### Abstract

This project was a pooled fund study that included participation by the Federal Highway Administration, Pennsylvania Department of Transportation, Florida Department of Transportation, North Carolina Department of Transportation, and was coordinated by the consulting firm of Michael Baker Jr., Inc. Design standards for pot bearings (a common name for a type of high load multi-rotational bearing) were developed to streamline the design process and provide consistency in manufacturing and installation. The standards are based on existing PENNDOT pot bearing design standards numbered BD-613M, which were released for use in June 2002. This study consisted of six (6) tasks which focused on expanding PENNDOT’s existing pot bearing design standards for use in other states and providing formal recommendations to AASHTO regarding specification changes to Section 14.7.4 of the AASHTO LRFD Bridge Design Specifications.

In addition, a presentation was given to the AASHTO T-2 Bearing Committee at the 2005 AASHTO Bridge Subcommittee meeting in Newport, Rhode Island in June 2005. This presentation focused on the use of the proposed standards and provided informal recommendations for design specification changes based on the philosophy used in the standards.

Through a cooperative effort, a set of pot bearing design standards have been developed that will save the participating agencies time and money with regard to pot bearing use in bridge construction. At this time, the AASHTO T-2 Bearing Committee has not responded to the formal recommendations made by the project panel with regard to pot bearing design specification changes.

### Key Words

- bearings, multi-rotational bearings, pot bearings

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EXECUTIVE SUMMARY

This project was a pooled fund study that included participation by the Federal Highway Administration, Pennsylvania Department of Transportation, Florida Department of Transportation, North Carolina Department of Transportation, and was coordinated by the consulting firm of Michael Baker Jr., Inc. Design standards for pot bearings (a common name for a type of high load multi-rotational bearing) were developed to streamline the design process and provide consistency in manufacturing and installation. The standards are based on existing PENNDOT pot bearing design standards numbered BD-613M, which were released for use in June 2002.

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BACKGROUND
The Pennsylvania Department of Transportation (PENNDOT) has developed an extensive list of bridge design and construction standards. This initiative not only streamlines the design and construction process, but also ensures consistency of structure design and construction throughout the Commonwealth of Pennsylvania.

A recent addition to this extensive list of standards was the introduction of a bridge design standard that summarizes the design and detailing of High Load Multi-Rotational Pot Bearings (commonly referred to as “pot” bearings). In addition to streamlining the design process and, thereby, greatly reducing the chance of design errors, this document standardizes the pot bearing manufacturing process. Prior to the introduction of the standards, fabricators providing bearings for PENNDOT bridges had to support the production of pot bearings resulting from many different design preferences.

Other state departments of transportation were aware of PENNDOT's efforts in this area and expressed interest in expanding the standards to encompass their own preferences for pot bearing design and fabrication. However, instead of each state developing independent standards, large economies of scale were achieved by instead developing a standard that includes the requirements of all participating states. Fortunately, several states pooled resources to develop regional or nationwide standards.

Participating agencies in this pooled fund study included the Pennsylvania Department of Transportation, the Federal Highway Administration (FHWA), the Florida Department of Transportation (FDOT), and the North Carolina Department of Transportation (NCDOT). The consulting firm of Michael Baker Jr. Inc. was selected as the contractor to facilitate this initiative. A project panel member list is provided in Appendix A.

INTRODUCTION
Historically, PENNDOT has relied on the bridge design engineer to design pot bearings rather than the bearing manufacturer. To facilitate and standardize the pot bearing design process, PENNDOT developed pot bearing design standards entitled “BD-613M: HIGH LOAD MULTI-ROTATIONAL POT BEARINGS”. The standards were released for use in June 2002.
The PENNDOT BD-613M standards are intended to provide “off the shelf” designs for pot bearings so that design engineers do not have to perform extensive design calculations. Sufficient details are provided in the standards to develop contract drawings. At this time, the standards are not intended to replace or eliminate the need for shop drawings during the fabrication process. However, the standards do provide PENNDOT preferred details for all bridges in the state and allow consistency of pot bearing design, fabrication, and installation.

The standards consist of fifteen (15) drawing sheets that include the design methodology used in developing the standards; design load calculation examples; dimension tables for fixed, guided, and non-guided pot bearings; various details for bearing components and anchorages; and various notes for materials, fabrication, and installation. Note that the standards can be used for design loads developed from either the AASHTO Standard Specifications (using service load combinations) or the 1998 AASHTO LRFD Bridge Design Specifications (using service and extreme event limit states).

The BD-613M standards provide pot bearing designs for vertical design load ranges of 200 kips (890 kN) to 1500 kips (6672 kN) and design rotations up to 0.03 radians (including 0.02 radians for construction tolerances). Note that pot bearing component sizes are provided in both English and metric units.

**PROJECT WORK PLAN**

The goal of this project was to expand the existing PENNDOT BD-613M standards to encompass pot bearing designs utilized by other state departments of transportation. The intent was that the expanded standards could be utilized regionally, or even nationwide, for pot bearing design.

PENNDOT, as the oversight agency, established a project work plan for the development of expanded pot bearing standards that was comprised of six (6) tasks:

- TASK 1: BD-613M Review Coordination
- TASK 2: Literature Review
- TASK 3: Research and Drafting of Pot Bearing Standards
- TASK 4: Proposed AASHTO revisions
- TASK 5: Draft Final Report
- TASK 6: Final Report, Oral Presentation, and *Ideas Have Consequences*
Each task is described in detail below.

**TASK 1: BD-613M REVIEW COORDINATION**

The first task of the project was to coordinate a project panel review of the existing PENNDOT BD-613M design standards for pot bearings. Each project panel member, or their agency representative, reviewed the existing standards and provided comments to Michael Baker Jr., Inc.

The comment and response process was completed in accordance to the following chronological order:

- July 20, 2004 – BD-613M standards distributed to panel members
- November 10, 2004 – comments compiled and sent to PENNDOT for review
- April 7, 2005 – responses distributed to panel members
- May 9, 2005 – revised responses distributed to panel members based on review comments of initial response submission

The final comment/response form is included in Appendix B. This task provided the FHWA, FDOT, and NCDOT panel members a first glimpse of the existing PENNDOT pot bearing standards. The initial review allowed the panel members to see how the standards may need to be modified for utilization within their respective agencies.

**TASK 2: LITERATURE REVIEW**

Task 2 consisted of a literature review that was performed concurrently with Task 1. Florida DOT and North Carolina DOT were solicited for information regarding pot bearing design, fabrication, and construction requirements within their respective agencies. The information from FDOT and NCDOT was then compared to the PENNDOT methodologies that were used in developing the existing BD-613M pot bearing standards.

A report entitled “TASK 2: LITERATURE REVIEW” was developed by Michael Baker Jr., Inc. The report included a component by component comparison of the material and construction specifications used for pot bearings within the three state
DOT agencies. The Task 2 report development was performed according to the following schedule:

- March 7, 2005 – draft report submitted to PENNDOT
- May 4, 2005 – comments received from PENNDOT
- May 9, 2005 – final report distributed to all panel members (concurrent with submission of final Task 1 comment/response form)

The Task 2 component comparisons demonstrated that there were more similarities than differences between the DOT agencies with regard to pot bearing design and manufacturing requirements. The narrative portion of the Task 2 report is included in Appendix C.

**TASK 1 & 2 SUMMARY**

Following the project panel review approval of the Task 1 and Task 2 deliverables, a conference call was held on May 26, 2005. During the conference call, the project panel members discussed and finalized the results of Tasks 1 and 2.

In addition, the scope of TASK 3: Research and Drafting of Pot Bearing Standards was established during the conference call. A list of twelve (12) revisions (or additions) to the existing BD-613M pot bearing standards were developed. The conference call meeting minutes are included in Appendix D.

**TASK 3: Research and Drafting of Pot Bearing Standards**

Task 3 consisted of revising the existing BD-613M standards as per the findings from Task 1 and Task 2. The revisions (or additions) that were decided upon during the May 25, 2005 Conference Call include the following:

1. Add dual material specs for plates > 4” thick.
2. Consideration of a bedding material thickness of 3/16”.
3. Add a PTFE attachment detail using a recess and adhesion only.
4. Consideration of a pad compressive deflection allowance when calculating the piston thickness.
5. Revise notes to be generic and not state specific.
6. Add metallizing as a steel corrosion protection method.
7. Add round sealing ring details.
8. Add internal guide details in addition to external guide details.
9. Add preformed anchor hole detail and include field placement instructions.
10. Add a note on Sheet 15 alerting the designer of potential bolt/thread misalignment when using beveled sole plates.
11. Add a note listing allowable service stress for weld design.
12. Delete dimension “Z” from Note 9 on Sheet 1.

The existing BD-613M standards were modified to incorporate the above list as stated except for three items. Item 2 was addressed by adding cotton-duck as an acceptable bedding material in Note B11 on Sheet 14 of the standards. However, after researching the material specification for cotton-duck (MIL-C-882E) and discussing the issue with NCDOT, the material thickness was not revised from 1/8” to 3/16”.

No action was taken on Item 4. After reviewing the response to NCDOT Comment 16 (see Task 1 comment/response form in Appendix B), NCDOT agreed that adequate allowance for compressive deflection of the neoprene pad under the piston was already accounted for in the calculated piston thicknesses listed in the standards.

Item 8 was a request to add internal guide bar details in addition to the external guide bar details shown in the existing BD-613M standards. We discussed this detail with a nationally known bearing manufacturer. The manufacturer stated that the internal guide bar detail requires a slot in the middle of the piston where the piston is subjected to its highest stress. For this reason, the manufacturer recommended against the internal guide bar detail. In addition, incorporating internal guide bar details would greatly expand the size and scope of the standards. After discussing these issues with NCDOT, they agreed to the external guide bar details shown in the existing standards.

Subsequent to the May 26, 2005 conference call, several more revisions to the existing BD-613M standards were identified. The first item was the clearance provided between the piston face and the inside of the pot wall. The existing BD-613M standards provided a total clearance of 0.02” (0.01” on each side). Discussions with bearing manufacturers during the Task 3 progression indicated that this tolerance was difficult to achieve. Therefore, the total clearance between the piston face and the inside of the pot wall was revised to 0.04” (0.02” on each side) and the piston diameters listed in the BD-613M standards were all reduced by 0.02”. No other dimensions were affected by this revision.
Additional items identified after the conference call included incorrect unit conversion from English units to metric units for several vertical load cases and minor rounding discrepancies for several bearing heights (listed as dimension “PP” in the standards).

The Task 3 deliverables were performed according to the following schedule:

- December 21, 2005 – draft standards submitted to panel members for review
- End of February 2006 – all comments received by panel members
- March 21, 2006 – final standards submitted to panel members in hard copy and electronic format

The final standards are included in Appendix E.

**TASK 4: PROPOSED AASHTO REVISIONS**

Task 4 included submitting formal recommendations to the AASHTO T-2 Bearing Committee regarding revisions to the existing bridge design specifications. The T-2 committee convened at the 2005 AASHTO Bridge Subcommittee meeting in Newport, Rhode Island in June 2005. However, since this project was not advanced sufficiently at that time, only informal recommendations were made to the committee during a presentation by Eric Martz, P.E. (Michael Baker Jr., Inc.). See Task 6 for more information regarding the presentation.

Once the project was at a stage when formal recommendations could be made to the T-2 committee, a letter was sent to the Committee Chairman, Ralph Anderson, P.E., by PENNDOT on behalf of the project panel. The letter was sent on October 18, 2005 by PENNDOT Acting Chief Bridge Engineer, Harold Rogers, P.E. A copy of the letter is included in Appendix F.

In general, the recommendations suggest changing several AASHTO equations in Section 14.7.4 back to service limit state so that design loads and rotations are not required for both strength and service limit states for pot bearing design. At this time, the T-2 committee has not responded to the formal recommendations.

**TASK 5: DRAFT FINAL REPORT**

Task 5 consisted of developing the Draft Final Report, which was submitted in April 2006.
TASK 6: FINAL REPORT, ORAL PRESENTATION, AND IDEAS HAVE CONSEQUENCES

Task 6 consists of three deliverables as follows:

- Final Report
- Oral Presentation to the AASHTO T-2 Bearing Committee
- Ideas Have Consequences

The Final Report is presented herein.

The Oral Presentation to the AASHTO T-2 Bearing Committee was given on June 28, 2005 by Eric Martz, P.E. (Michael Baker Jr., Inc.) at the 2005 AASHTO Bridge Subcommittee Meeting in Newport, Rhode Island. The presentation introduced this project to the committee, explained the concept and use of the existing PENNDOT BD-613M standards, and provided informal recommendations regarding AASHTO Section 14.7.4 specification changes. The presentation slides are provided in Appendix G.

Ideas Have Consequences is a form used by PENNDOT to summarize the project’s activities and outcomes. The form is included in Appendix H.

CONCLUSIONS

This pooled fund study was developed to expand PENNDOT’s existing bridge design standards for pot bearings so that the standards could be utilized by other state DOT agencies. Through a cooperative effort between FHWA, PENNDOT, FDOT, NCDOT, and Michael Baker Jr., Inc., a set of pot bearing design standards has been developed that can be used by multiple agencies to streamline the design process and provide consistency in pot bearing manufacturing and installation.

The representatives from FDOT and NCDOT have commented that the final standards will be a valuable resource in saving their agencies time and money. If other state DOT agencies were aware of the usefulness of the final pot bearing standards developed through this project, many of those agencies would likely adopt the standards as well.
# Project Panel Members

<table>
<thead>
<tr>
<th>Name</th>
<th>Title and Organization</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>
COMMENT/RESPONSE FORM

Submission Subject: National Pot Bearing Standards
Review of PENNDOT Standard BD-613M

Prepared By: Eric L. Martz, P.E. / Robert T. Doble, Jr., P.E.

Date of Response: May 9, 2005 Date of Receipt: August 2004
<table>
<thead>
<tr>
<th>Comment No.</th>
<th>Comment</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>FHWA</td>
<td><strong>Comments from FHWA:</strong>&lt;br&gt; Vasant Mistry, P.E.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>In general, the presentation and the design look good.</td>
<td>No response required.</td>
</tr>
<tr>
<td>2</td>
<td>GUIDED BEARING AND FIXED BEARING:&lt;br&gt;If the additional cost of a groove weld is not prohibitive, we recommend a groove weld at the guide bar connection with the side plate for the guided bearing and at the piston connection with the plate for the fixed bearing in lieu of the fillet weld shown.</td>
<td>We discussed this issue with a pot bearing manufacturer. They stated that a groove weld is considerably more expensive than a fillet weld. They also stated that they have used fillet welded connections successfully on hundreds of projects.</td>
</tr>
<tr>
<td>3</td>
<td>It is not clear if ring tension is considered in the design of the pot of the pot bearing. We recommend considering ring tension in designing the pot for pot bearings.</td>
<td>The equation listed as AASHTO Equation 14.7.4.7-1 is taken from NCHRP Report 432, Equation D-15 (page D16). Note that the constant in the equation was increased by AASHTO from 33 to 40. This equation is the result of a derivation that accounts for both hoop stresses and bending stresses.</td>
</tr>
<tr>
<td>FDOT</td>
<td><strong>Comments from FDOT:</strong>&lt;br&gt; Henry T. Bollmann, P.E.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Were the DS Brown MathCad calculations checked in detail by Michael Baker or a PE at PENNDOT? Need verification as the Standards are based on the DS Brown calculations.</td>
<td>Yes, the Mathcad calculations developed by D.S. Brown were checked by Baker. Baker presented a summary of the calculation check to PENNDOT during the BD-613M development stage and PENNDOT agreed with the calculation methodology.</td>
</tr>
<tr>
<td>2</td>
<td>Need provision in the Tables for plate thickness dimension at all 4 corners of the sole plate. These plates are often beveled transversely and longitudinally.</td>
<td>The sole plate thickness provided in the BD-613M standards is based on satisfying an allowable bending stress of 0.55*Fy. Since nearly every bridge will require different bevels in the longitudinal and/or transverse directions, the standards show the minimum sole plate thickness only. The designer then adds to the minimum thickness to account for the bevel (if required) and adjusts the total bearing height accordingly. This is explained in the “Sole Plate Design” notes (Note 2) on Sheet 1 of the BD-613M standards.</td>
</tr>
<tr>
<td>Page</td>
<td>Comment</td>
<td></td>
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<tr>
<td>------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Am I clear on how these “standards” are to be used? Bridge designer uses these sheets to size the pot bearing and related plates. Uses the notes and details as needed. The bearing supplier provides shop drawings for approval.</td>
<td>The intent of the BD-613M standards is to provide bearing component sizes based on calculated loads in lieu of performing a complete bearing design. PENNDOT still requires the pot bearings to be detailed on the contract drawings as per the BD-613M standards. The fabricator is still required to submit shop drawings during construction. However, as long as the bearing is detailed in accordance with the contract drawings, design calculations are not required with the shop drawing submission. PENNDOT’s intent is to evolve the BD-613M standards into construction standards, which would eliminate the need for shop drawings.</td>
</tr>
<tr>
<td>4</td>
<td>I like the design methodology shown here and the bearing design examples are helpful. I would use these “standards”. The design of the pot bearings and detailing has always been a time consuming task.</td>
<td>No response required.</td>
</tr>
<tr>
<td>5</td>
<td>It’s not clear to me where the direction of the guide bars is shown. I think in the plan view, section B-B sheet BD-613M, the direction of the guide needs to be shown (as a bearing) and how the masonry plate is oriented on the bridge pier. Note that for curved bridges each pot bearing will often have a different guide bearing angle.</td>
<td>The BD-613M standards depict the guide bars as parallel to the CL girder/beam and the masonry plate as perpendicular to the CL girder/beam. This is shown in Sections B-B and C-C on Sheet 12 of the standards. However, the designer can change the orientation of the guide bars and masonry plates as required as long as geometric clearances are verified. This is discussed in Note 12 on Sheet 1 of the standards.</td>
</tr>
<tr>
<td>6</td>
<td>There are notes “weld as per design”….as where pot is attached to the masonry plate. Are these notes directed to the Bridge designer or the pot bearing supplier?</td>
<td>The BD-613M standards are intended to be used by the bridge design engineer. Therefore, the notes are directed to the design engineer and as such he or she would be responsible for sizing the pot to masonry plate weld.</td>
</tr>
<tr>
<td>7</td>
<td>See the plan sheets I sent to Patricia Kiehl. Note the 6 inch block out for the swedge anchor bolt sheet C-112. We recommend this for construction tolerances. See note 9 on sheet C-112….we found this necessary to keep the bearings from being turned the wrong way in field placement. This has happened several times.</td>
<td>The BD-613M standards show a generic detail for the anchor bolt embedment. However, the blockout detail you refer to has been used on occasion for PENNDOT bridges as well. Notes 12 &amp; 13 on Sheet 14 of the BD-613M standards are intended to eliminate bearing misplacement in the field. The project team is willing to discuss the inclusion of additional anchor bolt details and field placement instructions.</td>
</tr>
<tr>
<td>8</td>
<td>Note the angle of the bolts which attach the top plate / bevel plate to the girder…sheet C-111. On our last job the contractor drilled the holes in the bottom flange of the girder at 90 degrees to the bottom of the box girder flange and the pot bearing manufacturer installed the bolts at 90 degrees to the top plate and so there was a fit up problem in the field…they had to bend the bolts to fit.</td>
<td>The sole plate attachment detail you reference is similar to the tapped bolt detail shown on Sheet 15 of the BD-613M standards. This sheet provides details for connecting sole plates to both steel girders and P/S concrete beams. However, situations often vary where other sole plate connection details are required. We suggest adding a note to the detail on Sheet 15 of the BD-613M standards that makes the designer aware of the potential for bolt/thread misalignment when using beveled plates.</td>
</tr>
<tr>
<td>9</td>
<td>An item of interest: DS Brown elected to fabricate the top plate and bevel plate shown on sheet C-111 from one plate. (made these into one plate).</td>
<td>No response required.</td>
</tr>
</tbody>
</table>

**NCDOT**

| Comments from NCDOT: |
| James Gaither, PE [comments 1 –11] ; T.K. Koch, PE [comments 12 -17] |

<p>| 1 | <strong>Standard Drawing Comments:</strong> Sheet 8—several of the sole plate, guide plate and guide bars are greater than 4” thick. Plates greater than 4” thick may not be available in M270 (ASTM A709), Grade 50. The AASHTO and ASTM specifications do not specify the yield for plates greater than 4”. Equivalent ASTM specifications require reduced yield for plates greater than 4”. |
| | We agree that the ASTM and AASHTO specifications do not specify yield strengths for plates over 4”. This was apparently overlooked during the generation of the standards. We contacted performed a review of material certifications for plates they received that were over 4” thick. Their certifications show that the yield strength is still generally above 50 ksi. However, the project panel members should discuss the incorporation of a dual material specification for plates greater than 4” thick. |
| Sheet 10 | pot is recessed into the masonry plate and caulked. We require the plate welded to the masonry plate and not recessed. We could not find reference in AASHTO on attaching the pot base to the masonry plate. There may be cost savings in welding instead of recessing and during an earthquake welding may perform better than recessing. | The primary reason for the recessed detail is to allow for future replacement of the pot bearing without the need to grind the existing weld or remove the masonry plate. See the last paragraph of AASHTO LRFD Bridge Design Specifications, Section C14.8.1, which suggests the recessed detail. Please note that the BD-613M standards also include an alternate welded connection for attaching the pot to the masonry plate (see BD-613M, Sheet 14, “Alternate Pot Plate Attachment”). This welded detail was included in the standards because PENNDOT used to specify welding only throughout the state. |
| Sheet 11 | ss plate is 13 gauge. AASHTO LRFD 14.7.2.3.2 and our PSP requires 11 gauge when dimension greater than 12” | The AASHTO LRFD Bridge Design Specifications (1998 &amp; 2004), Section 14.7.2.3.2 states that the SS mating surface shall be at least 16 gage when the maximum dimension of the surface is less than or equal to 12”, and at least 13 gage when the maximum dimension of the surface exceeds 12”. |
| Sheet 12 | two guide bars and a guide plate instead of a center guide key will significantly increase fabrication cost. It may be appropriate to develop a separate standard for light-loaded and heavy-loaded bearings. | PENNDOT prefers external guide bars for bearing inspection purposes. If center guide bars are used, they may not be as visible during inspections. In addition, AASHTO LRFD (1998) Section C14.7.4.7 discusses a few disadvantages of using a center guide bar. However, if the project team members prefer to use center guide bars, these details will be incorporated into the standards as an option. |
| Sheet 13 | bedding material 1/8”. We require 3/16”, although we have heard just recently that pads not in 1/8” increments are hard to obtain and are considering modifying this size. | The bedding material is used to create a more uniform bearing area under the masonry plate since the substructure concrete finish may be rough. Both material thicknesses mentioned will likely serve this purpose. |
| Sheet 13 | PTFE is attached to the guide plate by three methods (countersunk screws, adhesive and recessed PTFE). AASHTO requires only two attachment methods. Screw heads may be exposed after PTFE is worn down and damage the SS. | To ensure that the PTFE surfaces do not separate from the steel plates, PENNDOT prefers all three attachment methods. The standards could be modified to include attachment methods preferred by all agencies. |
| Sheet 14 | anchor bolts are F1554 Grade 55, we use A449. | PENNDOT prefers to use F1554 Gr. 55 anchor bolts. PENNDOT does not allow the use of A449 bolts because the bolts are quenched and tempered, and we are concerned about the potential for brittle failures. |</p>
<table>
<thead>
<tr>
<th>Sheet</th>
<th>Question/Comment</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Sheet 14, for curved girder bridges should guide bars be oriented toward fixed bearings, and if so how?</td>
<td>The guide bar orientation is determined by the bridge design engineer. Many factors may influence the preferred orientation, such as intended direction of movement, bearing configuration at other substructure units, expansion dam type, and others.</td>
</tr>
<tr>
<td>9</td>
<td><strong>Calculation comments:</strong> Sheet 3, Section 3F and Sheet 4 Section 4B—The equation to determine recess required for pot to masonry plate connection is not the equation referenced in eq. 6.7.6.2-1 and 6.7.6.2.2-2.</td>
<td>We agree. The calculation references to AASHTO LRFD, Section 6 are incorrect. The recess calculation is based on checking against the allowable bearing stress of 0.8<em>Fy using 1/3 of the pot circumference for bearing. A minimum recess depth of 1/4” is used if the stress check yields a smaller recess. The allowable stress of 0.8</em>Fy is taken from the AASHTO Standard Specifications for bearing on pins.</td>
</tr>
<tr>
<td>10</td>
<td>Sheet 6, Section 6C iv and Sheet 7 6D iv – To determine weld required for the guide bar SS connection, the calculations reference 1992 AASHTO Section 10.32.2 and Eq. 10-12. Why did it not reference AASHTO LRFD specification?</td>
<td>The AASHTO LRFD Bridge Design Specifications do not list provisions for service load design of welds. Therefore, the equations from the 1992 AASHTO Standard Specifications were used to determine the required weld size based on service loads. (Note that PENNDOT used the 1992 AASHTO Standard Specifications prior to switching to LRFD. The 1992 Standard Specifications are still used in lieu of the 1996 Standard Specifications for non-LRFD designs such as curved girder bridges.) We suggest adding a note to the BD-613M standards listing the allowable service stress for weld design.</td>
</tr>
<tr>
<td>11</td>
<td>Sheet 7, section 6E and sheet 10 Section 8D—To determine guide plate and sole plate thickness; the loaded area was calculated using a 56.31 degree angle. This could be a simplification of a finite element analysis; in any event, the origin of this value is unclear.</td>
<td>The 56.31 degree angle represents a 1.5:1 distribution of load through the plates.</td>
</tr>
<tr>
<td>12</td>
<td>3a) Piston Face width --The calculations do not appear to be using the latest equations from LRFD, especially 14.7.4.7-2. There is now a 1.5 in the numerator instead of 2.5.</td>
<td>The pot bearing design calculations supporting the BD-613M standards are based on the AASHTO LRFD Specs. (Second Edition, 1998). AASHTO Equation 14.7.4.7-2 (1998) lists the constant 2.5 in the numerator because the term “Hs” (also in the numerator) is the applied horizontal service load. The Third Edition of the AASHTO LRFD Specs. (2004) modified equation 14.7.4.7-2 to include the constant 1.5 in the numerator in place of 2.5 because the term “Hu” is the applied lateral load from applicable strength and extreme event limit states.</td>
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<tr>
<td>13</td>
<td>3b) eq. 14.7.4.6-3 has changed to .04Dp.</td>
<td>The 0.045 factor is recommended in the Structural Committee for Economical Fabrication (SCEF) Specification, Standard 106, Section 106.4.2.1.3. This specification was used in conjunction with the AASHTO specifications to develop the BD-613M standards. PENNDOT decided to use the more conservative value of 0.045.</td>
</tr>
<tr>
<td>14</td>
<td>3e) eq. 14.7.4.7-1 has changed – the 40 in the numerator is now 25.</td>
<td>See response to comment 12. The terms “Hu” and “θu” in AASHTO Eq. 14.7.4.7-1, which are the lateral load and rotation respectively, are calculated as strength or extreme limit state values in the Third Edition of the AASHTO LRFD Specs. Previously in the Second Edition, these terms were service limit state values. This difference accounts for the lower constant in the equation.</td>
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<tr>
<td>15</td>
<td>3F) the equation for pot recess does not match LRFD 6.7.6.2.2-1.</td>
<td>See response to comment 9.</td>
</tr>
<tr>
<td>16</td>
<td>4c) Piston Thickness—there appears to be no allowance for compressive deflection—i.e., no 2δu term. We should consider assuming some flat dimension like 1/16” for this term since it is difficult to quantify…</td>
<td>The equation cited is from the SCEF Specification, Standard 106, Section 106.4.2.3.2. This specification was used in conjunction with the AASHTO specifications to develop the BD-613M standards. The SCEF specification does not include a term for the compressive deflection. The SCEF equation was used to develop the BD-613M standards in lieu of the similar AASHTO equation. The actual compressive deflection is likely small when compared to the deflection due to rotation coupled with the extra 0.125” that is included in the calculation.</td>
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<tr>
<td>17</td>
<td>6E) Again – to echo JG’s comments—the origin of the 56.31 degree angle is obscure. I think most designers would assume 45 degrees.</td>
<td>See response to comment 11.</td>
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</tbody>
</table>

**Baker**

**Comments from Baker:**

<p>| | |</p>
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<tbody>
<tr>
<td>1</td>
<td>Sheet 1 of BD-613M, note 9 under “Instructions for Using Design Tables” lists dimension “Z” as one of the dimensions to reevaluate should the longitudinal movement exceed 3”. Dimension “Z” is the length of the guide bar and should not be included in this note. The guide bar is designed to accommodate the required length of guide plate PTFE and would be unaffected by a longitudinal movement greater than 3”.</td>
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<td>2</td>
<td>If this standard is to be used nationally, the references to PENNDOT specifications (DM-4 &amp; Pub. 408) should be removed and replaced with specifications appropriate for a national standard.</td>
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<td>3</td>
<td>Consider adding a note to the example “DESIGN LOADS” tables on sheet 2 of BD-613M alerting designers that all applicable horizontal and vertical loads should be considered when calculating the design horizontal and vertical loads. (CF, BR, and etc. may apply to the design of pot bearings in certain situations, not just DL, LL+I and wind.)</td>
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<tr>
<td>4</td>
<td>Dimension “V” listed in the BD-613M bearing tables is the piston diameter and has been set as 0.02” less than dimension “S”, which is the pot inside diameter and neoprene disc diameter. The 0.02” difference between these two dimensions represents the total clearance between the piston and the pot wall (0.01” clear around the perimeter) and is consistent for all bearing sizes listed in the BD-613M tables. AASHTO Section C14.7.4.7 states that an acceptable range for this clearance is 0.02” to 0.04”. AASHTO Equation 14.7.4.7-4 is also provided to determine the clearance required to prevent the escape of elastomer between the piston and pot wall and is based on geometry. Note that the 0.02” minimum controls over AASHTO Equation 14.7.4.7-4 for all design cases covered in the standards. In a recent review of shop drawings provided for pot bearings, the fabricator modified the clear dimension between the pot and piston to 0.04” (0.02” clear around the perimeter). The fabricator stated that the 0.02” total clearance was very tight and essentially unachievable given the tolerances in machining the pot and piston. As a result, the fabricator reduced the piston diameter to provide a total clearance of 0.04”. Consider modifying the piston diameter (dimension “V”) to allow for a clearance range, or list the minimum piston diameter allowed.</td>
</tr>
<tr>
<td>5</td>
<td>The length of the PTFE attached to the top of the guide plate (dimension “HH”) for guided pot bearings is less than the length of the PTFE mounted on the sides of the guide plate (dimension “KK”) for every design case listed in the BD-613M standards. Hence, one would expect the length of stainless steel mated to each of the PTFE surfaces (dimension “LL” for the guide plate stainless steel and dimension “NN” for the guide bar stainless steel) to vary in accordance with the length differences in PTFE surfaces so that the same movement capacity would be provided for each of the components. However, both the guide plate and guide bar stainless steel surfaces are listed as the same length in the guided pot bearing tables in the BD-613M standards. The guide plate stainless steel length (dimension “LL”) could be reduced based on the difference in PTFE lengths (dimension “KK” minus dimension “HH”).</td>
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<td>We agree that the stainless steel sheet attached to the sole plate that mates with the top PTFE surface could be reduced in length as stated. However, this would be a small reduction in length. In addition, it is likely that the same sheet of stainless steel would be used to fabricate both the guide bar stainless steel sheets and the sole plate stainless steel sheets. Therefore, making the sole plate sheet shorter would require an additional cut in the fabrication process. Please note that the dimensions of the PTFE surfaces mated to the top and sides of the guide plate were sized based on the allowable stress of the PTFE. Since the applied stress is different in the vertical and horizontal directions, the length of top PTFE surface is different than the length of the side PTFE surface.</td>
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</table>

cc: Patricia Kiehl, P.E., PENNDOT  
Vasant Mistry, P.E., FHWA  
Henry T. Bollmann, P.E., FDOT  
Tom Koch, P.E., NCDOT
Background

This project is a collaborative effort between the Federal Highway Administration (FHWA), the Florida Department of Transportation (FDOT), the North Carolina Department of Transportation (NCDOT), and the Pennsylvania Department of Transportation (PENNDOT). The goal of the project is to examine PENNDOT’s existing design standards and drawings for high load multi-rotational bearings (pot bearings), compare the standards to the procedures and methods used by the other participating agencies, and determine if a revised pot bearing design standard can be developed that can be utilized by all agencies involved.

In 2003, PENNDOT published pot bearing design standards and drawings entitled “BD-613M: HIGH LOAD MULTI-ROTATIONAL POT BEARINGS”. These standards provide designs for three configurations of pot bearings: fixed, guided, and non-guided. The standard designs are listed in tabular format and allow the designer to select the size of the various pot bearing components once the applied forces, movements, and rotations are known. The implementation of the standards greatly reduces the time required to design and detail pot bearings and ensures uniformity in pot bearing design throughout Pennsylvania. A copy of the BD-613M standards is included in Appendix A for reference and an overview of the standards is included below in the section entitled “BD-613M Overview”.

Introduction

The intent of this task report is to review the available pot bearing literature from the participating agencies and compare and contrast those guidelines to the BD-613M standards. Design standards, specifications, and sample design drawings submitted by the participating agencies were reviewed to determine how the BD-613M standards may be modified to encompass any differing guidelines. The literature considered in the development of this report is included in the appendices.

In this report, the typical components of a pot bearing are discussed individually, and the material and design requirements are reviewed. Where these vary from agency to agency, the differences are highlighted and discussed. Terminology used in this report corresponds to BD-613M since the names of the various components may vary from agency to agency.

Typical Types of Pot Bearings

As stated previously, BD-613M includes design tables and details for fixed, guided, and non-guided types of pot bearings. Fixed bearings are designed to resist movement in all directions and allow rotation in all directions. Guided bearings are designed to resist horizontal movement...
along one axis and allow rotation in all directions. Non-guided bearings are designed to allow movement and rotation in all directions.

**BD-613M Overview**

Service load design methodology was used in developing the BD-613M standards. However, the standards accommodate applied loads developed from either the AASHTO Standard Specifications for Highway Bridges (Standard Specs.) by using the service load group combinations or from the AASHTO LRFD Bridge Design Specifications (LRFD Specs.) by using the Service I and Extreme Event I limit states.

Both English unit and Metric unit tables are provided for each of the three types of pot bearings. The tables include pot bearing designs that will accommodate vertical loads from 200 kips (890 kN) to 1500 kips (5293 kN), with a choice of horizontal load values equal to 10% or 30% of the vertical load (the 30% horizontal load table is omitted for non-guided bearings). The pot bearing component sizes were designed for a total rotation of 0.03 radians, which includes 0.02 radians for construction tolerance.

The guided and non-guided bearings were designed to accommodate a maximum calculated longitudinal movement of 3”, plus 1” of construction tolerance in each direction. Additional longitudinal movement can be accommodated by increasing the length of the sole plate, stainless steel and guide bars. The non-guided bearings were designed to accommodate a maximum calculated transverse movement of ½”, plus ¾” of construction tolerance in each direction. Additional transverse movement can be accommodated by increasing the dimension of the sole plate and stainless steel.

Once the design loads, rotations, and movements are known, the designer can select pot bearing component sizes from the tables provided in the standards. Note that if the design horizontal load exceeds 10% of the vertical load for a fixed or guided pot bearing, the designer has two options: the 30% horizontal load table may be used, or the 10% horizontal load table may be used by proceeding to a larger vertical load case with a corresponding 10% horizontal load greater than the design horizontal load. The only caution required for the latter case is to ensure that the minimum design vertical load is at least 20% of the tabulated vertical load.

The procedure described above demonstrates how the BD-613M standards provide “off-the-shelf” pot bearing designs. Although the design of pot bearings with vertical design loads greater than 1500 kips is currently beyond the scope of BD-613M, the standards could be expanded.

**Pot Bearing Design Specifications**

The BD-613M design standards were developed with the understanding that service load design methodology would be phased out in favor of the LRFD Specifications. However, curved steel bridges are designed using the Standard Specifications, and PENNDOT wanted to ensure that the BD-613M standards could be used for curved steel bridges. Therefore, the standards were
developed to accommodate both specifications. The following lists the design procedure and specifications used by the participating DOT agencies:

- **FDOT**: Designers calculate loads per the AASHTO LRFD specifications and design several components of the pot bearing in accordance with the procedure outlined in the Structural Bearing Specification (SBI 1008 – 1991) by FHWA/SCEF (see Appendix B). The intent of the FDOT design is to determine the total maximum bearing height at the design stage to prevent significant changes in the bearing elevations during the shop drawing stage. The design also determines the outside diameter of the pot so that the masonry plate can be sized at the design stage. The major component dimensions of the pot bearings are shown on the design plans (see Appendix B for a sample set of pot bearing contract drawings). The remaining pot bearing components, such as the neoprene disc and piston, are sized by the designer by comparing different manufacturers’ sizes and selecting the component size which yields the largest total bearing height. However, the actual component design is left to the manufacturer during the shop drawing stage.

- **NCDOT**: Designers provide service loads, rotations, and movements based on the AASHTO Standard Specifications and the manufacturer is responsible for the pot bearing design.

**Pot Bearing Construction Specifications**

The BD-613M standards specify that the bearing manufacturer must provide materials and workmanship in accordance with PENNDOT Specifications, Publication 408 (specifically Section 1111, see Appendix A), ANSI/AASHTO/AWSD1.5 Bridge Welding Code, and contract special provisions. The other participating agencies list their construction specifications as follows:

- **FDOT**: Standard Specification 461, entitled “Multirotational Bearings”

- **NCDOT**: Standard Specification entitled “Pot Bearings”

These specifications are included in the appendices. Differences between the specifications will be discussed on a component basis as outlined below.

**Comparison of Pot Bearing Materials & Components: Design & Construction**

**Steel:**

Structural steel is the primary material used in the manufacture of pot bearings. BD-613M specifies the use of AASHTO M270/ASTM A709, Grade 50 steel. (Publication 408 also lists Grade 36 and 50W.)

- **FDOT**: ASTM A709 Grade 50W steel per their Standard Specification entitled “Multirotational Bearings”
Steel corrosion protection is required by PENNDOT for all three types of pot bearings. BD-613M requires shop painting the structural steel in accordance with Publication 408, Section 1060. Surfaces that are not to be painted include the PTFE, stainless steel, and the inside of the pot. In addition, only a prime coat of paint is to be applied to the contact area between the beam bottom flange and the sole plate, and to the bottom surface of the masonry plate.

**FDOT** specifies metallization of steel for pot bearings in accordance with their specification entitled “Multirotational Bearings”. However, in discussions with FDOT, the coating system for pot bearings varies among projects.

**NCDOT** specifies metallization of steel for pot bearings in accordance with their Special Provision for “Thermal Sprayed Coatings (Metallization)” (included in Appendix C).

**Pot:**

The pot is a typical component of all three types of pot bearings. This component is designed to resist the applied horizontal loads and to provide confinement for the neoprene disc under load.

In BD-613M, the pot wall thickness for fixed and guided bearings is calculated using AASHTO LRFD (1998), Equation 14.7.4.7-1 and Section C14.7.4.6. The pot wall thickness for non-guided bearings is designed for a nominal horizontal load equal to 10% of the vertical capacity of the bearing, as well as AASHTO LRFD (1998) Equation 14.7.4.6-5 and Section C14.7.4.6. The thickness of the pot base is calculated using AASHTO LRFD (1998) Equations 14.7.4.6-3 and 14.7.4.6-4.

The preferred method of attaching the pot to the masonry plate in BD-613M is to machine a recess into the masonry plate and place the pot in the recess. However, welding the pot to the masonry plate is an accepted alternative. When the recessed method is used, the perimeter of the pot is sealed to the masonry plate with an approved caulking compound in the shop after the paint has dried. The caulk is specified as Sikaflex IA or an approved equal. Recessing the pot in the masonry plate allows for ease of future replacement without the need to remove the anchor bolts and masonry plate.

**FDOT:** The pot base thickness is sized by the manufacturer. The sample contract drawings provided indicate a 3/16” recessed connection detail similar to that shown in the BD-613M standards.

**NCDOT:** The pot is designed by the manufacturer. The specification entitled “Pot Bearings” discusses welding the pot to the masonry plate but does not limit the attachment otherwise. The standard pot bearing details provided show a welded connection between the pot and masonry plate.
Elastomeric (Neoprene) Disc:

The elastomeric disc is a typical component of all three types of pot bearings. This component is confined by the pot and designed to accommodate vertical load and rotation.

In BD-613M, the disc diameter was calculated by limiting the average stress to 3.5 ksi per AASHTO LRFD (1998) Section 14.7.4.4. The disc thickness was calculated using AASHTO LRFD (1998) Equation 14.7.4.3-1.

The material for the elastomeric disc is specified in BD-613M as virgin plain neoprene or natural rubber with hardness of 50 Durometer (+/- 10) in accordance with AASHTO M251. The disc surfaces are to be lubricated with silicone grease in accordance with Military Specification MIL-S-8660 and as recommended by AASHTO LRFD (1998) Section C14.7.4.4.

- **FDOT**: The manufacturer is responsible for the design of the neoprene disc per the applicable design specification (either the Standard Specifications or the LRFD Specifications). Note that their specification entitled “Multirotational Bearings” does not discuss the material requirements for the neoprene disc. The sample contract drawings provided indicate the use of a PTFE sheet on top and bottom of the neoprene pad.

- **NCDOT**: Per their Pot Bearing specification, the maximum average stress on the disc is limited to 3500 psi. The material requirements for the disc are similar with a 50 Durometer hardness specified, but no allowable variance in hardness is listed. In addition, their specification states that the disc should allow for a minimum rotation of 0.02 radians. Instead of lubricating the disc with silicon grease, their specification indicates the use of a 1/64” thick PTFE disc on either side (top or bottom) of the disc or other material as approved by the Engineer.

Sealing Rings:

Sealing rings are a typical component of all three types of pot bearings. The purpose of the sealing rings is to prevent leakage of the neoprene disc under load.

In BD-613M, the sealing rings are comprised of three, 3/32” thick flat brass sealing rings with rectangular cross sections. Three rings are stacked and placed in a recess in the neoprene disc so that the top of the upper ring is flush with the top surface of the neoprene disc. Each end of the sealing rings is cut at a 45° angle with a maximum opening between the ends of 0.05”. The openings are staggered 120° apart. The width of the sealing rings listed in BD-613M was calculated by AASHTO LRFD (1998) Section 14.7.4.5.2. Sealing ring material requirements are per ASTM B36 (half hard).

- **FDOT**: Designers do not design or detail the sealing rings on the design drawings. This item is left to the manufacturer to detail in the shop drawing stage. Note that the SCEF SBI-1008 (1991) specification allows the use of flat or round sealing rings.
**NCDOT:** Their Pot Bearing specification discusses the use of a brass sealing ring. A round ring is shown on their standard details sheet, but the material specification is not mentioned. The manufacturer is responsible for sizing and detailing the sealing rings.

**Piston:**

The piston is a typical component of all three types of pot bearings. The purpose of the piston is to transfer loads and rotations from the sole plate or guide plate to the neoprene disc and the pot.

In BD-613M, the piston face width was calculated using AASHTO LRFD (1998) Equations 14.7.4.7-2 and 14.7.4.7-3, along with the provisions of Section C14.7.4.7. The piston diameter was calculated as the pot inner diameter minus a calculated clearance. The clearance is the maximum of the dimension calculated using AASHTO LRFD (1998) Equation 14.7.4.7-4 and 0.02” per AASHTO LRFD (1998) 14.7.4.7. However, given the range of pot bearing sizes and rotations covered by BD-613M, the minimum clearance of 0.02” controls over Equation 14.7.4.7-4. Therefore, the piston diameter is always 0.02” less than the inside pot diameter for standard derived bearings.

**FDOT:** Designers select a maximum piston height by comparing several manufacturers’ catalogs so that the total bearing height is known during the design stage. However, the piston face width and clearance are determined by the manufacturer. If the piston height is modified by the manufacturer during the shop drawing stage, the contractor is required to adjust the bearing elevations accordingly.

**NCDOT:** The manufacturer is responsible for sizing and detailing the piston based on design loads provided on the contract drawings by the designer.

**Sole Plate:**

The sole plate is a typical component of all three types of pot bearings. The purpose of this component is to provide a means of attachment to the beam/girder above the bearing. The sole plate is usually designed so its bottom surface is level and the top surface matches the anticipated slope of the bottom of the beam/girder in the final erected position.

For fixed bearings, the sole plate plan dimensions are a function of the piston diameter. For non-guided bearings, the sole plate plan dimensions are controlled by the piston diameter and the excess length and width required to accommodate the anticipated movements. For guided bearings, sole plate plan dimensions are set by the required length and width of the guide system. In addition, connection details to the beam/girder above may increase the plan dimensions. This is especially true with skewed structures.

In BD-613M, the thickness of the sole plate was designed for flexure by assuming an equivalent square area of the circular piston area or the square area of the PTFE attached to the upper
surface of the guide plate. The pressure transferred from the piston or PTFE was assumed to distribute through the sole plate at a 1.5:1 slope. The moment in the sole plate was determined by assuming that the sole plate acts as a cantilever beam with a length equal to the length of the loaded area beyond the edge of the piston or PTFE sheet. The required plate thickness was then determined using the calculated moment and an allowable bending stress of 0.55*Fy = 27.50 ksi.

Note that the BD-613M tables do not include any allowance for additional sole plate thickness that may be required for beveling the plate to match roadway geometry and/or beam camber. The total bearing heights listed in the BD-613M tables are based on the minimum sole plate thickness indicated. The total bearing height needs to be adjusted by the designer if the sole plate thickness is not constant.

- **FDOT**: The SCEF SBI-1008 (1991) specification lists the allowable bending stress at 0.75*Fy for sole plates. The example contract drawings provided by FDOT show a suggested beveled sole plate-to-beam connection using 1 ½” diameter A325 threaded rods with double heavy hex nuts. The sole plate plan dimensions and bevel thicknesses are provided by the designer on the contract drawings.

- **NCDOT**: The sample pot bearing details provided by NCDOT indicate that the sole plate dimensions are determined by the manufacturer based on the design loads provided on the contract drawings.

**Guide Plate:**

The guide plate is a typical component of guided pot bearings only. The guide plate is set on top of the piston in a guided bearing assembly.

The guide plate plan dimensions are controlled by the piston diameter and the dimensions of the PTFE required on top of the plate. The guide plate-to-piston connection detail shown in BD-613M includes recessing the piston into the guide plate.

In BD-613M, the thickness of the guide plate was designed for flexure by assuming the piston acts on an equivalent square area of the guide plate. The pressure transferred from the piston was assumed to distribute through the guide plate at a 1.5:1 slope. The moment in the guide plate was determined by assuming that the guide plate acts as a cantilever beam with a length equal to the length of the loaded area beyond the edge of piston. The required plate thickness was then determined using the calculated moment and an allowable bending stress of 0.55*Fy = 27.50 ksi. In addition, consideration of the required height of PTFE attached to the sides of the guide plate may control the required guide plate thickness.

- **FDOT**: The guide plate (termed “top plate”) thickness is shown on the sample contract drawings provided, indicating that the designer calculates the thickness. The drawings also indicate that the plate is bolted to the sole plate by the use of threaded rods as discussed previously. The plate is connected to the piston through the use of a guide key.
• **NCDOT:** The guide plate (termed “top steel plate”) is designed by the pot bearing manufacturer. The plate is attached to the piston through the use of a guide key.

**Guide Bars:**

Guide bars are a typical component of guided pot bearings only. The bars are typically welded to the sole plate, bolted to the sole plate, or machined in the sole plate. Their function is to restrict movement of the beam/girder along one horizontal axis.

Welded guide bars are shown in BD-613M, but the guide bars may also be machined in the sole plate from a single block of steel. Bolted guide bars are not preferred by PENNDOT.

In BD-613M, the guide bar height was designed to accommodate the thickness of the stainless steel sheet attached to the sole plate, the exposed thickness of the PTFE sheet embedded in the guide plate, and the depth of the guide plate. The length of the guide bars was set equal to the required sole plate length so that horizontal restraint is provided under all longitudinal movement conditions. The guide bar attachment was designed by considering the shear and moment applied to the guide bars through horizontal forces acting on the bearing.

• **FDOT:** The sample contract drawings provided show a single guide key placed along the centerline of the bearing. The thickness of the key is shown as ½” indicating that the designer sized the key, but the key height and keyway opening are determined by the manufacturer. (In speaking with a FDOT representative, we understand that their Department uses a simplified dynamic seismic analysis that generally equates to lower horizontal design forces when compared to the AASHTO simplified static force calculation. Note that the AASHTO contour maps showing acceleration coefficients for different parts of the country (AASHTO Figure 3.10.2-2) yield low acceleration coefficients for the state of Florida.)

• **NCDOT:** The standard pot bearing details provided also show a single, central guide key. Horizontal design loads are provided on the plans by the designer and the pot bearing manufacturer is responsible for the design of the guide key.

**PTFE:**

PTFE sheets are typical components of guided and non-guided pot bearings. The PTFE sheets are recessed into and bonded to the guide plate in guided bearings and to the piston in non-guided bearings to allow for movement with minimal friction. Stainless steel sheets are welded to the opposing steel surfaces and bear on the PTFE sheets.

For guided bearings that include guide bars instead of guide keys, PTFE surfaces and opposing stainless steel sheets are used between the guide bar/guide plate interfaces. This detail is shown on Sheet 13 of 15 in the BD-613M standards (see Appendix A).
For the PTFE surface attached to the piston for non-guided bearings, BD-613M details the PTFE sheets as 3/16” thick and cut circular in plan so that they mirror the piston geometry. For guided bearings, the PTFE is also 3/16” thick but is cut square with ½” rounded corners to match the shape of the guide plate.

BD-613M specifies that the PTFE sheets are to be unfilled, dimpled, and lubricated. The PTFE that is mounted to the sides of the guide plate is to be pigmented. The PTFE sheets are to be manufactured from virgin TFE resin and conform to ASTM D4894. The dimples in the PTFE are to have a minimum edge distance of ½” and conform to AASHTO LRFD (1998) Section 14.7.2.

To facilitate bonding the PTFE to the steel surfaces, both the PTFE and the steel surfaces are to be grit blasted and degreased prior to bonding. The BD-613M standards also require etching of the PTFE on the side to be bonded to the steel surface. The bonding adhesive is to be applied per the manufacturer’s instructions. For the PTFE that is attached to the guide bars, PENNDOT requires the PTFE to be recessed, bonded, and mechanically fastened.

For design of the PTFE sheets, BD-613M specifies maximum and minimum stresses on the PTFE of 3.5 ksi and 0.7 ksi. A coefficient of friction between the PTFE and stainless steel sheets was assumed to be 0.04 for calculating the horizontal load transfer due to sliding.

- **FDOT:** Unfilled PTFE sheets are shown on the sample contract drawings provided. Their specification entitled “Multirotational Bearings” allows the use of unfilled virgin PTFE or glass-fiber filled PTFE. The resin is to conform to ASTM D1457.

- **NCDOT:** Their standard specification for pot bearings indicates that the PTFE sheets are to be designed by the manufacturer. The specification lists acceptable material types as unfilled virgin PTFE or glass-fiber filled PTFE with resins conforming to the requirements of ASTM D4894 or D4895. The stress limit for design of the PTFE is limited to 3.5 ksi per the specification.

**Stainless Steel Sheets:**

Stainless steel sheets are typical components of guided and non-guided pot bearings. The sheets are mated with the PTFE material to reduce friction during movement of the bearing.

BD-613M specifies the use of 13 gage stainless steel sheets meeting the requirements of ASTM A240, Grade 30, Type 304, with an ANSI 0.02 mil surface finish or less. The stainless steel is attached to the guide bars or sole plate with a 1/16” continuous fillet weld around the perimeter of the sheet.

- **FDOT:** Their specification and sample contract drawings provided indicate that the stainless steel sheets are to conform to ASTM A240, Type 316. The sheet thickness is not indicated on the drawings, but their specification lists a minimum thickness of 1/16”.

- **NCDOT:** Their standard specification for pot bearings indicates that the stainless steel sheets are to be designed by the manufacturer.
• **NCDOT:** The manufacturer is responsible for designing the stainless steel sheets. Their standard specification for pot bearings lists the minimum sheet thicknesses as 16 gage for sheets less than 12” in plan and 11 gage for sheets greater than 12” in plan. The material type is listed as ASTM A240/A167, Type 304 with a minimum #8 mirror finish.

**Masonry Plate:**

The masonry plate is a typical component of all three types of pot bearings. The purpose of the masonry plate is to transfer loads from the pot to the bridge substructure.

In BD-613M, the masonry plate was sized assuming it will be placed normal to the beam/girder centerline. Other orientations are permitted, but the designer must then design the masonry plate according to the methodology outlined in the standards and ensure all geometric clearances are satisfied.

The masonry plate widths (dimension normal to the beam/girder centerline) listed in BD-613M were set by placing the anchor bolts outside the sole plate to ensure adequate horizontal clearance and adding the minimum edge distances from the anchor bolt centerline to the edge of plate. The masonry plate lengths (dimension parallel to the beam/girder centerline) were established based on the required width to resist shear applied by the horizontal loads acting through the pot.

To determine the required masonry plate thickness, the calculations used to develop the BD-613M standards assume the vertical load acting through the pot is evenly distributed through the masonry plate. The moment was calculated assuming the plate acts like a cantilever beam outside the diameter of the pot. The longest cantilever length from either direction is used to calculate the maximum moment in the plate. The allowable bending stress in the plate is limited to 0.55*Fy = 27.50 ksi per AASHTO Table 10.32.1A and the allowable concrete bearing stress is assumed to be 0.30 ksi.

BD-613M indicates two different details for attaching the pot to the masonry plate. The first detail includes setting the pot into a machined recess in the masonry plate and sealing around the perimeter of the pot base with an approved caulking compound. The second detail includes welding the pot to the masonry plate.

• **FDOT:** The masonry plate is sized by the designer per the SCEF SBI-1008 (1991) specification, which lists procedures to be used for masonry plate design. Note that this specification sets the allowable bending stress in the plate at 0.75*Fy. The sample contract drawings provided show the pot attached to the masonry plate through the use of a 3/16” deep machined recess.

• **NCDOT:** The masonry plate is sized by the designer and detailed on the contract drawings. The standard details provided show the pot attached to the masonry plate through the use of a welded connection.
**Anchor Bolts:**

Anchor bolts are a typical component of all three types of pot bearings. Anchor bolts are embedded in the bridge concrete substructure and attach the masonry plate to the substructure to ensure load transfer.

BD-613M requires the use of swedged anchor bolts meeting the requirements of ASTM F1554, Grade 55. The number of anchor bolts was determined by limiting the shear stress in the bolts to 0.33*Fy = 18.15 ksi. Anchor bolt nuts are to meet the requirements of ASTM A563, Grade DH and the washers are to meet the requirements of ASTM F436, Type 1.

Anchor bolts, nuts and washers are galvanized per PENNDOT Publication 408, Section 1105.02(S). The nut and washer installation procedure specified in BD-613M indicates that a single nut and washer are to be installed on each anchor bolt. The nut is to be installed finger-tight against the washer and then backed off ¼ turn. The anchor bolt threads are peened after the nut is installed to prevent the nut from loosening.

The anchor bolt detail in BD-613M indicates that the swedged bolts are embedded in the concrete substructure. However, another common method includes the use of preformed holes placed in the concrete substructure. This method allows installation of the anchor bolts through the use of non-shrink grout after construction of the substructure unit.

- **FDOT:** The sample contract drawings provided show a 6” diameter preformed blockout in the concrete substructure for anchor bolt installation. Notes provided on the sample contract drawings indicate that the swedged anchor bolts are to conform to ASTM A307 and are to be galvanized. The designer provides the anchor bolt diameter, length, and configuration on the contract drawings. Note that their specification entitled “Multirotational Bearings” does not discuss anchor bolts.

- **NCDOT:** The standard details provided show a preformed hole in the concrete substructure. The hole is created by using a 4” diameter x 1’-3” long standard pipe with a closed end. A grout tube is also placed outside of the masonry plate plan area and is attached to the side of the pipe near the bottom to facilitate placing of the non-shrink, non-metallic grout. Their standard specification for pot bearings indicates that the anchor bolt size and length are provided by the designer and detailed on the contract drawings.

**Bedding Material:**

Bedding material placed on top of the concrete substructure and under the masonry plate is typical for all three types of pot bearings. BD-613M specifies the use of 1/8” thick bedding material meeting the requirements of ASTM D378.

- **FDOT:** A 1/8” thick neoprene pad under the masonry plate is shown on the sample contract drawings provided.
• **NCDOT:** A 3/16” thick preformed neoprene pad under the masonry plate is shown on the standard details provided.

**Conclusions & Recommendations**

The component by component comparison outlined above demonstrates that there are more similarities than differences between the DOT agencies with regard to pot bearing design and manufacture. Through future discussions, the differences will likely be reduced or allowance can be made to account for the differences through the use of expanded design standards.

Upon PENNDOT approval, Baker recommends distributing the final report to the other project panel members for review and comment. Following the review and comment period, we also suggest meeting with all project panel members to determine the exact scope for expansion of the current BD-613M standards. This meeting will be the springboard for advancing the project to “Task 3: Research and Drafting of Pot Bearing Standards”.
SUMMARY OF POT BEARING DESIGN & CONSTRUCTION: AGENCY COMPARISON BY COMPONENT

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>PENNDOT</th>
<th>FDOT</th>
<th>NCDOC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structural Steel</strong></td>
<td>AASHTO/ASTM A709, Grade 50 (Grades 36 and 50 are also listed in Pub. 40B)</td>
<td>ASTM A759, Grade 50W</td>
<td>AASHTO M250 Grade 50W</td>
</tr>
<tr>
<td><strong>Steel Corrosion Protection</strong></td>
<td>Shop painting is required in accordance with Publication 40B, Section 1080.</td>
<td>Metallization of steel for pot bearings in accordance with their special specification for &quot;thermal sprayed coatings.&quot; (Metallization)</td>
<td>Metallization of steel for pot bearings in accordance with their special specification for &quot;thermal sprayed coatings.&quot; (Metallization)</td>
</tr>
<tr>
<td><strong>Pot</strong></td>
<td>The pot wall thickness and base plate thickness are determined according to equations in AASHTO LRFD (Second Edition). The preferred method of attachment at the base plate is a recess into the masonry plate. The manufacturer then bevels the edge of the machine recess to receive the masonry plate and place the pot in the recess. However, welding is an acceptable connection alternative.</td>
<td>The pot base thickness is sized by the manufacturer. A sample drawing provided shows a 1-1/4&quot; recessed connection detail, similar to the one in PENNDOT’s SCET-419M standard.</td>
<td>The pot is designed by the manufacturer. The specification entitled &quot;Pot Bearings&quot; discusses welding the pot to the masonry plate, but does not limit the attachment method. The standard pot bearing details provided show a welded connection between the pot and masonry plate.</td>
</tr>
<tr>
<td><strong>Elastomeric Disc</strong></td>
<td>Virgin pneumatic or natural rubber with a minimum thickness of 3/16&quot; per AASHTO M010 (half hard) specification.</td>
<td>Manufacturer is responsible for design of the neoprene disc per the applicable design specification.</td>
<td>Manufacturer is responsible for design of the neoprene disc per the applicable design specification.</td>
</tr>
<tr>
<td><strong>Sealing Rings</strong></td>
<td>PENNDOT requires 3 flax bases sealing rings meeting the AASHTO M010 (half hard) specification. Ends are cut at a 45° angle with a maximum gap of 0.02&quot;. The openings are staggered in the rings 130° apart. Sealing rings are recessed in elastomer discs so that the top sealing ring flush with upper surface of elastomer disc.</td>
<td>Manufacturer is responsible for design of the sealing rings.</td>
<td>Manufacturer is responsible for design of the sealing rings and detailing the pot bearing based on design loads provided on the contract drawings by the designer.</td>
</tr>
<tr>
<td><strong>Piston</strong></td>
<td>The piston face width is calculated using equations in AASHTO LRFD (Second Edition). The piston diameter is always 0.02&quot; less than the inside pot diameter for standard bearing diameters.</td>
<td>The SCEP SB-1005/1991 specification lists the allowable bending stress at 0.75*Fy for sole plates. The example contract drawings provided show a beveled sole plate to girder connection using threaded rod with minimum load requirement. The sole plate is bonded to the guide plate. The sole plate dimensions and total thicknesses are provided by the designer on the contract drawings.</td>
<td>The piston is designed by the manufacturer. The specifications provided do not mention the standard detail sheets. Sole plates are placed on top of the elastomeric disc and pot.</td>
</tr>
<tr>
<td><strong>Sole Plates</strong></td>
<td>The thickness of the sole plate is designed for use based on an allowable bending stress of 0.55*Fy. The standards show a tapped bolt or weld connection to the sole plate and girder. The sole plate plan dimensions and total thicknesses are provided by the designer on the contract drawings.</td>
<td>The guide plate (termed &quot;top plate&quot;) thickness is sized by the designer on the contract drawings. The plate is bolted to the sole plate by the use of threaded rods. The plane is connected to the piston through a center guide key. The sole plate is 2&quot; wide and bolted to the piston and guide plate.</td>
<td>The sole plate dimensions are determined by the manufacturer based on the design loads provided on the contract drawings.</td>
</tr>
<tr>
<td><strong>Guide Plate</strong></td>
<td>The thickness of the guide plate is designed for use based on an allowable bending stress of 0.55*Fy. The plate is connected to the sole plate by the use of a center guide key. The guide plate (termed &quot;top steel plate&quot;) is recessed in elastomer discs, bonded, and mechanically fastened with countersunk screws.</td>
<td>The guide plate (termed &quot;top guide plate&quot;) is recessed in elastomer discs, bonded, and mechanically fastened with countersunk screws.</td>
<td>The guide plate (termed &quot;top steel plate&quot;) is recessed in elastomer discs, bonded, and mechanically fastened with countersunk screws.</td>
</tr>
<tr>
<td><strong>Guide Bar</strong></td>
<td>External guide bars are typically welded to the sole plate, bolted to the sole plate or machined in the sole plate.</td>
<td>A single guide key is placed along the centerline of the bearing. The thickness is designed by the designer but the key height and keyway opening are determined by the manufacturer.</td>
<td>A single, center guide key is used. Horizontal design loads are provided by the designer and the pot bearing manufacturer is responsible for the design of the guide key.</td>
</tr>
<tr>
<td><strong>PTFE</strong></td>
<td>PTFE is required to be uniform, dimpled and lubricated. Made from virgin PTFE wax or ASTM D4949. Dimpler must have a minimum edge distance of 1/16&quot; and distance from 1/8&quot; to 1/2&quot; of AASHTO LRFD Section 14.7.2. Allowable design pressure = 2.50 psi (max). For non-guided pot bearings, the PTFE is bonded in a 3/32&quot; recess in the top of the piston. For guided pot bearings, the PTFE is attached to the top of the guide plate is bonded in a 3/32&quot; recess, while the PTFE on the edges of the guide plate is recessed, bonded, and mechanically fastened with countersunk screws.</td>
<td>Unfiled PTFE sheets are shown on the sample drawings provided. The PTFD specification entitled &quot;Multi-rotational Bearings&quot; allows the use of unified virgin PTFE or glass-filled PTFE. The resin is to conform to ASTM D4517-87. The sample drawing provided shows the PTFE bonded in a 1/16&quot; recess on the top of the piston.</td>
<td>Acceptable PTFE types are unfiled, virgin PTFE sheets or glass-filled PTFE sheets, resulting in a minimum load requirement of 3,500 psi (max). The specification provided states that the PTFE is bonded to the pot bearing by using heat cured high temperature epoxy capable of withstanding temperatures of -320°F to 300°F.</td>
</tr>
<tr>
<td><strong>Stainless Steel</strong></td>
<td>Stainless steel sheets are 13 gage and conform to ASTM A416, Grade 316. Type 304 with an AISI 0.02&quot; surface finish. Stainless steel is to be used where stainless steel is specified on the standard details sheet.</td>
<td>Stainless steel sheets are to conform to ASTM A516, Grade 304. Specification lists a minimum thickness of 1/16&quot;.</td>
<td>NCDOC specification calls for ASTM A240/A416, Type 304 with a maximum #6 mirror finish surface finish. Minimum thickness of 1/16&quot; thickness is provided in 0.02&quot; increments. Minimum dimension = 1/16&quot;, 1/16 gage for minimum dimension = 1/16&quot;.</td>
</tr>
<tr>
<td><strong>Masonry Plate</strong></td>
<td>Designed using an allowable bending stress of 0.55*Fy. Two methods to attach pot to masonry plate: welding the pot in a machined recess in the masonry plate and welding around the perimeter of the pot base with an approved caulking compound, or by bedding.</td>
<td>Designed by the designer per the SCEP SB 1008 (1991) specification, which lists procedures to be used for the masonry plate design. Allowable design stress = 0.75*Fy. Pot is attached to the masonry plate with a 3/16&quot; deep machined recess on sample drawings provided.</td>
<td>Designed by the designer and detailed on the contract drawings. Pot is attached to the masonry plate using a welded connection.</td>
</tr>
<tr>
<td><strong>Anchoring Bolts</strong></td>
<td>Galvanized, swaged anchor bolts conforming to ASTM F1554, Grade 5. The distance between bolts is 1 1/2&quot; (long standard pipe with a closed end). A grout tube is placed outside of the masonry plate plan area and is attached to the sole of the pipe near the bottom to facilitate placement of the non-ferrous, non-metallic grout.</td>
<td>Galvanized, swaged anchor bolts conforming to AASHTO207 are used. Anchor bolts are installed using 5&quot; diameter preformed blockout. Anchor bolts are embedded in concrete substrate.</td>
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</tr>
<tr>
<td><strong>Bedding Material</strong></td>
<td>A 3/16&quot; thick bedding material meeting the requirements of ASTM C378 is shown in the PENNDOT standards.</td>
<td>A 1/8&quot; thick neoprene pad is shown on the sample drawings provided.</td>
<td>A 3/16&quot; thick preformed neoprene pad is shown on the standard details sheet.</td>
</tr>
</tbody>
</table>
Project #03-03 (C07)
DEVELOPMENT OF POT BEARING STANDARDS
MEETING MINUTES

Purpose: Project Status Report
Date/Time: Thursday, May 26th, 2005, 2:30 PM
Place: Michael Baker Jr, Inc. (Harrisburg Office – via conference call)
S.O. #: 103731
Author: Robert Doble, Michael Baker Jr., Inc.
Issued on: July 13, 2005

Attendees:

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patti Kiehl</td>
<td>PENNDOT, Technical Advisor</td>
</tr>
<tr>
<td>Tom Koch</td>
<td>North Carolina DOT</td>
</tr>
<tr>
<td>Henry Bollmann</td>
<td>Florida DOT</td>
</tr>
<tr>
<td>Vasant Mistry</td>
<td>FHWA</td>
</tr>
<tr>
<td>Dave Marchese</td>
<td>Baker, Agreement Manager</td>
</tr>
<tr>
<td>Eric Martz</td>
<td>Baker, Project Manager</td>
</tr>
<tr>
<td>Dave Frey</td>
<td>Baker, QA/QC</td>
</tr>
<tr>
<td>Robert Doble</td>
<td>Baker, Project Engineer</td>
</tr>
</tbody>
</table>

Discussion:

On May 10, 2005, Baker sent out the Task 2 Report, along with responses to the Task 1 comments, to the project panel members for their review and comment. A conference call was held on May 26, 2005 with all project panel members to verify that comments were addressed and to discuss the scope for expanding the pot bearing standards.

Agenda Item 1: Task 1 Comments/Responses

Eric Martz (Baker) asked each panel member if they were satisfied with the responses to the Task 1 Comments and if they had any further comments. Henry Bollmann (Florida DOT) questioned how the BD-613M (bridge design) standard is used by PENNDOT. Eric stated that the Engineer develops the pot bearing loads, uses the tables in the standards to determine the pot bearing component dimensions, and uses the standard details to develop contract drawings. PENNDOT also provides standard Bridge Construction drawings that show construction details and are only referred to in the contract drawings. However, a PENNDOT bridge construction standard has not yet been developed for pot bearings.

Henry stated that the BD-613M standards seem to give the Engineer nearly all the information that is needed to detail the pot bearings except for the corner dimensions of the sole plate. Henry recommended adding columns to the design tables to include the corner dimensions of the sole.
plates. Henry stated that if the columns were added, the standards could serve as shop drawings.

Eric stated that since nearly every bridge will require different sole plate bevels, the BD-613M standards were developed assuming a constant thickness sole plate which equates to the minimum thickness required to satisfy flexural stresses. It is the Engineer’s responsibility to determine the required sole plate bevels and to increase the sole plate thickness up from the minimum listed in the standards accordingly.

Patti Kiehl (PENNDOT) stated that the details in the standards are generic for all loading conditions and are not intended to be used as contract drawings without modification.

Henry reiterated that if sole plate corner dimension tables were provided in the standards with blank values to be input by the Engineer during design, then the BD-613M drawings could be used as contract drawings without modification.

Vasant Mistry (FHWA) stated that he was satisfied with the responses to the Task 1 Comments.

Tom Koch (North Carolina DOT) stated that he had not received the Task 2 Report or Responses to the Task 1 comments. (Baker later verified that the package had been sent to the correct address and signed for. Tom located the report the next day.)

**Agenda Item 2: Task 2 Report**

Henry and Vasant stated that they were satisfied with the Task 2 Report and had no further comments.

**Agenda Item 3: Expansion of the PENNDOT BD-613M Standards**

Patti Kiehl provided a list of items that would need to be modified to expand PENNDOT’s BD-613M standard based on the comments received by the project panel members to date. The list is as follows (note: text in parentheses indicates the agency and Task 1 comment number, if applicable):

- Dual material specs for plates > 4” thick (NC1)
- Bedding Material (NC5)
- PTFE Attachment Methods (NC6)
- Piston Thickness (NC16)
- Revise notes to be generic and not state specific
- Add metallizing as steel corrosion protection method
- Add round sealing ring details
- Add internal guide details (NC4)
- Add preformed anchor hole detail & include field placement instructions (FL7)
- Add note on sheet 15 alerting designer of potential bolt/thread misalignment when using beveled plates (FL8)
- Add note listing allowable service stress for weld design (NC10)
- Delete dimension “Z” from note 9 (Baker1)
Robert Doble cautioned that any proposed alternate details would need to be considered carefully to determine the potential effect to the design calculations. For example, providing an internal guide detail will likely affect many other dimensions and would require revised design calculations and a new table of dimensions.

Henry stated that FDOT would not mind using external guide bars only. Tom said that he would check with fabricators in North Carolina to see if they would be receptive to using external guide bars exclusively.

Patti asked Tom (when he received the package) to check if he was satisfied with the response to his comment regarding the equation for piston thickness.

Eric asked the panel members if they had any further requests regarding the expansion of the standards. Henry asked if PENNDOT’s BD-613M standard could be modified to incorporate more stringent seismic requirements. Eric stated that there are separate tables in the standards for horizontal loads equal to 10% and 30% of the vertical capacity. If higher seismic forces create a horizontal load greater than 30%, a larger vertical capacity bearing can be used to provide a larger horizontal load capacity (assuming the minimum vertical load criteria is satisfied).

Henry stated that Eric’s explanation makes sense, but the pot bearing sizes can get too large using that procedure. Vasant stated that other bearing types may need to be utilized if the seismic forces are significantly higher than 30% times the vertical load. Vasant then stated that separate standards may be needed for bearings in high seismic areas.

Dave Marchese stated that special bearings may not be needed, just special details to hold the bearings down on the bearing seat. He stated that external guide bars can accommodate seismic forces easier than an internal guide bar.

Henry asked if FDOT could use the MATHCAD template developed by DS Brown if FDOT verified that the template agreed with their design spreadsheets currently in use. Patti said she would contact DS Brown to determine if they would be willing to release the electronic files.

Henry asked if PENNDOT’s BD-613M standards were sent to fabricators throughout Pennsylvania. Patti stated that the standards were sent to fabricators during the development stage, but only a few comments were received.

Subsequent to the conference call, Tom Koch sent the following comments via e-mail:

[I've had a chance to review your responses to NCDOT's comments and offer the following:

On page 12 -- NCDOT uses a 3/16 " preformed cotton duck pad, not a neoprene pad. However-- we are in the middle of changing our specs. to require a 1/8" pad since availability is greater for cotton duck pads in 1/8" increments.
One other comment -- several of PennDot's standards show a "neoprene disc" as the elastomer in the Pot bearing. We would prefer that to say "elastomer disc" since we, like most states, allow Neoprene or natural rubber.

Also -- while we recognize the benefit of using a double external guide bar system, we would like to still have the option to use a single bar guide key system.

I've also still got some of our other shop drawing review guys looking at it and I will submit any comments they have to you.

**Agenda Item 4: Presentation to the AASHTO T-2 Bearing Committee on June 28, 2005**

Eric stated he would be giving a presentation to the AASHTO T-2 Bearing Committee on June 28, 2005. Vasant asked if the AASHTO T-2 Bearing Committee could approve the National Pot Bearing Standards once complete, similar to the approval AASHTO granted the Segmental Bridge Details. Eric stated he would find out if an approval was possible.

Eric asked the panel members if they agreed with the service limit state design philosophy that the BD-613M standards are based on. The panel members acknowledged that they agreed with that methodology. Eric stated that the presentation to the AASHTO T-2 Bearing Committee would include a suggestion to modify the AASHTO Section 14.7.4 equations currently based on strength/extreme event limit states back to service limit state equations.

The information presented in these minutes represents the author’s interpretation and understanding of the discussions and decisions that occurred during the meeting. Any clarifications, corrections, or additions to these minutes are to be provided to the author within fifteen (15) days of the date issued. No response implies that information presented is agreed to be correct as written.

cc: Attendees:
Patricia Kiehl - PENNDOT
Henry Bollman – FDOT
Vasant Mistry – FHWA
Tom Koch – NCDOT
cfile
1. The thickness of the pot wall of the fixed and guided bearings was calculated using Ashto (1998) LRFD Equations 14.4.4-2 and 14.4.4-4.

2. The thickness of the pot wall of the non-guided bearings is designed for a maximum horizontal deflection of 0.0015 of the design vertical capacity (T1) and using Ashto (1998) LRFD Equations 14.4.4-2 and 14.4.4-4.

3. The thickness of the pot base was calculated using Ashto (1998) LRFD Equations 14.4.4-2 and 14.4.4-4.

Piston design:
1. The height of the piston rod was calculated using Ashto (1998) LRFD Equations 14.4.4-2 along with Section C14.4.4.2.4.

2. The deflection of the piston was calculated using Ashto (1998) LRFD Equations 14.4.4-2 and 14.4.4-4 and using a maximum deflection limit between the piston and the pot and a design rotation of 0.03 radians.

3. The piston was designed assigning it will be placed according to the design criteria. The maximum deflection between the piston and the pot and all geometry to ensure that all clearance requirements are satisfied.

4. The piston plate thickness has been designed for bearing reactions. The reaction is assumed to distribute evenly over the entire diameter of the pot plate. The minimum thickness is varied from 0.0015 of the pot plate with a cantilever length equal to the longest perpendicular distance between the edge of the piston plate and edge of the piston plate.

5. The stroke plate thickness has been designed for bearing reactions. The reaction is assumed to distribute evenly over the entire diameter of the stroke plate and the minimum thickness is varied from 0.0015 of the stroke plate.

6. The stroke plate thickness given in column "H" is the minimum thickness, and additional thickness, "T", is required to accommodate the bearing height as shown in column "PH".

7. A minimum stroke plate thickness of 21/0.00125°F was used for this standard.

INSTRUCTIONS FOR USING DESIGN TABLES:

1. Calculate the minimum vertical and horizontal deflection load reactions per bearing as follows:

   **LRFD Specifications**
   - Calculate the minimum vertical load reactions per bearing.
   - Calculate the minimum horizontal load reactions per bearing.

   **Standard Specifications**
   - Use the values of the load reactions per bearing.
   - Determine the percentage increase in allowable stress as defined by Ashto (1998) LRFD Equations 14.4.4-2 and 14.4.4-4.

2. For fixed and guided bearing calculate the maximum horizontal deflection load per bearing as in the following:

   **LRFD Specifications**
   - Use the service factor of 1.45 for fixed bearings.
   - Use the service factor of 1.45 for guided bearings.

   **Standard Specifications**
   - Use the service factor of 1.45 for fixed bearings.
   - Use the service factor of 1.45 for guided bearings.

3. Determine the controlling minimum and maximum vertical and horizontal deflection load reactions. These are the design loads to be used with the deflection load reactions per bearing.

4. Calculate the maximum gasket deflection rotation about each axis. Use the gasket deflection load as follows:

   **LRFD Specifications**
   - Use the gasket deflection load in the direction of rotation.
   - Calculate the gasket deflection load in the direction of rotation.

   **Standard Specifications**
   - Use the gasket deflection load in the direction of rotation.
   - Calculate the gasket deflection load in the direction of rotation.

INDEX OF SHEETS:

1. DESIGN METHODOLOGY
2. ILLUSTRATIVE DESIGN EXAMPLE
3. FIXED - 1000 HORIZONTAL LOAD (DESIGN TABLE)
4. FIXED - 5000 HORIZONTAL LOAD (DESIGN TABLE)
5. NON-GUIDED (DESIGN TABLE)
6. FIXED - 1000 HORIZONTAL LOAD (DESIGN TABLE)
7. FIXED - 5000 HORIZONTAL LOAD (DESIGN TABLE)
8. FIXED - 5000 HORIZONTAL LOAD (DESIGN TABLE)
9. 1000 PISTON SECTIONS AND DETAILS
10. NON-GUIDED - DETAILS
11. GUIDED - DETAILS
12. GUIDED - DETAILS
13. GUIDED - DETAILS
14. CONNECTION OPTIONS
15. NATIONAL STANDARD HIGH LOAD MULTI-ROTATIONAL POT BEARINGS DESIGN METHODOLOGY
### Design Tables for Fixed Pot Bearings (10% Horizontal Load - English Units)

#### Table 1

<table>
<thead>
<tr>
<th>Pot Diameter (in)</th>
<th>Pot Number</th>
<th>Pot Load (lbs)</th>
<th>Pot Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2000</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3000</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
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<tr>
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<td></td>
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</table>

#### Table 2

<table>
<thead>
<tr>
<th>Pot Diameter (in)</th>
<th>Pot Number</th>
<th>Pot Load (lbs)</th>
<th>Pot Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4</td>
<td>5000</td>
<td>50</td>
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<tr>
<td>5</td>
<td>5</td>
<td>6000</td>
<td>60</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>7000</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Beveled Sole Plate

- **Max. Height**: 11 in.
- **Min. Height**: 9 in.
- **Taper Angle**: 2° 15' 0"

### Note

- All metric or all English values must be used simultaneously.
- Either metric or English values may be used, but not both.
- The table values are subject to change.

---

**Design Generalization**

- The pot diameter, number, load, and pressure are calculated based on the given tables.
- The beveled sole plate details are provided for reference.

---

**National Standard**

- **High Load Multi-Notional**
  - **Pot Bearings - Fixed**

---

**Sheet 3 of 15**
### DESIGN TABLES FOR FIXED POT BEARINGS (30% HORIZONTAL LOAD) - ENGLISH UNITS

<table>
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### DESIGN TABLES FOR FIXED POT BEARINGS (30% HORIZONTAL LOAD) - METRIC UNITS

| VERTICAL LOAD (kN) | 890 | 1112 | 1334 | 1557 | 1779 | 2002 | 2224 | 2446 | 2669 | 2891 | 3114 | 3336 | 3558 | 3781 | 4003 | 4226 | 4449 | 4672 | 4893 | 5116 | 5338 | 5560 | 5782 |
|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| HORIZONTAL LOAD (kN) | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 | 1,610 |
| ROUGHENING 1/STAGE | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| SOLE PLATE | ANCHOR BOLT | POT | ELASTOMERIC DISC | PISTON | BEARING HEIGHT |
| 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 |
| 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 |
| 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 |
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| 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 283 |

### NATIONAL STANDARD HIGH LOAD MULTI-ROTATIONAL POT BEARINGS - FIXED 30% HORIZONTAL LOAD

- **BEARING HEIGHT** includes 3.2 1/8" bedding material. Effects of beveled sole plate are included. If beveled sole plate is used, calculate increased bearing height accordingly.

**Note:** Either all metric or all English values must be used on plans, metric and English values shown may not be mixed.
### Design Tables for Non-Guided Pot Bearings - English Units

<table>
<thead>
<tr>
<th>Vertical Load (kips)</th>
<th>Horizontal Load (kips)</th>
<th>Rotation (in.)</th>
<th>Masonry Plate</th>
<th>Anchor Bolt</th>
<th>SOLE PLATE</th>
<th>POT</th>
<th>Elastomeric Disc</th>
<th>Piston</th>
<th>PFFE</th>
<th>Stainless Steel</th>
<th>Bearing Height (in.)</th>
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### Design Tables for Non-Guided Pot Bearings - Metric Units

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**Note:** Either all metric or all English values must be used on plans. Metric and English values shown may not be mixed.
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<th>VERTICAL LOAD (kips)</th>
<th>HORIZONTAL LOAD (kips)</th>
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<th>MASONRY PLATE</th>
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**BEARING HEIGHT INCLUDES 1/8" BEVELED SOLE PLATE ARE NOT INCLUDED. IF BEVELED SOLE PLATE IS USED CALCULATE INCREASED BEARING HEIGHT ACCORDINGLY.**

**NOTE:** EITHER ALL METRIC OR ALL ENGLISH VALUES MUST BE USED ON PLANS. METRIC AND ENGLISH VALUES SHOWN MAY NOT BE MIXED.
| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10| 11| 12| 13| 14| 15| 16| 17| 18| 19| 20| 21| 22| 23| 24| 25| 26| 27|
| 28| 29| 30| 31| 32| 33| 34| 35| 36| 37| 38| 39| 40| 41| 42| 43| 44| 45| 46| 47| 48| 49| 50| 51| 52| 53|
| 54| 55| 56| 57| 58| 59| 60| 61| 62| 63| 64| 65| 66| 67| 68| 69| 70| 71| 72| 73| 74| 75| 76| 77| 78| 79|
| 80| 81| 82| 83| 84| 85| 86| 87| 88| 89| 90| 91| 92| 93| 94| 95| 96| 97| 98| 99| 100|101|102|103|104|105|

**NOTICE:** Either American or English values shown may be used.
### Design Tables for Guided Pot Bearings (1000 Horizontal Load - English Units)

**Sheet 8 of 15**

#### National Standard

**Pot Load Multi-Notational**

**30%**

**Horizontal Load**

**Guided**

### Notes:

1. **Bedding Material:** The choice of bedding material is crucial. It can significantly affect the performance and durability of the pot bearings. Always consult the manufacturer's specifications for recommendations.

2. **Material Compatibility:** Ensure that the chosen bedding material is compatible with the bearing's base material. Incompatible materials can lead to degradation over time.

3. **Installation:** Proper installation techniques are essential. Follow the manufacturer's guidelines to avoid misalignment or stress concentrations that could impair the bearing's performance.

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**Chart:**

- **Maximum Horizontal Load:** 1000 kN
- **Width and Length Variations:** Ranges from 250 to 400 mm, 750 to 900 mm
- **Thickness:** Ranges from 10 to 16 mm

---

**Per Design (Beveled Sole Plate):**

- **Height:** 3 mm
- **Technical Specifications:** Detailed in manufacturer's documentation.

---

**Recommendations:**

- Choose the right bedding material based on the load and expected environmental conditions.
- Ensure proper installation to avoid stress concentrations and misalignment.
- Consult the manufacturer for the latest technical specifications and guidelines.
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**BEVELED SOLE PLATE DETAIL**

- **BEARING HEIGHT INCLUDES 3.2 BEDDING MATERIAL.**

- **IF BEVELED SOLE PLATE IS USED, CALCULATE INCREASED BEARING HEIGHT ACCORDINGLY.**

**NOTE:** EITHER ALL METRIC OR ALL ENGLISH UNITS MUST BE USED ON PLANS. METRIC AND ENGLISH VALUES SHOWN MAY NOT BE MIXED.

---

**NATIONAL STANDARD HIGH LOAD MULTI-ROTATIONAL POT BEARINGS - GUIDED 30% HORIZONTAL LOAD (METRIC)**

**SHEET 9 OF 15**
FIXED POT BEARING PLAN

SECTION A-A

ALTERNATE SOLE PLATE ATTACHMENT
FOR FIXED BEARINGS ONLY

NOTE: EITHER ALL METRIC OR ALL ENGLISH VALUES
MUST BE USED ON PLANS. METRIC AND
ENGLISH VALUES SHOWN MAY NOT BE MIXED.

NATIONAL STANDARD
HIGH LOAD MULTI-ROTATIONAL
POT BEARINGS - FIXED
DETAILS

FOR ADDITIONAL DETAILS, SEE SHEETS 14 AND 15.
NON-GUIDED POT BEARING PLAN

SECTION A-A

DETAIL A

NOTE: FLAT SEALING RINGS ARE SHOWN FOR ROUND SEALING RINGS. SEE DETAIL A, SHEET 13.
FOR ADDITIONAL DETAILS, SEE SHEETS 14 AND 15

NOTE: EITHER ALL METRIC OR ALL ENGLISH VALUES MUST BE USED ON PLANS. METRIC AND ENGLISH VALUES SHOWN MAY NOT BE MIXED.
NATIONAL STANDARD
HIGH LOAD MULTI-ROTATIONAL
POT BEARINGS
CONNECTION OPTIONS

NOTE: EITHER ALL METRIC OR ALL ENGLISH VALUES MUST BE USED ON PLANS. METRIC AND ENGLISH VALUES SHOWN MAY NOT BE MIXED.
Mr. Ralph E. Anderson, P.E.
Engineer of Bridges and Structures
Chairman, Technical Committee
Illinois Department of Transportation
2300 South Dirksen Parkway, Rm. 240
Springfield, IL 62764

Subject: AASHTO T-2 Committee
Section 14.7.4 Recommendations

Dear Mr. Anderson:

As you are aware, PENNDOT and our pooled fund study partners (FHWA, Florida Department of Transportation, and North Carolina Department of Transportation) are developing national pot bearing design and detailing standards. These standards will be an expanded version of PENNDOT's current pot bearing design standards.

At the AASHTO Bridge Subcommittee meeting in June of this year, Eric Martz of Michael Baker Jr. Inc. presented an update on the progress of the pooled fund study to the T-2 Committee. As part of this presentation, informal recommendations were made with regard to several equations in the 2004 AASHTO LRFD Bridge Design Specifications. At this time, we would like to provide formal recommendations to the T-2 Committee for consideration as ballot items.

In general, these recommendations are focused on modifying Section 14.7.4 to service limit state design which is consistent with previous editions of the AASHTO specification. The specific recommendations are as follows:

1. Change Equation 14.7.4.7-1 from:

\[ t_w, t_h \geq \sqrt{\frac{25H_u \theta_u}{F_y}} \quad \text{to} \quad t_w \geq \sqrt{\frac{40H_s \theta_s}{F_y}} \]

where:

- \( H_u \) = strength/extreme lateral load
- \( \theta_u \) = strength rotation
- \( H_s \) = service lateral load
- \( \theta_s \) = service rotation

2. Change Equation 14.7.4.7-2 from:

\[ h_w \geq \frac{1.5H_u}{D_p F_y} \quad \text{to} \quad w \geq \frac{2.5H_s}{D_p F_y} \]

where:

- \( D_p \) = internal pot diameter
- \( H_u \) = strength/extreme lateral load
- \( H_s \) = service lateral load
3. Revise the constants in the following equations to change the design rotation from a strength limit state value to a service limit state value:

- Equation 14.7.4.3-1
- Equation 14.7.4.7-5
- Equation C14.7.4.3-1
- Equation C14.7.4.3-2

4. In Section 14.4.2.2.1, change the maximum rotation caused by fabrication and installation tolerances from 0.005 radians to 0.01 radians. Also change the allowance for uncertainties from 0.005 radians to 0.01 radians.

Implementing the recommendations listed above will offer the following advantages:

- Pot bearing design will be simplified if a single limit state is used for all load types (dead, live, wind, etc.).
- Using the service limit state will eliminate the need to factor the loads and generate several additional load combinations.
- Maximum/minimum load factors will not be needed if service limit state is used.
- Only one limit state load combination will be required for all design checks (e.g. elastomer stress vs. PTFE stress), which will eliminate confusion and potential design errors.
- Maintains consistency with past industry practice.
- Saves time and money.

We realize that the above recommendations do not address seismic loads at the extreme event limit state. The proposed national pot bearing standards instruct the designer to divide the horizontal seismic loads, derived from either the AASHTO Standard Specification or the AASHTO LRFD Specification, by 1.5 per AASHTO (1992) Standard Specification, Division I-A, Section 7.1. While we are not including this item as a formal recommendation, the T-2 committee may want to discuss this issue with regard to implementing the recommendations listed above.

We appreciate the committee’s consideration of these recommendations. If you have any questions or comments, please contact Patricia Kiehl, P.E. of my staff at (717) 772-0568.

Sincerely,

[Signature]

Harold C. Rogers, P.E.
Acting Chief Bridge Engineer
DEVELOPMENT of NATIONAL POT BEARING STANDARDS

Presented by:
Eric L. Martz, P.E., Michael Baker Jr., Inc.
(on behalf of PENNDOT)
Project Background

Goal:
Develop pot bearing standards that can be used nationwide.

Pooled fund study managed by PENNDOT
Bureau of Planning & Research

Project Partners:
- Federal Highway Administration – Vasant Mistry, P.E.
- Florida DOT – Henry Bollmann, P.E.
- North Carolina DOT – Tom Koch, P.E.
- Michael Baker Jr., Inc. – Managing Consultant

Intent of BD-613M Standards:

- Provide uniform designs
- Interpret design criteria for design engineers
- Save time & money
- Create fair bidding practices for fabricators
- Eliminate the need for shop drawings (future enhancement)
AASHTO PTFE contact stress (Table 14.7.2.4-1)
- Strength Limit State
  - Confined sheet: 4 ksi permanent loads (6 ksi all loads)

AASHTO Elastomer stress
- Service Limit State
  - 3.5 ksi

AASHTO PTFE coefficient of friction
- Service Limit State

Decided to use service limit state and 3.5 ksi
Recent AASHTO Section 14.7.4 Changes

Pot Wall & Base Thickness

- AASHTO Equation 14.7.4.7-1 (2004):

\[ t_w, t_b \geq \sqrt{\frac{25H_u \theta_u}{F_y}} \]

where:
- \( H_u \) = strength/extreme lateral load
- \( \theta_u \) = strength rotation

Consider going back to service limit state as per 1998 AASHTO LRFD (Equation 14.7.4.7-1):

\[ t_w \geq \sqrt{\frac{40H_s \theta_s}{F_y}} \]

where:
- \( H_s \) = service lateral load
- \( \theta_s \) = service rotation
Recent AASHTO Section 14.7.4 Changes (cont.)

- Height from top of piston rim to underside of piston
  - AASHTO Equation 14.7.4.7-2 (2004):
    \[ h_w \geq \frac{1.5H_u}{D_p F_y} \]
    
    - \( H_u \) = strength/extreme lateral load
    - \( D_p \) = internal pot diameter

- Consider going back to service limit state as per 1998 AASHTO LRFD (Equation 14.7.4.7-2):
  \[ W \geq \frac{2.5H_s}{D_p F_y} \]
  
  - \( H_s \) = service lateral load
Additional AASHTO Sect. 14.7.4 Considerations

- Design Rotation, $\theta_u$ - strength limit state as per Section 14.4.2
  - Equation 14.7.4.3-1, depth of elastomeric disc
  - Equation C14.7.4.3-1, pot cavity depth
  - Equation C14.7.4.3-2, piston-pot wall vert. clear.
  - Equation 14.7.4.7-5, piston rim to wall clear.

Consider revising equations to service limit state rotations for ease and consistency of design, and revising the tolerance rotation back to 0.01 radians.
Justification for Service Limit State Design

- Pot bearing design is much more simplified if a single limit state is used for all load types (dead, live, wind, etc.).
- Using the service limit state eliminates the need to factor the loads and generate several additional load combinations.
- Max./min. load factors are not needed if only service limit state is used.
- Eliminates going back and forth between limit states for similar design checks (e.g. elastomer stress vs. PTFE stress).
- Maintains consistency with past industry practice.
- Project panel members and our main fabrication industry contact (D.S. Brown) agree with the service limit state only approach.
Summary of Suggestions to T-2 Committee

Modify AASHTO Section 14.7.4 to Service Limit State Design

Advantages:

- Simplify design by using only service limit state (thus eliminating the need to calculate strength limit state loads)
- Eliminate confusion & potential design errors
- Save time and money
- Consistency with past specifications & industry practice

Formal recommendations will be made at a later date.
PENNDOT BD-613M Contents

- Design Methodology (service design using LFD* or LRFD)
  - modification of 1998 AASHTO LRFD
- Instructions for using design tables
- An LFD* & an LRFD design example
- Tables of dimensions for fixed, guided, & non-guided bearings (English & Metric Units)
- Details for each bearing type
- General Notes
- Beam/Girder connection details

* LFD was included for curved girder bridges. LRFD is used for all other bridge types.
BD-613M: Range of Design Criteria

- Vertical loads from 200 to 1500 kips
- Horizontal loads of 10% and 30% x vertical load*
- Total rotation of 0.03 radians *
- Maximum 3” longitudinal movement *
- Maximum ½” transverse movement *

* These values were selected to encompass the majority of designs.

* Standards still valid if parameters exceed these limits. Designer may increase component dimensions, choose a larger capacity bearing, or provide a beveled sole plate.
## BD-613M Sample Table of Dimensions

### DESIGN TABLES FOR FIXED POT BEARINGS (30\% HORIZONTAL LOAD)

<table>
<thead>
<tr>
<th>VERTICAL LOAD (KIPS)</th>
<th>HORIZONTAL LOAD (KIPS)</th>
<th>ROTATION (RADS.)</th>
<th>MASONRY PLATE</th>
<th>SOLE PLATE</th>
<th>PISTON</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>60</td>
<td>0.03</td>
<td>1 3/8</td>
<td>12 7/8</td>
<td>20 3/8</td>
</tr>
<tr>
<td>250</td>
<td>75</td>
<td>0.03</td>
<td>1 3/8</td>
<td>14 1/8</td>
<td>21 5/8</td>
</tr>
<tr>
<td>900</td>
<td>270</td>
<td>0.03</td>
<td>2 3/16</td>
<td>25 1/4</td>
<td>37 1/8</td>
</tr>
<tr>
<td>950</td>
<td>285</td>
<td>0.03</td>
<td>2 3/16</td>
<td>25 7/8</td>
<td>37 5/8</td>
</tr>
<tr>
<td>1000</td>
<td>300</td>
<td>0.03</td>
<td>2 3/16</td>
<td>26 5/8</td>
<td>38 3/8</td>
</tr>
<tr>
<td>1100</td>
<td>330</td>
<td>0.03</td>
<td>2 3/16</td>
<td>28 5/8</td>
<td>39 5/8</td>
</tr>
<tr>
<td>1200</td>
<td>360</td>
<td>0.03</td>
<td>2 5/16</td>
<td>29 1/8</td>
<td>40 3/4</td>
</tr>
<tr>
<td>1300</td>
<td>390</td>
<td>0.03</td>
<td>2 1/4</td>
<td>30 1/4</td>
<td>41 3/4</td>
</tr>
<tr>
<td>1400</td>
<td>420</td>
<td>0.03</td>
<td>2 1/4</td>
<td>31 1/2</td>
<td>42 7/8</td>
</tr>
<tr>
<td>1500</td>
<td>450</td>
<td>0.03</td>
<td>2 1/4</td>
<td>33</td>
<td>43 7/8</td>
</tr>
</tbody>
</table>
Calculated Design Loads (service):

- **Vertical**: 1209 kips max., 704 kips min.
- **Horizontal**: 410 kips max. (34% of vertical)

Check min. vertical load / vertical capacity

\[
\frac{704}{1400} = 50\% \quad > \quad 20\% \text{ min.} \quad \Rightarrow \quad \text{OK}
\]
BD-613M Example – Guided Bearing

Calculated Design Loads:

Vertical: 364 kips max., 180 kips min.

Horizontal: 44 kips max. (12% of vertical)

Check min. vertical load / vertical capacity

= 180/450 = 40%  > 20% min.  ⇒ OK
Compare to 30% Table:
Vertical: 364 kips max., 180 kips min.
Horizontal: 44 kips max. (12% of vertical)

Check min. vertical load / vertical capacity
= 180/400 = 45%  > 20% min. ⇒ OK
Expansion of BD-613M for Pooled Fund Study

- Task 1: Review of BD-613M Standards (*completed*)
- Task 2: Literature Review Report (*completed*)
- Task 3: Research & Drafting of Expanded Standards
- Task 4: Proposed AASHTO Revisions
- Task 5: Draft Final Report
- Task 6: Final Report & Presentation
Task 1: BD-613M Review

- Distributed PENNDOT BD-613M standards for review
- Received review comments from panel members
- PENNDOT & Baker reviewed comments & sent responses
- Summary of design related comments/responses
- Summary of fabrication related comments/responses
Task 2: Literature Review

- Reviewed FHWA, FDOT, & NCDOT design, fabrication, and construction practices for pot bearings
- Developed a report which compared the agencies’ practices to the BD-613M standards

Summary of differences in design practices
- PENNDOT – LRFD (currently LFD for curved girders)
- FDOT – LRFD (currently LFD for curved girders)
- NCDOT – LFD (moving to LRFD in near future)

Summary of differences in fabrication/construction practices
- Guided bearing systems
- Material specifications
- Attachment methods
Scope of Remaining Tasks

Project conference call held on May 26, 2005

Issues for consideration:

• Expansion to a construction standard
• Possible inclusion of bearings w/central guide bars
• Inclusion of round sealing rings
• Alternate PTFE attachment methods
• Alternate sole plate attachment methods
• Additional anchor bolt details (pre-formed blockouts)
• Alternate corrosion protection methods
• Addition of alternate material specifications
Questions/Comments

Please contact:

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Eric L. Martz, P.E.
Michael Baker Jr., Inc.
(717) 221-2023
emartz@mbakercorp.com
RFQ #: 03-03 (C07)
Project Title: Development of Pot Bearing Standards

PROBLEM STATEMENT

The purpose of this research is to expand the current PENNDOT bridge design standards for pot bearings so that other state departments of transportation can utilize the standards to streamline their pot bearing design process.

PROJECT DESCRIPTION

This project involved the participation of the Federal Highway Administration, Pennsylvania Department of Transportation, Florida Department of Transportation, North Carolina Department of Transportation, and was coordinated by Eric L. Martz, P.E., Project Manager, Michael Baker Jr., Inc. To complete the goal of developing regional or nationwide pot bearing design standards, the established project work plan consisted of six (6) tasks. The tasks focused on expanding PENNDOT’s existing pot bearing design standards for use in other states and providing formal recommendations to AASHTO regarding specification changes to Section 14.7.4 of the AASHTO LRFD Bridge Design Specifications.

FINDINGS

Through a comparison of pot bearing design, material specifications, and construction practices among the participating agencies, the investigation found that there were more similarities between the agencies than differences with regard to pot bearings. The differences were compared and an initial list of twelve (12) revisions or additions to the existing PENNDOT pot bearing design standards were decided upon. During the revision process, a few of the items on the initial list of revisions were eliminated through research and discussion and a few additional items were added to correct minor errors in the existing standards. This review and coordination process yielded pot bearing design standards that can be utilized by the participating agencies to save time and money.

In addition to the development of the standards, a presentation was made to the AASHTO T-2 Bearing Committee at the 2005 AASHTO Bridge Subcommittee meeting held in June 2005 at Newport, Rhode Island. An overview of this project was presented as well as informal recommendations regarding design specification revisions to Section 14.7.4 of the AASHTO LRFD Bridge Design Specifications. In October 2005, formal recommendations were sent to the AASHTO T-2 Committee in a letter from PENNDOT’s Chief Bridge Engineer.

RECOMMENDATIONS

This report recommends that the participating agencies, namely the Florida Department of Transportation and the North Carolina Department of Transportation, institute the pot bearing design standards within their agencies. AASHTO should consider the formal recommendations presented in the October 2005 letter that resulted from the findings of this project. In addition, other state DOT agencies should consider
the use of the pot bearing design standards as developed through this project to save time and money within their agencies.

For More Information Contact:

Pennsylvania Department of Transportation
Bureau of Planning and Research
Internet: www.dot.state.pa.us/
References:


Military Specification Number MIL-C-882E, “Cloth, Duck, Cotton or Cotton-Polyester Blend, Synthetic Rubber Impregnated, and Laminated, Oil Resistant,” 1989

