Prestressed Concrete Girders and Bearings

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DEPARTMENT OF TRANSPORTATION

Bridge Office | mndot.gov/bridge

Roadmap

- Prestressed Concrete Girders
  - MH Shapes
  - Debonding
  - 300 ksi Strands
  - Filling out Standard Plan Sheets
  - Camber
  - Inverted T’s
- Bearings
  - Curved Plate Bearing Assemblies
  - Disc Bearing Details


Photo credit: Forterra

MH Shapes

MH Shapes: Recognizing a Need

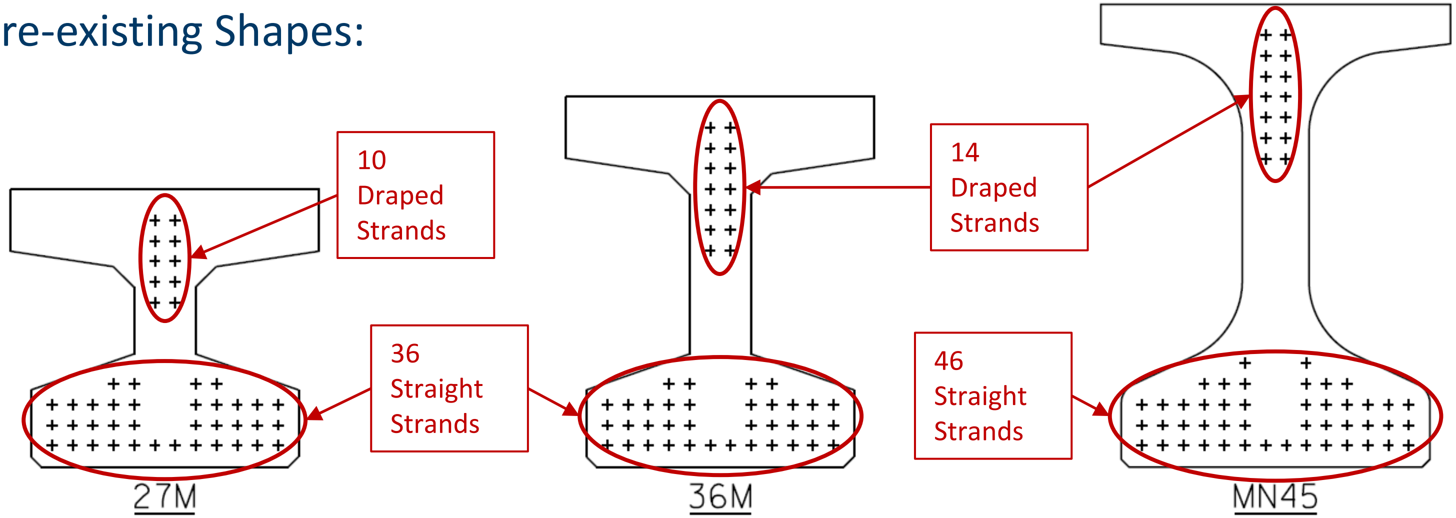
- MnDOT has a variety of prestressed girder depths that are used to meet certain span lengths

- A significant portion of our bridges have the following parameters:
    - 75-105 ft span lengths
    - 27-45 inch girder depths

- Goal: develop efficient shapes within those parameters, while also minimizing their depth to help with vertical clearance concerns on overpasses and railroad crossings

MH Shapes: New Kids on the Block

Pre-existing Shapes:



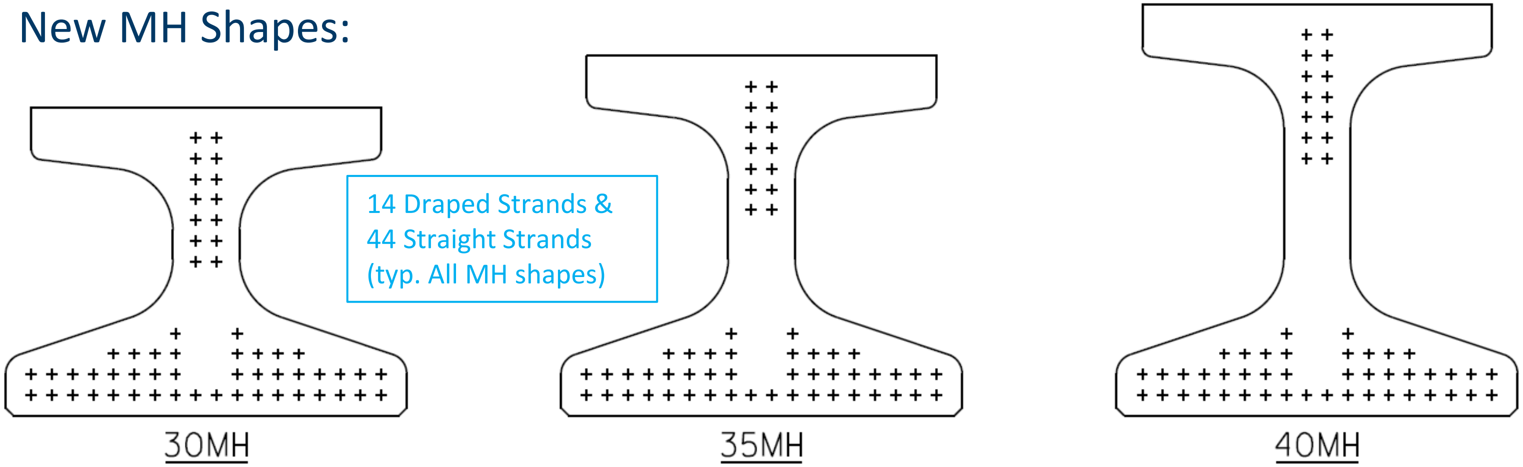
10 Draped Strands

14 Draped Strands

36 Straight Strands

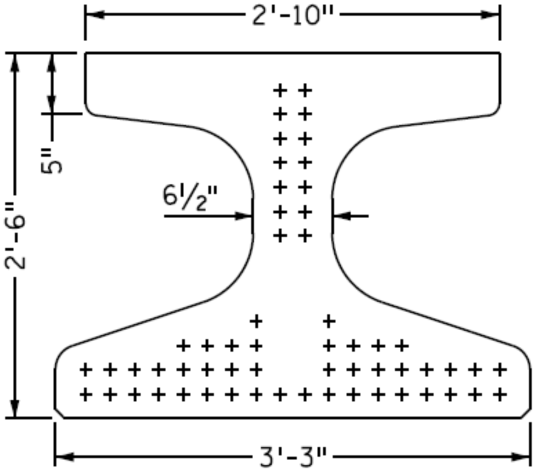
46 Straight Strands

New MH Shapes:

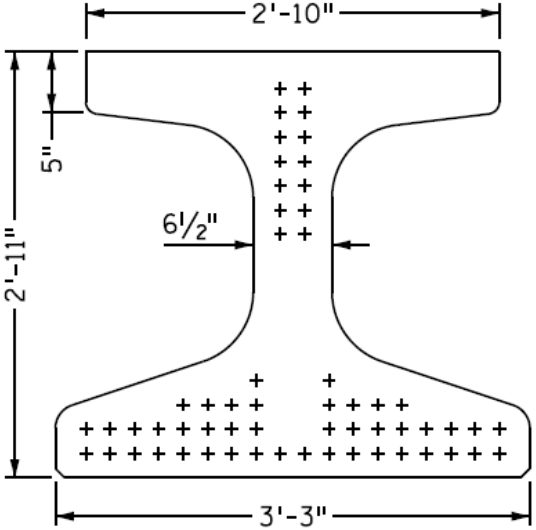


14 Draped Strands & 44 Straight Strands (typ. All MH shapes)

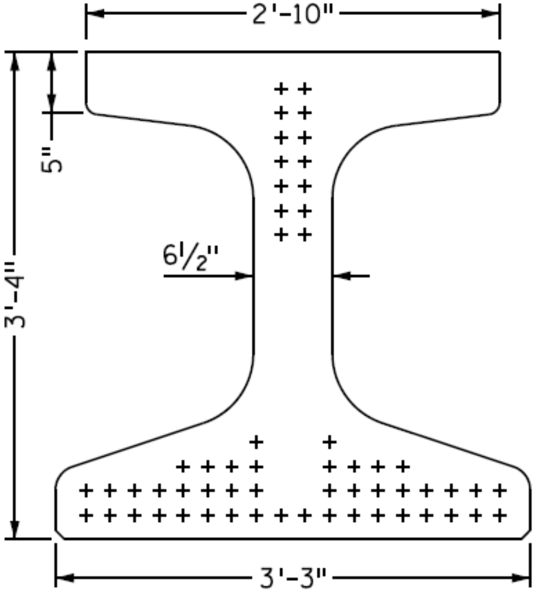
MH Shapes: Cross-Sections



30MH

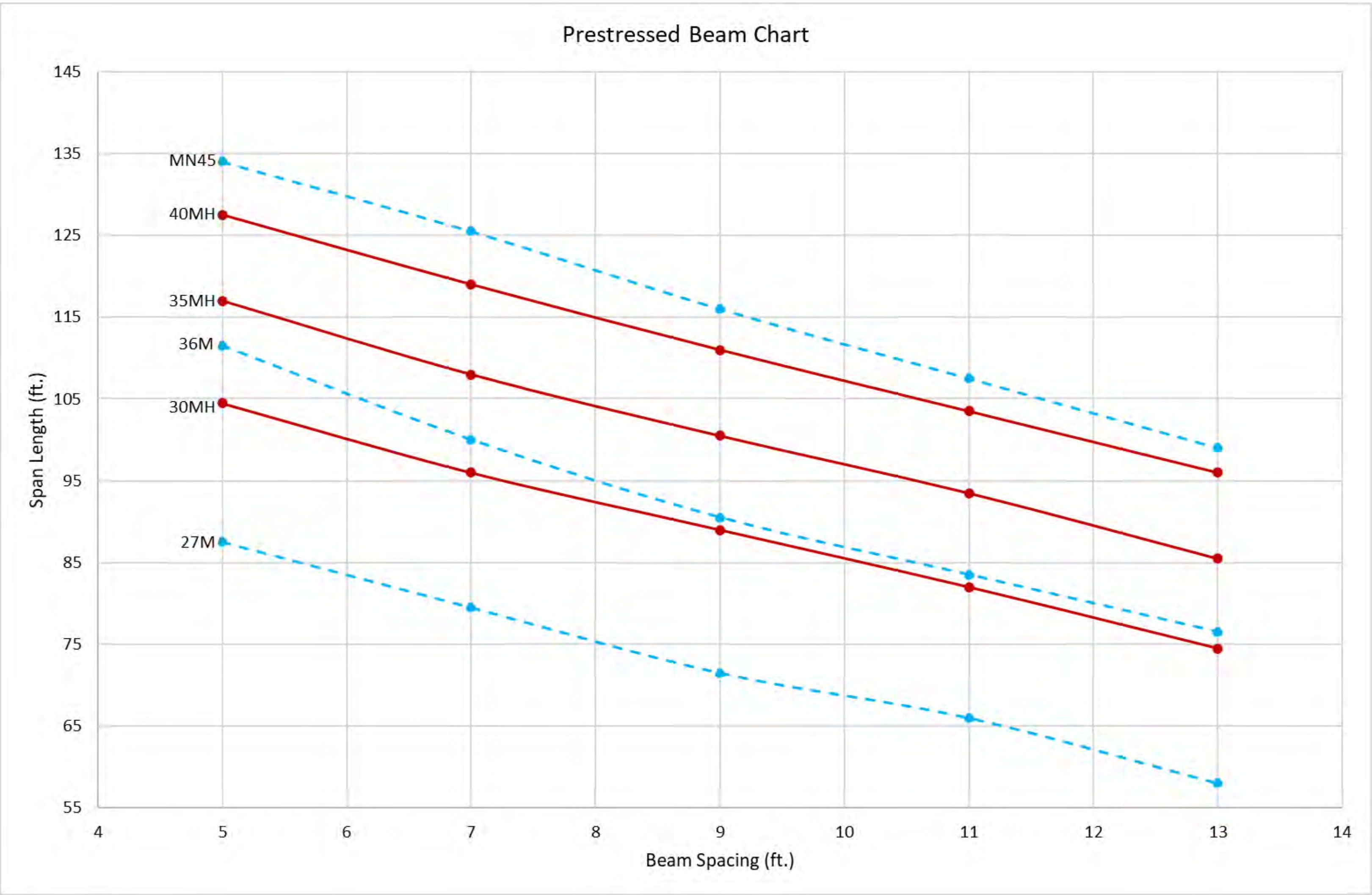


35MH



40MH

MH Shapes: Prestressed Beam Chart

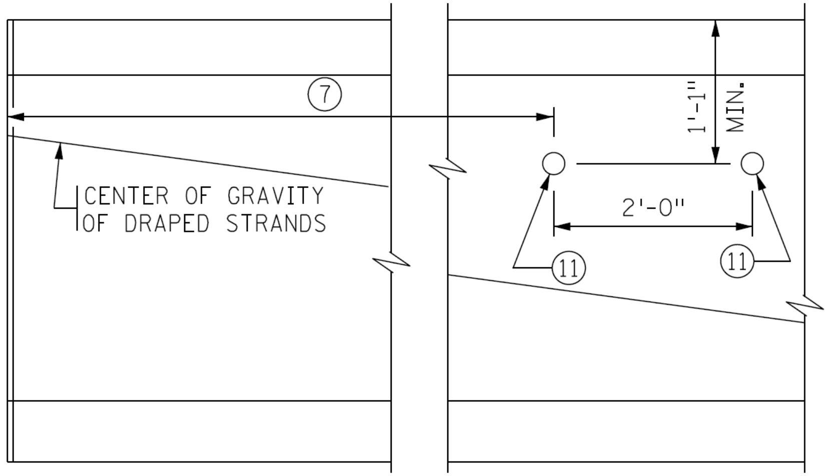


MH Shapes: Ready for Use

- Began specifying for use starting with 2019 lettings
- MnDOT's LRFD Bridge Design Manual (BDM) includes some more details that aren't mentioned here
- Standard Beam Sheets are available in the Bridge Details Manual, Part II;
  - 30MH: 5-397.501
  - 35MH: 5-397.502
  - 40MH: 5-397.503

MH Shapes: Transportation

- Stability checks are now required for **all** prestressed girders, with span lengths exceeding 145’, during shipping and handling (see BDM 5.4.6 and AASHTO 5.5.4.3)
- Relatively wide flanges help with stability checks
- Hold-downs during transportation
  - 30MH and 35MH shapes are strapped over the top flange
  - 40MH shape allows optional 2” sleeves through the web

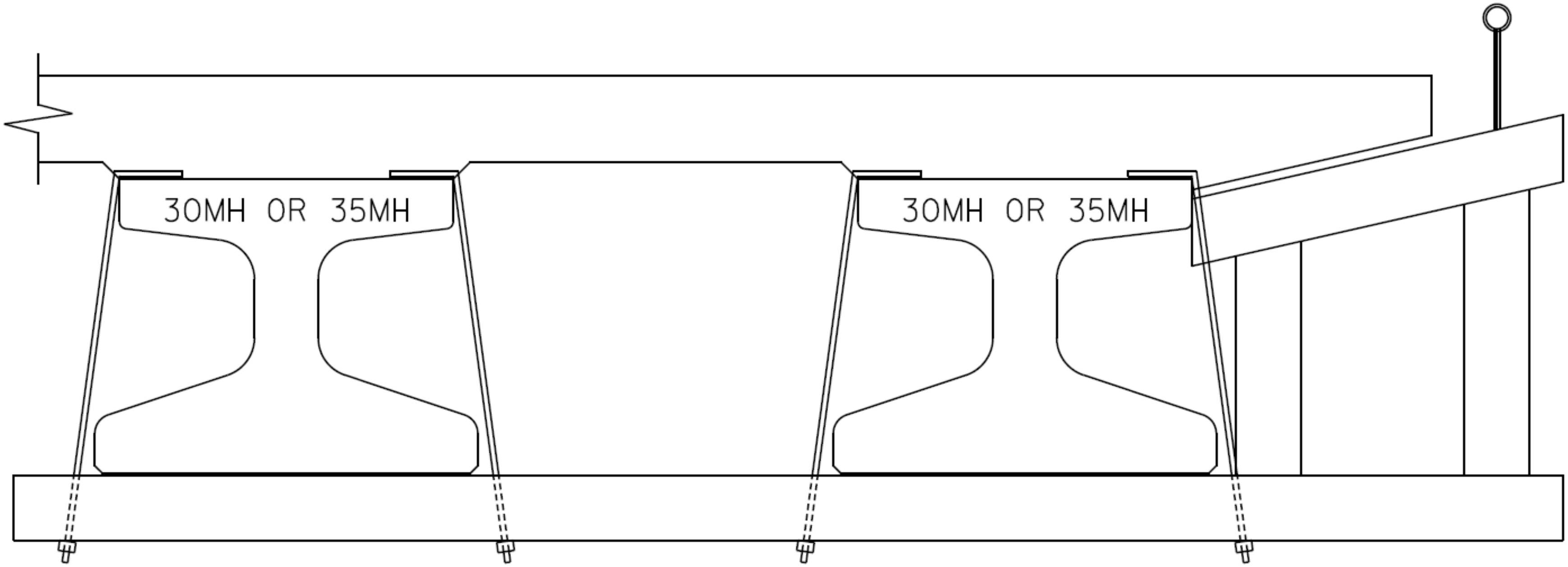


⑦ DIMENSION DETERMINED BY CONTRACTOR. MAINTAIN 2" MINIMUM CLEAR FROM STRANDS.

⑪ OPTIONAL: 2" MAX. DIA. SLEEVE FOR HAULING (AFTER INSTALLATION, COAT WITH APPROVED EPOXY BONDING AGENT & FILL WITH APPROVED NON-SHRINK GROUT).

MH Shapes: Intermediate Diaphragms

- 30MH and 35MH shapes don’t have intermediate diaphragms
  - Contractor must verify stability and provide temporary bracing during construction
  - Include standard temporary bracing note to the “Construction Notes” on the front portion of the plans (see Appendix 2-C in the BDM)
- 40MH shapes require intermediate diaphragms: see BDM 5.4.1



MH Shapes: Cost

- The cost for a MH shape can exceed the cost of a MN45 of the same span length
- Lack of diaphragms provides some savings
- Average bid price:
  - MH Shapes: $325/LF
  - M/MN Shapes: $300/LF

MH Shapes: Design Criteria

- Girder end overhang dimensions: follow the guidance per BDM 5.4.1 for RB, M and MN shapes (i.e. 7.5” overhang, measured from centerline of bearing)
- Camber
  - Use the 1.4 multiplier
  - Follow the guidance per BDM 5.4.5
- Bearings for MH shapes
  - Tables in the BDM (14.7.1, 14.7.2 and 14.7.3) now include designs for MH shapes
  - Minimum elastomeric bearing pad size is 12 inches (length A) by 30 inches (width B)
- Assumptions for deck overhang criteria in BDM Figure 9.2.1 are valid for MH shapes
- With approval from the State Bridge Design Engineer, may permit f_c’ values up to 10 ksi if necessary

MH Shapes: Updated Standards

- B303 Sole Plate
- B305 Elastomeric Bearing Pad (30” wide, deviates from 24” norm)
- B307 Bearing Pad Restraint (Pattern A-3 used for MH shapes)
- B309 Tapered Bearing plate assembly
- B310/B311 Curved Plate Bearing Assemblies (fixed and expansion)
- B403 Steel Intermediate Bolted Diaphragm (40MH only)
- B814 Concrete End Diaphragm – Parapet Abutment

Photo credit: engineeringcivil.org

Debonding

Debonding: Background

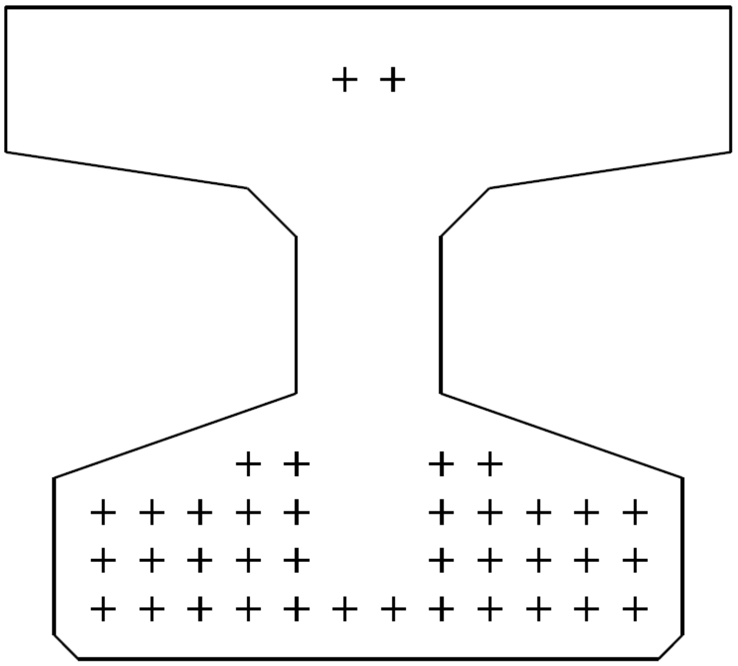
- What is Debonding?
  - Prior to casting girder concrete, prestressing strands are encased in sheathing material to prevent them from bonding to concrete for a portion of their length
  - Since strands in debonded regions are free to move relative to the concrete, they typically do not induce stresses in the concrete
- MnDOT did not allow in the past
  - Historically, MnDOT has used draped strands exclusively to reduce release stresses
  - Concerned with potential water and chloride buildup in the gap between the sheathing material and strand,
  - Other states with similar climates have observed good performance

Debonding: Limitations

- Memo to Designers will be issued soon: girders designed with debonded strands will be the preference for certain scenarios
- Refer to AASHTO 5.9.4.3.3 for general guidance
- Currently, MnDOT does not allow debonded strands to be used in conjunction with draped strands
- Debonded strands are only permitted on bridges where both ends of the girder will be encased in concrete
    - Integral or semi-integral abutments
    - Piers with continuity diaphragms, or other type of encasement

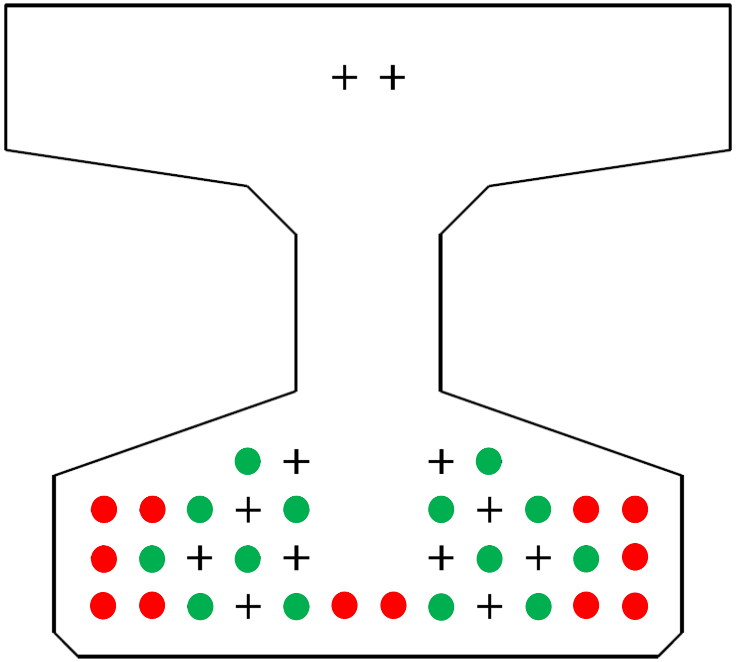
Debonding: Methodology

- Typically, strands will be debonded in the bottom flange near the girder ends to reduce the release stresses in the concrete
- May require straight strands in the top flange to reduce tensile stresses in the top flange at release
- Some scenarios may require debonding the top flange strands at midspan



Debonding: Strand Patterning

- Strands that can not be debonded:
  - Strands beneath the web
  - Base strands, required for all designs (see BDM 5.4.3)
  - Outermost strands of flange section
- Debonded strands should use a "checkerboard" pattern, i.e. do not debond two adjacent strands in a row or column
- Example of a possible debonding pattern, shown in green



(Example pattern shown for 27M)

Debonding: Design Requirements

- When computing shear depth, d_v, neglect debonded strands over their length of debonding
- Transfer and development length of debonded strands begin at the end of their sheathing
- May need to check additional critical locations along the girder, since not all prestressing force is introduced at girder ends

Debonding: Camber

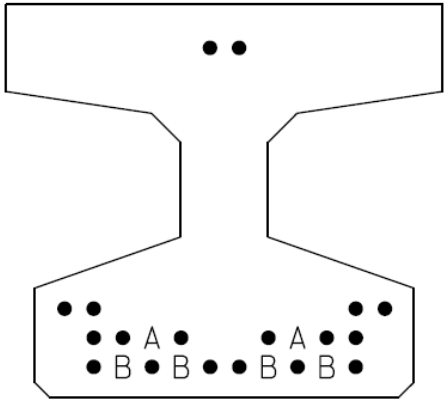
Girders with debonded strands need to follow the guidance from publication FHWA-NHI-15-058, when estimating camber due to prestressing:

- $\Delta_{ps} = \dfrac{P_t \cdot e_s \cdot L^2}{8 \cdot E_{ci} \cdot I}$ (straight bonded strands)
- $\Delta_{ps} = \dfrac{P_t \cdot e_s \cdot \left[L^2 - (L_t + 2 \cdot L_x)^2\right]}{8 \cdot E_{ci} \cdot I}$ (debonded strands)
  - Δ_{ps} = upward camber of beam immediately after release, due to prestress alone (in)
  - P_t = prestress force immediately after release (kips)
  - e_s = eccentricity of prestress force with respect to the beam centroid at midspan (in)
  - L = design span length of beam (in)
  - L_t = transfer length of strand (in)
  - L_x = length of debonding from end of beam (in)
  - E_{ci} = modulus of elasticity of concrete at prestress transfer (ksi)
  - I = beam moment of inertia (in^4)

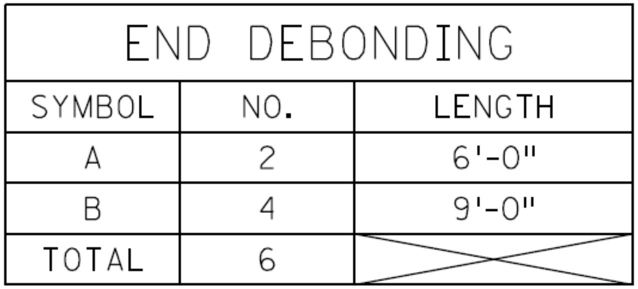
Debonding: Modifying Standard Plan Sheets

To date, there are no standard beam sheets that incorporate debonding, and certain modifications must be made;

- Use letters in "End View" to indicate debonded strand locations
- Strands with different lengths of debonding receive a unique letter
- Include a table indicating the length of debonding



END VIEW

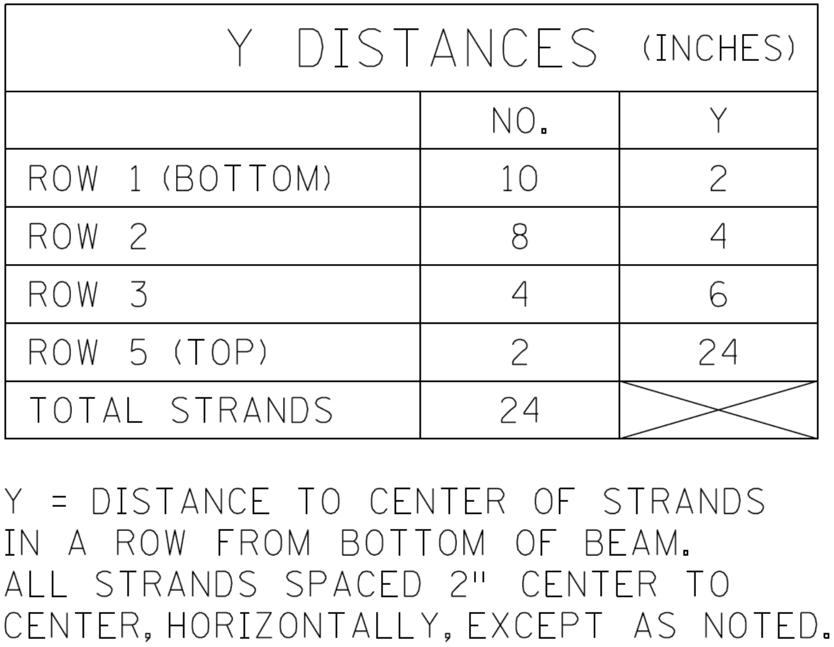


END DEBONDING		
SYMBOL	NO.	LENGTH
A	2	6'-0"
B	4	9'-0"
TOTAL	6	

DEBONDING LENGTHS FOR A AND B ARE MEASURED FROM EACH END OF BEAM.

Debonding: Modifying Standard Plan Sheets

- Remove all references to draped strands
- Modify the “Y Distances” table to show the number of strands per row, and that row’s corresponding center of gravity



Y DISTANCES (INCHES)

	NO.	Y
ROW 1 (BOTTOM)	10	2
ROW 2	8	4
ROW 3	4	6
ROW 5 (TOP)	2	24
TOTAL STRANDS	24	

Y = DISTANCE TO CENTER OF STRANDS IN A ROW FROM BOTTOM OF BEAM.
ALL STRANDS SPACED 2" CENTER TO CENTER, HORIZONTALLY, EXCEPT AS NOTED.

Debonding: Special Provisions

- Currently not in the 2020 “SB” Bridge Special Provisions: contact the MnDOT Bridge Office for the latest version, until it’s incorporated
- Girders with debonded strands need to follow a modified prestress transfer sequence, where debonded strands are released last
- Describes materials, tolerances, and procedures that must be followed during fabrication

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300 ksi Strands

300 ksi Strands: Background

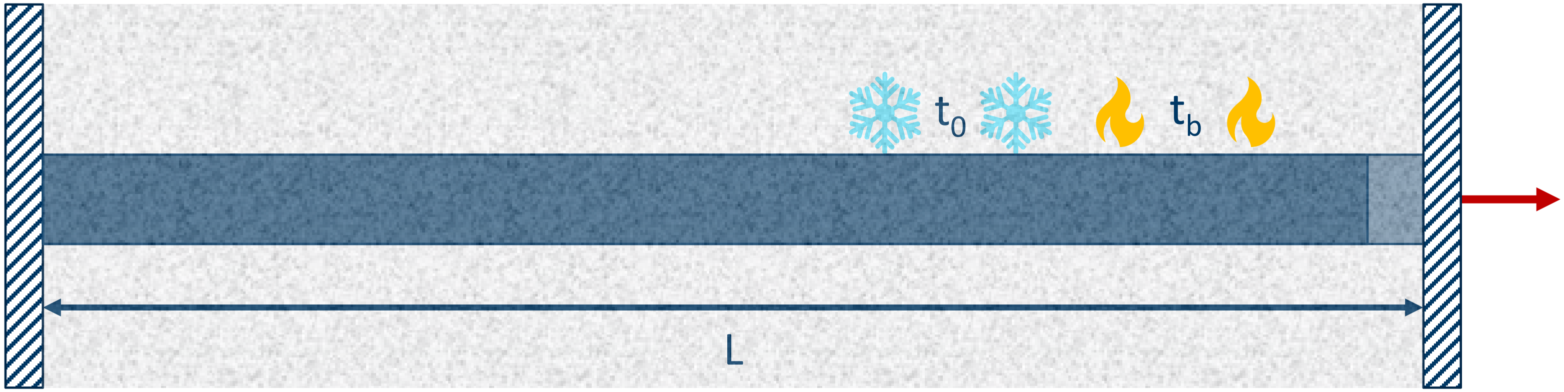
- Memo to Designers 2021-01: issued on 01/21/2021 (see BDM)
  - Effective immediately for girders that have not been designed yet: use 300 ksi strands
- Reasoning for change
  - 300 ksi strands are now readily available. Since the strand diameter is the same as a 270 ksi strand, the fabricators don't need to update their equipment
  - Increased girder design capacity
    - Potential for longer spans, increased girder spacing, or reduction in total number of strands required per girder
  - Enables a wider range of temperatures during strand stressing procedures (see MnDOT Research Report 2015-50)

300 ksi Strands: Design Parameters

- Uncoated, low-relaxation, seven-wire strand with tensile strength, f_{pu} = 300 ksi
- Design jacking stress: $0.72 \cdot f_{pu}$
- Nominal strand diameter, d_{str} = 0.6 in.
- Nominal strand area, $A_{str} = 0.217\ in^2$
- Strand yield strength, $f_{py} = 0.9 \cdot f_{pu}$
- Strand modulus of elasticity, E_p = 28,500 ksi
- Strain compatibility parameters have not been finalized yet – for now, may conservatively use the parameters for a 270 ksi strand

Deviation from past practice!

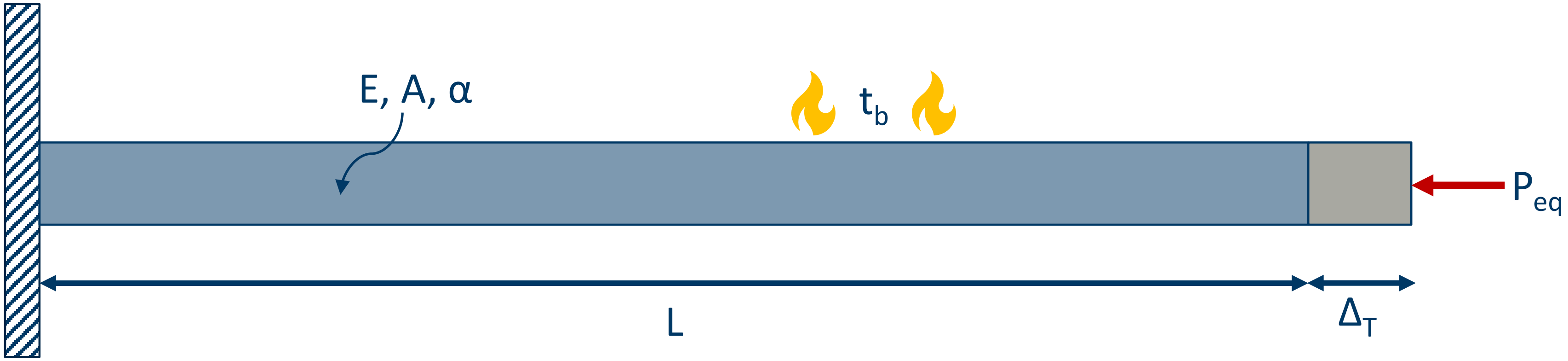
300 ksi Strands: Thermal Losses



Simplified example: determine what happens to the force in a prestressing strand due to an increase in temperature

- The strand is stressed at a low ambient initial temperature, t_0
    - Per MnDOT Special Provision article 2405, strands may be tensioned at ambient temperatures as low as 32°F
- After stressing the strand, both ends are fixed, so the length L is constant.
- Cast the concrete: temperature at bond, t_b, typically reaches 95°F

300 ksi Strands: Thermal Losses



- If the strand ends were not fixed, this thermal increase ($t_b - t_0$) would result in a strand axial elongation of: $\Delta_T = \alpha \cdot L \cdot (t_b - t_0)$
- Since both ends <u>are</u> fixed, the total axial deflection is zero. Thus, we need to determine the equivalent axial load required to counteract this thermal deflection: $\frac{P_{eq} \cdot L}{EA} = \Delta_T$
- Combining the two equations: $P_{eq} = E \cdot A \cdot \alpha \cdot (t_b - t_0)$, where P_{eq} represents the loss of prestressing force in the strand, due to thermal effects (about 3 kips per strand)

300 ksi Strands: Thermal Losses

- Fabricators have two options to correct for the prestressing force lost in the strand due to thermal effects, P_{eq}:
  1. Increase the ambient temperature during stressing procedures (expensive)
  2. Increase the jacking stress (inexpensive): allowed to stress up to $0.80 \cdot f_{pu}$
- The jacking force in the strand at the time of concrete/strand bonding must match the value assumed in design
  - 270 ksi strands were designed with a jacking stress of $0.75 \cdot f_{pu}$
    - Permissible jacking force range: $(0.80-0.75) \cdot (270 \text{ ksi}) \cdot (0.217 \text{ in}^2) = 2.9$ kips/strand
  - 300 ksi strands are designed with a jacking stress of $0.72 \cdot f_{pu}$
    - Permissible jacking force range: $(0.80-0.72) \cdot (300 \text{ ksi}) \cdot (0.217 \text{ in}^2) = 5.2$ kips/strand

300 ksi Strands: Jacking Stress

- Why do we use $0.72 \cdot f_{pu}$ design jacking stress for 300 ksi strands?
  - This jacking stress (216 ksi) exceeds that of a 270 ksi strand that is jacked to $0.75 \cdot f_{pu}$ (202.5 ksi), so it's possible to obtain increased girder capacity with the same strand layout
  - Provides an increased range of permissible jacking force for the fabricator, corresponding to a wider range of permissible temperatures during stressing procedures
- In cases where a design with 300 ksi strands jacked to $0.72 \cdot f_{pu}$ is inadequate, but jacking to $0.75 \cdot f_{pu}$ meets design requirements:
  - Contact the fabricators to determine when the beam will be fabricated (high ambient temperatures means they will observe low thermal losses)
  - Contact the MnDOT Final Design Engineer, then the State Bridge Design Engineer to discuss a possible exception

300 ksi Strands: Pertinent Updates

- Documents that have been updated to account for 300 ksi strands:
  - Special provisions 2405 and 3348
  - Standard prestressed beam plan sheets
  - BDM prestressed concrete beam charts
    - Figure 5.4.6.2
    - Figure 5.4.6.3 (MW shapes)
- Some software programs may not be equipped to handle 300 ksi strands yet

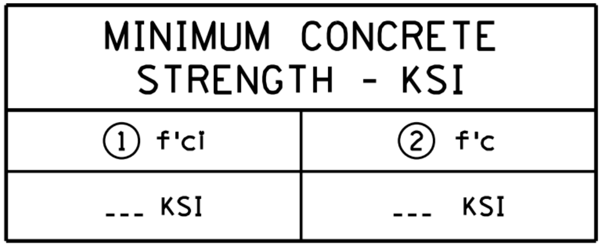
Filling Out Standard Beam Plan Sheets

Standard Beam Sheets: Topics for discussion

- Follow guidance provided in BDM 5.4.3
- Main topics to consider when filling out
  - Concrete strengths
  - Strand patterning
  - Strand grade and jacking stress

Standard Beam Sheets: Concrete Strengths

- Concrete strength at time of prestress transfer, f'_{ci}
  - Try to keep below 7.5 ksi (higher strengths increase the cost)
  - Strengths above 8.0 ksi must be approved by the State Bridge Design Engineer
  - Should be 0.5 to 1.0 ksi lower than final concrete strength
- Final concrete strength, f'_{c}
  - Try to keep below 9.5 ksi
  - Strengths above 9.5 ksi must be approved by the State Bridge Design Engineer
- f'_{ci} and f'_{c} should be reported to the nearest tenth of a ksi



MINIMUM CONCRETE STRENGTH - KSI

① f'ci	② f'c
--- KSI	--- KSI

Standard Beam Sheets: Concrete Strengths

- Do not use the maximum concrete strengths unless absolutely required. The general process is as follows:
  1. Determine a strand pattern that works for your design,
  2. Optimize the design strengths by back-calculating the initial and final concrete strengths required to meet stress limits, and
  3. Re-analyze the beam with the optimized concrete strengths
- Generally, adding strands to meet design requirements is more expensive than increasing the concrete strengths

Standard Beam Sheets: Strand Patterning

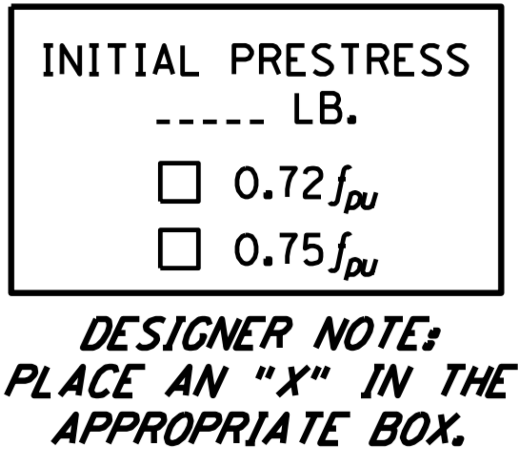
- Follow the guidance per BDM 5.4.3 when patterning strands
  - Intended for use with girders that have draped strands
  - Some modifications will be required for girders with debonded strands
- Try to use a consistent strand pattern for all girders on the same project – this provides efficiency and economy during fabrication

Standard Beam Sheets: Strand Grade and Jacking Stress

- Strand Grade
  - General Notes section assumes 300 ksi strands
  - If designing with 270 ksi strands, the standard note needs to be modified per the designer note provided in the standard figure

New section to fill out in standard sheet:

- $0.72 \cdot f_{pu}$ (Use for most designs with 300 ksi strands)
- $0.75 \cdot f_{pu}$
  - Use for designs with 270 ksi strands
  - Use for designs with 300 ksi strands <u>that have an approved design exception</u> from the State Bridge Design Engineer



INITIAL PRESTRESS

----- LB.

☐ $0.72 f_{pu}$

☐ $0.75 f_{pu}$

DESIGNER NOTE: PLACE AN "X" IN THE APPROPRIATE BOX.

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Camber for Prestressed Girders

Camber for Prestressed Girders

- Refer to BDM 5.4.5 for camber requirements
- Girders must have some residual camber
  - If the residual camber is less than one inch, consider adding strands
- Determining erection camber
  - MW shapes: refined camber analysis required
  - All other prestressed girder shapes: use a camber multiplier of 1.4 for deflections due to prestressing and girder self-weight
- MnDOT is continuing to monitor field survey data to verify the adequacy of our camber multipliers

Inverted T’s

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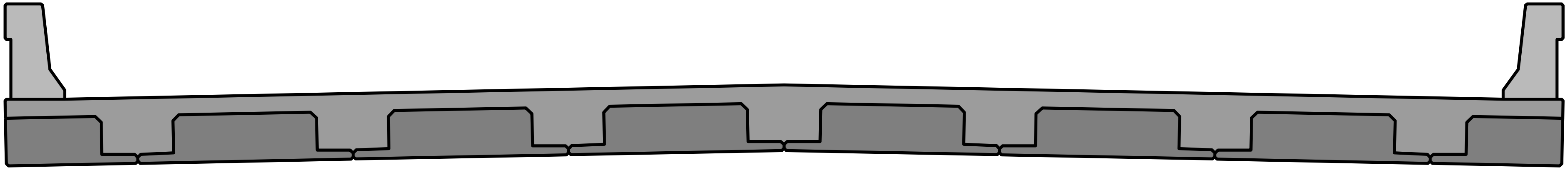
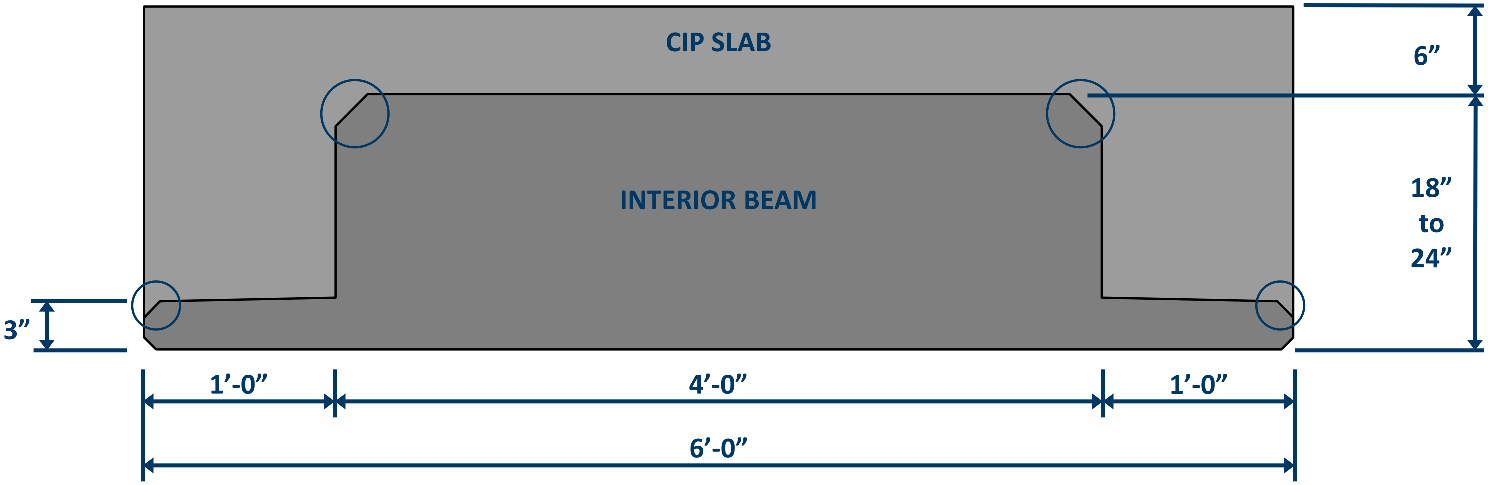
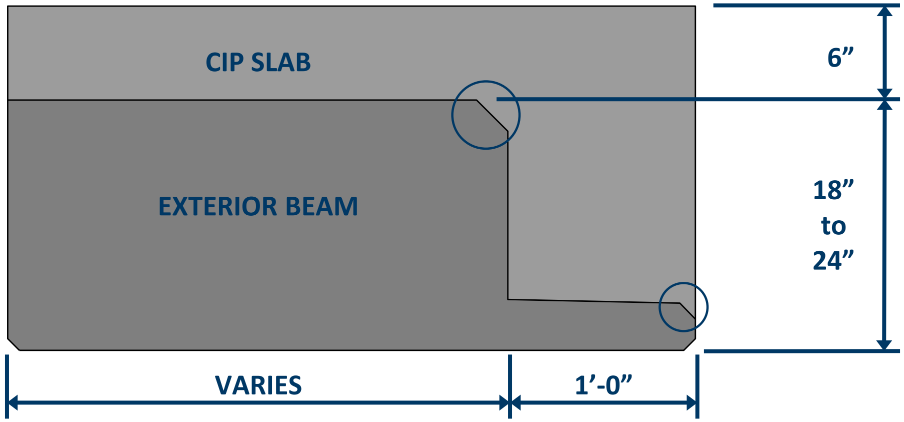
Inverted T's: General

- Development began in 2004 as an alternative to slab span bridges
- Spans up to 45'
- Typically not used on skewed bridges
- Beams act as formwork - intended to speed up construction
- Roughly 5 generations of Inverted T bridges have been built, with each generation showing improved performance – issues with deck map cracking in earlier generations
- MnDOT is working towards producing guidelines and standardized plan sheets

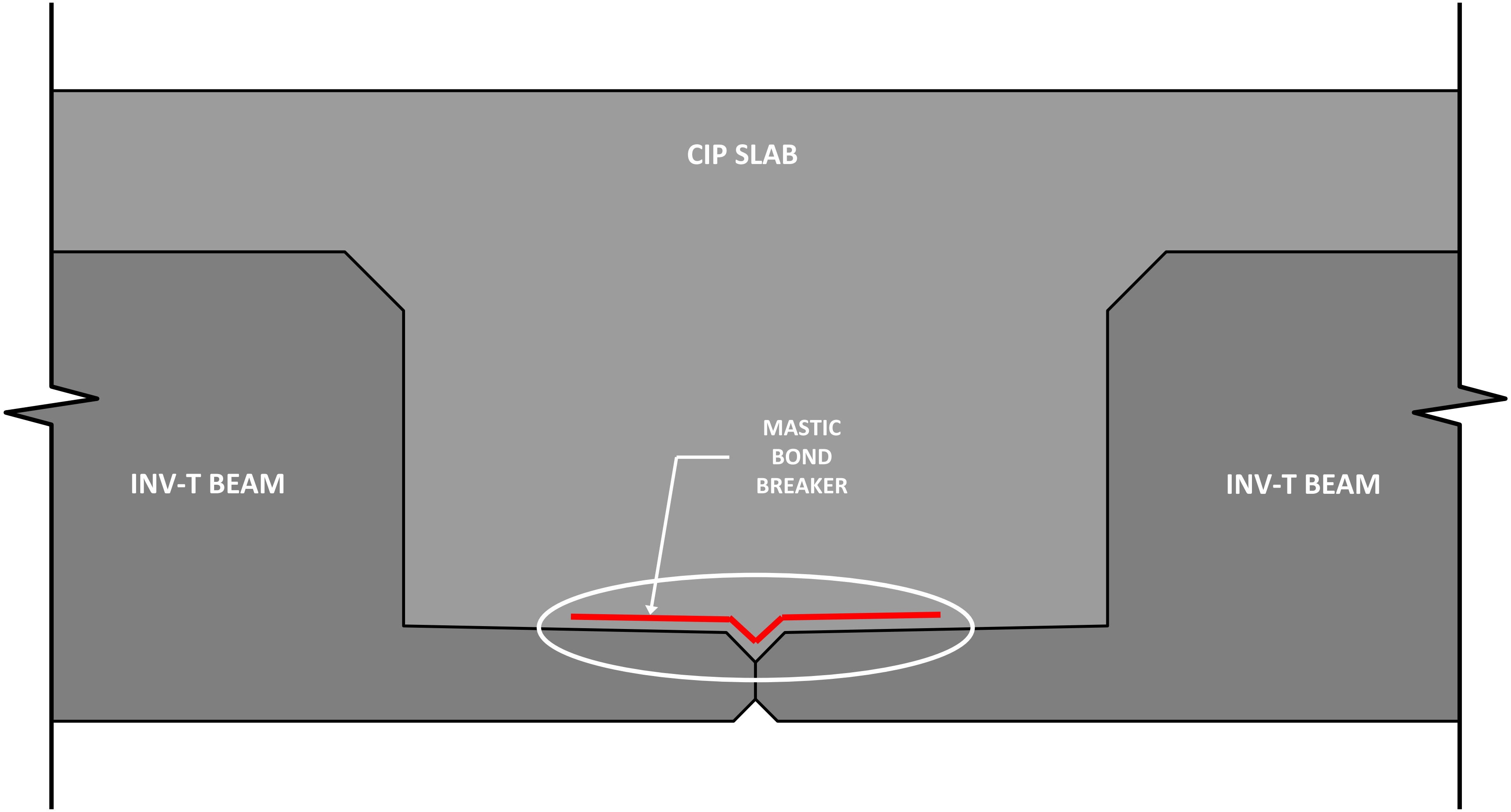


Inverted Tees - Geometry

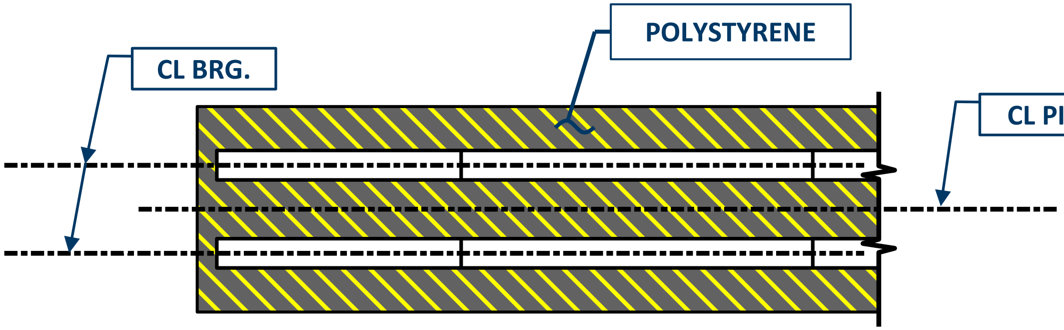




Inverted Tees - Geometry



Inverted Tees: Connecting to Substructures



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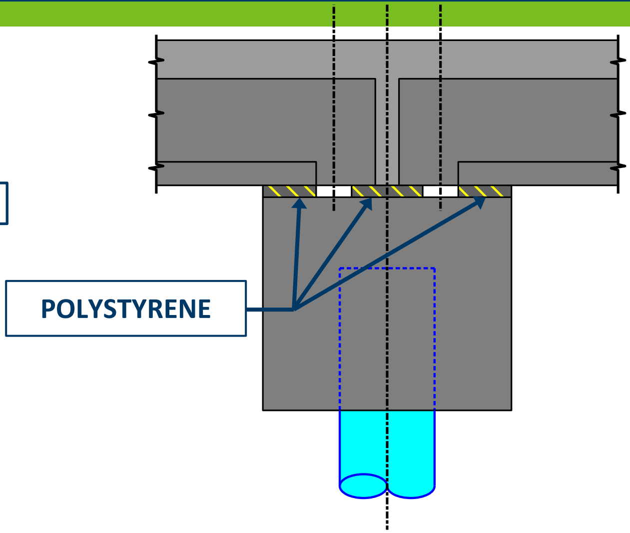

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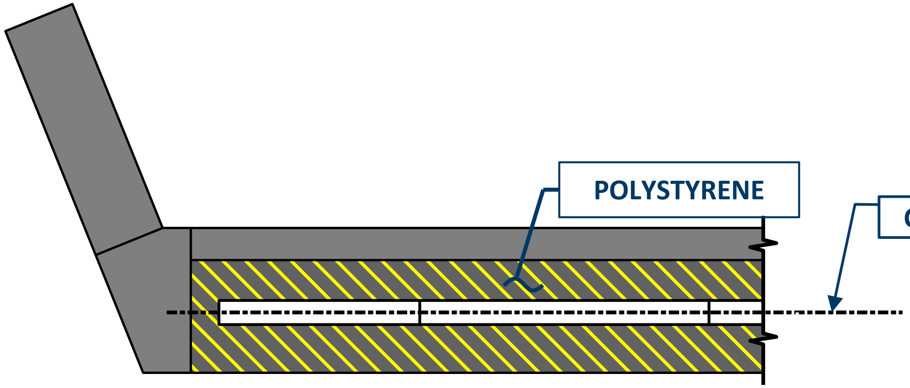

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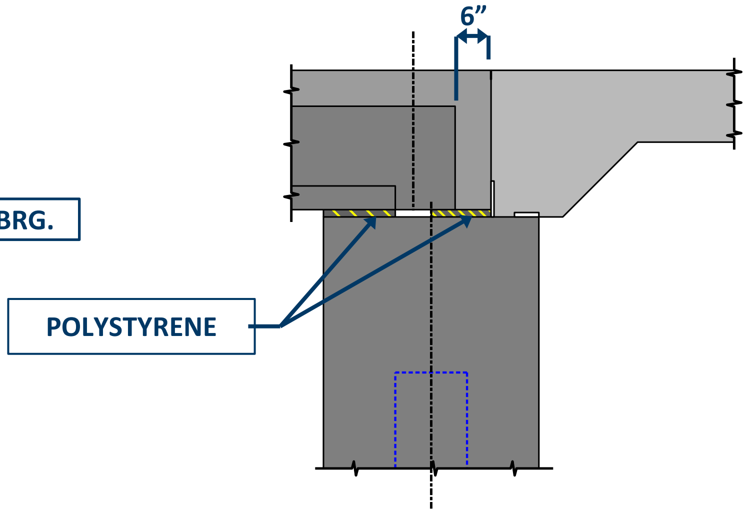
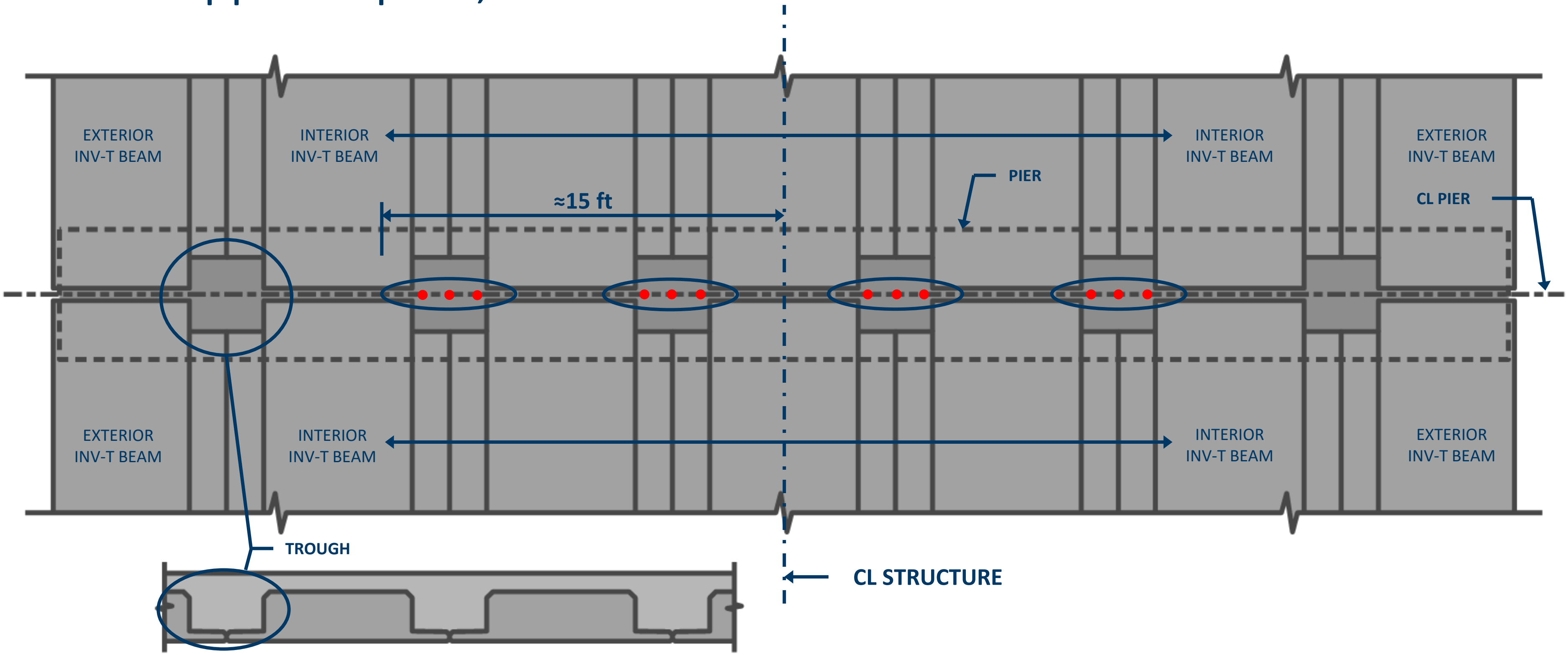


ABUTMENT

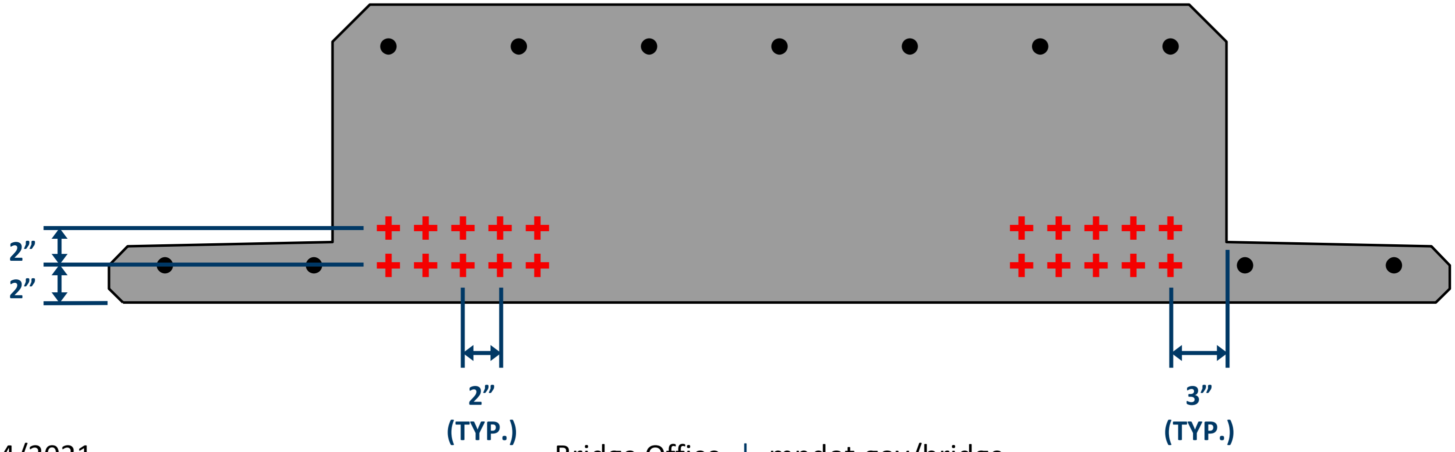
Inverted Tees: Dowels

- Stainless steel
- Wrapped at piers, not abutments



Inverted Tees - Materials

- Beam Concrete
  - f'_{ci} = 4 ksi minimum (5 ksi maximum)
  - f'_c = 9 ksi maximum (6 ksi typical)
- Slab Concrete (includes poly-fibers to mitigate cracking)
  - f'_c = 4 ksi
- 0.6” diameter 7-wire low-relaxation strands (300 ksi or 270 ksi)



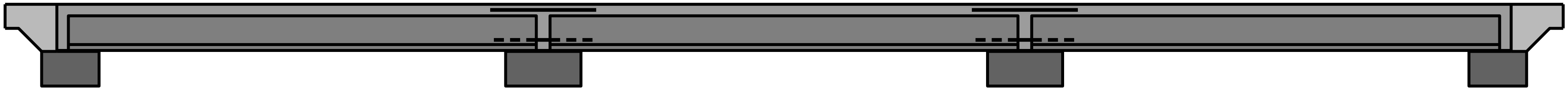
Inverted Tees – Design

- LLDF calculated assuming slab-type bridge
- Additional loads:
  - Restraint moment
  - Thermal gradient

CONSTRUCTION SEQUENCE FOR THREE-SPAN BRIDGE WITH INVERTED TEES MADE CONTINUOUS FOR LIVE LOADS

PRECAST GIRDERS PLACED ON SUBSTRUCTURE

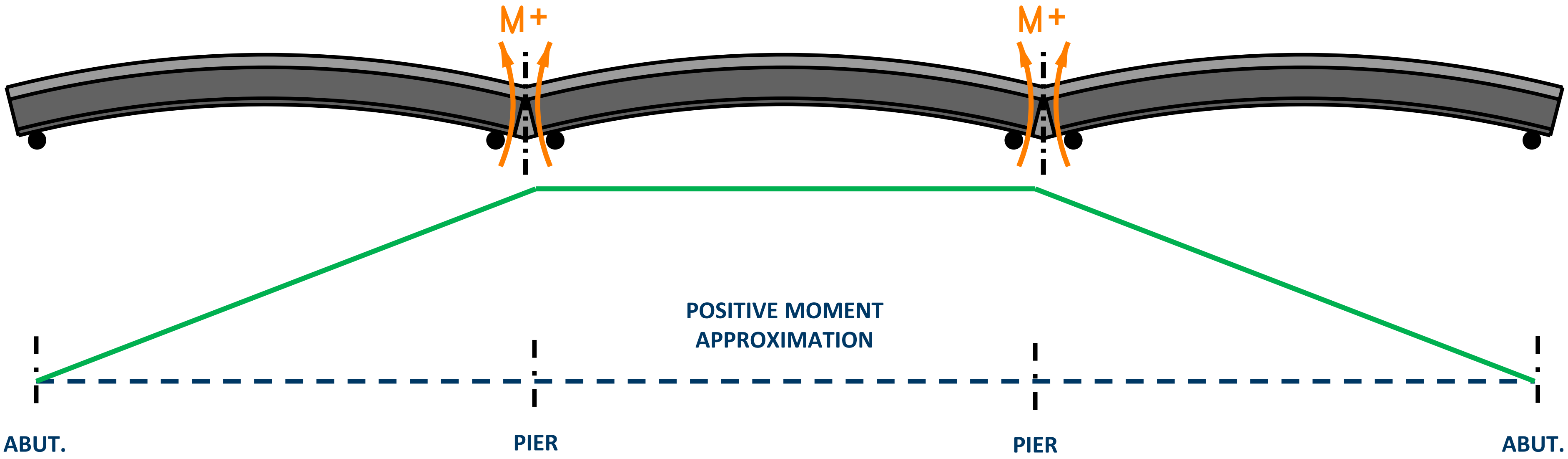
REINFORCEMENT PLACED OVER PIERS



CAST-IN-PLACE SLAB POURED

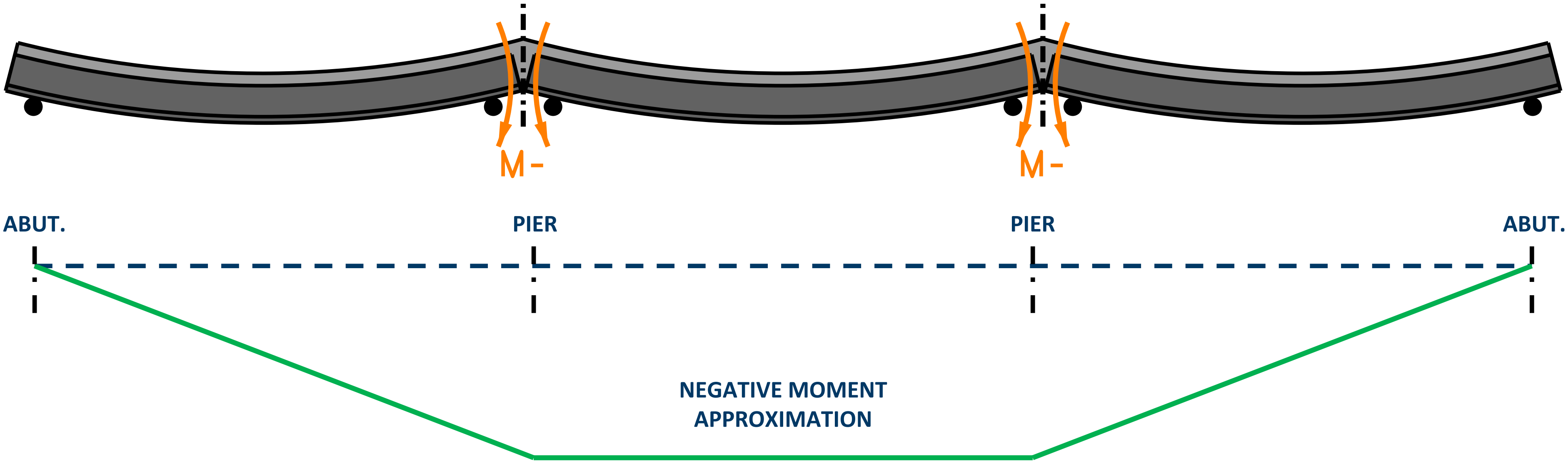
Inverted Tees - Design

- Positive restraint moments
  - Beam prestress creep
- Positive thermal gradient



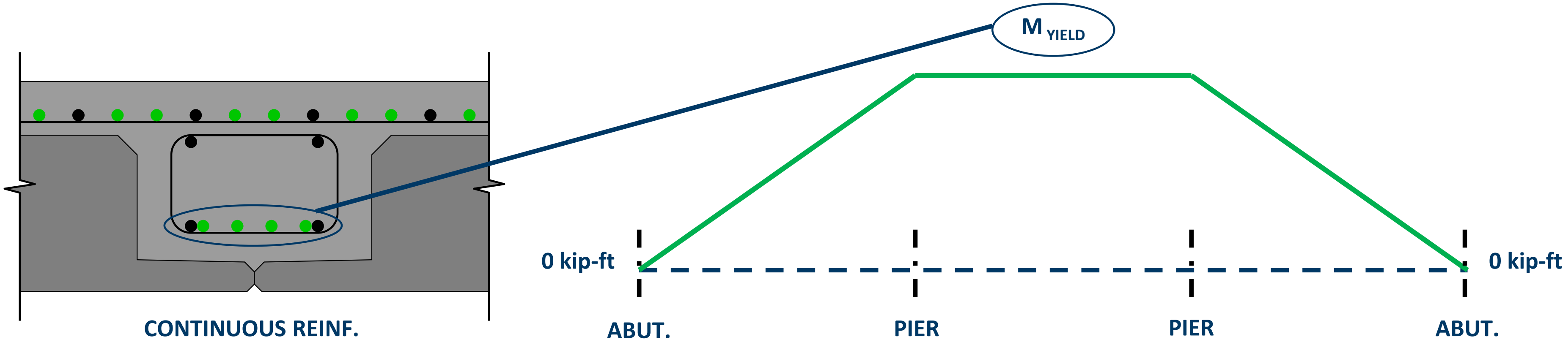
Inverted Tees - Design

- Negative restraint moments
  - Dead load creep (beam self-weight, CIP deck weight)
  - Deck shrinkage
- Negative thermal gradient



Inverted Tees – Design

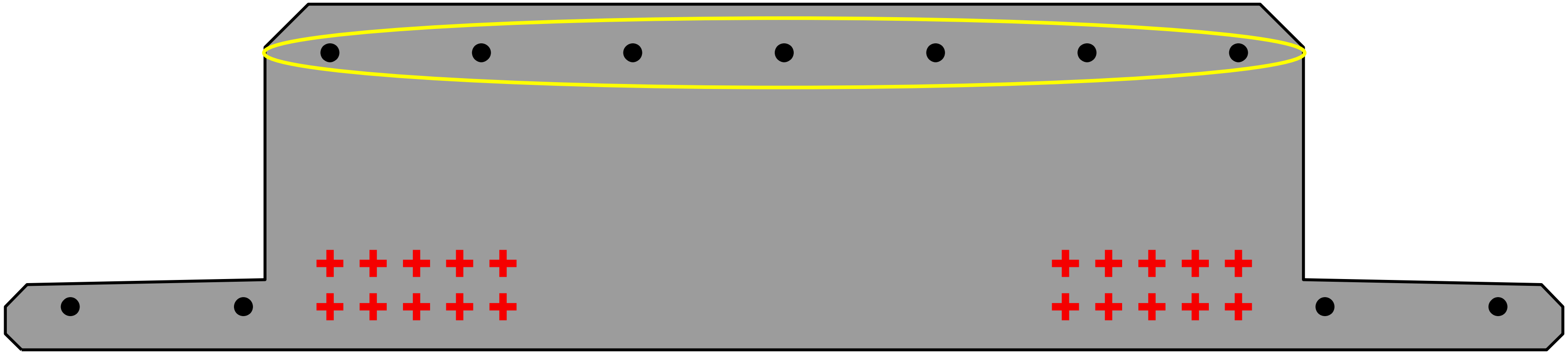
- Beams designed as simple-span for all loads
- Restraint moments and thermal gradient combination included by taking yield moment of trough reinforcement continuous over the piers



RESTRAINT/THERMAL GRADIENT
MOMENT APPROXIMATION

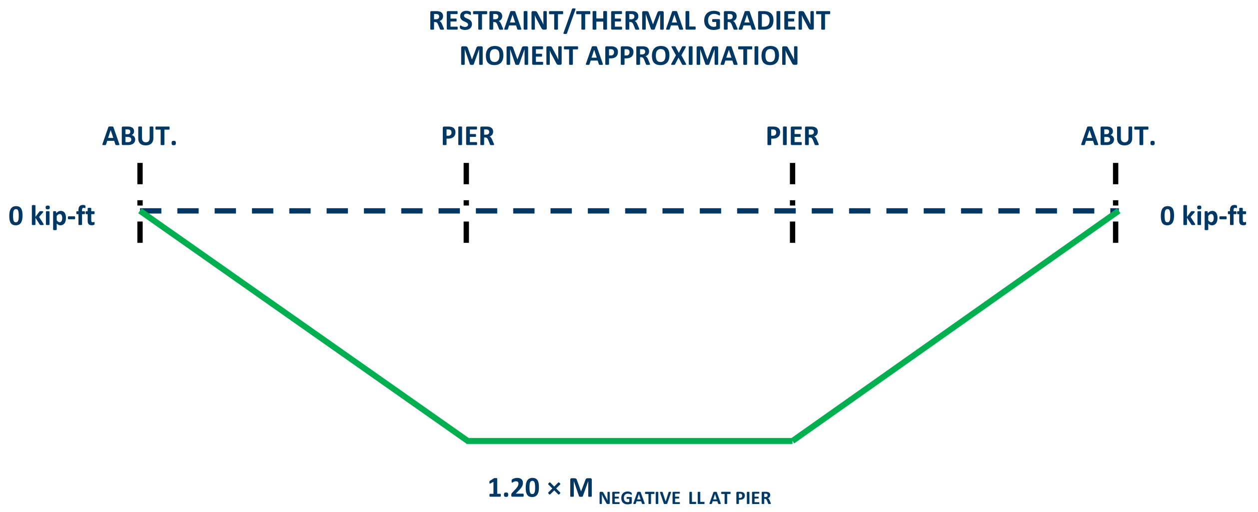
Inverted Tees – Beam Design

- Tension at release limited to $0.24\sqrt{f'_{ci}}$ rather than $0.0948\sqrt{f'_{ci}}$ or 200 psi used for typical prestressed beams



Inverted Tees – Slab Design

- Designed as continuous for loads applied after slab cures (barrier, FWS, LL)
- Restraint moments and thermal gradient included by applying a factor of 1.20 to the negative LL moment at the piers



DEPARTMENT OF TRANSPORTATION

Curved Plate Bearing Assemblies

Curved Plate Bearing Assemblies: Standardized Designs

- Delivery timing of bearing assemblies often results in construction delays
- BDM Tables 14.7.1, 14.7.2 and 14.7.3 (curved plate bearing assemblies for prestressed concrete beams)
  - Recently updated to provide standardized designs
  - Use these design tables whenever possible, for consistency and economy (if you use your own spreadsheet, try to match the values provided in standard tables)
  - Standardized designs enable the fabricators and contractors to stockpile bearings, which can reduce the likelihood of construction delays

Curved Plate Bearing Assemblies: BDM Table 14.7.1

BDM Table 14.7.1 (fixed bearing assembly): only need to know the beam series and maximum service load (DL+LL)

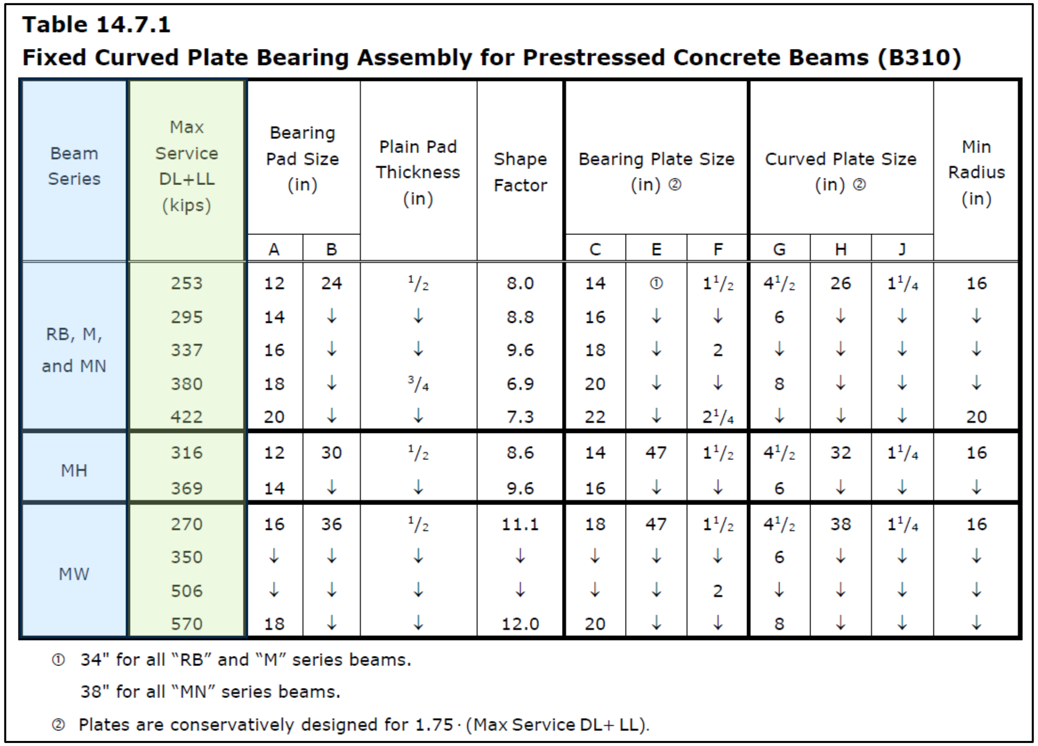


Table 14.7.1

Fixed Curved Plate Bearing Assembly for Prestressed Concrete Beams (B310)

Beam Series	Max Service DL+LL (kips)	Bearing Pad Size (in)		Plain Pad Thickness (in)	Shape Factor	Bearing Plate Size (in) ②			Curved Plate Size (in) ②			Min Radius (in)
		A	B			C	E	F	G	H	J	
RB, M, and MN	253	12	24	$^{1}/_{2}$	8.0	14	①	$1^{1}/_{2}$	$4^{1}/_{2}$	26	$1^{1}/_{4}$	16
	295	14	↓	↓	8.8	16	↓	↓	6	↓	↓	↓
	337	16	↓	↓	9.6	18	↓	2	↓	↓	↓	↓
	380	18	↓	$^{3}/_{4}$	6.9	20	↓	↓	8	↓	↓	↓
	422	20	↓	↓	7.3	22	↓	$2^{1}/_{4}$	↓	↓	↓	20
MH	316	12	30	$^{1}/_{2}$	8.6	14	47	$1^{1}/_{2}$	$4^{1}/_{2}$	32	$1^{1}/_{4}$	16
	369	14	↓	↓	9.6	16	↓	↓	6	↓	↓	↓
MW	270	16	36	$^{1}/_{2}$	11.1	18	47	$1^{1}/_{2}$	$4^{1}/_{2}$	38	$1^{1}/_{4}$	16
	350	↓	↓	↓	↓	↓	↓	↓	6	↓	↓	↓
	506	↓	↓	↓	↓	↓	↓	2	↓	↓	↓	↓
	570	18	↓	↓	12.0	20	↓	↓	8	↓	↓	↓

① 34" for all "RB" and "M" series beams.
38" for all "MN" series beams.

② Plates are conservatively designed for 1.75 · (Max Service DL+ LL).

Curved Plate Bearing Assemblies: BDM Table 14.7.2

BDM Table 14.7.2 (expansion bearing assembly):

- Need maximum service load (DL+LL) and girder shape
- Determine the required number of laminates per Table 14.7.3
- Interior laminate thickness is used for bearing pad design in Table 14.7.3

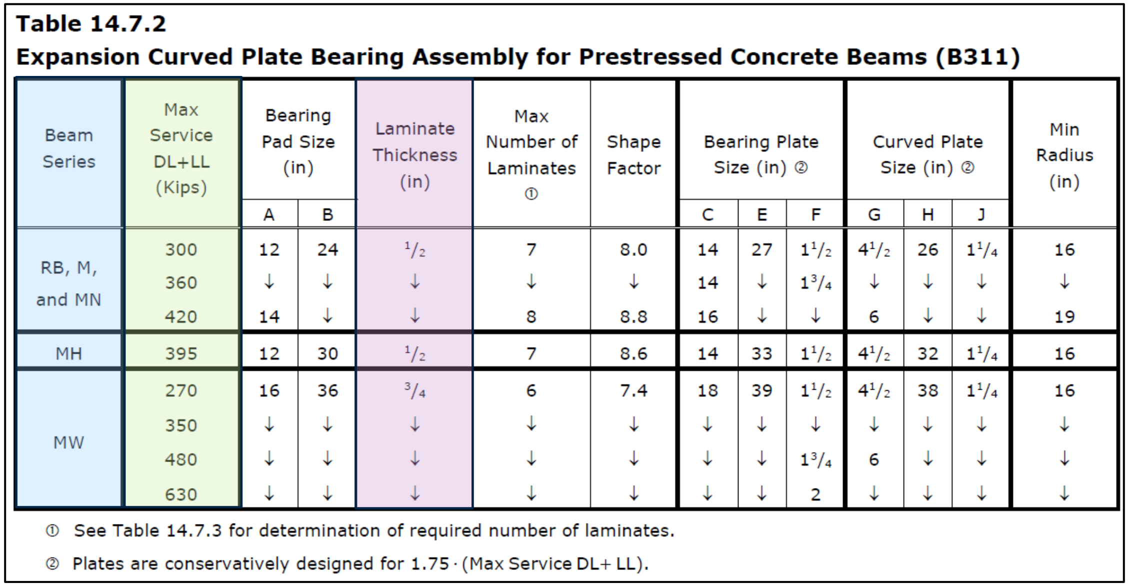


Table 14.7.2

Expansion Curved Plate Bearing Assembly for Prestressed Concrete Beams (B311)

Beam Series	Max Service DL+LL (Kips)	Bearing Pad Size (in)		Laminate Thickness (in)	Max Number of Laminates ①	Shape Factor	Bearing Plate Size (in) ②			Curved Plate Size (in) ②			Min Radius (in)
		A	B				C	E	F	G	H	J	
RB, M, and MN	300	12	24	$^{1}/_{2}$	7	8.0	14	27	$1^{1}/_{2}$	$4^{1}/_{2}$	26	$1^{1}/_{4}$	16
	360	↓	↓	↓	↓	↓	14	↓	$1^{3}/_{4}$	↓	↓	↓	↓
	420	14	↓	↓	8	8.8	16	↓	↓	6	↓	↓	19
MH	395	12	30	$^{1}/_{2}$	7	8.6	14	33	$1^{1}/_{2}$	$4^{1}/_{2}$	32	$1^{1}/_{4}$	16
MW	270	16	36	$^{3}/_{4}$	6	7.4	18	39	$1^{1}/_{2}$	$4^{1}/_{2}$	38	$1^{1}/_{4}$	16
	350	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	480	↓	↓	↓	↓	↓	↓	↓	$1^{3}/_{4}$	6	↓	↓	↓
	630	↓	↓	↓	↓	↓	↓	↓	2	↓	↓	↓	↓

① See Table 14.7.3 for determination of required number of laminates.

② Plates are conservatively designed for 1.75 · (Max Service DL+ LL).

Curved Plate Bearing Assemblies: BDM Table 14.7.3

Table 14.7.3 (elastomeric bearing pad design):

- Interior laminate thickness determined in Table 14.7.2
- Need to determine the maximum longitudinal service movement due to thermal loading, Δ_s
- Note 5: for “RB”, “M” and “MN series;
  - If $\Delta_s \leq 1.0$”, use 3-½” laminates
  - If 1.0”< $\Delta_s \leq 1.75$”, use 6-½” laminates

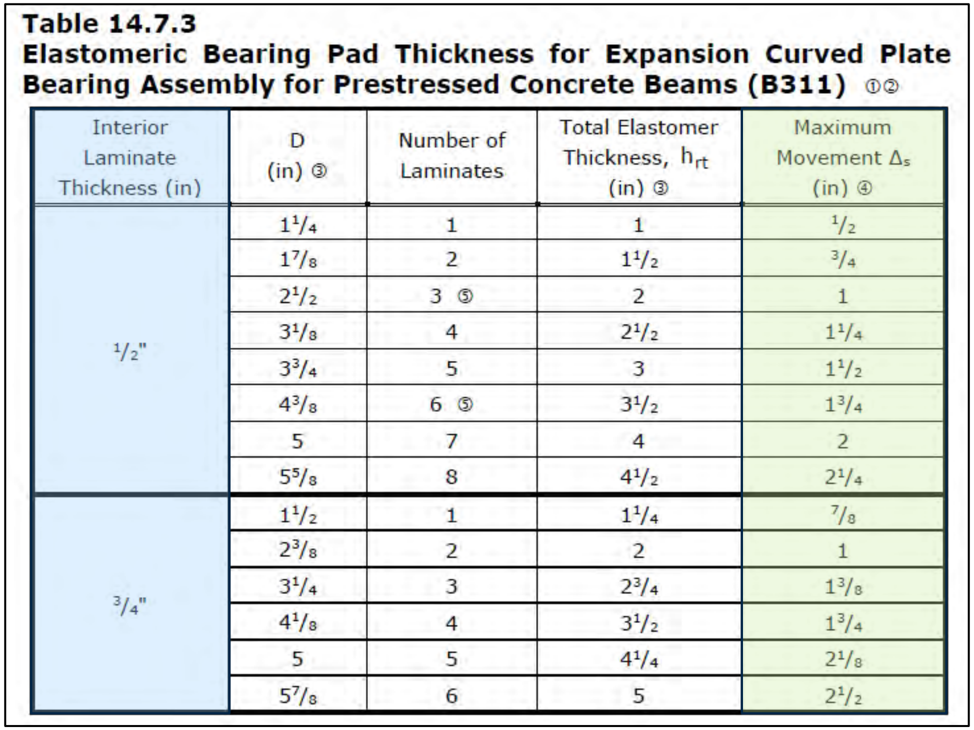


Table 14.7.3
Elastomeric Bearing Pad Thickness for Expansion Curved Plate Bearing Assembly for Prestressed Concrete Beams (B311) ①②

Interior Laminate Thickness (in)	D (in) ③	Number of Laminates	Total Elastomer Thickness, h_{rt} (in) ③	Maximum Movement Δ_s (in) ④
1/2"	1 1/4	1	1	1/2
	1 7/8	2	1 1/2	3/4
	2 1/2	3 ⑤	2	1
	3 1/8	4	2 1/2	1 1/4
	3 3/4	5	3	1 1/2
	4 3/8	6 ⑤	3 1/2	1 3/4
	5	7	4	2
	5 5/8	8	4 1/2	2 1/4
3/4"	1 1/2	1	1 1/4	7/8
	2 3/8	2	2	1
	3 1/4	3	2 3/4	1 3/8
	4 1/8	4	3 1/2	1 3/4
	5	5	4 1/4	2 1/8
	5 7/8	6	5	2 1/2

Curved Plate Bearing Assemblies: BDM Table 14.7.3

Additional checks for bearing pads designed per Table 14.7.3:

- Determine longitudinal movements of the bearing pad from its undeformed state to the point of maximum deformation due to a change in temperature of 75°F - note that these movements vary from AASHTO guidance:
  - Δ_u: Movement at the strength limit state (use a 1.0 load factor)
  - Δ_s: Movement at the service limit state (use a 1.3 load factor)
- Verify minimum compressive load requirement: $P_{min} \geq 5 \cdot G \cdot A_{pad} \cdot \Delta_u / h_{rt}$, where P_{min} is the minimum factored compressive load ($0.9 \cdot DC + 1.75 \cdot LL_{min}$)

Curved Plate Bearing Assemblies: Alternative Designs

If the calculated loads or movements fall outside the limits provided in the table, there are two alternative options:

1. Complete a special elastomeric bearing design (and modify the corresponding B-Detail)
2. Use a disc bearing

DEPARTMENT OF TRANSPORTATION

Disc Bearing Details

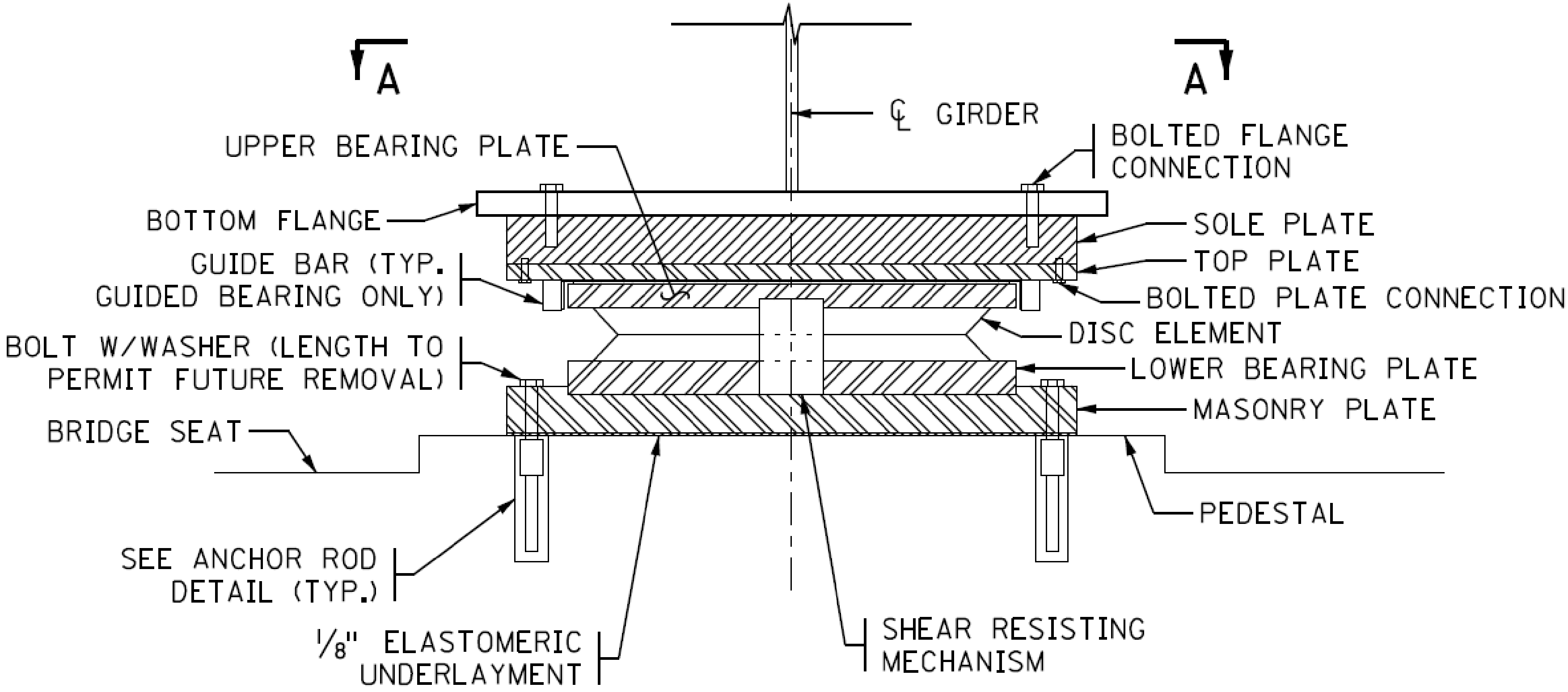
Disc Bearings: The New Alternative

- If curved plate bearing assemblies are inadequate for the design loads, rotations or deflections:
  - Historically, pot bearings were used (no longer allowed)
  - Now, design using disc bearings instead (more economical than pot bearings)
- Reference standards for disc bearings are in development
  - If a design requires disc bearings, contact the MnDOT Bridge Office for the latest standards
  - Refer to BDM 14.3.4 for general guidance

Disc Bearings: General

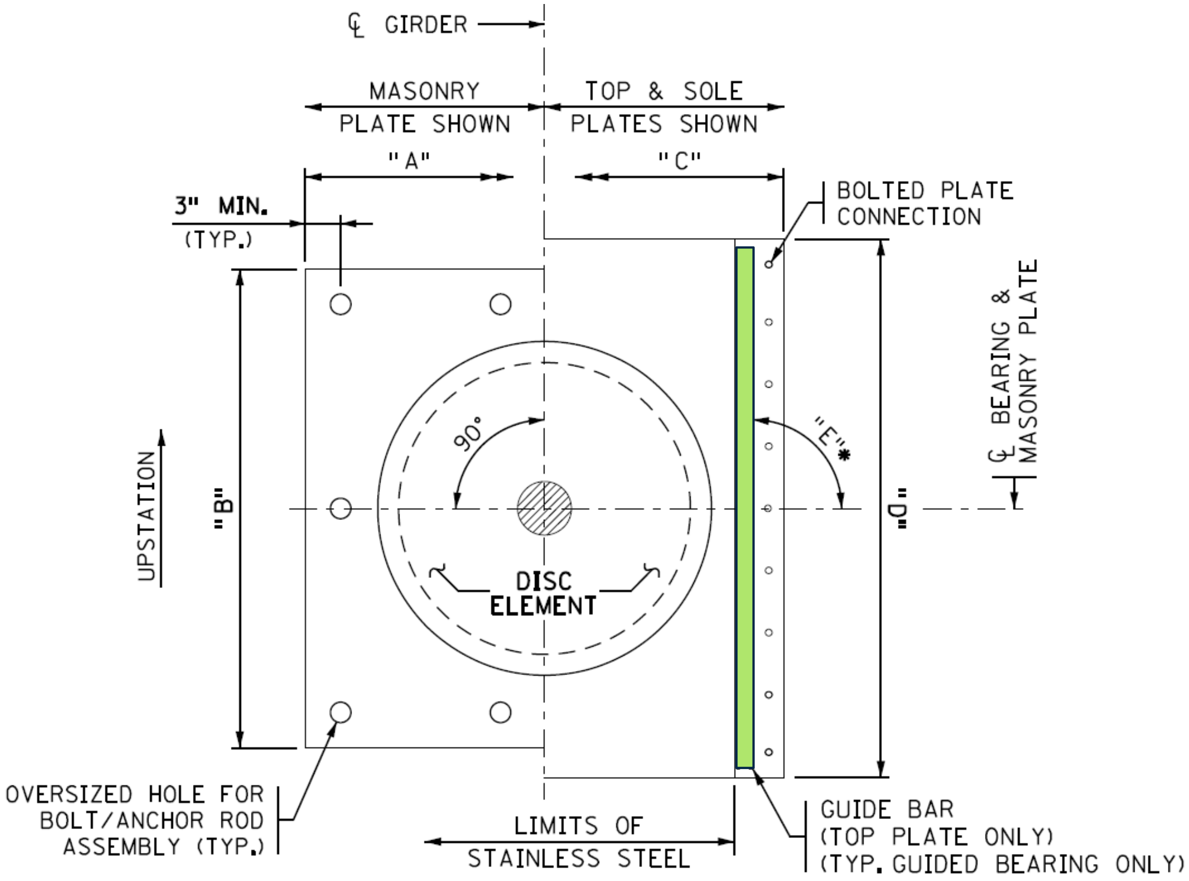
- Disc bearings can be designed to withstand large deflections and loading
- May be detailed for all types of superstructures
- Design options for disc bearings:
  - Expansion (free to translate in all horizontal directions)
  - Guided (free to translate along a horizontal axis)
  - Fixed (no lateral translation allowed)

Disc Bearings: Components



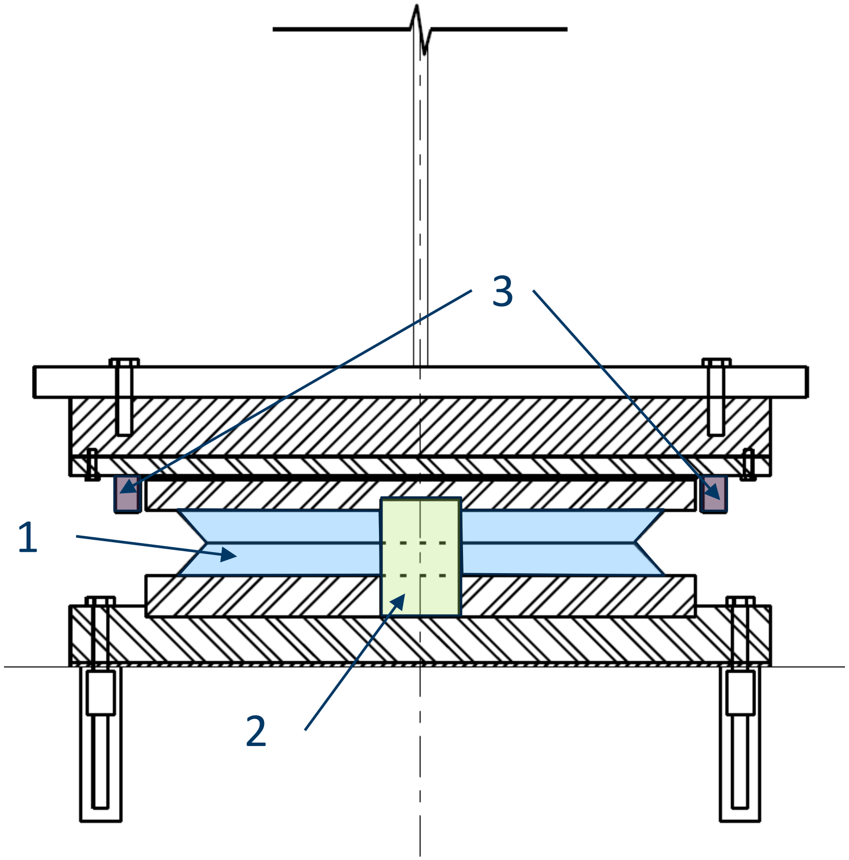
ELEVATION - GUIDED OR NON-GUIDED BEARING

Disc Bearings: Components



SECTION A-A (PLAN) - GUIDED OR NON-GUIDED BEARING

Disc Bearings: Load Transfer



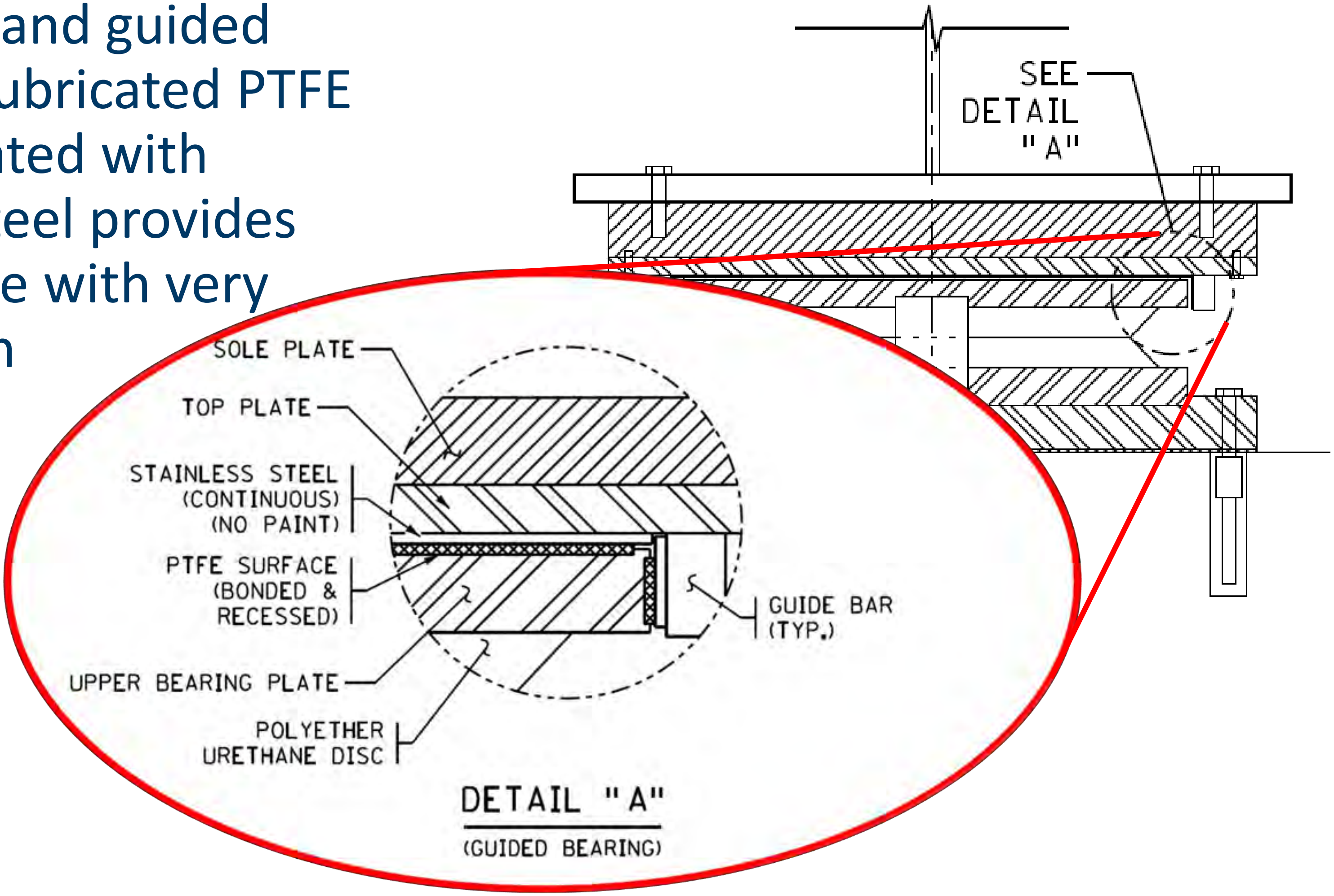
1. Polyether urethane disc element: supports vertical loads and enables rotations

2. Shear resisting mechanism: transfers lateral shear loads (isolates shear loads away from the disc element)

3. Guide Bars: restrict lateral movement to one horizontal axis (guided bearings only)

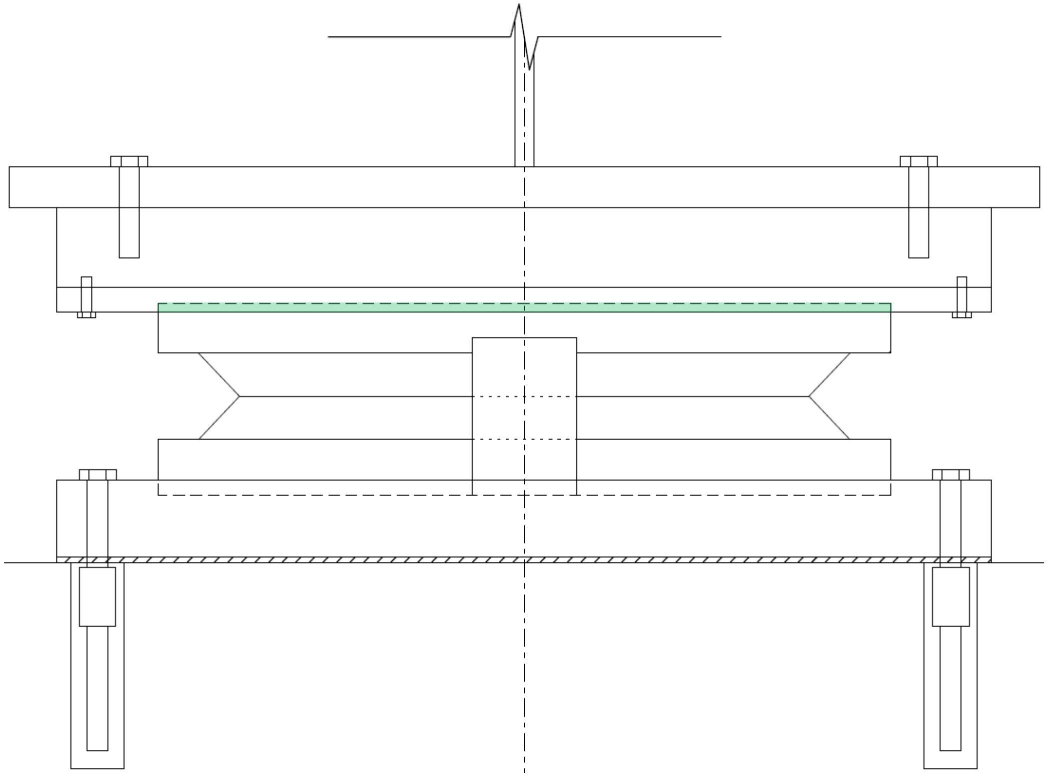
Disc Bearings: Expansion and Guided Details

Expansion and guided bearings: lubricated PTFE surface mated with stainless steel provides an interface with very low friction



Disc Bearings: Fixed Detail

- Disc bearings are typically fixed by recessing the upper bearing plate into the top plate surface
- Important to verify no bearing uplift in design



Disc Bearings: Design Procedure

- All components of disc bearings are designed by the supplier (including anchor rods) – more details on these requirements may be found in AASHTO 14.7.8
- Will not know the height of the bearing assembly during design
  - Visit producer website to determine an estimated height
  - Pedestal elevations will need to be updated once the bearings have been designed (revised sheets)
- Need to provide a disc bearing data table in the plan set that the supplier will use for their bearing design

Disc Bearings: General Design Considerations

Pertinent information to include in disc bearing data table (not an exhaustive list):

- Bearing type - fixed, expansion or guided (include orientation of guide bars)
- Vertical loads
- Horizontal loads – based on the larger of:
  - Analyzed horizontal loads
  - 15% of the service vertical load demand (AASHTO 14.7.9.2)
- Design longitudinal movements
- Maximum and minimum permissible dimensions of components
  - Minimum masonry plate dimensions must pass concrete bearing checks
  - For steel girders, consider using a 12” girder overhang from centerline of bearing, to ensure the sole plate does not extend beyond girder end

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Questions?

Braden Cyr