

Asphaltic plug joints are suitable for joints between two pavements with asphalt concrete pavement.

Skid resistance of this joint diminishes with time and it may become a hazard to motorcyclist and bicyclists.

### PRECOMPRESSED FOAM SILICONE JOINT SEAL

C

Specify precompressed joint (PFSJ) seals only for joint rehabilitation. PFSJ seals can be specified for joints with a design movement up to 2 ½ inches. Limit a joint installation width smaller than 3 inches to ensure joint performance. Field verify the joint width. Specify factory-fabricated bends for inside corners at the gutter line. Field verify a bend angle required for the existing inside corner and show the bend angle on project plans.

This joint system can be field-spliced, which makes it suitable for staged construction and partial joint repair.

When joints cross sidewalk on a bridge, specify a PFSJ seal system that is suitable for pedestrian traffic and provide joint details according to *RD722*.

Splicing between bridge and pedestrian PFSJ seals are possible.

### FILLED JOINT

**C**

Use filled joints for short span bridges with pin end bent connection.

These joints are the least expensive joint and easy to repair.

### CONTROL JOINT

C

For rehabilitation projects, control joints can be used in continuous concrete bridge deck over intermediate bents when it is necessary to control cracking in a particular location. Use ½ inch sawcut width to accommodate hot applied joint sealant installation. The control joint may be specified for contraction movement up to ¼ inch.

Use a control joint to control the location of cracking at the end of bridge approach slab and in pavement over joints.

Check the *Qualified Products List* for the currently acceptable materials and joint systems.

### CONSTRUCTION JOINTS

**C**

Minimize the number of deck construction joints to avoid potential leaks through the deck.

It is often necessary to provide deck construction joints to avoid shrinkage or deflection cracking. See *BDM 1.6.2.15* for more information on joints on steel structures, and *BDM 1.11.2.5* and *1.11.2.6* for options to eliminate joints.

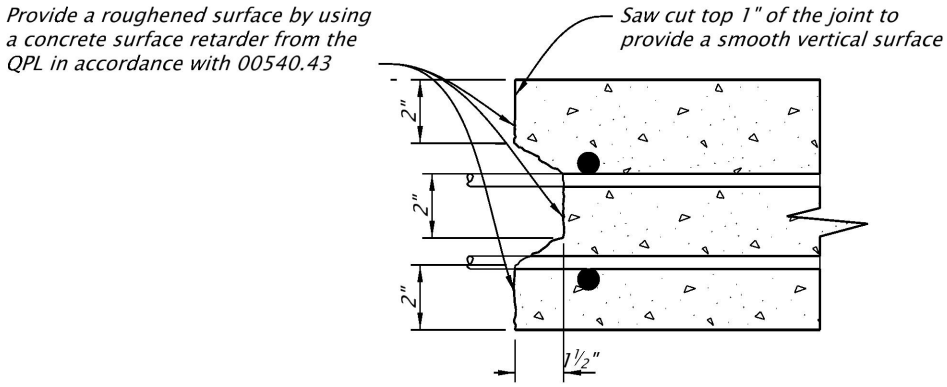
Normally for non-continuous spans, deck concrete placements are full length or stopped at a transverse beam. The

construction joint surface is normally vertical and roughened, according to *SP 00540.43(a)*, between placements.

Show construction joints with a roughened surface finish unless shear keys are required and shown on the plans. For continuous spans or for emergency situations, provide a shear key with a roughened surface between placements. Show typical key details on the plans as detailed in *Figure 1.14.2.2.1-1*.

Normally, shear keys at construction joints are unnecessary.

Figure 1.14.2.2.1-1 Shear Key Detail




## 1.14.2.3 Expansion Joint Setting

## C 1.14.2.3

Use a minimum change of joint width due to shrinkage of ¼ inch per 100 feet for the full length of non post-tensioned concrete segments (both pretensioned and conventional).

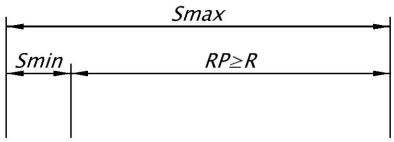
Use a minimum change of joint width due to creep and shrinkage of ½ inch per 100 feet for the contributing length of post-tensioned segments.

Use the following equations for calculating thermal effects:

Steel Girder Superstructure: $R = LF * (TR + TF)$

Concrete Superstructure: $R = LF * (TR + TF) + LF * (CR + SH)$

Figure 1.14.2.3-1 Calculation of Thermal Effects




Where:

$Smin$ = Minimum serviceable seal width

$Smax$ = Maximum serviceable seal width

R = Required seal range

RP = Provided seal range $(Smax - Smin)$

CR = Creep movement $CR = (ES) * (CF)$

SH = Shrinkage movement

TF = Temperature fall movement

TR = Temperature rise movement

ES = Elastic shortening

CF = Creep factor

LF = Load Factor from *LRFD Table 3.4.1-1* and *LRFD 3.4.1*

Use the Strength Limit State Load Factor that produces the largest movement in each load combinations.

For the compression seals shown on *BR140*, always limit shear deformation of the seal to 10 degrees.

For the compression seals shown on Drawing *BR140* $Smin$ and $Smax$ are the width of the seal under a compressive force of 50 and 10 pounds per inch, respectively. In skewed joints, $Smin$ and $Smax$ may be limited by the allowable shear deformation of the seal.

Table 1.14.2.3-1 Creep and Shrinkage Factors

| Thermal Effect | Conventional Concrete | Prestressed Concrete | P/T Concrete |
|---|---|---|---|
| Creep: Creep Factor | -- | 1.5 | 1.5 |
| Portion of Creep to use | -- | 50 percent | 70 percent |
| Shrinkage: ultimate | 0.0004 | 0.0004 | 0.0004 |
| Portion of Shrinkage to use | 60 percent | 60 percent | 60 percent |

### JOINT SETTING AT MEAN TEMPERATURE

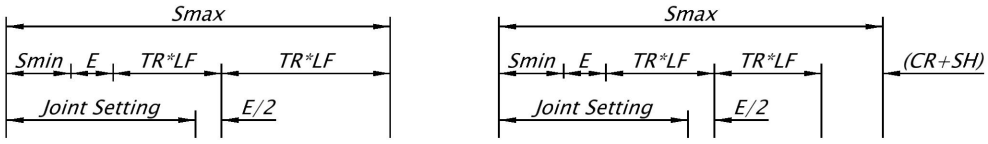
Equally distribute this excess [$\boldsymbol{E = RP - R}$] for expansion and contraction.

### C

In most cases, the range of serviceable seal width provided by a standard joint seal (RP) will be somewhat larger than the range required by design (R).

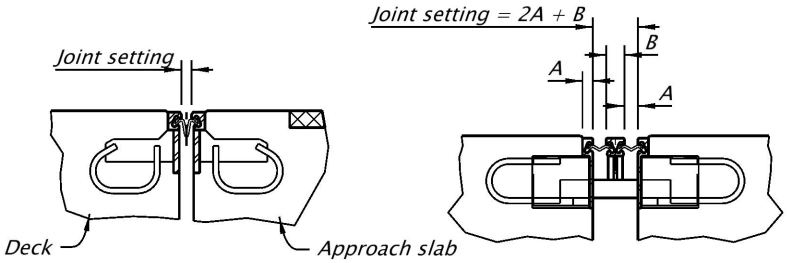
*Figures 1.14.2.3-2 and 1.14.2.3-3* show joint settings for the two design cases above.

Figure 1.14.2.3-2 Joint Setting Schematic




Use the form in *Figure 1.14.2.3-3* to call out joint settings on the plans.

Figure 1.14.2.3-3 Joint Setting Call-outs



Decrease Joint setting ___ inches for every 10$^0$F of structure temperature above ___$^0$F.

Increase joint setting ___ inches for every 10$^0$F of structure temperature below ___$^0$F.

## 1.14.2.4 Details for Expansion Joints

See *Standard Drawings BR139, BR140, BR141, BR145, BR157, DET3138 and DET3150* for joint details.

See *BDM 1.9.2.1.2* for reinforcing details.

For joints that span a pedestrian walkway, provide joint details according to standard drawings and details. Cover joint openings 3 inches or wider with a cover plate. Ensure that surfaces on the cover plate comply with ADA slip resistance and surface requirements.

For modular joints, detail the bottom of the rail section at the same depth as the bearing boxes, as noted as **Point F** on *DET3150*.

### 1.14.2.4.1 Expansion Joint Blockout

Show a blockout detail, similar to *Figure 1.14.2.4.1-1,* on the plans to allow the expansion joint assembly to be placed a period of time after the final deck pour.

Expansion joints are normally set after pretensioning is complete, so elastic shortening is not included in the joint setting width.

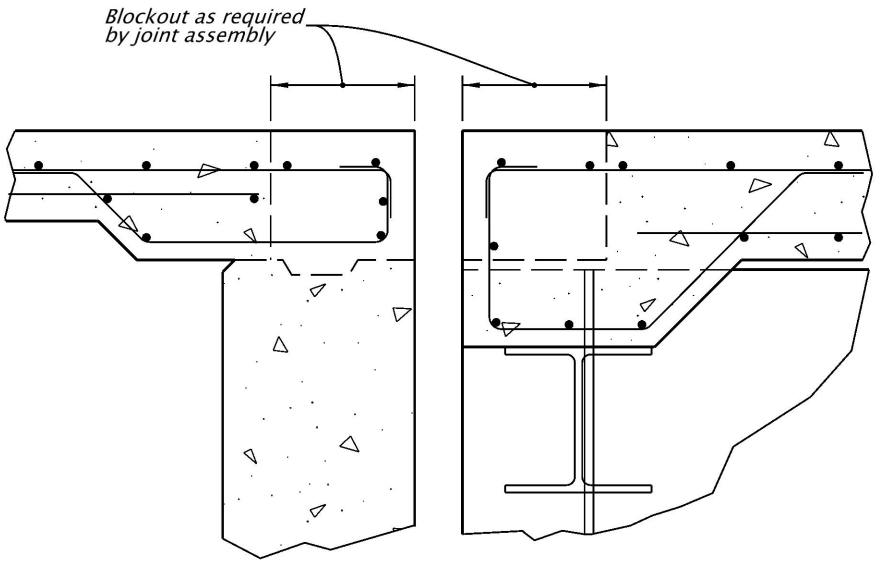
## C 1.14.2.4

Drawings *BR141, BR145 and DET3150* show the depth of metal to be 8 inches, with a plate being welded to the 2 inch deep rail section.

### C 1.14.2.4.1

Providing a blockout makes the adjacent deck pour easier, provides smoother deck transition to joint, and allows the majority of the superstructure shrinkage to occur prior to joint assembly placement.

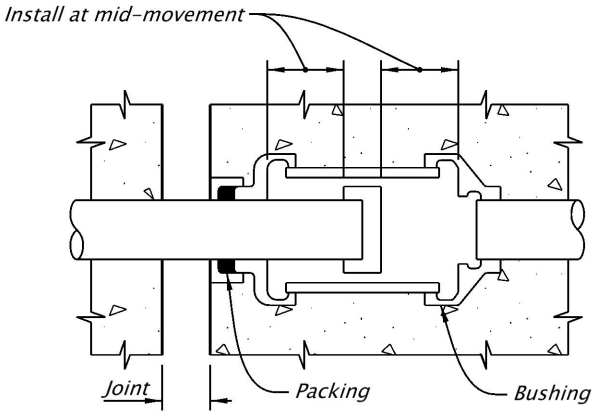
Figure 1.14.2.4.1-1 Expansion Joint Blockout Detail




## 1.14.2.4.2 Electrical Conduit Expansion Joint

At locations on the structure where an electrical conduit crosses an expansion joint show a detail similar to *Figure 1.14.2.4.2-1* on the plans.

Figure 1.14.2.4.2-1 Electrical Conduit Expansion Joint



## 1.14.2.5 Measurement and Payment of Joints

List joint types and estimated quantities of joints in *SP 00585*.

Filled joints do not need bid items.

Control joints shown on *BR165* are paid with paving work.

Hot applied joint sealant is paid with paving work except when replacement of hot applied joint sealant is specified for rehabilitation projects. Use *SP 00585* to add the hot applied joint sealant work to the list of bid items.

## C 1.14.2.5

The payment for filled joints is included in payment for constructing bridge elements next to the filled joints. Hot applied joint sealant in filled joints is also included.

This includes sawcutting and hot applied joint sealant. For rehabilitation projects, new control joints are sometimes specified. When the control joint is not included in payment for paving work, *SP 00585* has an option to list the new control joints as a bid item.