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Memo

Date: 12/20/2018

To: Bridge Design Engineers

From: Arielle Ehrlich
State Bridge Design Engineer

RE: Memo to Designers #2018-01: New 30MH, 35MH, and 40MH Prestressed Concrete Beams

Recently, MnDOT began investigating prestressed beam shapes that could be used more effectively in span ranges of 75 to 115 ft. The MH series shape that has been developed incorporates elements of several prestressed concrete beams currently in use around the country. Three beam depths have been chosen, which are designated as 30MH, 35MH, and 40MH. Based on discussions with fabricators related to obtaining forms, we have agreed to start specifying the 30MH and 35MH beams for lettings July 1, 2019 and later. The 40MH beams may be used for lettings November 1, 2019 and later.

Attached are Figures 5.4.6.1 and 5.4.6.2 that will be updated in the LRFD Bridge Design Manual (BDM) showing beam section properties and the preliminary beam selection chart for the RB, M, MH, and MN series. The 27M and the 36M beams will still be available and should continue to be used where appropriate.

Below is a listing of the Standard Plans and B-Details that were developed or modified for the new shape:

- 5-397.501 30MH Prestressed Concrete Beam
- 5-397.502 35MH Prestressed Concrete Beam
- 5-397.503 40MH Prestressed Concrete Beam
- B303 Sole Plate
- B307 Bearing Pad Restraint
- B309 Tapered Bearing Plate Assembly
- B310 Curved Plate Bearing Assembly - Fixed
- B311 Curved Plate Bearing Assembly - Expansion
- B403 Steel Intermediate Bolted Diaphragm
- B814 Concrete End Diaphragm – Parapet Abutment

These standards are currently approved and available for use.

Several criteria currently listed in the BDM for prestressed girders have been changed due to the development of the MH series and are discussed below.

Intermediate Diaphragms

Intermediate diaphragms are not required for 30MH and 35MH beams. The 40MH will follow BDM Article 5.4.1 guidelines for intermediate diaphragm spacing.

Beam End Dimensions

For MH prestressed beams, follow the guidance given in BDM Article 5.4.1 for RB, M, and MN shapes.

Camber Prediction

For MH prestressed beams, follow the guidance given in BDM Article 5.4.5 for RB, M, and MN shapes and the use of camber multipliers.

Overhang Criteria

Overhang criteria remains the same as is shown in Figure 9.2.1 of the BDM.

Bearings

The majority of guidance given in BDM Section 14 regarding bearings applies when using MH series prestressed beams. However, the minimum elastomeric pad size for MH beams is 12 inches (length A) by 30 inches (width B). In addition, BDM Tables 14.7.1, 14.7.2, and 14.7.3 have been revised to include standard B310 and B311 bearing dimensions for the MH and MW series beams. The revised tables are included as attachments to this memo.

Material Properties

Concrete, prestressing strand, and mild reinforcement properties remain as specified in the BDM. The attached charts for span length and beam spacing assume a concrete release strength (f'_{ci}) of 7.5 ksi and a final concrete strength (f'_c) of 9 ksi. With approval of the State Bridge Design Engineer, final concrete strengths of 10 ksi may be permitted for the MH series beams.

For questions about this policy, please contact Dave Dahlberg (dave.dahlberg@state.mn.us or (651) 366-4491) or Arielle Ehrlich (arielle.ehrlich@state.mn.us or (651) 366-4506).

cc: K. Western
D. Dahlberg
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Attachments: 5-29.1, 5-29.2, 14-15, 14-16 of the LRFD Bridge Design Manual

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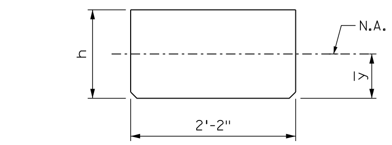
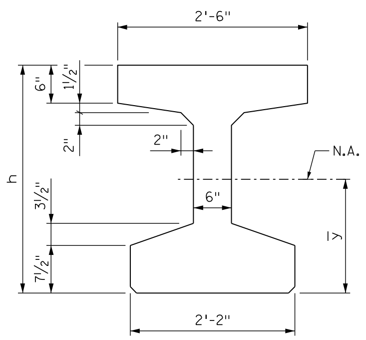
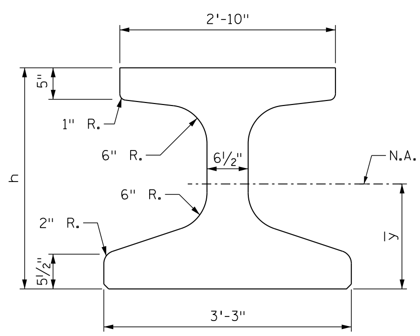


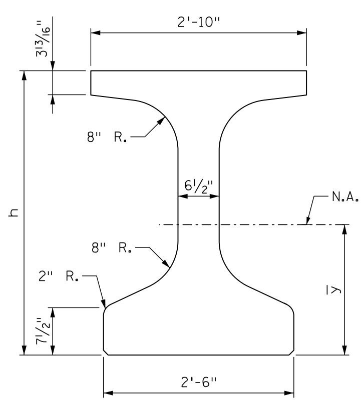
RECTANGULAR BEAM



"M" SERIES I-BEAM



"MH" SERIES I-BEAM



"MN" SERIES I-BEAM

DESIGN ASSUMPTIONS FOR PRESTRESSED CONCRETE BEAM CHART:

2017 AASHTO LRFD Bridge Design Specifications, 8th Edition.

HL-93 Live Load

Beam Concrete: f'_c = 9.0 ksi f'_{ci} = 7.5 ksi w_{bm} = 0.155 kips/ft^3

$E_c = 1265\sqrt{f'_c} + 1000$ ksi

Deck Concrete: f'_c = 4.0 ksi E_c = 3987 ksi
w_c = 0.145 kcf for E_c computation
w_c = 0.150 kcf for dead load computation

0.6" diameter low relaxation strands, $E_S = 28{,}500$ ksi
$f_{pu} = 270$ ksi with initial pull of $0.75\ f_{pu}$

Simple supports with six beams and deck without wearing course.
Deck carries two Type S Barriers with no sidewalk or median.
Skew = 0 degrees.

Effective deck thickness is total deck thickness minus $^1/_2$" of wear.

$1^1/_2$" stool height used for composite beam section properties.
$2^1/_2$" average stool height used for dead load calculations.

Rail dead load applied equally to all beams.
Dead load includes 0.020 ksf future wearing course.

Approximate long term losses are used per LRFD 5.9.5.3.

Service Concrete Tensile Stress Limits:
After Initial Losses: $0.094\sqrt{f'_{ci}} \leq 0.2$ ksi
After All Losses: $0.19\sqrt{f'_c}$

Beam Properties

BEAM	h (in)	AREA (in^2)	W ① (lb/ft)	$\bar{y}$ (in)	I (in^4)	S_B (in^3)	A_c ② (in^2)
14RB	14	364	392	7.00	5,945	849	312
18RB	18	468	504	9.00	12,640	1,404	364
22RB	22	572	616	11.00	23,070	2,097	416
27M	27	516	555	13.59	43,080	3,170	296
30MH	30	639	688	13.66	70,416	5,155	403
35MH	35	672	723	15.85	105,570	6,661	419
36M	36	570	614	17.96	93,530	5,208	323
40MH	40	704	758	18.07	149,002	8,246	435
MN45	45	690	743	20.58	178,780	8,687	427
MN54	54	749	806	24.63	285,230	11,580	457
MN63	63	807	869	28.74	421,750	14,670	486

① Based on 155 pounds per cubic foot.

② Based on a 9" slab with $^1/_2$" of wear and $1^1/_2$" stool. See LRFD 5.8.3.4.2 for A_c definition.

Figure 5.4.6.1
Precast Prestressed Concrete Beam Data (RB, M, MH, MN)

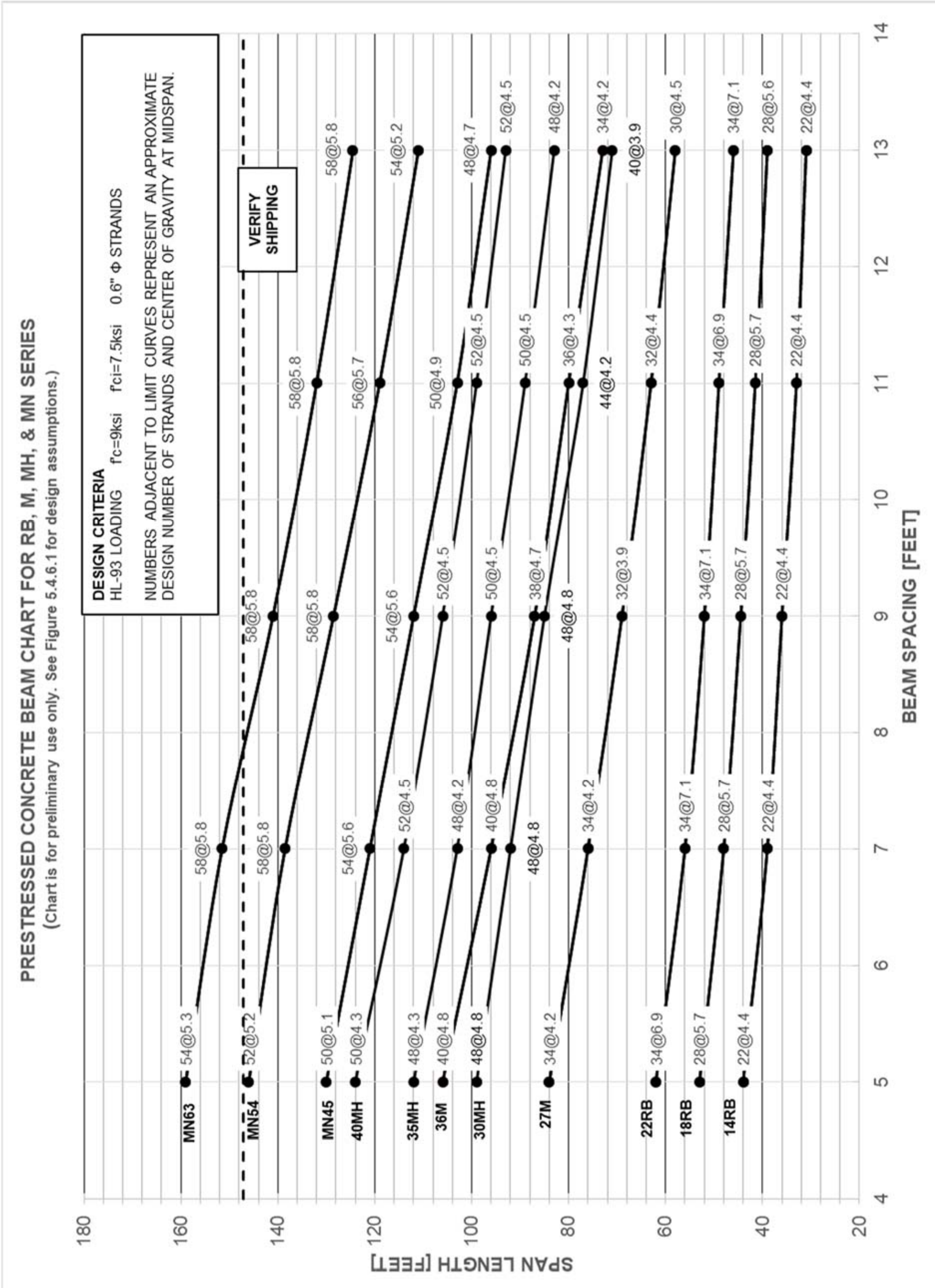

PRESTRESSED CONCRETE BEAM CHART FOR RB, M, MH, & MN SERIES
(Chart is for preliminary use only. See Figure 5.4.6.1 for design assumptions.)
DESIGN CRITERIA
HL-93 LOADING f'c=9ksi f'ci=7.5ksi 0.6" Φ STRANDS
NUMBERS ADJACENT TO LIMIT CURVES REPRESENT AN APPROXIMATE DESIGN NUMBER OF STRANDS AND CENTER OF GRAVITY AT MIDSPAN.
VERIFY SHIPPING
SPAN LENGTH [FEET]
BEAM SPACING [FEET]
MN63
MN54
MN45
40MH
35MH
36M
30MH
27M
22RB
18RB
14RB
54@5.3
58@5.8
58@5.8
58@5.8
58@5.8
52@5.2
58@5.8
58@5.8
58@5.8
58@5.8
50@5.1
56@5.7
54@5.2
50@4.3
54@5.6
54@5.6
48@4.3
52@4.5
52@4.5
50@4.9
40@4.8
48@4.2
48@4.7
48@4.8
40@4.8
50@4.5
52@4.5
52@4.5
48@4.8
38@4.7
50@4.5
48@4.2
34@4.2
48@4.8
36@4.3
34@4.2
44@4.2
40@3.9
34@4.2
32@3.9
32@4.4
30@4.5
34@6.9
34@7.1
34@7.1
34@6.9
34@7.1
28@5.7
28@5.7
28@5.7
28@5.7
28@5.6
22@4.4
22@4.4
22@4.4
22@4.4
22@4.4

Figure 5.4.6.2

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	$\frac{1}{2}$	8.0	14	①	$1\frac{1}{2}$	$4\frac{1}{2}$	26	$1\frac{1}{4}$	16
	295	14	↓	↓	8.8	16	↓	↓	6	↓	↓	↓
	337	16	↓	↓	9.6	18	↓	2	↓	↓	↓	↓
	380	18	↓	$\frac{3}{4}$	6.9	20	↓	↓	8	↓	↓	↓
	422	20	↓	↓	7.3	22	↓	$2\frac{1}{4}$	↓	↓	↓	20
MH	316	12	30	$\frac{1}{2}$	8.6	14	47	$1\frac{1}{2}$	$4\frac{1}{2}$	32	$1\frac{1}{4}$	16
	369	14	↓	↓	9.6	16	↓	↓	6	↓	↓	↓
MW	270	16	36	$\frac{1}{2}$	11.1	18	47	$1\frac{1}{2}$	$4\frac{1}{2}$	38	$1\frac{1}{4}$	16
	350	↓	↓	↓	↓	↓	↓	↓	6	↓	↓	↓
	506	↓	↓	↓	↓	↓	↓	↓	8	↓	↓	↓
	570	18	↓	↓	12.0	20	↓	2	8	↓	↓	↓

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

② Plates are conservatively designed for $1.75 \cdot (\text{Max Service DL} + \text{LL})$.

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	$\frac{1}{2}$	7	8.0	14	27	$1\frac{1}{2}$	$4\frac{1}{2}$	26	$1\frac{1}{4}$	16
	360	12	↓	↓	7	8.0	14	↓	$1\frac{3}{4}$	↓	↓	↓	↓
	420	14	↓	↓	8	8.8	16	↓	↓	6	↓	↓	19
MH	395	12	30	$\frac{1}{2}$	7	8.6	14	33	$1\frac{1}{2}$	$4\frac{1}{2}$	32	$1\frac{1}{4}$	16
MW	270	16	36	$\frac{3}{4}$	6	7.4	18	39	$1\frac{1}{2}$	$4\frac{1}{2}$	38	$1\frac{1}{4}$	16
	350	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	480	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	630	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

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

② Plates are conservatively designed for $1.75 \cdot (\text{Max Service DL} + \text{LL})$.

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

① Table is based on requirements of *AASHTO LRFD Bridge Design Specs*. Art. 14.7.6.3.4:
$h_{rt} > 2\Delta_3$.
Engineer must also check that the minimum compressive load requirement (discussed in Article 14.3.3.3.1) is satisfied. Specifically:

$$P_{min} \geq 5 \cdot G \cdot A_{pad} \cdot \frac{\Delta_u}{h_{rt}}$$

where P_{min} is the minimum factored load ($0.9 \cdot DC + 1.75 \cdot LLmin$), G is equal to the maximum shear modulus value (0.200 ksi), A_{pad} is the plan area of the bearing pad, and Δ_u is the movement of the bearing pad from the undeformed state using a 75°F temperature.

② Engineer must also check the elastomeric bearing pad for compression deflection based on the requirements from *AASHTO LRFD Bridge Design Specifications* Articles 14.7.6.3.3 and 14.7.5.3.6.

③ Pad thickness D includes h_{rt} and 1/8" steel reinforcement plates. Total elastomer thickness h_{rt} includes interior laminates plus 1/4" cover layers.

④ Maximum movement Δ_s is the movement of the bearing pad from the undeformed state to the point of maximum deformation. Use a 75°F temperature change with a 1.3 load factor for calculation of maximum movement.

⑤ For "RB", "M", and "MN" series prestressed beam expansion elastomeric bearings, the number of laminates has been standardized for the movements that are most often encountered.

- If $\Delta_s \leq 1.00$", use 3 – ½" laminates.
- If 1.00" < $\Delta_s \leq 1.75$", use 6 – ½" laminates.