# INDIANA DEPARTMENT OF TRANSPORTATION

*Driving Indiana's Economic Growth*

## Design Memorandum No. 23-05

June 14, 2023

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| **TO:** | **All Design, Operations, and District Personnel, and Consultants** |
| **FROM:** | ***/s/ Stephanie Wagner***<br>**Stephanie Wagner**<br>**Director of Bridge Engineering** |
| **SUBJECT:** | **Standardized Elastomeric Bearings** |
| **REVISES:** | ***Indiana Design Manual* Section 409-7.03(03), 409-7.04, and Figures 409-7A thru 409-7E** |
| **EFFECTIVE:** | **Stage 3 submittals on or after September 1, 2023** |

IDM Figures 409-7A thru 7E have been updated to provide maximum DL + LL beam reactions and maximum tributary expansion lengths for the standardized elastomeric bearings shown in INDOT Standard Drawings series E 726-BEBP. The values shown in the tables have been revised for consistency with the requirements of AASHTO *LRFD Bridge Design Specifications*, 9th Edition (LRFD).

IDM Section 409-7.03 has been updated to remind designers that bearings located at expansion joints, even standard bearings, need to be checked for instantaneous live load deflection in accordance with LRFD.

Section 409-7.04 has been updated to highlight that, in accordance with LRFD, the least favorable shear modulus allowed by the *Standard Specifications* should be used in the design of elastomeric bearings. *SS* Section 915.04(b) specifies an allowable durometer of 55 + 5, which results in a shear modulus range of 0.095 ksi to 0.200 ksi per LRFD Table 14.7.6.2-1.

For questions related to this design memo, please contact the Bridge Engineering Division at Bridgedesignoffice@indot.in.gov

**IDM Revisions**

**Chapter 409**

### 409-7.03(03) Determining Standard Bearing-Device Type [Rev. May 2013, Aug. 2020, Jun. 2023]

The procedure for determining the applicable standard elastomeric bearing device is the same for each structural-member type.

Determine the dead-load plus live-load reaction, and calculate the maximum expansion length for the bridge at the support for which the device is located. Then enter Figure 409-7B, 409-7C, 409-7D, or 409-7E, Elastomeric Bearing Pad or Assembly Types, Properties, and Allowable Values, for the appropriate structural-member type, with the reaction and maximum expansion length. The required bearing-device size is that which corresponds to the reaction and expansion-length values shown in the figure which are less than or equal to those determined. If the reaction or expansion length is greater than the figure's value, use the next larger device size. If the reaction or expansion length is greater than the maximum value shown on the figure, the pad must be properly resized and designed. For bearings located at bridge expansion joints, or other locations where live load deflections may cause serviceability concerns, the compressive strain in the bearings due to instantaneous live load should be checked in accordance with *LRFD*. The maximum deflection at an expansion joint due to live load should be limited to 1/8 in., as suggested in the LRFD commentary.

*LRFD* C14.7.6.1 indicates that Method A, which is the design method used for the design of the standard bearing devices shown on the *Standard Drawings*, is based on a maximum rotation of 0.02 radians. Therefore, the standard bearing device design tables shouldn't be used if design rotations exceed 0.02 radians.

The requirement for a tapered plate shall be determined in accordance with *LRFD* 14.8.2. See Figure 409-7F for a typical elastomeric bearing pad with tapered steel plate. In order to minimize the number of bearings that are required to be randomly tested on a contract, load plates which are required to be vulcanized to the pads should be of a consistent size and thickness whenever feasible. Variations in taper rates should be accommodated by using tapered shims between the load plate and bottom flange on steel superstructure bridges, and tapered load plates on prestressed beam superstructure bridges. Plates should not be tapered when the calculated difference in thickness between the parallel edges is less than 1/8 in. Stainless steel should be considered only when located beneath an expansion joint. When a stainless steel tapered plate is specified, the steel plate cast with the beam, steel stud, and welds must also be specified as stainless steel.

**409-7.04 Nonstandardized Elastomeric Bearing Device [Rev. Aug. 2020], Jun. 2023]**

The design should be based on *LRFD* 14.7.6, Method A whenever the requirements of *LRFD* 14.7.6.1 and C14.7.6.1 are satisfied. Method B should only be used where project specific parameters preclude the use of Method A.

Each pad or assembly shall be sized according to the load capacities and expansion lengths that it can accommodate.

An elastomeric bearing device not shown on the INDOT *Standard Drawings* may be used if its parameters check, or its design is in accordance with *LRFD* 14.7.6. *LRFD* defines certain limitations in terms of allowable stresses, movements, or minimum dimensions. These limitations are as follows.

1. Shear Modulus. See *LRFD* 14.7.6.2. The design of an elastomeric bearing pad shall include, but shall not be limited to, the consideration of increased *G* at a temperature below 73 °F; see *LRFD* 14.6.3.1. The shear modulus used for design should be based on the durometer range allowed per the *Standard Specifications*, and the least favorable values should be used for each applicable design check.

2. Design Shear Force. The elastomer with the lowest temperature tolerance shall be used. The total elastomer thickness shall be sufficient to resist twice the design shear force.

3. Relationship of Device Dimensions. Both the width and the length of the device shall be at least three times the total thickness of the pad. For a circular pad, the diameter of the pad shall be at least four times the total thickness of the pad.

4. Stress Due to Dead Load Plus Live Load without Impact. This stress shall be less than or equal to the lesser of 1.25 ksi or 1.25$GS$.

5. Rotational Deflection. Sufficient pad thickness or a tapered plate/shim shall be provided to prevent a liftoff condition on the leading edges of the device. Tapered plates should not be used where the calculated difference in thickness between parallel edges is less than 1/8 in. *LRFD* C14.7.6.1 indicates that Method A is based on a maximum rotation of 0.02 radians. If service rotations exceed this limit, Method B should be used for design.

6. Anchorage. The pad or assembly shall be secured against seismic or other extreme-event resistant anchorage to defy the horizontal movement in excess of that accommodated by shear in the pad, unless it is intended to act as a fuse as required by *LRFD* 14.7.6.3.8.

The calculations are performed in the Strength-Limit state. The load modifiers for ductility (*LRFD* 1.3.3), redundancy (*LRFD* 1.3.4), and importance (*LRFD* 1.3.5) must be accounted for.

**<u>IDM Figures</u>**

Figures 409-7A thru 409-7E were revised

| Bearing Type | Load | | Translation | | Rotation | Costs | |
|---|---|---|---|---|---|---|---|
| | Min. (kip) | Max. (kip) | Min. (in.) | Max. (in.) | Limit (rad) | Initial | Maint. |
| Elastomeric Pad | | | | | | | |
| Plain (PEP) | 0 | 100 | 0 | 0.5 | 0.010 | Low | Low |
| Cotton Duck (CDP) | 0 | 315 | 0 | 0.25 | 0.003 | Low | Low |
| Fiberglass (FGP) | 0 | 135 | 0 | 1 | 0.015 | Low | Low |
| Steel Reinforced Elastomeric | 50 | 1007 | 0 | 4 | 0.04 * | Low | Low |
| Flat Polytetrafluoroethylene (PTFE) Slider | 0 | > 2250 | 1 | > 4 | 0 | Low | Moderate |
| Curved Sliding Cylindrical | 0 | 1575 | 0 | 0 | > 0.04 | Moderate | Moderate |
| Pot | 270 | 2250 | 0 | 0 | 0.02 | Moderate | High |
| Rocker | 0 | 405 | 0 | 4 | > 0.04 | Moderate | High |
| Single Roller | 0 | 100 | 1 | > 4 | > 0.04 | Moderate | High |
| Curved PTFE | 270 | 1575 | 0 | 0 | > 0.04 | High | Moderate |
| Multiple Rollers | 112 | 2250 | 4 | > 4 | > 0.04 | High | High |

* Elastomeric bearings designed using LRFD Method A are limited to 0.02 radians.

**SUMMARY OF EXPANSION-BEARING CAPABILITIES**

**Figure 409-7A**
**[Rev. Jun. 2023]**

| Maximum $DL + LL$ Reaction, (kip) | Maximum Expansion Length, (ft) | Bearing-Pad Type | $W$ (in.) | $L$ (in.) | Area (in.$^2$) | Shape Factor, $S$ | $h_{rt}$ (in.) | Number of Internal Elastomeric Layers, $n$ | Allowable Compressive Stress, $\sigma_{TL}$ (psi) |
|---|---|---|---|---|---|---|---|---|---|
| 100 | 195 | **1** | 14 | 10.5 | 147 | 6.00 | 2.0625 | 3 | 710 |
| 120 | 245 | **2** | 14 | 11.5 | 161 | 6.31 | 2.5625 | 4 | 750 |
| 160 | 245 | **3** | 18 | 11 | 198 | 6.83 | 2.5625 | 4 | 810 |
| 270 | 295 | **4** | 24 | 12 | 288 | 8.00 | 3.0625 | 5 | 950 |

*Note: For bearings located at bridge expansion joints, or other locations where live load deflections may cause serviceability concerns, the compressive strain in the bearings under instantaneous live load should be checked in accordance with LRFD.*

**ELASTOMERIC BEARING PAD TYPES, PROPERTIES, AND ALLOWABLE VALUES FOR AASHTO I-BEAMS**

**Figure 409-7B**
**[Rev. Jun. 2023]**

| Maximum $DL + LL$ Reaction, (kip) | Maximum Expansion Length, (ft) | Bearing-Pad Type | $W$ (in.) | $L$ (in.) | Area (in.$^2$) | Shape Factor, $S$ | $h_{rt}$ (in.) | Number of Internal Elastomeric Layers, $n$ | Allowable Compressive Stress, $\sigma_{TL}$ (psi) |
|---|---|---|---|---|---|---|---|---|---|
| 210 | 245 | **5A** | 22 | 11 | 242 | 7.33 | 2.5625 | 4 | 870 |
| 100 | 245 | **5B** | 12 | 12 | 144 | 6.00 | 2.5625 | 4 | 710 |
| 175 | 245 | **6A** | 22 | 10 | 220 | 6.88 | 2.5625 | 4 | 815 |
| 85 | 245 | **6B** | 12 | 11 | 132 | 5.74 | 2.5625 | 4 | 680 |
| 150 | 195 | **7A** | 22 | 9 | 198 | 6.39 | 2.0625 | 3 | 760 |
| 75 | 195 | **7B** | 12 | 10 | 120 | 5.45 | 2.0625 | 3 | 645 |

*Note: For bearings located at bridge expansion joints, or other locations where live load deflections may cause serviceability concerns, the compressive strain in the bearings under instantaneous live load should be checked in accordance with LRFD.*

**ELASTOMERIC BEARING PAD TYPES, PROPERTIES, AND ALLOWABLE VALUES FOR BOX BEAMS**

**Figure 409-7C**
**[Rev. Jun. 2023]**

| Maximum $DL + LL$ Reaction, (kip) | Maximum Expansion Length, (ft) | Bearing-Pad Type | $W$ (in.) | $L$ (in.) | Area (in.$^2$) | Shape Factor, $S$ | $h_{rt}$ (in.) | Number of Internal Elastomeric Layers, $n$ | Allowable Compressive Stress, $\sigma_{TL}$ (psi) |
|---|---|---|---|---|---|---|---|---|---|
| 255 | 295 | **T1** | 23 | 12 | 276 | 7.89 | 3.0625 | 5 | 935 |
| 330 | 340 | **T2** | 23 | 14 | 322 | 8.70 | 3.5625 | 6 | 1035 |
| 380 | 460 | **T3** | 23 | 17 | 391 | 8.23 | 4.7812 | 7 | 975 |
| 480 | 515 | **T4** | 24 | 19 | 456 | 8.93 | 5.3750 | 8 | 1060 |
| 460 | 295 | **TH1** | 36 | 12 | 432 | 9.00 | 3.0625 | 5 | 1070 |
| 600 | 340 | **TH2** | 36 | 14 | 504 | 10.88 | 3.5625 | 6 | 1195 |
| 705 | 460 | **TH3** | 36 | 17 | 612 | 9.72 | 4.7812 | 7 | 1155 |
| 850 | 515 | **TH4** | 36 | 19 | 684 | 10.47 | 5.3750 | 8 | 1240 |

*Notes: Bearing pads with T designation are for Indiana bulb-tee members. Bearing pads with TH designation are for hybrid bulb-tee members.*

*For bearings located at bridge expansion joints, or other locations where live load deflections may cause serviceability concerns, the compressive strain in the bearings under instantaneous live load should be checked in accordance with LRFD.*

**ELASTOMERIC BEARING PAD TYPES, PROPERTIES, AND ALLOWABLE VALUES FOR INDIANA BULB-TEE AND HYBRID BULB-TEE MEMBERS**

**Figure 409-7D**

**[Rev. Jun. 2023]**

| Maximum $DL + LL$ Reaction, (kip) | Maximum Expansion Length, (ft) | Bearing-Assembly Type | $W$ (in.) | $L$ (in.) | Area (in.$^2$) | Shape Factor, $S$ | $h_{rt}$ (in.) | Number of Internal Elastomeric Layers, $n$ | Allowable Compressive Stress, $\sigma_{TL}$ (psi) |
|---|---|---|---|---|---|---|---|---|---|
| 45 | 115 | **S1-a** | 11 | 8 | 88 | 4.63 | 1.5625 | 2 | 550 |
| 45 | 155 | **S1-b** | 11 | 8 | 88 | 4.63 | 2.0625 | 3 | 550 |
| 65 | 115 | **S2-a** | 12 | 9 | 108 | 5.14 | 1.5625 | 2 | 610 |
| 65 | 155 | **S2-b** | 12 | 9 | 108 | 5.14 | 2.0625 | 3 | 610 |
| 85 | 155 | **S3-a** | 13 | 10 | 130 | 5.65 | 2.0625 | 3 | 670 |
| 85 | 195 | **S3-b** | 13 | 10 | 130 | 5.65 | 2.5625 | 4 | 670 |
| 120 | 195 | **S4-a** | 15 | 11 | 165 | 6.35 | 2.5625 | 4 | 750 |
| 120 | 230 | **S4-b** | 15 | 11 | 165 | 6.35 | 3.0625 | 5 | 750 |
| 155 | 195 | **S5-a** | 16 | 12 | 192 | 6.86 | 2.5625 | 4 | 815 |
| 155 | 230 | **S5-b** | 16 | 12 | 192 | 6.86 | 3.0626 | 5 | 815 |
| 240 | 230 | **S6-a** | 20 | 13 | 260 | 7.88 | 3.0625 | 5 | 930 |
| 240 | 270 | **S6-b** | 20 | 13 | 260 | 7.88 | 3.5625 | 6 | 930 |
| 305 | 270 | **S7-a** | 20 | 15 | 300 | 8.57 | 3.5625 | 6 | 1015 |
| 305 | 310 | **S7-b** | 20 | 15 | 300 | 8.57 | 4.0625 | 7 | 1015 |

*Note: For bearings located at bridge expansion joints, or other locations where live load deflections may cause serviceability concerns, the compressive strain in the bearings under instantaneous live load should be checked in accordance with LRFD.*

**ELASTOMERIC BEARING ASSEMBLY TYPES, PROPERTIES, AND ALLOWABLE VALUES FOR STRUCTURAL-STEEL MEMBERS**

**Figure 409-7E**

**[Rev. Jun. 2023]**