Illinois Department of Transportation

Memorandum

To: ALL BRIDGE DESIGNERS 22.3 (REV)

From: Jayme F. Schiff

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Subject: High Load Multi-Rotational Pot and Disc Bearing Base Sheets

Date: August 26, 2022 (Revised December 12, 2023)

The Prequalified Structural System List for High Load Multi-Rotational (HLMR) bearings currently includes two different types: pot and disc bearings. Owners and designers have often questioned when each type should be used, and the differences in detailing requirements between the two. To better clarify HLMR bearing policy and improve plan consistency, IDOT has developed base sheets for each bearing type. This memorandum introduces base sheets for fixed, guided expansion, and non-guided expansion pot and disc bearing types.

HLMR bearings support high loads and are able to rotate in any direction. They typically are necessary for long span or unique structures. They are suited for bearing designs beyond the limitations of the standard elastomeric bearings shown in the Bridge Manual. If a curved bridge is equivalently straight or bearing locations on curved bridges will result in lateral movements not exceeding the movement capacity of standard elastomeric bearings, then standard elastomeric bearings may be used. For curved bridges that are not equivalently straight or when the elastomeric bearing movement capacity is exceeded, HLMR bearings shall be required for structures designed for curvature.

HLMR Bearing Type and Class

The HLMR Bearing types (Pot or Disc) can be divided into one of three classes based on its expansion requirements. The three classes of HLMR bearings are: Fixed, Guided expansion, and Non-Guided expansion. Fixed and guided expansion HLMR bearings are analogous to fixed bearings and elastomeric bearings with side retainers and are used in similar scenarios. A non-guided expansion HLMR bearing is similar to an elastomeric bearing without a side retainer and is applicable in cases where both longitudinal and lateral displacements are required to be accommodated, such as very wide structures, some curved structures, or structures with large lateral seismic displacements.

The details shown herein are readily available from suppliers on the Qualified Producer List (QPL). The base sheet details have been thoroughly vetted and should result in better serviceability than alternate details. Because of unknown availability and potential serviceability issues, alternate bearing types such as inverted bearings or center-guided bearings are not allowed.

Figures 1, 2, 3, and 4 present an illustrative example of typical plan details for a fixed, guided expansion, and non-guided expansion pot bearing, respectively.

Figures 5, 6, and 7 present an illustrative example of typical plan details for a fixed, guided expansion, and non-guided expansion disc bearing, respectively.

Figures 1 through 7 shall replace Bridge Manual Section 3.7.5 HLMR bearing figures 3.7.5-1 and 3.7.5-2.

Base sheets for each bearing type and class are now available.

HLMR Bearing Dimensions

The dimensions used for pot bearings are:

D = Base Cylinder Diameter, inch
L_b = Masonry Plate Length, inch
L_p = Transverse Piston Diameter, inch
L_t = Sole Plate Length, inch
T_b = Masonry Plate Thickness, inch
T_h = Bearing Assembly Total Height, inch
T_t = Sole Plate Thickness, inch
W_b = Masonry Plate Width, inch
W_t = Sole Plate Width, inch

The dimensions used for disc bearings are:

D_d = Disc Diameter, inch
D_{db} = Bottom Disc Plate Diameter, inch
D_{dt} = Top Disc Plate Diameter, inch
L_d = Transverse length of the top disc plate for fixed bearings or disc diameter for expansion bearings, inch
T_b = Masonry Plate Thickness, inch
T_h = Bearing Assembly Total Height, inch
T_t = Sole Plate Thickness, inch
W_b = Masonry Plate Width, inch
W_t = Sole Plate Width, inch

Dimensions L_p and L_d will equal the diameter value for either the piston or top disc plate, respectively. The “L” nomenclature dimensions are meant to be analogous to the L_e dimension shown in Bridge Manual Figure 3.7.4-21.

HLMR Bearing Selection

The HLMR bearing and its components will be designed by the bearing manufacturer to meet the project specific requirements provided in the Design Data table on the plans and the AASHTO LRFD Bridge Design Specifications. The bridge designer shall contact the bearing manufacturer when selecting the bearing size to meet the design requirements.

Pot bearings shall be shown on the plans for vertical load capacities less than 300 kips and disc bearings shall be shown on the plans for vertical load capacities equal to and greater than 300 kips. However, if pot and disc bearings are required on the same structure, it is recommended to detail disc bearings at the pot bearing locations for economy. Elastomeric bearings may be used in addition to HLMR bearings on the same structure provided the same bearing type is used across the same substructure unit.

HLMR Bearing Design

Manufacturer literature for the Department's Prequalified List for HLMR Bearing manufacturers may be found on the IDOT web site at Prequalified Structural Systems under Find Your List. This list also states which manufacturers are pre-approved for pot bearings, disc bearings, or both.

The bridge designer shall calculate the Service I Factored Vertical Reaction to determine the type of HLMR bearing – pot or disc – to use. The bridge designer shall calculate the Maximum Strength or Extreme Event Lateral Reaction. The bridge designer shall determine rotations and movement using AASHTO 14.4.2.2 and the current AASHTO / NSBA Steel Bridge Collaboration "Steel Bridge Bearing Design and Detailing Guidelines".

For each bearing size, type, and class on a bridge, the bridge designer shall evaluate bearing manufacturer literature from the Prequalified List to determine the appropriate bearing depth, and pot and piston outside diameter (pot bearings) or disc diameter and disc plate diameters (disc bearings). These dimensions shall be chosen based upon the Service I Factored Vertical Reaction shown in the Design Data table shown on the plans.

Article C14.6.1 of the AASHTO LRFD Bridge Design Specifications states that bearings loaded to less than 20 percent of their vertical capacity require special design. This occurs when the ratio of dead loads to live loads is very small. Therefore, when choosing a bearing size, bridge designers shall verify that the Unfactored Dead Load Vertical Reaction is not less than 20 percent of the Service I Factored Vertical Reaction:

$$\frac{\text{Unfactored Dead Load Vertical Reaction}}{\text{Service I Factored Vertical Reaction}} > 0.2$$

The bridge designer shall also verify that there is not any uplift at the bearing location due to Service I Factored Live Loads:

$$\text{Service I Factored Vertical Reaction} > 0$$

If either of these conditions are encountered and cannot be avoided by choosing a different bearing size, the bridge designer shall provide a vertical restraint at the bearing location to prevent uplift. These vertical restraints are typically in the form of horizontal tabs or clamps extending from the Masonry Plate over the top of the bottom flange. Bearing suppliers are aware of this issue and have their own supplier-specific and bearing-specific details. Therefore, details for vertical restraints are not included on the base sheets. Vertical restraints shall be shown on the plans when required.

The bridge designer shall determine required dimensions of the Sole Plate and Masonry Plate for the plate dimensions and loads assumed in design. The bridge designer shall detail the bevel slope of the Sole Plate, if required. See "Sole and Masonry Plate Dimensions" of this memorandum for more information.

The bridge designer should evaluate as many manufacturers' bearing literature as feasible and choose the bearing with the largest bearing height for the type and vertical capacity required. The overall bearing height and plate thicknesses stated on the contract plans shall be chosen such that more than one manufacturer is capable of bidding on the project.

The design of HLMR bearing components will be the responsibility of the bearing manufacturer in accordance with AASHTO based on the parameters outlined below.

The bearing will be designed by the supplier for the exact parameters specified in the Design Data table. The load value specified in the pay item name is an approximate vertical load capacity that is used for letting and bidding purposes only. See “Plan Presentation” and “Completing the Bill of Material” sections of this memorandum.

The Maximum Strength or Extreme Event Lateral Reaction will be used by the bearing manufacturer to design required bearing components such as guide bars, pot thicknesses, etc. Due to this, details provided by the bearing manufacturer such as Sole and Masonry Plate dimensions may be slightly larger to account for the additional lateral loads. These slightly larger details should not be expected to be so large that the Sole and Masonry Plate thicknesses determined by the bridge designer will be inadequate. The bearing manufacturer may refine the dimensions of the Sole Plate and Masonry Plate when designing the bearing.

Upon receipt of the shop drawings, the bridge designer shall verify the Sole and Masonry Plate thicknesses shown on the shop drawings. The supplier has the option of recessing various elements, such as pistons and pots, into the Sole and Masonry Plates. When this occurs, the minimum plate thicknesses shall be verified against the thickness of the plate in the location of the recess.

The bearing plate lengths, widths, and thicknesses prescribed by this memorandum are intended to be used as guidance for achieving a similar bearing in cost and overall depth by all suppliers. It also assists the designer in determining the seat elevation and construction gap necessary for the bearing. However, the lengths and widths of the bearing plates actually provided by the supplier may vary substantially from those shown on the contract plans. These variances, used in conjunction with the plate thickness formulas prescribed by this memorandum, may result in substantial variances in plate thicknesses. When checking shop drawings for HLMR bearings, plate lengths and widths provided on shop drawings may vary, but plate thicknesses thinner by more than 25% of those shown on the contract plans should be returned with a comment requesting verification.

The bridge designer shall be responsible for the design of the threaded studs of the Sole Plate to flange connection and anchor bolts.

Sole and Masonry Plate Dimensions

Masonry Plate dimensions assume a 2 inch minimum edge distance for anchor bolts. This is based upon the minimum edge distance for a 1 ½ inch diameter anchor bolt according to Table 6.13.2.6.6-1 of the AASHTO LRFD Bridge Design Specifications. If a different anchor bolt size / edge distance is used, the equations below for L_b shall be modified for the given edge distance. For Masonry Plates with anchor bolts with diameters greater than 1 ½ inch, the edge distance shall be increased according to the minimum edge distance requirements found in the AASHTO specification.

In the plate dimension equations below, 2 inches is allowed between the edge of Sole Plate and the line of anchor bolts in the Masonry Plate. If a different spacing is used, the equations below for L_b shall be modified for the given spacing between the Sole Plate and the line of anchor bolts.

The calculations for L_t, W_t, L_b and W_b are minimum dimensions. The dimensions may be adjusted if other factors dictate.

Plate thicknesses Tt and Tb shall be determined according to top and bottom bearing plate equations found on Bridge Manual Figure 3.7.4-21.

Fixed Pot Bearings: The dimensions of the Sole Plate on a fixed pot bearing (Figure 1) shall be:

$$L_t = D + 2\left(\frac{1}{2}\text{ in.}\right)$$

$$W_t = D + 2\left(\frac{1}{2}\text{ in.}\right) + 1\text{ in.}$$

The dimensions of the Masonry Plate on a fixed pot bearing (Figure 1) shall be:

$$L_b = L_t + 2(2\text{ in.}) + 2(2\text{ in.})$$

$$W_b = D + 2\left(1\frac{1}{4}\text{ in.}\right)$$

Guided Expansion Pot Bearings: The dimensions of the Sole Plate on a guided expansion pot bearing (Figure 2 and 3) shall be:

$$L_t = D + 2\left(\frac{1}{2}\text{ in.}\right) + 2\left(\frac{1}{16}\text{ in.}\right) + 2\left(1\frac{3}{4}\text{ in.}\right) + 2(1\text{ in.})$$

$$W_t = L_t + 1\text{ in.}$$

The dimensions of the Masonry Plate on a guided expansion pot bearing (Figure 2 and 3) shall be:

$$L_b = L_t + 2(2\text{ in.}) + 2(2\text{ in.})$$

$$W_b = D + 2\left(1\frac{1}{4}\text{ in.}\right)$$

Non-Guided Expansion Pot Bearings: The dimensions of the Sole Plate on a non-guided expansion pot bearing (Figure 4) shall be:

$$L_t = D + 2\left(\frac{1}{2}\text{ in.}\right) + 2\left(1\frac{1}{2}\text{ in.}\right)$$

$$W_t = L_t + 1\text{ in.}$$

The dimensions of the Masonry Plate on a non-guided expansion pot bearing (Figure 4) shall be:

$$L_b = L_t + 2(2\text{ in.}) + 2(2\text{ in.})$$

$$W_b = D + 2\left(1\frac{1}{4}\text{ in.}\right)$$

For pot bearings, to determine Sole Plate thickness, T_t, the transverse dimension of the pot, dimension L_p, shall be substituted for the variable L_e.

To determine Masonry Plate thickness, T_b, the outside diameter of the base cylinder, dimension D, shall be substituted for the variable L_e.

<u>Fixed Disc Bearings</u>: The dimensions of the Sole Plate on a fixed disc bearing (Figure 5) shall be:

$$L_t = D_{dt} + 2\left(1\frac{1}{2}\text{ in.}\right)$$

$$W_t = D_{dt} + 2\left(1\frac{1}{2}\text{ in.}\right) + 1\text{ in.}$$

The dimensions of the Masonry Plate on a fixed disc bearing (Figure 5) shall be:

$$L_b = L_t + 2(2\text{ in.}) + 2(2\text{ in.})$$

$$W_b = D_{db} + 2(1\text{ in.})$$

To determine T_t, the diameter of the top disc plate, dimension D_{dt}, shall be substituted for the variable L_e.

To determine Masonry Plate thickness, T_b, the diameter of the bottom disc plate, dimension D_{db}, shall be substituted for the variable L_e.

<u>Guided Expansion Disc Bearings</u>: The dimensions of the Sole Plate on a guided expansion disc bearing (Figure 6) shall be:

$$L_t = D_{dt} + 2\left(\frac{1}{16}\text{ in.}\right) + 2\left(1\frac{3}{4}\text{ in.}\right) + 2(1\text{ in.})$$

$$W_t = L_t + 1\text{ in.}$$

The dimensions of the Masonry Plate on a guided expansion disc bearing (Figure 6) shall be:

$$L_b = L_t + 2(2\text{ in.}) + 2(2\text{ in.})$$

$$W_b = D_{db} + 2(1\text{ in.})$$

To determine Sole Plate thickness, T_t, the diameter of the disc, dimension D_d, shall be substituted for the variable L_e.

To determine Masonry Plate thickness, $T_{b,}$ the diameter of the bottom disc plate, dimension D_{db}, shall be substituted for the variable L_e.

Non-Guided Expansion Disc Bearings: The dimensions of the Sole Plate on a non-guided expansion disc bearing (Figure 7) shall be:

$$L_t = D_{dt} + 2\left(1\frac{1}{2}\text{ in.}\right)$$
$$W_t = L_t + 1\text{ in.}$$

The dimensions of the Masonry Plate on a non-guided expansion disc bearing (Figure 7) shall be:

$$L_b = L_t + 2(2\text{ in.}) + 2(2\text{ in.})$$
$$W_b = D_{db} + 2(1\text{ in.})$$

To determine Sole Plate thickness, T_t, the diameter of the disc, dimension D_d, shall be substituted for the variable L_e.

To determine Masonry Plate thickness, $T_{b,}$ the diameter of the bottom disc plate, dimension D_{db}, shall be substituted for the variable L_e. If a bottom disc plate is not used, the diameter of the disc, dimension D_d shall be substituted for the variable L_e.

The bridge designer shall combine the design thicknesses for Sole and Masonry Plates with the maximum height of bearing components from manufacturers' literature to calculate the total bearing height, T_h. Shim plates and ⅛ inch leveling pad are not included in total bearing height.

Flange Connection Design

The bridge designer shall design the Sole Plate to flange connection for the Maximum Strength or Extreme Event Lateral Reaction. The bridge designer shall determine the number of stud bolts for the connection between the Sole Plate and bottom flange. A minimum of four stud bolts shall be used. Additional stud bolts may be added as required by design.

Anchor Bolt Design

Anchor bolts for HLMR bearings shall be designed according to Section 3.7.3 of the Bridge Manual. A minimum of four anchor bolts shall be used. Additional anchor bolts may be added as required by design.

Plan Presentation

The bridge designer shall use the applicable base sheet for the bearing type and class selected. A separate base sheet shall be used for each bearing type and class. The bridge designer shall provide the bearing height, T_h and the Sole and Masonry Plate dimensions L_t, L_b, W_b, T_t, and T_b. When bearings of the same type and class, but with different loads, are required on the same bridge, the base sheet may be modified to account for the different bearing dimensions and loads on the same sheet.

The bridge designer shall specify the diameter, grade and number of anchor bolts on the plans.

The bridge designer shall specify the diameter and number of stud bolts for the Sole Plate to flange connection on the plans.

The bridge designer shall provide the required reactions, vertical and lateral loads, thermal movements and rotations to complete the Design Data table on the base sheet.

Completing the Bill of Material

The bridge designer shall complete the Bill of Material for each bearing, type and loads shown on the base sheet. The pay items will be for the type and class of bearing, bearing load capacity and anchor bolt required. Pay items will be available for the type and class of bearing and load capacity specified. The load capacities will be available in 100 kip increments up to 1000 kips. The load increment will increase in 250 kip increments thereafter. Please contact the Department if a bearing's load capacity pay item is not available, and a pay item will be created.

When determining pay items, the bridge designer shall round up the Service I Factored Vertical Reaction to the next largest 100 kips increment available (for bearings with Service I Factored Vertical Reaction up to and including 1000 kips) or next largest 250 kips increment available (for bearings with Service I Factored Vertical Reaction exceeding 1000 kips) to choose an approximate bearing capacity for the pay item. The pay item will be HIGH LOAD MULTI-ROTATIONAL BEARING of the type, class and designated vertical capacity.

The ANCHOR BOLT pay item shall be for the diameter required.

Available HLMR bearing and anchor bolt pay items may be found on the IDOT web site at Letting Specific Items under Coded Pay Items.

Guide Bridge Special Provision (GBSP)

The Department's GBSP #13 for HLMR bearings describes material, fabrication, installation, and testing requirements for all types of HLMR bearings.

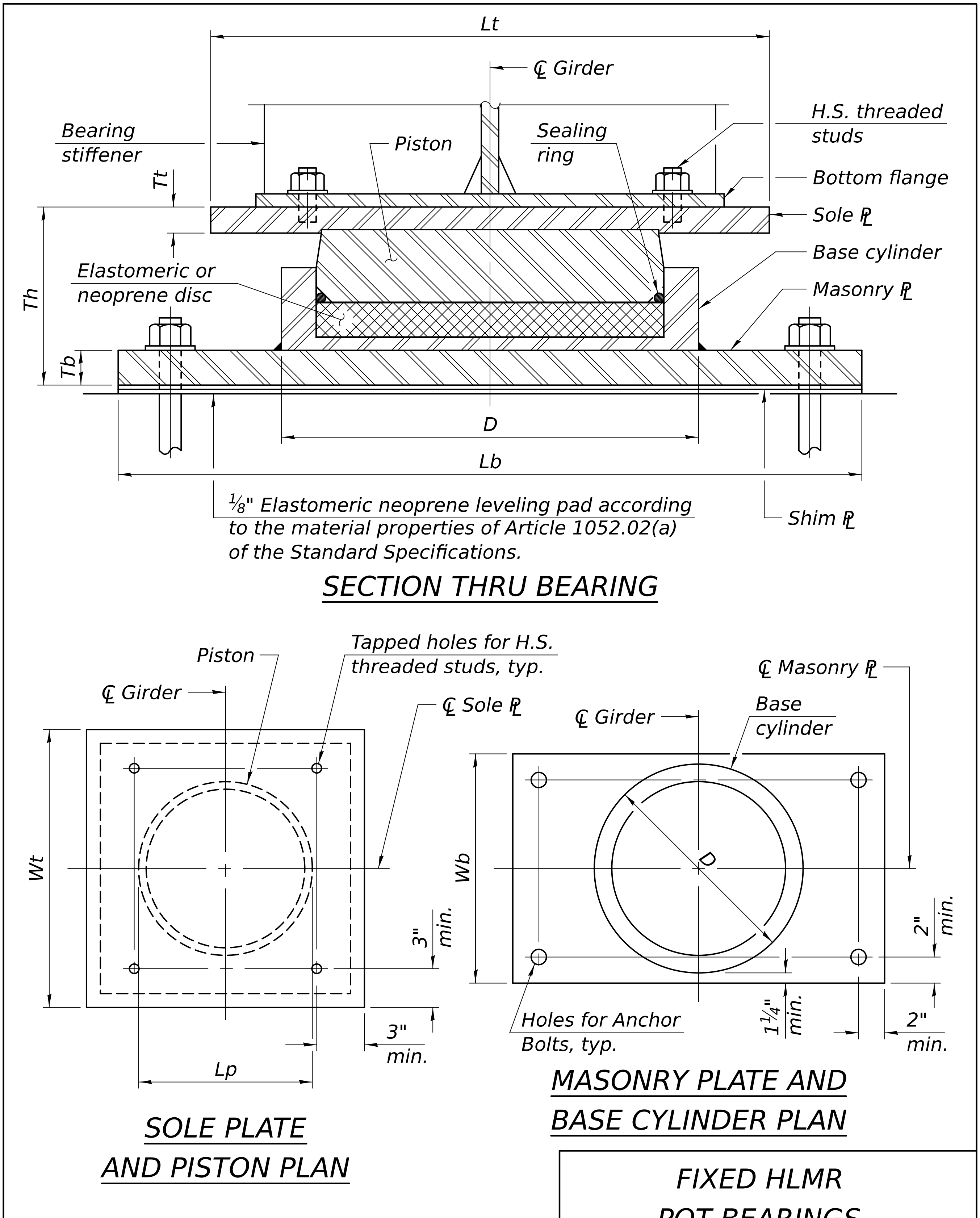
Implementation

The HLMR bearing base sheets dated 5-15-2023 shall be implemented, as soon as practical, on all applicable projects that have not been let. The base sheets are located in the Bearings-Steel Beams CADD cell library.

Please direct questions to Mark Shaffer, Policy, Standards, and Final Plan Control Unit Chief, by telephone at (217) 785-2914 or email at mark.shaffer@illinois.gov.

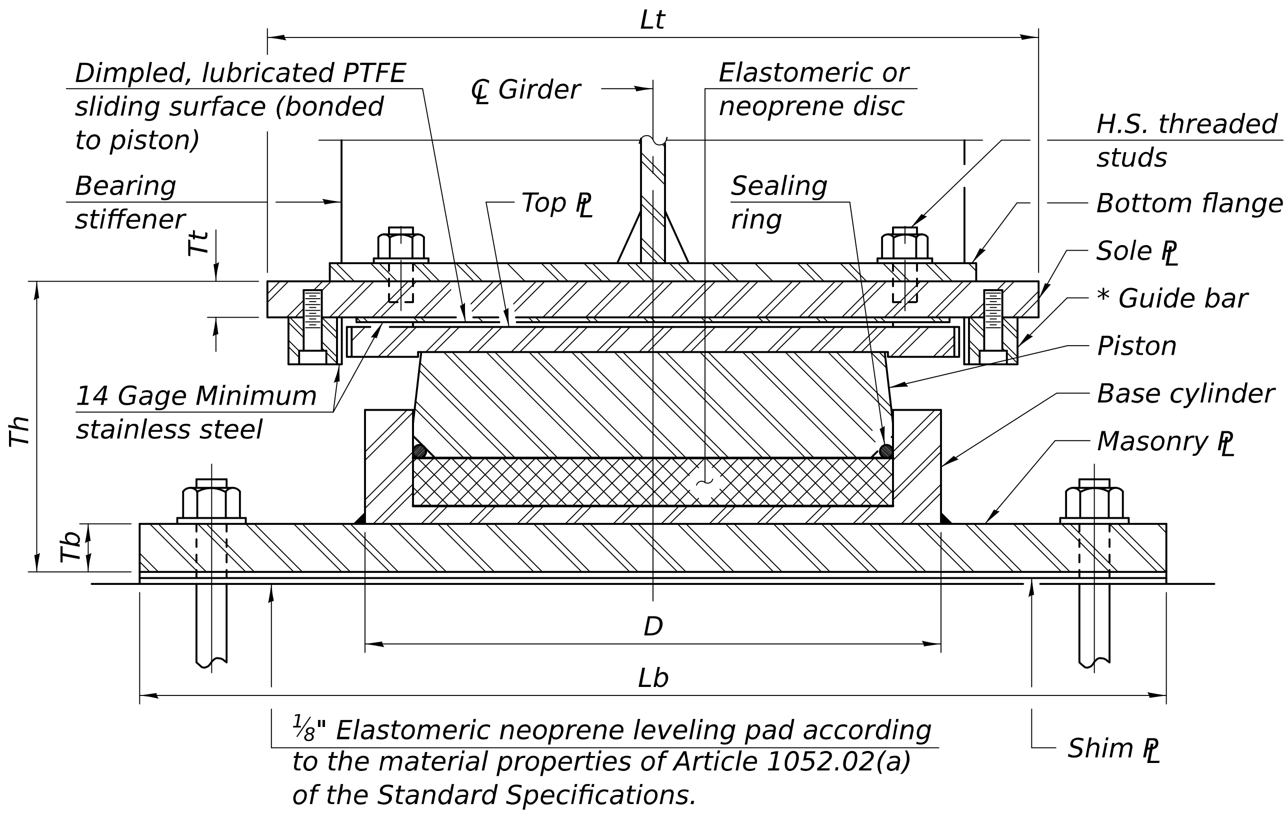
Attachment

KLR/CME/kktABD22.3REV-20231212



FIXED HLMR
POT BEARINGS

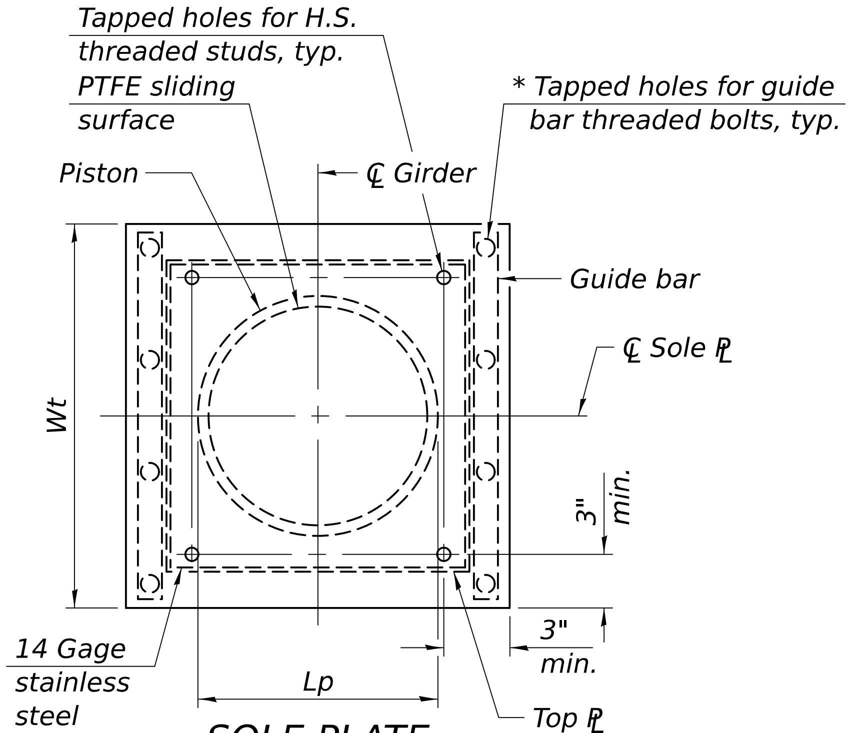
Figure 1



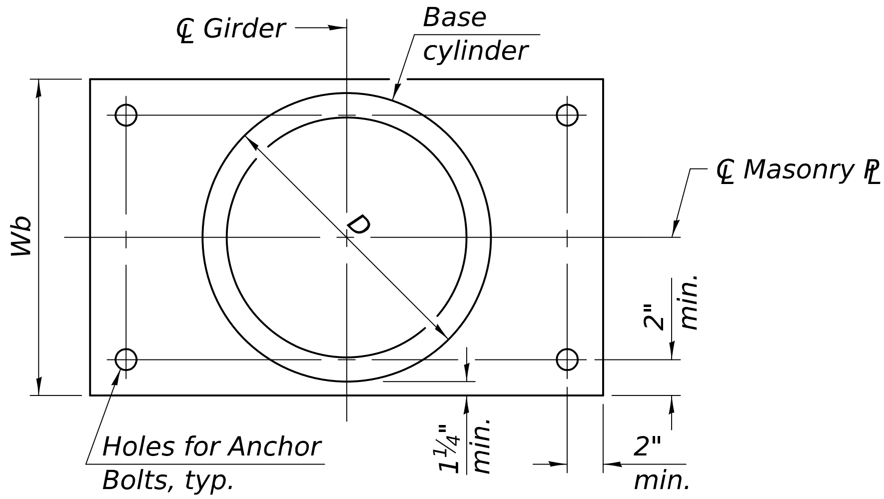
SECTION THRU BEARING

* As alternates to the bolted connection shown, the guide bars may be connected to the top bearing plate by groove welds or the guide bars and top bearing plate may be fabricated as a single piece.

GUIDED EXPANSION
HLMR POT BEARINGS



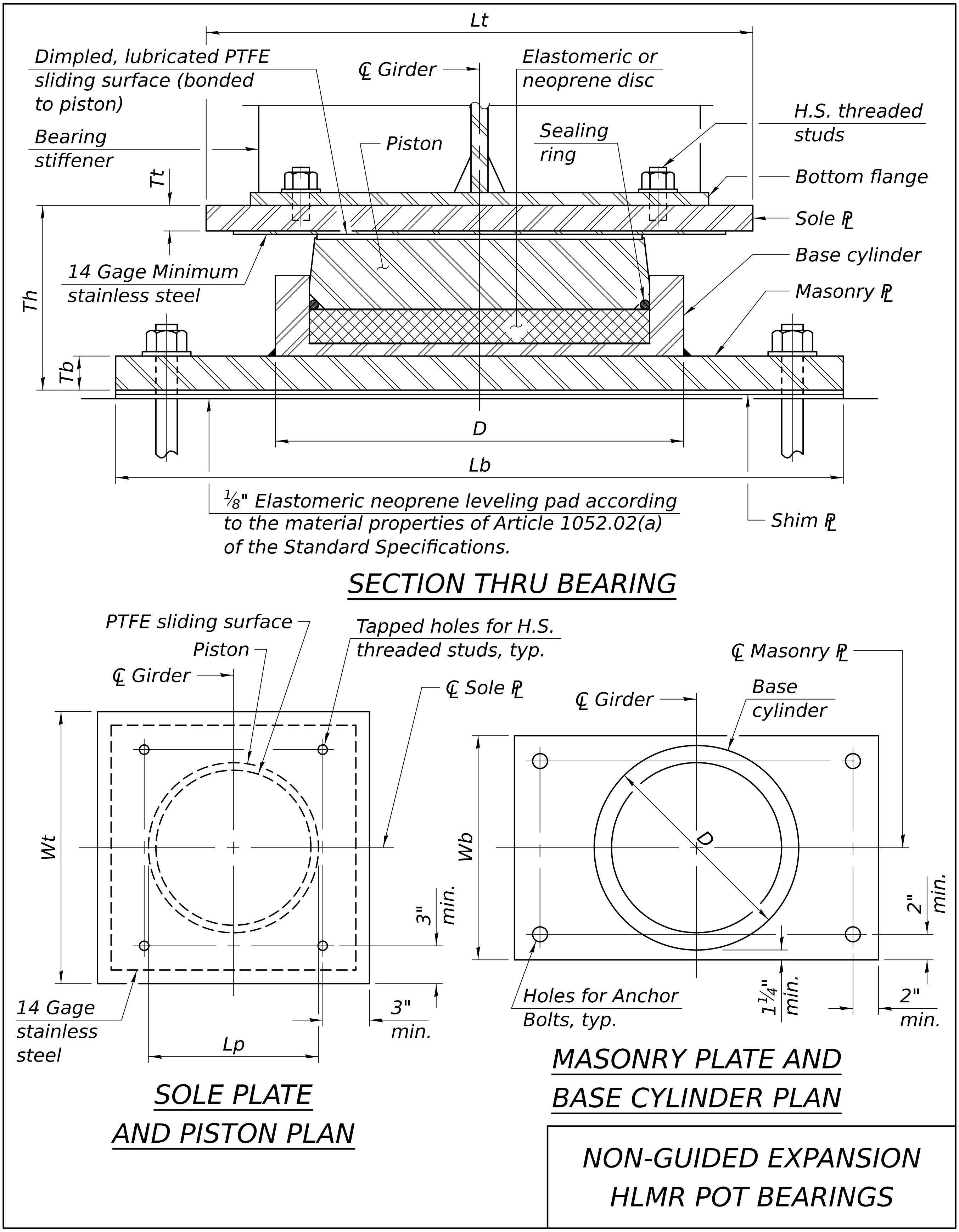
SOLE PLATE AND PISTON PLAN

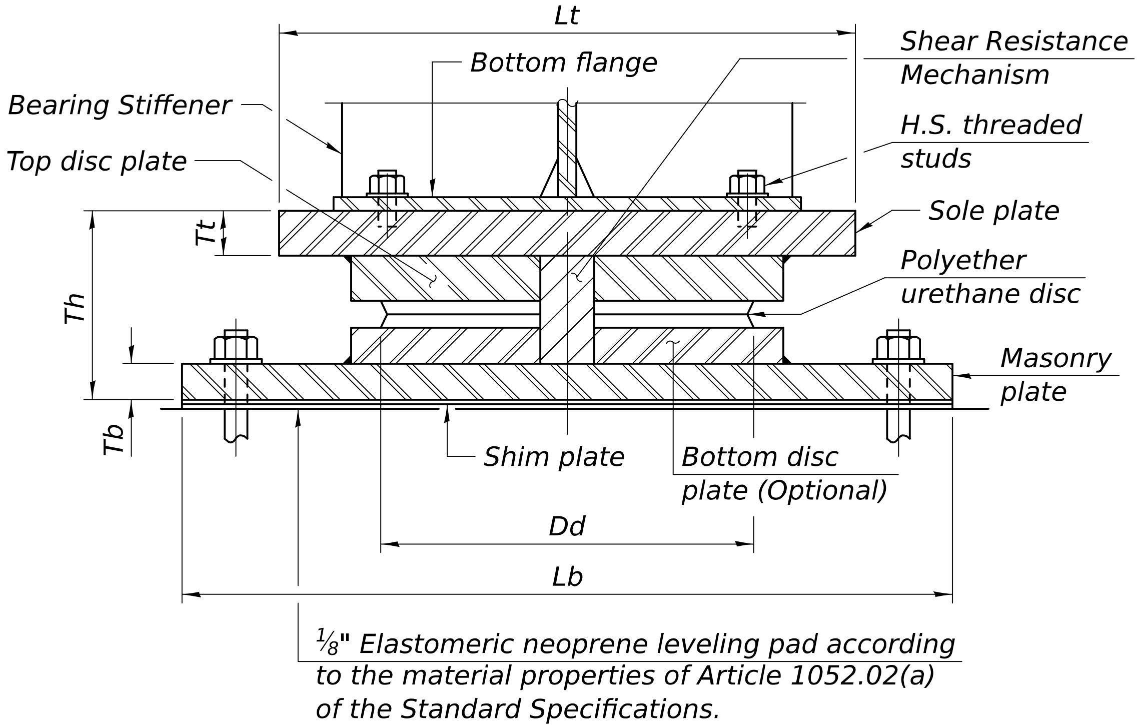


MASONRY PLATE AND BASE CYLINDER PLAN

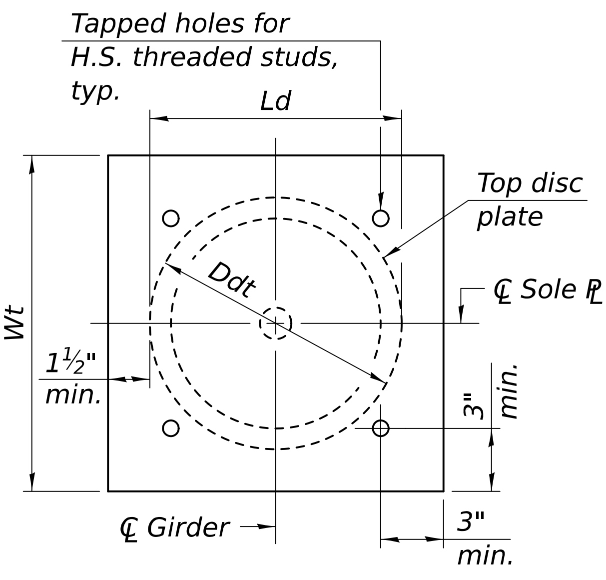
* As alternates to the bolted connection shown, the guide bars may be connected to the top bearing plate by groove welds or the guide bars and top bearing plate may be fabricated as a single piece.

GUIDED EXPANSION
HLMR POT BEARINGS

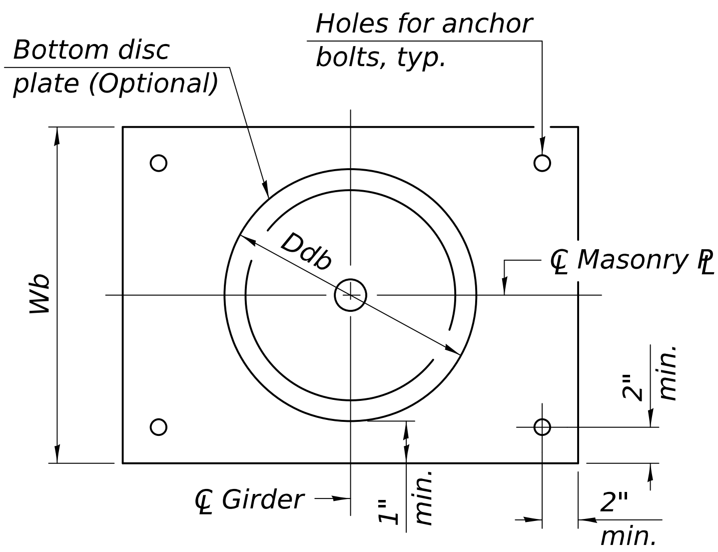

Lt
Dimpled, lubricated PTFE sliding surface (bonded to piston)
℄ Girder
Elastomeric or neoprene disc
H.S. threaded studs
Bearing stiffener
Piston
Sealing ring
Bottom flange
Tt
Sole PL
Base cylinder
Masonry PL
14 Gage Minimum stainless steel
Th
Tb
D
Lb
1/8" Elastomeric neoprene leveling pad according to the material properties of Article 1052.02(a) of the Standard Specifications.
Shim PL
SECTION THRU BEARING
PTFE sliding surface
Piston
Tapped holes for H.S. threaded studs, typ.
℄ Girder
℄ Sole PL
Wt
3" min.
14 Gage stainless steel
Lp
3" min.
SOLE PLATE AND PISTON PLAN
℄ Masonry PL
℄ Girder
Base cylinder
Wb
D
2" min.
Holes for Anchor Bolts, typ.
1 1/4" min.
2" min.
MASONRY PLATE AND BASE CYLINDER PLAN
NON-GUIDED EXPANSION HLMR POT BEARINGS



SECTION THRU BEARING

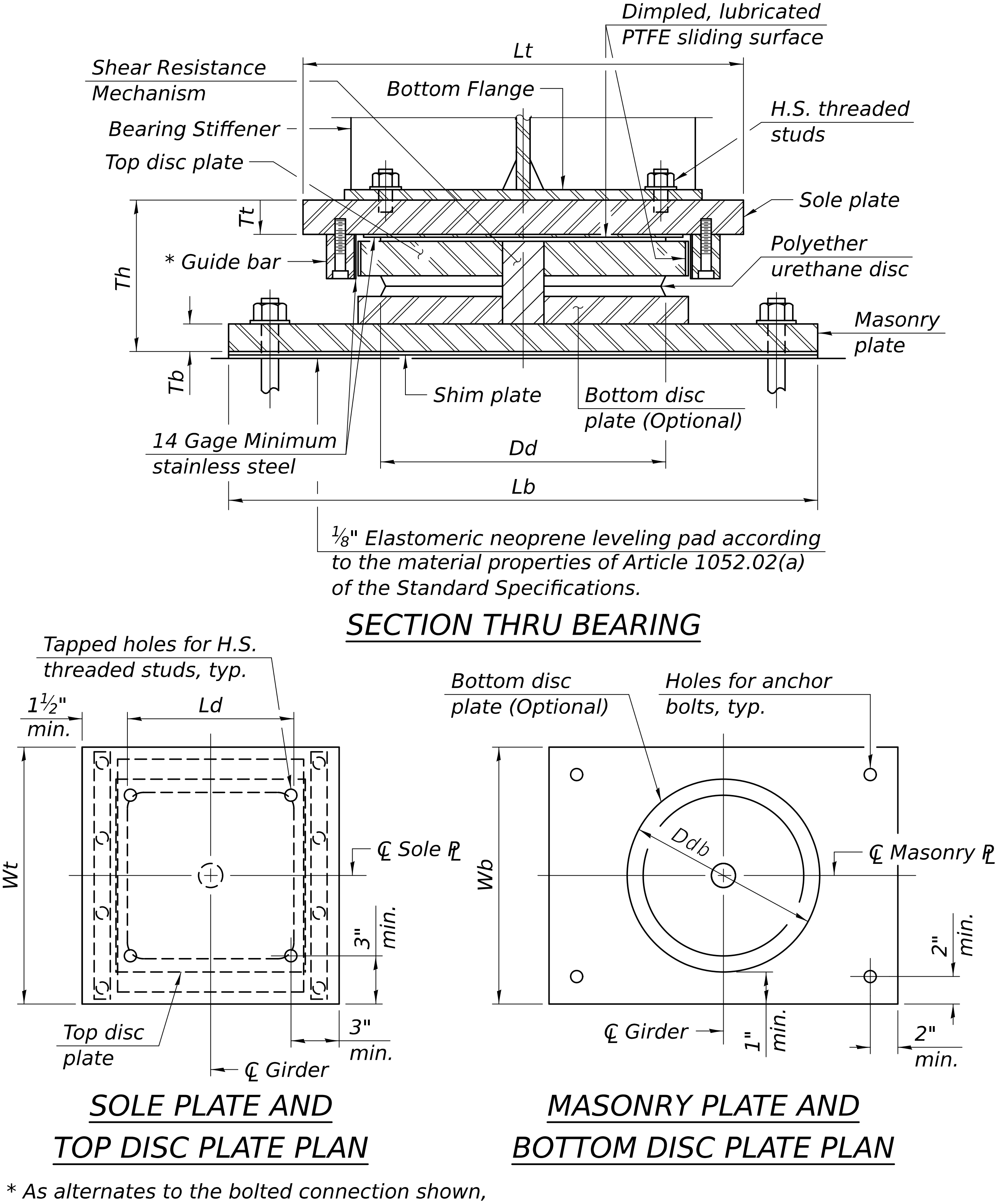


SOLE PLATE AND TOP DISC PLATE PLAN



MASONRY PLATE AND BOTTOM DISC PLATE PLAN

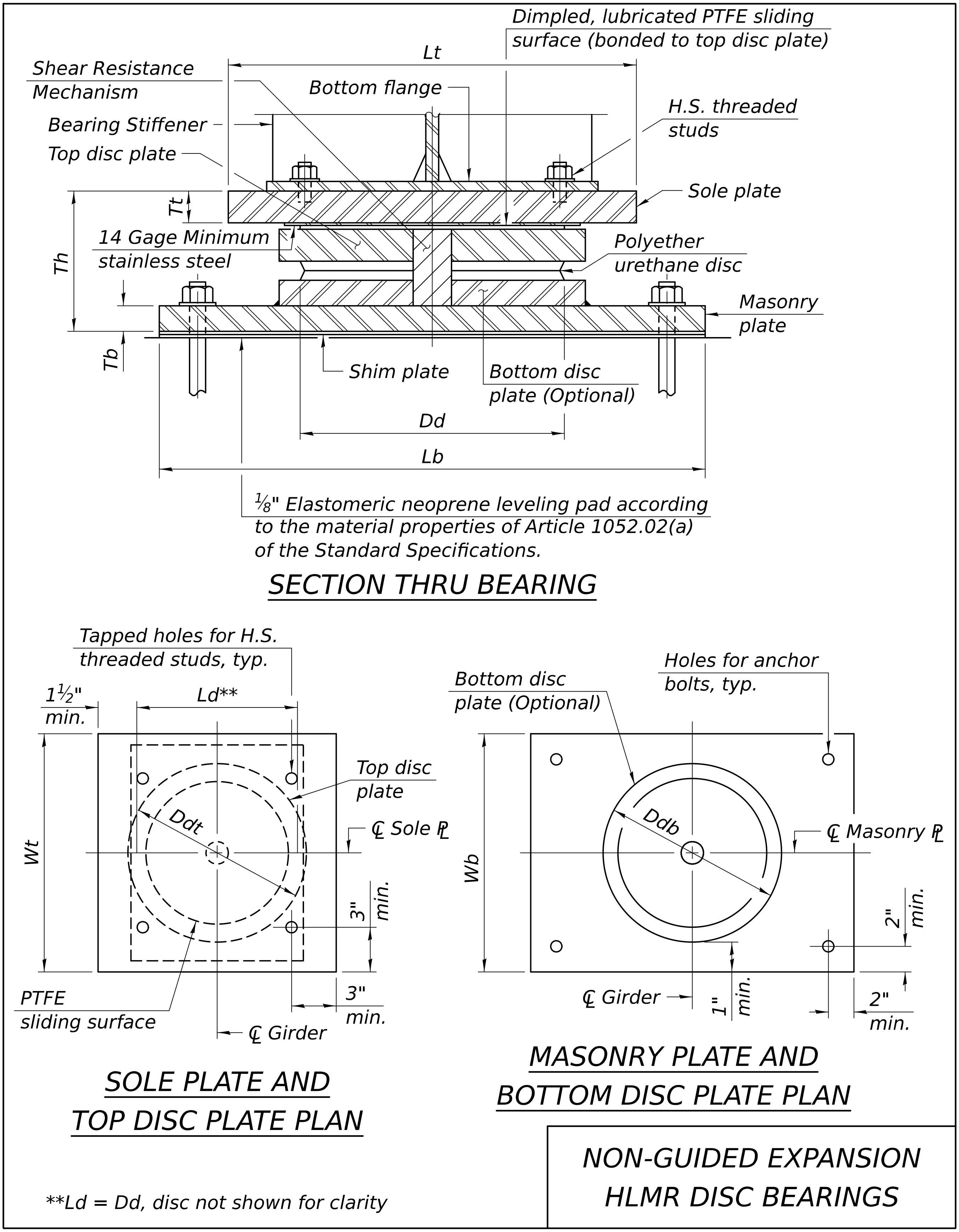
FIXED HLMR
DISC BEARINGS



* As alternates to the bolted connection shown, the guide bars may be connected to the top bearing plate by groove welds or the guide bars and top bearing plate may be fabricated as a single piece.

GUIDED EXPANSION HLMR DISC BEARINGS

Figure 6



Dimpled, lubricated PTFE sliding surface (bonded to top disc plate)
Lt
Shear Resistance Mechanism
Bottom flange
H.S. threaded studs
Bearing Stiffener
Top disc plate
Sole plate
Tt
Th
14 Gage Minimum stainless steel
Polyether urethane disc
Masonry plate
Tb
Shim plate
Bottom disc plate (Optional)
Dd
Lb
⅛" Elastomeric neoprene leveling pad according to the material properties of Article 1052.02(a) of the Standard Specifications.
SECTION THRU BEARING
Tapped holes for H.S. threaded studs, typ.
1½" min.
Ld**
Top disc plate
Ddt
℄ Sole ℙ
Wt
3" min.
PTFE sliding surface
3" min.
℄ Girder
SOLE PLATE AND TOP DISC PLATE PLAN
Holes for anchor bolts, typ.
Bottom disc plate (Optional)
Ddb
℄ Masonry ℙ
Wb
2" min.
℄ Girder
1" min.
2" min.
MASONRY PLATE AND BOTTOM DISC PLATE PLAN
NON-GUIDED EXPANSION HLMR DISC BEARINGS
**Ld = Dd, disc not shown for clarity

Figure 7