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Memo

TO: Bridge Design Engineers

FROM: Kevin Western
State Bridge Design Engineer

DATE: July 29, 2011

MEMO TO DESIGNERS (2011-01): New 82MW and 96MW Prestressed Concrete Beams Archiving 45M through 81M PCB Standards

Recently, MnDOT began investigating prestressed beam shapes that could be used effectively in span ranges of 150 to 200 ft. The shape that has been developed incorporates elements of several deep prestressed concrete beams currently in use around the country. The two beams that have been finalized at this time are the 82MW and the 96MW.

Attached are Figures 5.4.6.3 and 5.4.6.4 that will be added to the LRFD Manual showing beam section properties and the preliminary beam selection chart for the 82MW and 96MW. Additionally, Figures 5.4.6.1 and 5.4.6.2 are included here to reflect the archiving of the standards of the 45M through 81M beams. These standards were archived because the shapes are not as efficient as similar depth MN and MW shapes. The MN sections allow for longer spans, or fewer beam lines than the equal depth M shapes. The 27M and the 36M will still be available, as there is no corresponding MN shape at those depths.

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

5-397.531	82MW Prestressed Concrete Beam
5-397.532	96MW Prestressed Concrete Beam
B303	Sole Plate
B310	Curved Plate Bearing Assembly - Fixed
B311	Curved Plate Bearing Assembly - Expansion
B412	Steel Intermediate Bolted Diaphragm (All MW Prestressed Concrete Beams)
B814	Concrete End Diaphragm – Parapet Abutment

These standards will be approved and available in the next few weeks.

Several criteria currently listed in the LRFD Manual for prestressed girders have been changed due to the development of the MW series.

Intermediate Diaphragms

Intermediate diaphragms are not required for 14RB, 18RB, 22RB, and 27M beams. For all other beam sizes, the following applies. Intermediate diaphragms are not required for single spans of 45'-0" or less. For spans greater than 45'-0", provide one intermediate diaphragm for every 45 feet of span length. The intermediate diaphragms should be spaced evenly in the span. For spans over traffic, place additional diaphragms in the fascia bay approached by traffic to provide bracing against impact from over-height traffic loads. For two-lane roadways, place one diaphragm approximately over each shoulder. For additional lanes, space additional diaphragms at intervals of about 25'-0" over the roadway.

Beam End Dimensions

At piers, provide 4 inches of clearance between the ends of MW beams. If an expansion joint is provided at a pier, additional width will be required. Guidance for all other types of prestressed beams remains as is shown in the LRFD Manual in Article 5.4.1.

Locate the centerline of bearing 8½ inches from the end of the beam for MW beams. This dimension can be adjusted if used with higher movement bearings, as opposed to the typical curved plate bearings shown in Section 14 of the LRFD Manual. However, if the 8½ inch dimension is exceeded, a special design for the bearing, sole plate, and beam end region must be completed.

Beam Length on Slopes

Although there is no change to policy regarding beam lengths on sloped bridges, it is important to reiterate the existing language. The length of the MW beams makes the effect of a sloped profile more pronounced. For bridges on significant grades ($\geq$ 3%) the sloped length of the beam will be significantly longer than the horizontal length between substructure units. If the sloped length is ½ inch or more than the horizontal length, identify the sloped length dimension on the beam detail plan sheets.

Top Flange Surface Treatment

The outside 6 inches on each side of the top flange of the MW shapes will be treated with a bond breaker to facilitate future removal of the deck with minimal damage to the beam flange. See standard sheet for locations of surface treatments.

Camber Prediction

Given the lack of historical data for camber behaviors of the MW shapes, camber tracking will be needed to ensure constructability of the deck. A refined analysis should be completed using an appropriate creep model. Estimated camber values should be given in tabular form, varying with the age of the girder.

Deck Pour Sequence

Because of the height of the MW shapes, a deck pour sequence should be investigated to limit the rotation of the end of the beams and its effect on the deck.

Overhang Criteria

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

Shipping

Very large beams, such as the 82MW and the 96MW, are more susceptible to damage during shipping than smaller beams due to lateral instability. Handling and shipping of MW beams must be analyzed prior to fabrication. This analysis is to be performed by the girder supplier. Special provisions detailing shipping requirements will be available in the near future.

Material Properties

Concrete, prestressing strand, and mild reinforcement properties remain as specified in the LRFD Manual. 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 MW series beams.

In the future, we will be continuing the development of the series to accommodate post-tensioning ducts. These beams, type MWPT, will be 82", 96" or 110" height beams that have 8 inch webs. The MWPT sections will use the same forms as the MW shapes, but they will be 1½" wider. The standards will be released in the future as needed.

For questions about this policy, please contact Arielle Ehrlich at arielle.ehrlich@state.mn.us or (651) 366-4515.

cc: N. Daubenberger
A. Ehrlich
D. Dahlberg
P. Rowekamp
C. Harer/Design Consultants

Attachments: 5-28, 5-29.1, 5-29.2, 5-29.3 of LRFD Bridge Design Manual

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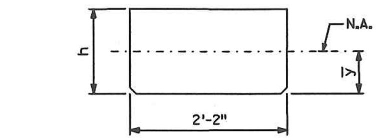
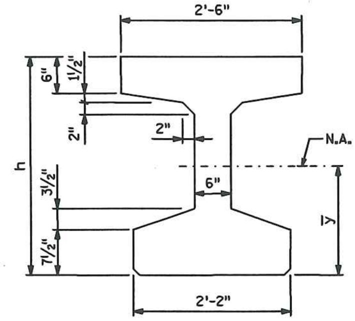
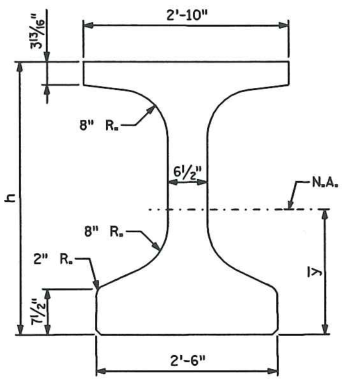


RECTANGULAR BEAM



"M" SERIES I-BEAM



"MN" SERIES I-BEAM

DESIGN ASSUMPTIONS FOR PRESTRESSED CONCRETE BEAM CHART:

2010 AASHTO LRFD Bridge Design Specifications, 5th 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 $E_c = 3644$ ksi $w_c = 0.150$ kips/ft^3

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 F-Rails 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: $0.094\sqrt{f'_{ci}} \le 0.2$ ksi

After All Losses: $0.19\sqrt{f'_c}$

Beam Properties

BEAM	h (in)	SHAPE	AREA (in^2)	W ① (lb/ft)	$\bar{y}$ (in)	I (in^4)	S_B (in^3)	A_c ② (in^2)
14RB	14	Rect.	364	392	7.00	5,945	849	312
18RB	18	Rect.	468	504	9.00	12,640	1,404	364
22RB	22	Rect.	572	616	11.00	23,070	2,097	416
27M	27	I-Beam	516	555	13.59	43,080	3,170	296
36M	36	I-Beam	570	614	17.96	93,530	5,208	323
MN45	45	I-Beam	690	743	20.63	179,000	8,677	427
MN54	54	I-Beam	749	806	24.68	285,690	11,580	457
MN63	63	I-Beam	807	869	28.80	422,570	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, MN)

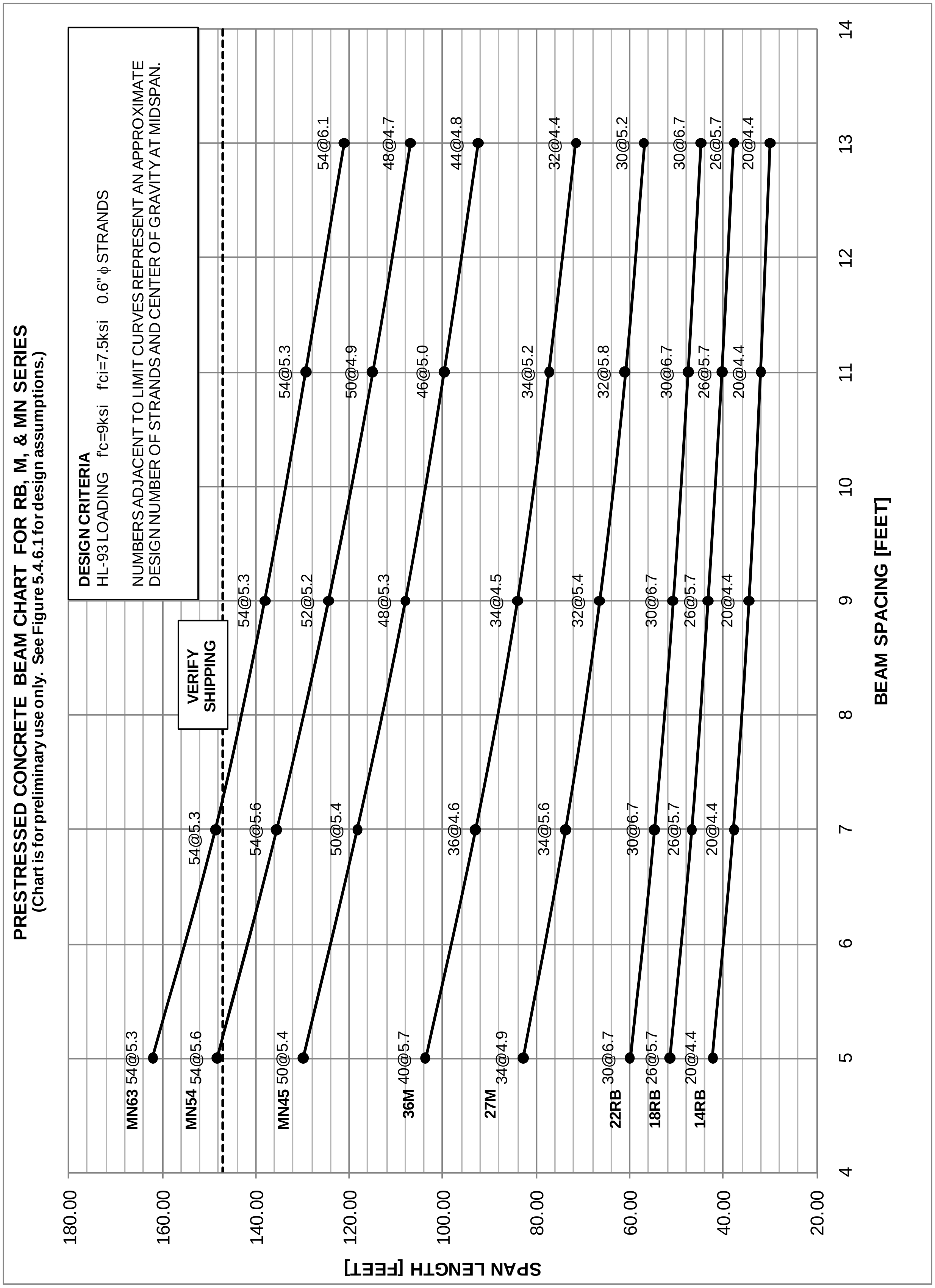
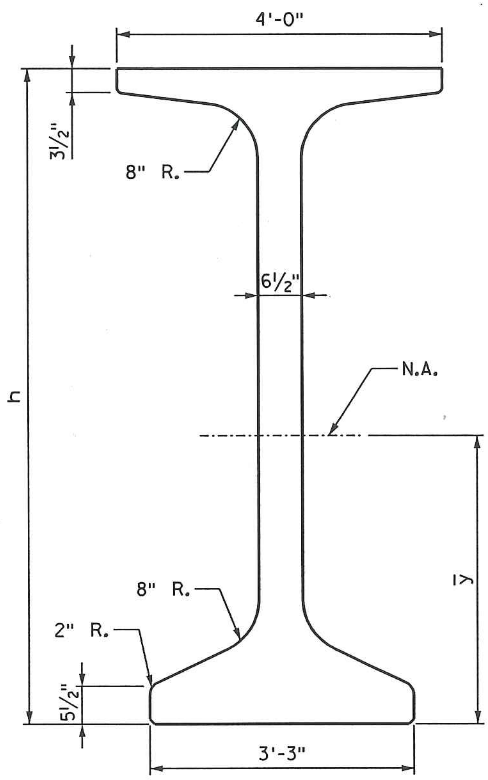

PRESTRESSED CONCRETE BEAM CHART FOR RB, M, & MN SERIES
(Chart is for preliminary use only. See Figure 5.4.6.1 for design assumptions.)
DESIGN CRITERIA
HL-93 LOADING f'c=9ksi f'ci=7.5ksi 0.6" ϕ STRANDS
NUMBERS ADJACENT TO LIMIT CURVES REPRESENT AN APPROXIMATE DESIGN NUMBER OF STRANDS AND CENTER OF GRAVITY AT MIDSPAN.
VERIFY SHIPPING
MN63
MN54
MN45
36M
27M
22RB
18RB
14RB
SPAN LENGTH [FEET]
BEAM SPACING [FEET]
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
4
5
6
7
8
9
10
11
12
13
14

Figure 5.4.6.2



"MW" SERIES I-BEAM

DESIGN ASSUMPTIONS FOR PRESTRESSED CONCRETE BEAM CHART:

2010 AASHTO LRFD Bridge Design Specifications, 5th 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 $E_c = 3644$ ksi $w_c = 0.150$ kips/ft^3

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 F-Rails 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)	SHAPE	AREA (in^2)	W ① (lb/ft)	$\bar{y}$ (in)	I (in^4)	S_B (in^3)	A_c ② (in^2)
82MW	82	I-Beam	1062	1143	38.37	1,010,870	26,345	609
96MW	96	I-Beam	1153	1241	45.02	1,486,510	33,019	655

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 5.4.6.3
Precast Prestressed Concrete Beam Data for MW Series

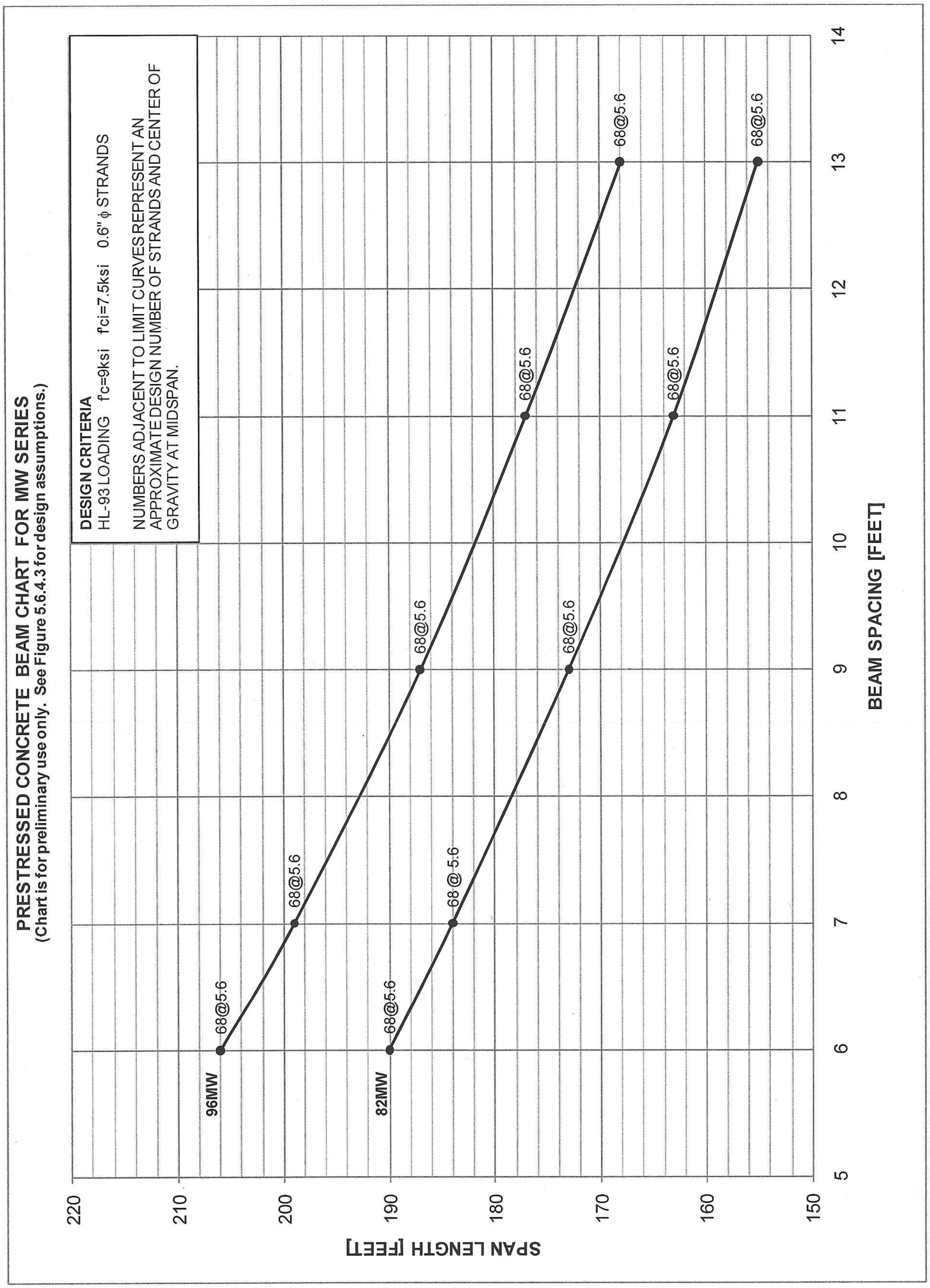

PRESTRESSED CONCRETE BEAM CHART FOR MW SERIES
(Chart is for preliminary use only. See Figure 5.6.4.3 for design assumptions.)
DESIGN CRITERIA
HL-93 LOADING f'c=9ksi f'ci=7.5ksi 0.6" ϕ STRANDS
NUMBERS ADJACENT TO LIMIT CURVES REPRESENT AN APPROXIMATE DESIGN NUMBER OF STRANDS AND CENTER OF GRAVITY AT MIDSPAN.
96MW
82MW
68@5.6
68 @ 5.6
SPAN LENGTH [FEET]
BEAM SPACING [FEET]
220
210
200
190
180
170
160
150
5
6
7
8
9
10
11
12
13
14

Figure 5.4.6.4