New Jersey Turnpike Authority
PO Box 5042, Woodbridge, NJ 07095

Document Change Announcement

2007 Design Manual

DCA2014-DM-05

DATE: **December 3, 2014**

Subject: **Revisions to Section 2.2.4.3. of the Design Manual**

Description of Change

Design Manual language is to be changed to coincide with new Standard Drawings and Standard Specifications. Revisions are made to Subsections 2.2.4.3.1 and 2.2.4.3.2. Additional change is made to account for thermal movement of skewed and curved bridges.

Instructions to Designers and Consultants

Effective immediately, the revisions contained in this announcement shall be applied to all projects that have not reached Phase C of design. Contact your NJTA Project Manager for instructions. Attached revision is noted in italics.

Designers may access these revisions in the NJTA Design Manual, which is available on the Authority's Web Page: http://www.state.nj.us/turnpike/professional-services.html.

Information for In-House Staff

The revisions have been incorporated into the Design Manual, which is available on the S drive @ S:\Project Files\Design-Procedure Manual. Please distribute the information to your respective Project Managers and have them direct their consultants appropriately.

Approved By:

John M. Keller, P.E.
Acting Deputy Chief Engineer - Design

Robert J. Fischer, P.E.
Chief Engineer

cc: Senior Staff Engineering, Operations & Maintenance Departments, All Prequalified Consultant Firms, File

New Jersey Turnpike Authority

DOCUMENT UPDATE REQUEST

Forward to Chief Engineer

Initiator	David Mykulak	**Submittal Date**	10/7/14
Firm	HNTB Corporation	**Telephone**	856-536-3351

Document (check one)

☐ Procedures Manual
☒ Design Manual
☐ Sample Plans
☐ Standard Drawings
☐ Standard Specifications

Description of Change

Delete Section 2.2.4.3.1 and replace with the following:

1. Standard Drawings:

   Standard details have been created for Seismic Isolation Bearings, Laminated Elastomeric Bearings and High Load Multi Rotational (HLMR) Bearings and can be found on Standard Drawings Nos. BR-9 to BR-12.

The following is added after the first paragraph of Subsection 2.2.4.3.2:

Laminated Elastomeric Bearings shall be designed in accordance with Method B as outlined in the current edition of the AASHTO LRFD Bridge Design Specifications. Accordingly, the following sections of the AASHTO LRFD Specifications are revised as follows:

<u>Section 14.7.5.2</u>
Replace the first sentence of the second paragraph with the following:
"The elastomer shall have a specified shear modulus between 0.095and 0.150 ksi.

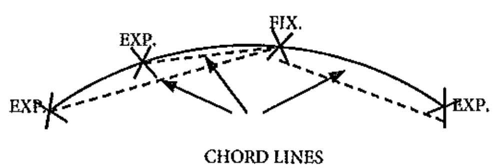
Replace the second bullet item in the third paragraph with the following: "Does not permit a shear modulus below .095 ksi.

The following is added after the fourth paragraph of Subsection 2.2.4.3.2:

For both High Load Multi Rotational (HLMR) Bearings and Seismic Isolation Bearings, the Contractor bears sole responsibility for the final design, detailing, and furnishing of the complete bearing assembly including the masonry plates, sole plates, anchor bolts, hardware, and bearing pads. It is the responsibility of the Designer to provide adequate information so that the bearing can be completely designed and detailed by the Contractor or Contractor's engineer. This shall be accomplished via furnishing of appropriate as-built documents as reference drawings, or by providing sufficient details in the Contract Plans. Additionally, the Designer shall provide all design loads (vertical and lateral), rotations, and movements or displacements required for the complete design and detailing of the bearing. Contract Plans shall consider the use of all Approved Manufacturers (a list of Approved Manufacturers for each bearing type can be found in the Standard Specifications). Coordination with the Approved Manufacturers verifying the suitability of their details for bearing fitment shall be obtained and documented.

Add the following to the end of Section 2.2.4.3

6. **Provisions for Thermal Movement:**
   Bearings for curved girder bridges shall be guided along the anticipated direction of movement of the curved structure, which will allow the bridge to expand and contract freely under thermal forces. Longitudinally guided expansion bearings shall be oriented along a chord that runs from the expansion bearing point to the fixed bearing point of the same girder line. The graphic below demonstrates the proper alignment for each girder line.



BEARING ORIENTATION OF A CURVED GIRDER LINE

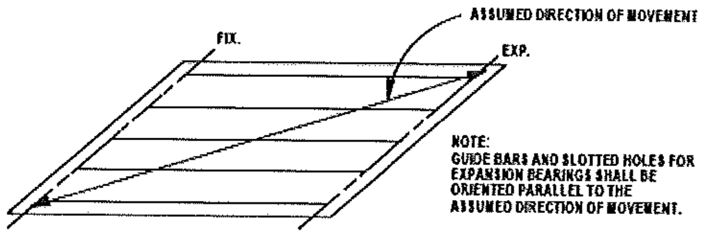
Bearings for skewed straight girder bridges shall be arranged in a manner that best maintains the alignment of the superstructure relative to the roadway centerline. Longitudinally guided expansion bearings for skewed straight girder bridges should permit movement along the direction of the girder centerline. The designer shall consider using as few fixed bearings as possible based on the lateral demand and lines of fixed bearings shall be symmetrical to the centerline of the bridge.

Reason for Change

To update Design Manual language to coincide with new Standard Drawings and Standard Specifications. This DUR also addresses the alignment of bearings to account for thermal movement for both curved and skewed girder bridges, see the attached White Papers for additional information.

This white paper investigates the proper alignment of guided expansion bearings for highly skewed bridges. The main objective is to determine a consistent recommendation to make to the designer for laying out and aligning the bearings, and incorporate this into the updated NJTA Standard Drawings, Specifications, and Design Manual.

The primary concern in arranging the bearings of a skewed bridge is to maintain the alignment of the skew. It is well understood that the direction of thermal expansion and contraction of a skewed bridge is along its longest diagonal axis, from acute corner to acute corner.
The AASHTO/NSBA Steel Bridge Collaboration G 9.1-2004, Steel Bridge Bearing Design and Detailing Guidelines, discusses this concept and provides the following illustration:

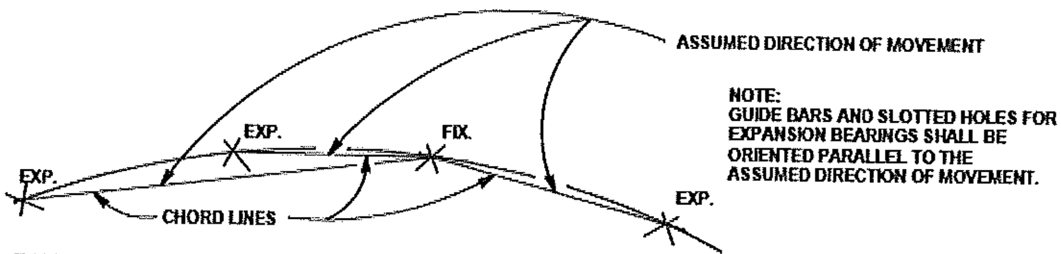


THERMAL MOVEMENT OF LARGE SKEW BRIDGES
NOT TO SCALE

Although the guidelines show a note saying to orient guide bars and slotted holes for expansion bearings parallel to the assumed direction of movement, this is not practical for skewed bridges. Many factors can affect the thermal behavior and directions of expansion of a bridge, from shade cast by surrounding structures to irregular weather patterns. Therefore, it is nearly impossible to predict the correct orientation of guided bearings in this manner, and a certain amount of racking will almost always occur. Instead, the primary goal should be to maintain the alignment of the skew as best as possible. In this way, the barriers at the interface of the bridge and wingwalls will not become misaligned, which if they did could pose a serious threat to oncoming traffic. In order to maintain alignment, the best solution is to use systems of fixed and longitudinally guided bearings for the girders closest to the interior, and leave the girders at the exterior free to move in all directions, so that the bridge expands and contracts from the centerline out. Longitudinally guided bearings should permit movement along the direction of the girder centerline. It is recommended to use as few fixed bearings as possible based on the lateral demand, allowing the bridge to be able to breathe under both thermal and seismic loads. In the ideal solution, the center girder would be fixed at one end and longitudinally guided with an expansion bearing at the other. All other bearings would be free. If the lateral demand cannot be taken by a single fixed bearing, additional lines of girders may be fixed at one end and longitudinally guided at the other, symmetrical to the centerline, until the proper capacity is achieved.

This white paper investigates the proper alignment of expansion bearings for curved bridges. There is a general consensus that for curved bridges, the guided expansion bearing assemblies shall be oriented to form a chord in the direction of the fixed bearings. The following references support this behavior:

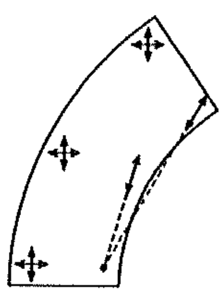
1. AASHTO/NSBA Steel Bridge Collaboration G 9.1-2004, Steel Bridge Bearing Design and Detailing Guidelines, notes that the most common approach is to "design bearing devices to expand along a chord that runs from the point of zero movement... to the bearing element under consideration", as demonstrated in the figure below.



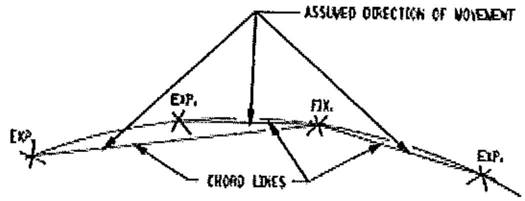
BEARING ORIENTATION ON A HORIZONTALLY CURVED ALIGNMENT

NOT TO SCALE

2. NCHRP Report 424: Improved Design Specifications for Horizontally Curved Steel Girder Highway Bridges states that under a uniform temperature change, orienting the bearing guides toward a fixed point and allowing the bridge to move freely along rays emanating from the fixed point will theoretically result in zero thermal forces.
3. Bridge Deck Analysis, by Damien L. Keogh and Eugene O'Brien, recommends the following allowable bearing movements curved bridges, demonstrating that the orientation of movements tends to radiate outwards from the fixed bearing.

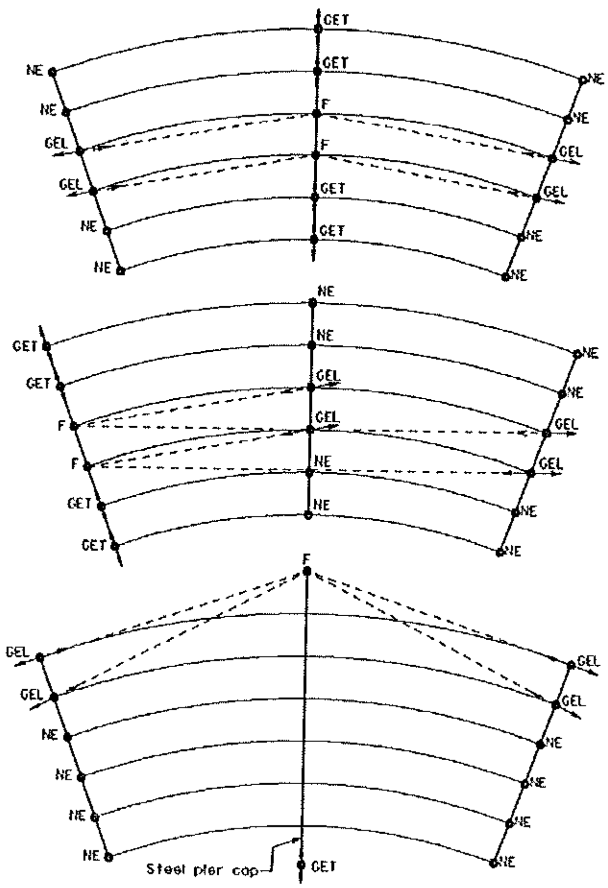


4. The Missouri Department of Transportation Policy Guide on Bearings notes that "for curved bridges, assume the free movement direction to be along a chord connecting the ends of the beam."
5. The New York Department of Transportation notes on their standard drawing BD-BG3E that the slotted holes in a bearing masonry plate shall be oriented "along the chord to the fixed bearing on curved beams". The following graphic is shown on Standard Drawing BD-BG6E, which also demonstrates this principal:



BEARING ORIENTATION ON A HORIZONTALLY CURVED ALIGNMENT

6. The DOT of the Commonwealth of Virginia uses an alternative set of graphics to convey this concept on Standard BBD-6/7A and 7B: Notes to Designer, Expansion of Curved Girder Bridges Using HLMR Bearings. As seen in the graphics, the line of movement is consistently directed back to the fixed bearing points.



• - Bearing Location
F - Fixed Bearing
GET - Guided Expansion Transverse
GEL - Guided Expansion Longitudinal
NE - Nonguided Expansion
→ - Direction of Movement

7. From the Mass Highway Bridge Manual – Part I: "It has been well documented that curved girder bridges do not expand and contract along the girder lines. The most often

used approach is to design bearing devices to expand along a chord that runs from the point of zero movement (usually a fixed substructure element) to the bearing element under consideration."

8. FHWA Steel Bridge Design Handbook, Design Example 5, Page 27: "Curved bridges do not expand and contract along the girder line, but more so along the aforementioned chord lines [between fixed support and each expansion bearing]. Orientating the bearings in the manner discussed significantly reduces the longitudinal stresses in the girders that can occur due to thermal loading."
9. FHWA Steel Bridge Design Handbook, Bearing Design Page 17: It is generally accepted for design purposes that the direction of movement for structures on a horizontally curved alignment is along the chord from the fixed point to the expansion point.
10. NHCRP: Performance testing for modular bridge joint systems, Issue 467 By Robert Joseph Dexter states that "the movement of curved bridges should be calculated along the chord through the fixed bearing locations"
11. FHWA Steel Bridge Design Handbook, Bearing Design: "It is generally accepted for design purposes, that the direction of movement for structures on a horizontally curved alignment is along the chord from the fixed point to the expansion point."