STATE OF LOUISIANA

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

STRINGER LOAD RATING
AISC Cb MODIFICATION

SAMPLE

RECALL NO. 052640
Approach Truss Span D
(Three Span Continuous)

Inventory Rating for Interior Girder (G2)

SPREADSHEET DEVELOPED by

Dr. SHAWN SUN, P.E.

BACKGROUND

Some of Louisiana's bridges built in the 1950s and 1960s used two-girder or truss systems, in which floorbeams are carried by main members and continuous (spliced) stringers are supported by the floorbeams. The main members are either two edge (fascia) girders or trusses. Stringer bottom flanges are in compression at the negative moment region, which could result in lateral torsional buckling. When the continuous stringers are load-rated using AASHTOWare Bridge Rating™ analysis software, C_b is calculated in accordance with the AASHTO LRFD Bridge Design Specifications, which does not account for the bracing effect of noncomposite deck properly and therefore underestimates the flexural strength. This spreadsheet is provided to load rate the continuous stringers using recommended C_b from 18-4ST Project.

ASSUMPTIONS

1. Continuous stringers are rated using the AASHTO Load and Resistance Factor Rating (LRFR) method.
2. Figs. 1 to 3 in "Load Rating" spreadsheet correspond to rating per HL-93 (Inventory) at Strength I limit state. The spreadsheet can also be used to rate other vehicles as long as the live load factors are revised accordingly.
3. BrR follows the AASHTO LRFD Art. A 6.3.3 to calculate the stringer flexural resistance. BrR output is available to be used as input for the spreadsheet.
4. The stringer flexural resistance is controlled by its lateral torsional buckling resistance.
5. Stringers use rolled I-shaped members that have compact sections. The bridge satisfies the AASHTO LRFD Art. A6.1 provisions.
6. If one section is subject to both positive and negative moments, i.e., the moment envelope approach is used, input the negative moment in the spreadsheet.
7. The spreadsheet is applicable to continuous stringers with continuously braced top flanges only.
8. Recommended Cb is calculated using the AISC Specification for Structural Steel Buildings (2016) Eq. C-F1-5:

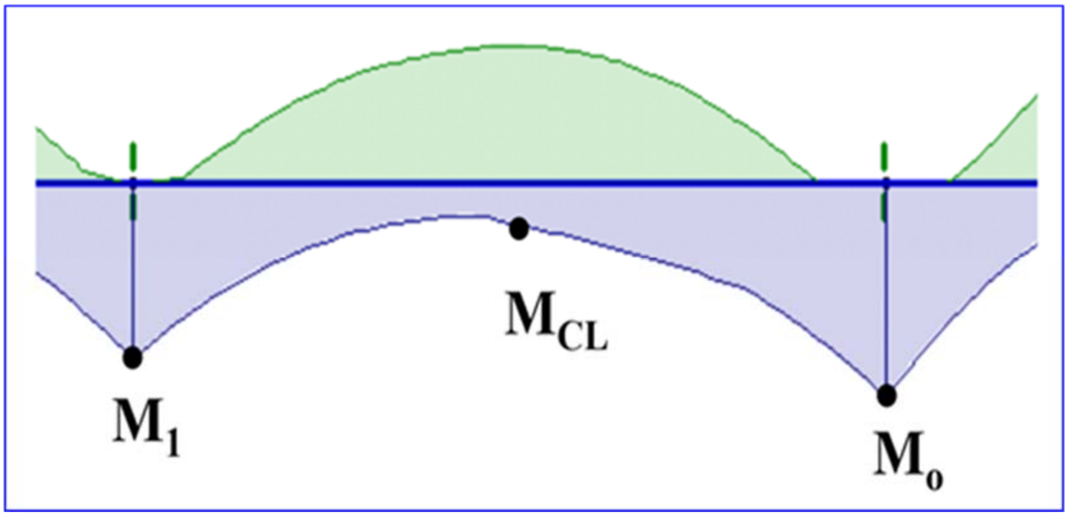
$$C_b = 3.0 - \frac{2}{3}\left(\frac{M_1}{M_o}\right) - \frac{8}{3}\left[\frac{M_{CL}}{\left(M_o + M_1\right)^*}\right]$$

where,

M0 = moment at the end of the unbraced length that gives the largest compressive stress in the bottom flange;
M1 = moment at other end of the unbraced length;
MCL= moment at the middle of the unbraced length; and

(M0 + M1)* = M0, if M1 is positive, causing tension on the bottom flange.
Note that M0 and M1 above are defined differently from the AASHTO LRFD Art. A 6.3.3.

Moment sign convention: Negative moment results in a compressive stress in the stringer bottom flange. M1, MCL, and M0 are all negative in the figure below.



As a check, assume a uniform negative moment field, i.e., let M1 = MCL = M0 = -1, then Cb = 1.0 as expected.

9. The BrR calculated flexural resistance of the stringer is increased proportionally based on the ratio between the recommended and existing moment gradient factors and shall not exceed the plastic moment.
10. LRFR rating equation is provided as follows:

$$RF = \frac{\phi_c \phi_s \phi R_n - M_{u\_DL}}{(\gamma_L) M_{LL}}$$

See spreadsheet for variable definitions. IM (dynamic load allowance) is included in the live load moment, MLL.

11. The tab named "Load Rating" can be copied multiple times as needed to account for more cases.
12. The relevant equations on the stringer flexural resistance in the AASHTO LRFD Art.

A6.3.3 is provided for information only.

A6.3.3—Lateral Torsional Buckling Resistance

For unbraced lengths in which the member is prismatic, the flexural resistance based on lateral torsional buckling shall be taken as:

- If $L_b \le L_p$, then:

$$M_{nc} = R_{pc} M_{yc} \quad \text{(A6.3.3-1)}$$

- If $L_p < L_b \le L_r$, then:

$$M_{nc} = C_b \left[1 - \left(1 - \frac{F_{yr} S_{xc}}{R_{pc} M_{yc}} \right) \left(\frac{L_b - L_p}{L_r - L_p} \right) \right] R_{pc} M_{yc} \le R_{pc} M_{yc} \quad \text{(A6.3.3-2)}$$

- If $L_b > L_r$, then:

$$M_{nc} = F_{cr} S_{xc} \le R_{pc} M_{yc} \quad \text{(A6.3.3-3)}$$

in which:

L_b = unbraced length (in.).
L_p = limiting unbraced length to achieve the nominal flexural resistance $R_{pc}M_{yc}$ under uniform bending (in.)

$$= 1.0 r_t \sqrt{\frac{E}{F_{yc}}} \quad \text{(A6.3.3-4)}$$

L_r = limiting unbraced length to achieve the nominal onset of yielding in either flange under uniform bending with consideration of compression-flange residual stress effects (in.)

$$= 1.95 r_t \frac{E}{F_{yr}} \sqrt{\frac{J}{S_{xc} h}} \sqrt{1 + \sqrt{1 + 6.76 \left(\frac{F_{yr}}{E} \frac{S_{xc} h}{J} \right)^2}} \quad \text{(A6.3.3-5)}$$

C_b = moment gradient modifier. In lieu of an alternative rational analysis, C_b may be calculated as follows:

- For unbraced cantilevers and for members where $M_{mid}/M_2 > 1$ or $M_2 = 0$

$$C_b = 1.0 \quad \text{(A6.3.3-6)}$$

- For all other cases,

$$C_b = 1.75 - 1.05 \left(\frac{M_1}{M_2} \right) + 0.3 \left(\frac{M_1}{M_2} \right)^2 \le 2.3 \quad \text{(A6.3.3-7)}$$

F_{cr} = elastic lateral torsional buckling stress (ksi)

$$= \frac{C_b \pi^2 E}{(L_b/r_t)^2} \sqrt{1 + 0.078 \frac{J}{S_{xc} h} (L_b/r_t)^2} \quad \text{(A6.3.3-8)}$$

J = St. Venant torsional constant (in.[4])

$$= \frac{D t_w^3}{3} + \frac{b_{fc} t_{fc}^3}{3} \left(1 - 0.63 \frac{t_{fc}}{b_{fc}} \right) + \frac{b_{ft} t_{ft}^3}{3} \left(1 - 0.63 \frac{t_{ft}}{b_{ft}} \right) \quad \text{(A6.3.3-9)}$$

r_t = effective radius of gyration for lateral torsional buckling (in.)

$$= \frac{b_{fc}}{\sqrt{12 \left(1 + \frac{1}{3} \frac{D_c t_w}{b_{fc} t_{fc}} \right)}} \quad \text{(A6.3.3-10)}$$

where:

F_{yr} = compression-flange stress at the onset of nominal yielding within the cross-section, including residual stress effects, but not including compression-flange lateral bending, taken as the smaller of $0.7F_{yc}$, $R_h F_{yt} S_{xt}/S_{xc}$ and F_{yw}, but not less than $0.5F_{yc}$
D_c = depth of the web in compression in the elastic range (in.). For composite sections, D_c shall be determined as specified in Article D6.3.1.
h = depth between the centerline of the flanges (in.)
M_{mid} = major-axis bending moment at the middle of the unbraced length, calculated from the moment envelope value that produces the largest compression at this point in the flange under consideration, or the smallest tension if this point is never in compression (kip-in.). M_{mid} shall be due to the factored loads and shall be taken as positive when it causes compression and negative when it causes tension in the flange under consideration.
M_0 = moment at the brace point opposite to the one corresponding to M_2, calculated from the moment envelope value that produces the largest compression at this point in the flange under consideration, or the smallest tension if this point is never in compression (kip-in.). M_0 shall be due to the factored loads and shall be taken as positive when it causes compression and negative when it causes tension in the flange under consideration.
M_1 = moment at the brace point opposite to the one corresponding to M_2, calculated as the intercept of the most critical assumed linear moment variation passing through M_2 and either M_{mid} or M_0, whichever produces the smaller value of C_b (kip-in.). M_1 may be calculated as follows:

- When the variation in the moment along the entire length between the brace points is concave in shape:

$$M_1 = M_0 \quad \text{(A6.3.3-11)}$$

- Otherwise:

$$M_1 = 2M_{mid} - M_2 \ge M_0 \quad \text{(A6.3.3-12)}$$

M_2 = except as noted below, largest major-axis bending moment at either end of the unbraced length causing compression in the flange under consideration, calculated from the critical moment envelope value (kip-in.). M_2 shall be due to the factored loads and shall be taken as positive. If the moment is zero or causes tension in the flange under consideration at both ends of the unbraced length, M_2 shall be taken as zero.
M_{yc} = yield moment with respect to the compression flange determined as specified in Article D6.2 (kip-in.)
M_{yt} = yield moment with respect to the tension flange determined as specified in Article D6.2 (kip-in.)
R_h = hybrid factor determined as specified in Article 6.10.1.10.1
R_{pc} = web plastification factor for the compression flange determined as specified in Article A6.2.1 or Article A6.2.2, as applicable
S_{xc} = elastic section modulus about the major axis of the section to the compression flange taken as M_{yc}/F_{yc} (in.[3])
S_{xt} = elastic section modulus about the major axis of the section to the tension flange taken as M_{yt}/F_{yt} (in.[3])

13. The AASHTO LRFD Art. A6.1 provisions are shown below for information only.

A6.1—GENERAL

These provisions shall apply only to sections in straight bridges whose supports are normal or skewed not more than 20 degrees from normal, and with intermediate diaphragms or cross-frames placed in contiguous lines parallel to the supports, that satisfy the following requirements:

- the specified minimum yield strengths of the flanges and web do not exceed 70.0 ksi,
- the web satisfies the noncompact slenderness limit:

$$\frac{2D_c}{t_w} < 5.7\sqrt{\frac{E}{F_{yc}}} \qquad \text{(A6.1-1)}$$

and:

- the flanges satisfy the following ratio:

$$\frac{I_{yc}}{I_{yt}} \geq 0.3 \qquad \text{(A6.1-2)}$$

where:

D_c = depth of the web in compression in the elastic range (in.). For composite sections, D_c shall be determined as specified in Article D6.3.1.

I_{yc} = moment of inertia of the compression flange of the steel section about the vertical axis in the plane of the web (in.^{4})

I_{yt} = moment of inertia of the tension flange of the steel section about the vertical axis in the plane of the web (in.^{4})

FYI

Stage 3: (Composite short term) - The computation for this stage are based on a standard modular ratio of n (not adjusted for creep). Temporary loads such as Live load are applied to Composite (short term) Stage 3.

Rating Results Summary Report

Name: STCANT Bridge ID: 052640- New NBI: 61174500900001N
Struct-Def: Stringers_Appr Truss Span D (3-span) Member: G2 Member alt: INT W24x76

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HL-93 (US)	Truck + Lane	LRFR	Inventory	4.75	0.132	28.67	1 - (80.4)	STRENGTH-I Steel Fl...	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + La...	LRFR	Inventory	5.61	0.156	28.53	1 - (80.0)	STRENGTH-I Steel Fl...	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	5.57	0.155	28.67	1 - (80.4)	STRENGTH-I Steel Fl...	As Requested	As Requested

Objective

Perform load rating of a continuous stringer using recommended C_b from 18-4ST Project

Note

Input highlighted in yellow

BrR Output

Left moment (factored moment due to all loads), M_{u_left}	-575.0	kip-ft	Fig. 1
Right moment (factored moment due to all loads), M_{u_right}	-575.0	kip-ft	
Mid moment (factored moment due to all loads), M_{u_mid}	-110.3	kip-ft	
Moment gradient factor per BrR, C_b	1.00		
Yield moment with respect to the compression flange, M_{yc}	586.8	kip-ft	Fig. 2
Web plastification factor for the compression flange, R_{pc}	1.213		
Nominal flexural resistance, M_{nc}	206.8	kip-ft	
Unfactored moment due to live loads that controls the load rating, M_{LL}	-242.0	kip-ft	Fig. 3

Recommended moment gradient factor

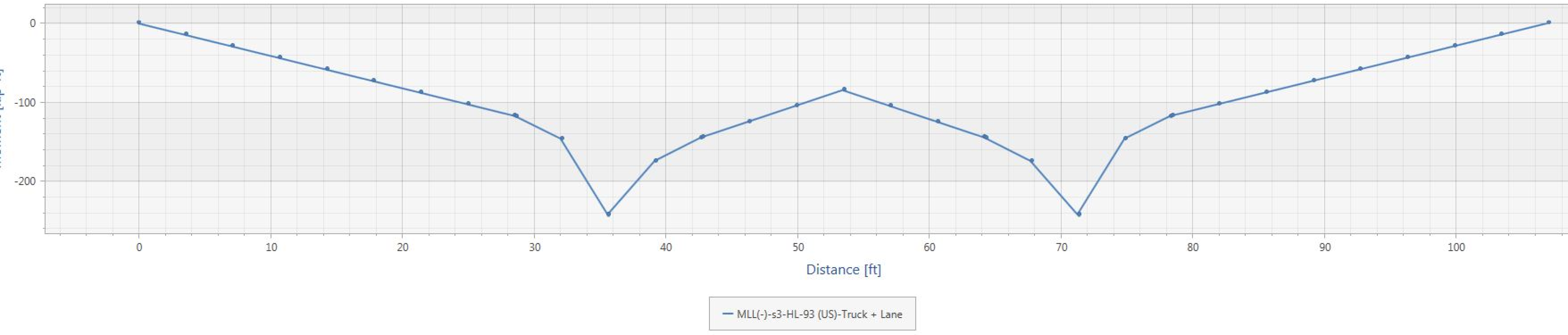
Factored moment due to all loads at the end of the unbraced length that gives the largest compressive stress in the stringer bottom flange, M_0	-575.0	kip-ft	Figs. 4 and 5
Factored moment due to all loads at the other end of the unbraced length, M_1	-575.0	kip-ft	
Factored moment due to all loads at the middle of the unbraced length, M_{CL}	-110.3	kip-ft	
$M_1 + M_0$ (= M_0, if M_1 is positive)	-1150.0	kip-ft	
Recommended moment gradient factor, C_{br}	**2.08**		

Revised Flexural Resistance

Revised flexural resistance, R_n	429.6	kip-ft

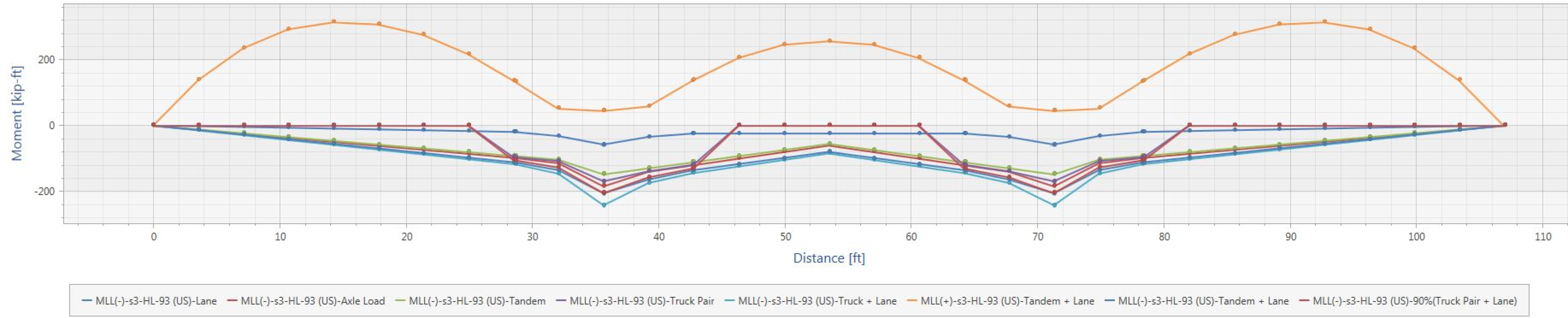
Revised Load Rating Factor

LRFD resistance factor, φ	1	
Condition factor, φc	1	
System factor, φs	1	
Lower limit of φcφs	0.85	
Live load factor, γ_L	1.75	
Factored moment due to all dead loads (DC+DW), M_{u_DL}	-151.4	kip-ft
Rating factor, RF	**0.66**	



- Moment
  - Dead Load
  - Live Load
    - Composite (short term) (Stage 3)
      - HL-93 (US)
        - Lane
        - Axle Load
        - Tandem
        - Truck Pair
        - Truck + Lane
          - Positive
          - ☑ Negative
        - Tandem + Lane
        - 90%(Truck Pair + Lane)
- Shear
  - Dead Load

Span	Location	Distance	MLL(-)-s3-HL-93 (US)-Truck + Lane
1	21.40	21.4	-87.72
1	24.97	24.97	-102.34
1	28.53	28.53	-117.05
1	28.67	28.67	-117.68
1	32.10	32.1	-146.13
1	35.67	35.67	-242.04
2	0.00	35.67	-242.04
2	3.57	39.23	-174.27
2	7.00	42.67	-145.27
2	7.13	42.8	-144.36
2	10.70	46.37	-124.47
2	14.27	49.93	-104.57
2	17.83	53.5	-84.67
2	21.40	57.07	-104.57
2	24.97	60.63	-124.47
2	28.53	64.2	-144.36
2	28.67	64.33	-145.27
2	32.10	67.77	-174.27



- Moment
  - Dead Load
  - Live Load
    - Composite (short term) (Stage 3)
      - HL-93 (US)
        - Lane
        - Axle Load
        - Tandem
        - Truck Pair
          - Positive
          - Negative
        - Truck + Lane
          - Positive
          - Negative
        - Tandem + Lane

Span	Location	Distance	MLL(-)-s3-HL-93 (US)-Lane	MLL(-)-s3-HL-93 (US)-Axle Load	MLL(-)-s3-HL-93 (US)-Tandem	MLL(-)-s3-HL-93 (US)-Truck Pair	MLL(-)-s3-HL-93 (US)-Truck + Lane	MLL(+)-s3-HL-93 (US)-Tandem + Lane	MLL(-)-s3-HL-93 (US)-Tandem + Lane	MLL(-)-s3-HL-93 (US)-90%(Truck Pair + Lane)
1	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	3.57	3.57	-2.50	-12.12	-11.49	0.00	-14.62	138.36	-13.99	0.00
1	7.13	7.13	-5.00	-24.24	-22.98	0.00	-29.24	235.53	-27.98	0.00
1	10.70	10.7	-7.49	-36.37	-34.47	0.00	-43.86	293.34	-41.97	0.00
1	14.27	14.27	-9.99	-48.49	-45.96	0.00	-58.48	314.53	-55.96	0.00
1	17.83	17.83	-12.49	-60.61	-57.46	0.00	-73.10	307.91	-69.95	0.00
1	21.40	21.4	-14.99	-72.73	-68.95	0.00	-87.72	276.66	-83.93	0.00
1	24.97	24.97	-17.49	-84.85	-80.44	0.00	-102.34	217.93	-97.92	0.00
1	28.53	28.53	-20.07	-96.98	-91.93	-96.13	-117.05	137.52	-112.00	-104.59
1	28.67	28.67	-20.25	-97.43	-92.36	-96.58	-117.68	134.16	-112.60	-105.15
1	32.10	32.1	-32.61	-113.52	-103.42	-108.15	-146.13	51.95	-136.02	-126.68
1	35.67	35.67	-58.29	-183.75	-148.04	-169.32	-242.04	45.34	-206.33	-204.84
2	0.00	35.67	-58.29	-183.75	-148.04	-169.32	-242.04	45.34	-206.33	-204.84
2	3.57	39.23	-34.99	-139.28	-129.54	-138.91	-174.27	59.00	-164.53	-156.51
2	7.00	42.67	-25.14	-120.13	-111.72	-119.81	-145.27	135.86	-136.86	-130.45
2	7.13	42.8	-24.98	-119.38	-111.03	-119.07	-144.36	138.79	-136.01	-129.64
2	10.70	46.27	-24.98	-99.40	-92.52	0.00	-124.47	206.28	-117.51	0.00

Steel Rolled - At Location = 35.6670 (ft) - Right   Stage 3

Section at Brace Point

Moment Gradient Modifier, Cb, Calculation

INPUT:
Section Prismatic in Unbraced Length: Yes
Section is Unbraced Cantilever: No

Top Flange Left Brace Location   =   35.6670 (ft)
Top Flange Middle of Unbraced Length Location =   53.5005 (ft)
Top Flange Right Brace Location   =   71.3340 (ft)

Bot Flange Left Brace Location   =   35.6670 (ft)
Bot Flange Middle of Unbraced Length Location =   53.5005 (ft)
Bot Flange Right Brace Location   =   71.3340 (ft)

SUMMARY:
Cb = 1.0   (A6.3.3-6)
Cb = 1.75 - 1.05*(M1/M2) + 0.3*(M1/M2)^2 <= 2.3   (A6.3.3-7)

		Input			Output					
Limit State	Load Comb	Left Moment (kip-ft)	Mid Moment (kip-ft)	Right Moment (kip-ft)	Concave Moment	Mmid (kip-ft)	M2 (kip-ft)	M1 (kip-ft)	Eq.	Cb
STR-I	1, DesInv	-67.175	444.369	-67.175	Yes	-444.369	67.175	67.175	7	1.0000
STR-I	1, DesInv	-574.957	-110.329	-574.957	Yes	110.329	574.957	574.957	7	1.0000
STR-I	2, DesInv	-72.048	487.791	-72.048	Yes	-487.791	72.048	72.048	7	1.0000
STR-I	2, DesInv	-512.461	-103.019	-512.461	Yes	103.019	512.461	512.461	7	1.0000
STR-I	3, DesInv	-151.388	37.847	-151.388	Yes	-37.847	151.388	151.388	7	1.0000
STR-I	3, DesInv	-509.861	37.847	-509.861	Yes	-37.847	509.861	509.861	7	1.0000
SER-II	1, DesInv	-56.384	331.723	-56.384	Yes	-331.723	56.384	56.384	7	1.0000
SER-II	1, DesInv	-433.593	-80.338	-433.593	Yes	80.338	433.593	433.593	7	1.0000
SER-II	2, DesInv	-60.004	363.979	-60.004	Yes	-363.979	60.004	60.004	7	1.0000
SER-II	2, DesInv	-387.167	-74.908	-387.167	Yes	74.908	387.167	387.167	7	1.0000
SER-II	3, DesInv	-118.941	29.735	-118.941	Yes	-29.735	118.941	118.941	7	1.0000
SER-II	3, DesInv	-385.236	29.735	-385.236	Yes	-29.735	385.236	385.236	7	1.0000

Note: For Input Moments, compression is negative, tension is positive.
      For Output Moments signs are switched. Compression is positive, tension is negative.

Load Combination Legend:

Code	Vehicle
1	HL-93 (US) - Truck + Lane
2	HL-93 (US) - Tandem + Lane
3	HL-93 (US) - 90%(Truck Pair + Lane)

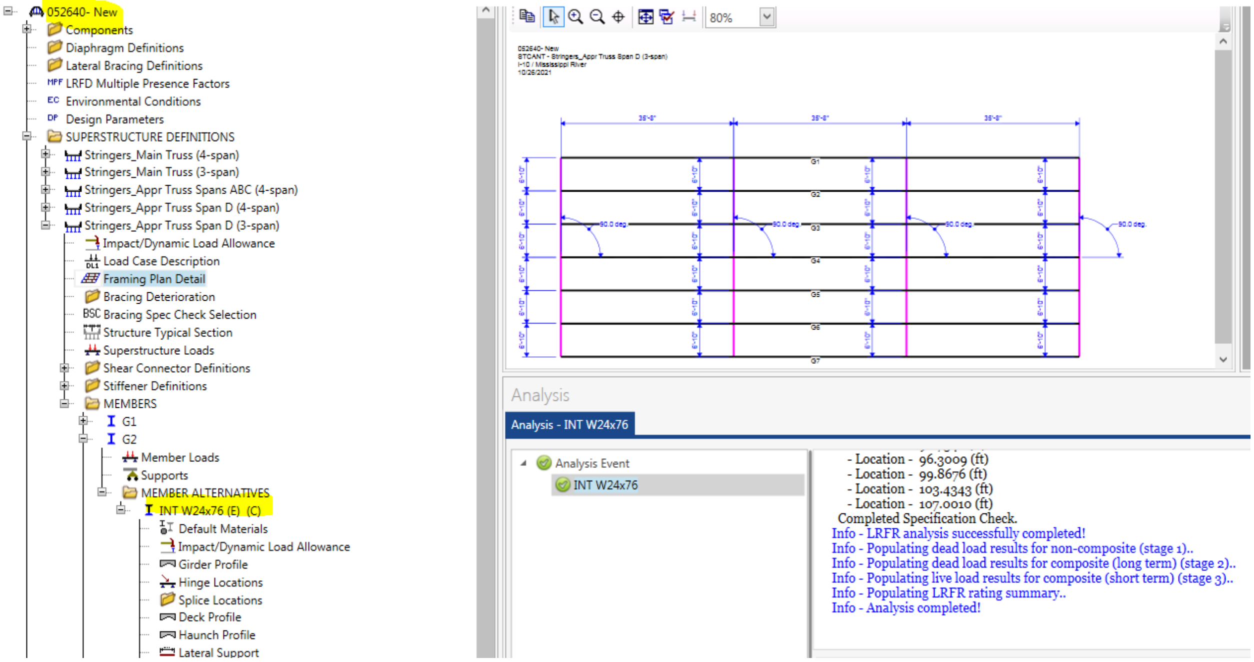
Spec Check Detail for APPA6.3.3 Lateral Torsional Buckling Resistance

```
If Lb <= Lp  then Compact Unbraced Length and

     Mnc(LTB) = Rpc*Myc                    (A6.3.3-1)

Else

     Fyr = min(0.7Fyc, Rh*Fyt*Sxt/Sxc, Fyw) >= 0.5Fyc


          D*tw^3   bfc*tfc^3 |‾          tfc‾|  bft*tft^3 |‾          tft‾|
     J =  ------ + ---------*|1 -0.63*-----| + ---------*| 1 - 0.63*--- |     (A6.3.3-9)
            3          3     |          bfc |      3     |          bft |
                             ‾             ‾             ‾             ‾

                            E        |‾  J  ‾|        |‾         |‾            |Fyr  Sxc*h‾|^2‾| ‾|
     Lr = 1.95 *rt * ---- * SQRT|-------| * SQRT| 1 + SQRT| 1 + 6.76* |----*------|     |  |      (A6.3.3-5)
                          Fyr        | Sxc*h |        |         |            |E      J   |     |  |
                                     ‾       ‾        ‾         ‾            ‾           ‾     ‾  ‾

     If Lp < Lb <= Lr then Noncompact Unbraced Length and

                      |‾   |‾       Fyr*Sxc‾| |‾Lb - Lp‾| ‾|
          Mnc(LTB)=  Cb * |1 - | 1 - --------|*| ------- |  |* Rpc * Myc <= Rpc*Myc      (A6.3.3-2)
                      |    |        Rpc*Myc| | Lr - Lp |  |
                      ‾    ‾              ‾  ‾        ‾  ‾

     Else Slender Unbraced Length and

                Cb*Pi^2*E         |‾              J                  ‾|
          Fcr =  --------- * SQRT| 1 + 0.078*------*(Lb/rt)^2 |         (A6.3.3-8)
                (Lb/rt)^2         |              Sxc*h                 |
                                  ‾                                   ‾

          Mnc(LTB) = Fcr*Sxc <= Rpc*Myc          (A6.3.3-3)
```

Limit State	Load Comb	Flexure Type	Dc (in)	rt (in)	Fyc (ksi)	Myc (kip-ft)	Myt (kip-ft)	Lp (in)	Compact	Fyr (ksi)	J (in^4)	Lr (in)	Slender	Cb	Fcr (ksi)	Rpc	Rh	Mnc(LTB) (kip-ft)
STR-I	1, DesInv	Pos**	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
STR-I	1, DesInv	Neg	12.8459	2.2690	36.0	586.2	755.9	64.4	No	25.2	2.4	272.2	Yes	1.000	12.7	1.213	1.000	206.62
STR-I	2, DesInv	Pos**	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
STR-I	2, DesInv	Neg	12.8459	2.2690	36.0	586.2	755.9	64.4	No	25.2	2.4	272.2	Yes	1.000	12.7	1.213	1.000	206.62
STR-I	3, DesInv	Neg	12.8459	2.2690	36.0	586.2	755.9	64.4	No	25.2	2.4	272.2	Yes	1.000	12.7	1.213	1.000	206.62
STR-I	3, DesInv	Neg	12.8459	2.2690	36.0	586.2	755.9	64.4	No	25.2	2.4	272.2	Yes	1.000	12.7	1.213	1.000	206.62
SER-II	1, DesInv	Pos**	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
SER-II	1, DesInv	Neg	12.8459	2.2690	36.0	586.8	758.0	64.4	No	25.2	2.4	272.2	Yes	1.000	12.7	1.212	1.000	206.76
SER-II	2, DesInv	Pos**	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
SER-II	2, DesInv	Neg	12.8459	2.2690	36.0	586.8	758.0	64.4	No	25.2	2.4	272.2	Yes	1.000	12.7	1.212	1.000	206.76
SER-II	3, DesInv	Neg	12.8459	2.2690	36.0	586.8	758.0	64.4	No	25.2	2.4	272.2	Yes	1.000	12.7	1.212	1.000	206.76
SER-II	3, DesInv	Neg	12.8459	2.2690	36.0	586.8	758.0	64.4	No	25.2	2.4	272.2	Yes	1.000	12.7	1.212	1.000	206.76

** Top Flange continuously supported for composite sections, article does not apply to positive flexure.

Recall #052640 – Stringers_Appr Truss Span D (3-Span)



FYI:

Stage 3: (Composite short term) - The computation for this stage are based on a standard modular ratio of n (not adjusted for creep). Temporary loads such as Live load are applied to Composite (short term) Stage 3.