NCHRP 12-68

FY 2004

Rotational Limits for Elastomeric Bearings

Final Report

APPENDIX B

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APPENDIX B Survey of Current Practice

B.1 Introduction

As part of Task 1 for the NCHRP 12-68 project, a phone survey was conducted to determine the current practice of elastomeric bearings across the nation. The survey sampled a broad cross section of the nation by questioning 46 states. Only four states, Delaware, Michigan, Rhode Island, and West Virginia, could not be reached for comment. During most of these phone surveys, time limitations meant that only one or two design engineers from each bridge engineering office could be questioned. These respondents were typically engineers or bearing specialists for the state.

The survey content was focused on several key issues including:

- how often elastomeric bearings are used,
- what design methods are used,
- what type of rubber is used (neoprene or natural rubber),
- the manufacturer(s) from which bearings are usually purchased,
- any field issues that have occurred,
- any design problems caused by rotation requirements.

These issues are discussed in the sections that follow.

B.2 Elastomeric Bearing Use

All 46 of the states that responded use elastomeric bearings. Some states use the bearings almost exclusively, while other states only use them for certain ranges of span length and structure types. The following is a discussion of the use of elastomeric bearings by the different states.

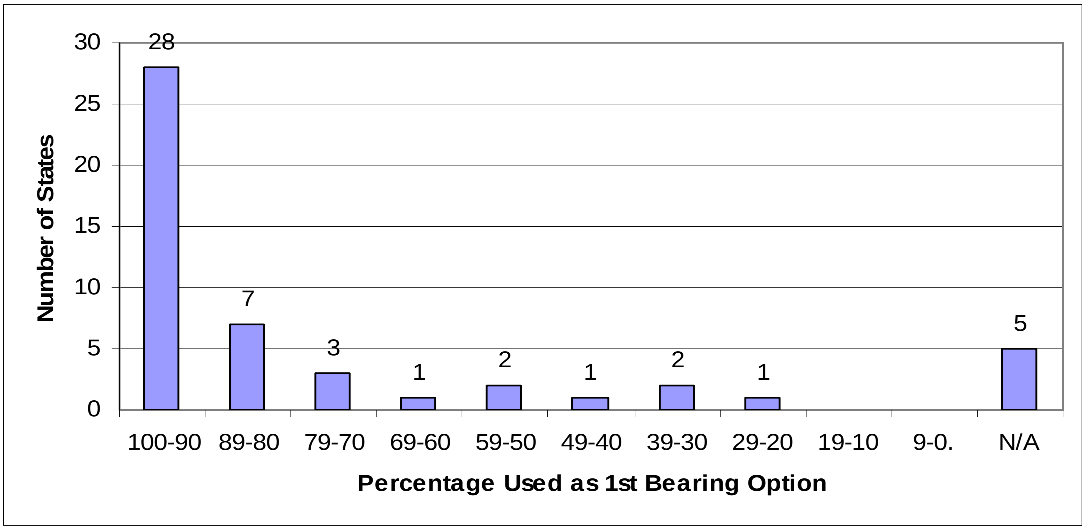

Figure B-1 Histogram of Elastomeric Bearing Use.

Figure B-1 shows the frequency with which elastomeric bearings are chosen as the first bearing option. The data show that elastomeric bearings are used much more often than any other type of bearing.

Table B-1gives the breakdown of responses from the individual states and shows that many states use elastomeric bearings almost exclusively. Furthermore, several states have said that they are using elastomeric bearings more and more frequently because of their simplicity, robustness, and low maintenance needs.

The data do not show preferential use in any one climate. For example, states like Alaska and Minnesota (cold climates) report using elastomeric bearings with the same frequency as Texas and Georgia (warm climates).

Table B-1 Bearing Use: Breakdown by State.

% of Bearings	States	Number
100 - 90	AK, AL, AZ, CO, FL, GA, HI, IL, IN, KY, LA, MA, ME, MN, MO, MS, MT, ND, NE, NM, NV, OH, OK, OR, SC, TX, WA, WY	28
89 - 80	AR, CA, ID, NC, NH, PA, TN	7
79 - 70	CT, NY, UT	3
69 - 60	WI	1
59 - 50	KS, VA	2
49 - 40	IA	1
39 - 30	MD, VT	2
29 - 20	SD	1
19 - 10		
9 - 0.0		
No Answer	DE, MI, NJ, RI, WV	5
Total		46

The states that use elastomeric bearings less than 50% of the time (South Dakota, Maryland, Vermont, and Iowa) gave various reasons for the bearings' infrequent use. South Dakota said that most of their bridges were integral abutment bridges that do not require bearings. Maryland and Vermont build mostly steel bridges and prefer other types of bearings for these bridges. Those other bearings used had performed satisfactorily, and the states saw no need for change. Iowa began using elastomeric bearings on steel bridges only in the last four or five years, so the proportion reported represents only that time.

One of the reasons why elastomeric bearings are not used exclusively is that at times a bearing could not be designed satisfactorily using the AASHTO specifications. The reasons include:

- The stress limits in the specification dictate the minimum size of the bearing, and the available space was insufficient to accommodate it.
- A bearing that satisfied the requirements of the AASHTO Specifications could be designed, but the engineer did not like it, and opted for a different bearing type.
- Rotation requirements in the AASHTO Specifications made the design difficult. These are discussed below.

Reluctance to change is another reason why elastomeric bearings are not used even more widely. States often continue to use the same bearing type (steel rocker, pot, disk, etc.) that they always have, until it causes problems. This behavior is partly explained by the fact that the choice of bearing type often reflects a personal viewpoint, because one individual in the DOT acts as the bearing specialist. Special circumstances may also impose special constraints on the choice. For example, rehabilitation or widening of an existing bridge will often dictate that the same bearing type be used in the new and existing portions of the structure.

B.3 Design Methods

The AASHTO LRFD Specifications contain two methods for designing elastomeric bearings. Method A is the simpler of the two, and has fewer testing requirements. Method A leads to viable elastomeric bearing designs for common bridges (e.g. simple span 100 to 150 ft. span prestressed concrete or steel girder bridges). Method B requires greater design effort and requires more extensive testing, and is usually used only when a bearing cannot be designed using Method A. Some states use different design methods; for example, Texas has its own method that is similar to AASHTO, but with some modifications. Some states use the AASHTO Specification, but have not adopted all of the interim Specification requirements.

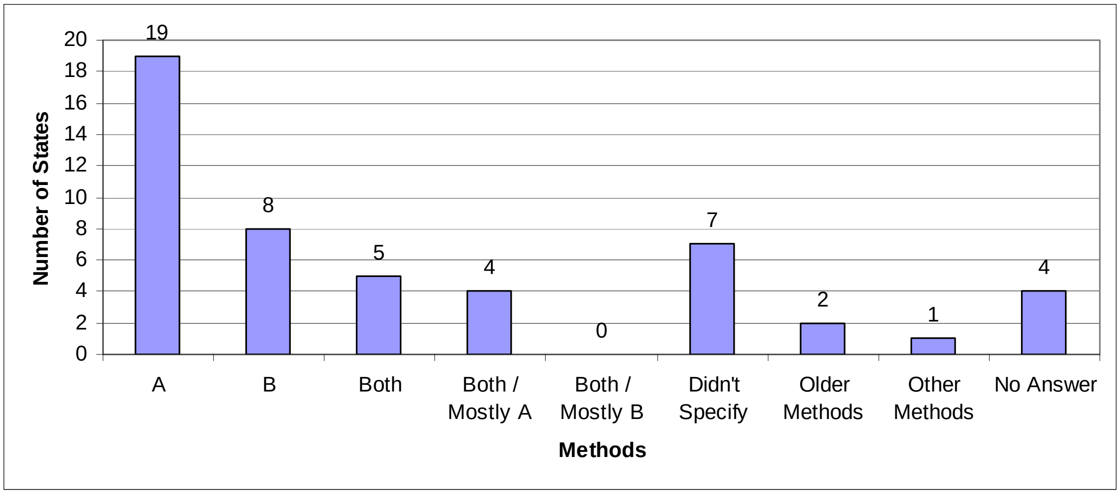

Figure B-2 Use of Design Methods A and B.

Figure B-2 Use of Design Methods A and B.Figure B-2 shows that use of Method A is predominant. Several respondents were not sure which method their states used, but their responses suggested that most of them use Method A because of:

- the reported controlling compressive stresses,
- the testing that was required,
- the bridge types most commonly used.

Table B-2 gives a detailed breakdown of the use of the design methods.

Table B-2 Design Methods Used: Breakdown by State.

AASHTO Method		
Method	**States**	**Number**
A	AZ, CT, IA, IL, IN, KS, MD, MS, NC, ND, NE, NH, NM, NV, NY, OH, SC, VT, WY	19
B	AK, CO, FL, GA, MA, MT, OK, OR	8
Both	AR, HI, KY, NJ, WA	5
Both / Mostly A	ID, PA, TN, UT	4
Both / Mostly B	--	0
Didn't Specify	AL, LA, ME, MN, MO, SD, WI	7
Older Methods	CA, VA	2
Other Methods	TX	1
No Answer	DE, MI, RI, WV	4
Total		46

The widespread use of Method A can be explained by the cost of the long term testing required by, and the extra design time needed for, Method B. In addition, many states use prestressed concrete girders that have standard bottom flange widths of approximately 25”. The width of the bearing (i.e. perpendicular to the span of the girder) is generally chosen to be about 1” less than that of the flange, in order to maximize rotational stability of the girder during erection. If the length is chosen to be about 9” (perhaps dictated by bearing stability requirements in the longitudinal direction) the resulting bearing has plan dimensions of about 24” x 9”. The total load on such a bearing is typically less than 150 kips, so the compressive stress is seldom larger that 700 psi. For such bearings, therefore, the high compressive stresses made possible by the use of Method B are unnecessary.

B.4 Design Problems

Most of the respondents reported some problems with meeting the AASHTO design requirements for combined compression and rotation. The specifications require that the axial stress always be greater than a minimum value in order to prevent lift-off on the “tension” side of the bearing. The minimum stress is a function of the design rotation and the bearing height, so, for light loads and large rotations, the specification requirements lead to a tall bearing. However, a tall bearing can become unstable under compressive load. Finding a design that simultaneously satisfies both sets of requirements can require several iterations and become time-consuming. In some cases it proves impossible, especially when considering the load-case represented by construction conditions, when girder camber, and therefore bearing rotation, is a maximum but the compressive load is a minimum. Some designers believed that no damage would be caused by temporary lift-off under these conditions, and were therefore faced with the choice of ignoring the specification requirements and using an elastomeric bearing anyway, or selecting some other bearing type that would satisfy the specifications but that would, in their opinion, prove less satisfactory in practice.

Figure B-3 shows the design problems reported by the states, and Table B-3 gives a breakdown by state of the same information.

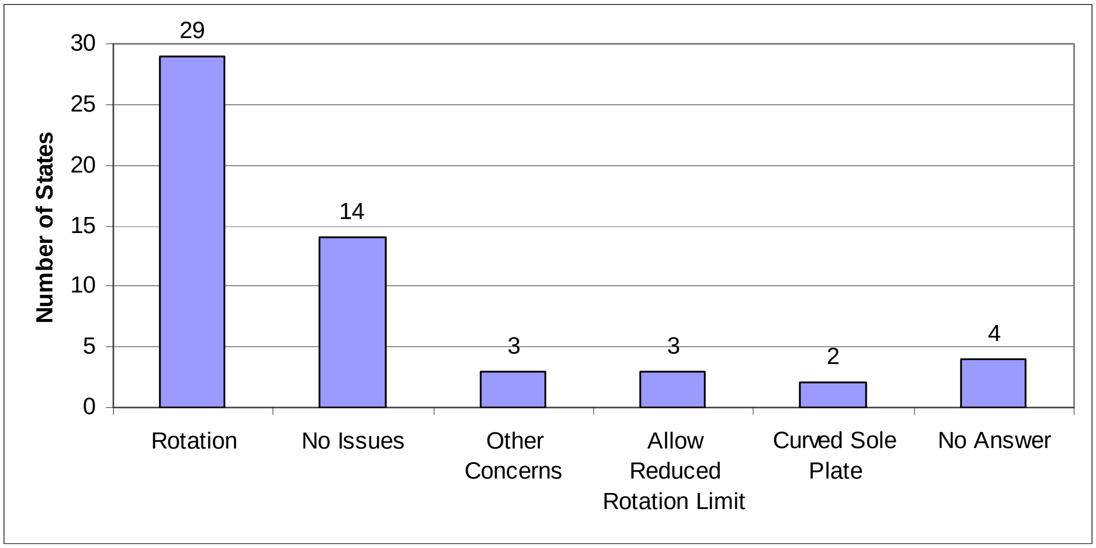

Figure B-3 Design Problems Reported.

Several states have developed various solutions to manage the rotation problems, including:

- allowing the 0.005 radian rotation for construction uncertainty to be reduced under specific circumstances (span length, load applied),
- ignoring the rotations that occur due to camber before the girder has full dead load applied,
- using a curved sole plate on top of the bearing that allows the girder to rotate on the plate, thereby reducing the rotation on the bearing itself.

Table B-3 Design Issues: Breakdown by State.

Design Issues		
Issue	**States**	**Number**
Rotation	AK, AR, AZ, CA, CT, FL, GA, IA, ID, IL, KY, MD, ME, MO, MN, MT, NC, NH, NJ, NV, NY, OH, OK, OR, PA, UT, VA, WA, WY	29
No Issues	AL, CO, HI, KS, LA, MA, MS, ND, NE, NM, SD, TN, TX, VT	14
Other Concerns	AR, SC, WI	3
Allow Reduced Rotation Limit	NY, OH, PA	3
Curved Sole Plate	IA, MN	2
No Answer	DE, MI, RI, WV	4

B.5 Field Problems

The engineers were also asked about field problems that occurred after design. Table B-4 gives a state by state breakdown of reported field problems. The field problems that were reported include:

- elastomeric bearings walking out (slipping from their original position under the girder),
- debonding between the rubber layers and steel reinforcement,
- excessive bulging between the layers,
- elastomeric bearings rolling up onto themselves due to excessive shear deformation.

Table B-4 Field Issues: Breakdown by State.

Field Issues		
Issue	**States**	**Number**
Debonding	AZ, MD, WY	3
Walking Out / Slip	AZ, ID, KS, MA, MO, MT, NC, NH, NM, OK, SD, TN, TX, WI	14
Excessive Bulging	HI, IL, OH	3
Other Issues	AL, CO, GA	3
No Issues	CT, FL, IA, IN, LA, MN, NJ, NY, OR, VA, VT, WA	12
No Answer	AK, AR, CA, DE, KY, ME, MI, MS, NE, NV, PA, RI, SC, UT, WV	15

Many engineers reported having no problems. However, some said that field problems were dealt with by inspectors and not reported back to the design office, so the lack of reported problems was no guarantee of their absence.

B.6 Elastomer Type and Bearing Manufacturers

The states were asked what type of rubber (typically neoprene or natural rubber) they specified, and which manufacturer(s) commonly provided their elastomeric bearings. Usually the state design specification defines the type of rubber allowed. In many cases, the engineers spoken to did not know who manufactured their elastomeric bearings because the bearings are supplied by a subcontractor, and the designers are only in contact with the main contractor.

Table B-5 shows the state breakdown of the rubber type used for the elastomeric bearings. Neoprene is used most widely. Most of the states that use natural rubber are cold climate states that require natural rubber in order to meet the AASHTO low temperature requirements.

Table B-5 Elastomer Type Used: Breakdown by State.

Elastomer Type	State	Number
Neoprene	AL, AZ, CA, CT, FL, GA, HI, IA, KS, LA, MA, MD, MO, MS, MT, NM, NV, OH, OK, OR, PA, SC, TX, VT, WI	25
Natural Rubber	AK, ID, ME, NH, SD	5
Both	CO, IN, KY, NC, ND, NE, NJ, NY	8
Both / Mostly Neoprene	TN, WA	2
Both / Mostly Natural Rubber	UT, WY	2
Didn't Specify	AR, IL, MN, VA	4
No Answer	DE, MI, RI, WV	4

Table B-6 shows the reported bearing manufacturers by the states. D.S. Brown, and Scougal Rubber Company were the most commonly reported manufacturers, but several others have a share in the market. Based on recent annual sales figures, the approximate market distribution is:

- Seismic Energy Products 33%
- DS Brown 25%
- Scougal 15%
- Dynamic Energy Products/COSMEC 12%
- others 15%

These data suggest that DS Brown and Scougal Rubber provide the largest number of bearings, but Seismic Energy Products and D.S. Brown provide the more expensive, high-end bearings.

Table B-6 Manufacturers used: Breakdown by State.

Bearing Manufacturers		
Manufacturer	**States**	**Number**
DS Brown	AL, AZ, CA, CT, NJ, NM, NV, NY, OH, PA, UT, VT, WI, WY	14
Scougal	AL, AZ, CA, ID, KY, MS, MT, NV, NY, OR, TN, TX, WA	13
Dynamic Rubber/ COSMEC	AL, CT, GA, MS, NY, TX, VT	7
Seismic Energy Products	GA, KY, NM, TX	4
Furon	MS, ND, NY	3
RJ Watson	NH, VT	2
Dynamic Isolation Sys.	MS	1
Lewis Eng.	KS	1
Watson-Bowman	AZ, OH	2
Structural Specialities	AK	1
Conserve	NE	1
Voss Eng.	NE	1
Applied Rubber	TX	1
Didn't Specify	AR, CO, FL, HI, IA, IL, IN, LA, MA, MD, ME, MN, MO, NC, OK, SC, SD, VA	18
No Answer	DE, MI, RI, WV	4

B.7 Survey Highlights

Several states reported unique practices that are used in the design of elastomeric bearings. This section highlights some of those practices.

Iowa
Iowa has also done a survey of other states, but their survey focused on specific issues such as how many states use elastomeric bearings (laminated only) versus steel rocker bearings and what other states' design practices are for elastomeric bearings. They found results similar to those obtained by this survey. Iowa reported using uses a curved sole plate on top of the elastomeric bearing to meet the rotation requirements when rotation demands become too large.

Kentucky
Kentucky uses AASHTO design methods, but is prepared to use elastomeric bearings for much higher loads than other states. Kentucky has used four 3 ft x 5 ft bearings nested together (using separate bearings to make one large bearing system of 6 ft x 10 ft) to make an elastomeric bearing to carry 16,000 kips from a bridge that has a span of over 780 ft. Dividing the bearing into four was necessary because no press existed that could make it one piece. No other state reported using such a large bearing.

New York
New York allows the construction uncertainty allowance of 0.005 radians to be reduced to 0.002 radians with high quality control of the bearing seat and the girders. The agency that ensures the quality of the seat, and the quality control procedures used, were not reported.

Minnesota
Minnesota also uses a curved sole plate to accommodate the rotation requirements.

Ohio
Ohio excludes from the design rotation any contribution that is caused by girder camber before the complete dead load is applied.

Pennsylvania
For bridge spans under 100 ft, Pennsylvania allows the 0.005 radians of construction uncertainty allowance to be reduced if needed. They said that they often could not get an elastomeric bearing design to work when the full uncertainty allowance was included in design rotations. They also reported having problems with liftoff on prestressed concrete box girders that are skewed, in which case the load intended for both bearings is in fact carried on one. They sometimes allow the gap that develops due to liftoff to remain because they feel that elastomeric bearing performance is forgiving, despite the fact that the compressive stress is double the design value.

Virginia
Virginia reported that they use a version of the AASHTO design specifications without adoption of some of the latest interim requirements.

Illinois
Illinois use three different types of elastomeric bearings:

- Type I is an elastomeric bearing with a sole plate on top,
- Type II is an elastomeric bearing with a PTFE-stainless steel sliding surface on it, and
- Type III is an elastomeric bearing with a sliding surface but with a shear restrictor pin in the middle of the bearing to prevent excessive shear movement.

They also limit their shape factor to less than 6. These bearings are made only in certain standard sizes, and conform to the requirements of Method A.

Florida
Florida has 5 standard elastomeric bearings that have been designed in accordance with AASHTO Method B, but with some exceptions to the combined rotation and compression requirements. These are used on their standard AASHTO Girders and Florida Bulb-Ts.

New Hampshire
New Hampshire ignores the initial rotation caused by the camber of the girder that is present before full dead load is applied.

Oklahoma
Oklahoma uses Method B of the Sixteenth Edition, AASHTO 1996 specifications without the interim revisions.

Massachusetts
Massachusetts' standard bearing is a circular bearing.

Texas
Texas has set up its own design specifications. Some of the highlights include limiting the total stress to 1.5 ksi and the dead load stress to 1.2 ksi max, 1.0 ksi optimum, and 0.65 ksi minimum on the bearings.

B.8 Summary

The survey revealed that elastomeric bearings are the most widely used of all types. One of the main reasons is that most of the engineers consider them forgiving. Even if a problem does arise, the elastomeric bearings are believed to be capable of performing well enough to do the intended job. Elastomeric bearings are seen as economical for both initial and life cycle costs, and require little or no maintenance.

A number of engineers said that they feel the AASHTO LRFD Specifications were overly restrictive, particularly with respect to rotation. Several felt that elastomeric bearings have been used for a long time without the current restrictive specifications, and that those older elastomeric bearings have performed satisfactorily. They feel the specification requirements could be relaxed without jeopardizing performance, and it would make the design process simpler. This would permit the successful design of elastomeric bearings for circumstances in which it is presently not possible, and would consequently increase use the bearings.