



# Development of Pot Bearing Standards

FINAL REPORT

May 2006

Michael Baker Jr., Inc.

COMMONWEALTH OF PENNSYLVANIA  
DEPARTMENT OF TRANSPORTATION

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<b>16. Abstract</b> <p>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.</p> <p>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 <i>AASHTO LRFD Bridge Design Specifications</i>.</p> <p>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.</p> <p>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.</p>			
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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.

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 the time of this report, 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.

## **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.