

## **DESIGN GUIDELINES FOR ELASTOMERIC BEARINGS**

Elastomeric bearings shall consist of either plain elastomeric pads or steel-reinforced laminated pads.

The bearings may be designed by either Method A (Article 14.7.6) or Method B (Article 14.7.5) of the AASHTO LRFD Bridge Design Specifications.

Method A is the required design procedure for plain elastomeric pads.

Method B is the preferred method of design for steel-reinforced laminated pads.

In Idaho two grades of elastomer are used: Grade 3 in moderate temperature zones and Grade 4 in cold temperature zones. Grade 4 elastomer should be specified when the bridge is located in AASHTO low temperature Zone D, if Grade 3 is used in Zone D the other components of the bridge must be designed to resist 1.5 times the shear force determined by Article 14.6.3.1 when a low friction sliding surface is used or 4 times this shear force for a non-sliding surface (see Article 14.7.5.2). Zone D for Idaho shall be defined as any area above an elevation of 3800 feet or any location in Bonner or Boundary County regardless of elevation. Grade 3 elastomer may be used in all other areas of the state. When Grade 4 elastomer is used it should be clearly noted in the plans to ensure that the correct testing is performed. In accordance with ITD standard specifications subsection 720.02 Grade 4 elastomer must be tested for low temperature shear modulus and compression stiffness (AASHTO M 251-06 section 8.9.1 & 8.9.2).

When designing by Method A the elastomeric material shall be specified by its hardness and grade. Most bearing designs for Method A should be based on 60 durometer elastomer, Grade 3. The shear modulus for 60 durometer elastomer shall be assumed to range from 130 psi to 200 psi, with the least favorable value being used for the particular design parameter being considered. Typically bearings designed by Method A are used for rotations only and not for horizontal displacement, therefore the provisions requiring increased shear forces on other components, as stated above, do not come into play and the use of Grade 3 in Zone D is acceptable in this case.

When designing by Method B the elastomeric material shall be specified by shear modulus and grade. The shear modulus should be specified as 130 psi with the design value increased or decreased by 15% whichever is the least favorable value for the particular parameter being considered. Grade 3 or 4 may be specified depending on the temperature zone. Live Load reactions for bearing design shall be based on the girder distribution factor for shear, Article 4.6.2.2.3.

In calculating the live load rotations the whole structure cross-section, acting as a unit, may be used with the same Truck and Lane load combinations presented in Article 3.6.1.3.2 for calculating deflections.

All loads and rotations used in bearing design shall be determined using the Service I limit state including dynamic load allowance (IM).

### **Bearing Design Criteria for Prestressed/Precast Concrete Girders**

For the purpose of simplification all girder reactions may be based on simple span analysis, even if the girders are made continuous for composite loads. However, the live load rotations may still be determined assuming continuous action.

The instantaneous compressive deflection (LL and IM only) shall be less than 1/8". The long term compressive deflection due to dead load including creep shall be limited to 3/16" (the value of 3/16" for the allowable long term compressive deflection is considered acceptable for smoothness of ride without restricting the design of the bearings unnecessarily).

For expansion bearings without a sliding surface shear deformation shall be determined from the combined effects of thermal, creep and shrinkage movements of the structure. The thermal movement shall be based on 65% of the total design thermal range (LRFD Article 3.12.3.1). A creep and shrinkage factor of 0.0003 may be used in lieu of a more precise calculation. For bearings with a stainless steel TFE sliding surface the shear deformation shall be determined from the shear force calculated by multiplying Dead Load reaction with the coefficient of friction for the appropriate bearing surface type in accordance with Table 14.7.2.5-1 of the LRFD specifications.

Combined compression, rotation and shear shall be checked by assuming Service I reactions are applied to the bearing in combination with Live Load rotation and initial lack of parallelism as defined below. Dead load rotation need not be included since the internal prestress force produces an end rotation that is at least as great as the dead load rotation and in the opposite direction, thereby canceling the effect of the dead load rotation.

Live Load Rotation – shall be taken as the rotation due to all design lanes on the structure being loaded in a manner that produces the maximum rotation and assuming the load is distributed to all girders equally. Dynamic load allowance shall be included. When combining compression and rotation the Live Load reaction may be either the maximum load or the load associated with the rotation.

Initial Lack of Parallelism – a rotation of 0.005 radians shall be assumed due to construction tolerances; this initial lack of parallelism includes the net difference between the dead load girder end rotation and the prestress end rotation. However this is not sufficient in many cases to include the effects of the roadway profile grade, consequently the beam seats of a precast concrete girder should be constructed on the same slope as the girder when the girder slope is less than or equal to 3%. (The slope of the girder is defined here as the difference in bearing seat elevations of the two girder ends divided by the length of the girder; this is not necessarily the same as the roadway grade.) When the girder slope is more than 3% the bearing pad should be placed level and a beveled sole plate should be embedded or attached to the bearing area of the girder.

## Bearing Design Criteria for Steel Girders

Compressive stress shall be determined from the combined Service I reactions as determined from the structural model used for the girder design.

The instantaneous compressive deflection (live load and impact only) shall be less than 1/8". The long term compressive deflection due to dead load including creep shall be limited to 3/16".

Shear deformation shall be determined based on 65% of the total design thermal range (LRFD Article 3.12.3.1). For bearings with a stainless steel TFE sliding surface the shear deformation shall be determined from the shear force calculated by multiplying Dead Load reaction with the coefficient of friction for the appropriate bearing surface type in accordance with Table 14.7.2.5-1 of the LRFD specifications.

Combined compression and rotation requirements shall be checked by assuming the Dead Load and Live Load reactions, as determined above, are applied to the bearing in combination with the Dead Load rotation (for non-cambered girders only), Live Load rotation and initial lack of parallelism as defined below:

Dead Load Rotations – need only be included for girders constructed of rolled sections that have not been cambered. Cambered girders should have no net dead load rotation.

Live Load Rotation – shall be taken as the rotation due to all design lanes on the structure being loaded in a manner that produces the maximum rotation and assuming the load is distributed to all girders equally. Dynamic load allowance shall be included.

Initial Lack of Parallelism – a rotation of 0.005 radians shall be assumed due to construction tolerances. However this is not sufficient in many cases to include the effects of the roadway profile grade. A beveled sole plate shall be used to compensate for grade. Consequently the bearing surfaces on the abutments and piers should be constructed level for steel structures.

## Bearing Details

Steel reinforced elastomeric bearings shall consist of alternating layers of a minimum of 14 gage A36 steel and neoprene bonded together. All internal layers of neoprene shall be of equal thickness, there is no limit on the maximum thickness of internal layers as there was in previous specifications provided all design criteria are met. However, the minimum thickness of internal layers should be 3/16" so that a minimum external layer does not violate the requirement to be no more than 70%

of the thickness of an internal layer (Article 14.7.5.1). Exterior layers shall have a minimum thickness of 1/8" to provide enough cover to protect the reinforcement.

Sole plates for steel girders (and in some cases concrete girders) shall be welded to the bottom flange to provide a level surface for the elastomeric pads to bear against. Sole plates shall be beveled to compensate for the longitudinal grade of the bridge. Sole plates shall be detailed with enough length (in the direction of the span) to accommodate construction tolerances.

### **Information for Required Testing**

All steel reinforced elastomeric bearings are to be tested in accordance with AASHTO M 251-06. In order to perform this test the maximum design load for each bearing size and type is required. Therefore the method (A or B) that was used in design, along with the maximum design load for each size and type of bearing, must be called out on the bearing detail sheet so that all the information for fabrication and testing is available in one place.

### **Commentary**

In most cases Method B will result in significantly smaller and thinner bearing pads and although it requires more rigorous testing it will result in a more practical sized bearing.

### **Revisions**

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| July 2009 | Revision to specify material by shear modulus for Method B and the definition of thermal movement to comply with 2008 interims.   |
| Feb 2012  | Revised to include references to AASHTO M 251-06 which was adopted as the acceptance criteria for elastomeric bearings. Also a couple of clarifications were added to make it clear that Grade 3 can be specified in Zone D when no horizontal movement is required and to limit the slope of the bearings on concrete girders to 3% before a beveled sole plate is required. |