Bridge No:	N/A	Owner:	VAOT
Town/City:	Rockingham	Maintainer:	
Route Carried:	VT Route 121	Year Built	2015
Crosses:	Saxtons River	Year(s) Rebuilt/Rehab:	Note: piers are pre-existing

SUMMARY OF BRIDGE RATING

LRFR Load Rating Factors

Loading Levels	Truck							
	H20	HL-93	3s2	6-axle	3A. Str.	4A. Str.	5A. Semi	
Tonnage	20	36	36	66	30	34.5	38	Interior Negative Flexure
Inventory	4.136	1.187						Governs Load Rating
Posting								
Operating	5.36	1.54	3.72	1.84	3.67	3.21	3.21	
Comments		**						

** HL-93 Loading governing the negative moment load rating is the negative moment truck train

Group 1 Posting Analysis (Configuration 1)

Governing Posting: N/A

Governing Load Model: N/A

Group 2 Posting Analysis (Configurations 2 - 5)

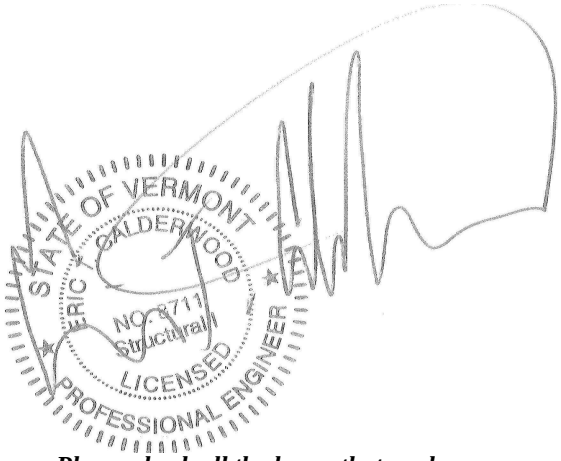
Governing Posting: N/A

Governing Load Model: N/A

Group 3 Posting Analysis (Configurations 6 - 8)

Governing Posting: N/A

Governing Load Model: N/A



LRFR Evaluation Factors: LL Rating

Live Load Distribution Factor:	0.83	Positive Moment Flex
	0.83	Negative Moment Flex
	1.12	Shear Dist. Factor
Live Load DF Special Hauling:	N/A	
Impact Factor:	33%	
Governing Condition Factor, ϕ_c:	1	
System Factor, ϕ_s:	1	
ADTT :	3700	

Please check all the boxes that apply:

Bridge load rating is:

- [ ] governed by substructure rating
- [ ] Connections control the load rating
- [ ] Exterior girder controls load rating
- [ ] As-built load rating
- [ ] As-inspected load rating
- [ ] One Lane Loaded
- [ ] Advanced Analysis Used
- [ ] Actual Measurements Taken
- [ ] Finite Fatigue Life 75 years*

BREAKDOWN OF BRIDGE RATING

Town/City: Rockingham
Bridge No: N/A

Route Carried: VT Route 121
Crosses: Saxtons River

LOAD RATING POINTS OF INTEREST

Bridge Component	HL-93			
	Inv 72.0 kip	Oper 72.0 kip		
Exterior Beam Strength I Positive Moment	2.39	3.09		
Exterior Beam Strength I Negative Moment	1.33	1.73		
Exterior Beam Strength I Shear	1.85	2.40		
Exterior Beam Service 2 Positive Moment	3.04	3.95		
Exterior Beam Service 2 Negative Moment	1.51	1.97		
Interior Beam Strength I Positive Moment	2.46	3.19		
Interior Beam Strength I Negative Moment	1.19	1.54		
Interior Beam Strength I Shear	1.70	2.21		
Interior Beam Service 2 Positive Moment	3.04	3.95		
Interior Beam Service 2 Negative Moment	1.32	1.72		
CONTROLLING RATING FACTORS	1.19	1.54		

Table of Contents – Superstructure Steel Design – Load Rating Per LRFR – Capacities from AASHTO LRFD

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Sumary of Load Rating

	Section	Live Load	Inventory		Operating	
Exterior Girder	Positive Flexure	HL-93	2.385	85.88 T	3.09	111.32 T
	Strength I	3s2	3.872	139.4 T	5.02	180.71 T
		6at	2.54	167.66 T	3.29	217.33 T
		3as	3.312	99.35 T	4.29	128.79 T
		4as	2.878	99.3 T	3.73	128.72 T
		5as	3.291	125.07 T	4.27	162.13 T
		h20	4.534	90.68 T	5.88	117.54 T
Interior Girder	Positive Flexure	HL-93	2.46	88.56 T	3.19	114.8 T
	Strength I	3s2	3.993	143.76 T	5.18	186.36 T
		6at	2.62	172.9 T	3.4	224.13 T
		3as	3.415	102.46 T	4.43	132.81 T
		4as	2.968	102.4 T	3.85	132.75 T
		5as	3.394	128.98 T	4.4	167.2 T
		h20	4.676	93.51 T	6.06	121.22 T
Exterior Girder	Negative Flexure	HL-93	1.331	47.91 T	1.73	62.11 T
	at Piers	3s2	3.218	115.85 T	4.17	150.17 T
	Strength I	6at	1.592	105.05 T	2.06	136.17 T
		3as	3.172	95.17 T	4.11	123.37 T
		4as	2.776	95.77 T	3.6	124.15 T
		5as	2.781	105.67 T	3.6	136.98 T
		h20	4.639	55.62 T	6.01	72.1 T
Interior Girder	Negative Flexure	HL-93	1.187	42.72 T	1.54	55.38 T
	at Piers	3s2	2.869	103.3 T	3.72	133.91 T
	Strength I	6at	1.419	93.67 T	1.84	121.42 T
		3as	2.829	84.87 T	3.67	110.01 T
		4as	2.475	85.4 T	3.21	110.7 T
		5as	2.48	94.23 T	3.21	122.15 T
		h20	4.136	49.59 T	5.36	64.29 T
Exterior Girder	Negative Flexure	HL-93	1.983	71.38 T	2.57	92.54 T
	6.3' from piers	3s2	3.472	124.97 T	4.5	162 T
	Strength I	6at	2.388	157.64 T	3.1	204.34 T
		3as	3.422	102.67 T	4.44	133.09 T
		4as	2.995	95.77 T	3.88	124.15 T
		5as	3	114 T	3.89	147.78 T
		h20	6.435	128.69 T	8.34	166.82 T
Interior Girder	Negative Flexure	HL-93	1.808	65.08 T	2.34	84.36 T
	6.3 ft from piers	3s2	3.165	113.93 T	4.1	147.69 T
	Strength I	6at	2.177	143.71 T	2.82	186.29 T
		3as	3.12	93.6 T	4.04	121.33 T
		4as	2.73	85.4 T	3.54	110.7 T
		5as	2.735	94.23 T	3.55	122.15 T
		h20	4.562	91.24 T	5.91	118.27 T

Sumary of Load Rating

		Section	Live Load	Inventory		Operating	
	Exterior Girder	Positive Flexure	HL-93	3.04	109.3 T	3.95	142.09 T
		Service II	3s2	4.93	177.42 T	6.41	230.65 T
			6at	3.23	213.39 T	4.2	277.4 T
			3as	4.21	126.45 T	5.48	164.38 T
			4as	3.66	126.38 T	4.76	164.3 T
			5as	4.19	159.19 T	5.45	206.94 T
			h20	5.77	115.41 T	7.5	150.03 T
	Interior Girder	Positive Flexure	HL-93	3.04	109.29 T	3.95	142.07 T
		Service II	3s2	4.93	177.4 T	6.41	230.62 T
			6at	3.23	213.36 T	4.2	277.37 T
			3as	4.21	126.43 T	5.48	164.36 T
			4as	3.66	126.37 T	4.76	164.28 T
			5as	4.19	159.17 T	5.45	206.92 T
			h20	5.77	115.39 T	7.5	150.01 T
	Exterior GIrder	Negative Moment	HL-93	1.51	54.44 T	1.97	70.77 T
		Service II	3s2	3.66	131.63 T	4.75	171.12 T
			6at	1.81	119.35 T	2.35	155.16 T
			3as	3.6	108.14 T	4.69	140.58 T
			4as	3.15	108.81 T	4.1	141.46 T
			5as	3.16	120.07 T	4.11	156.09 T
			h20	5.27	105.41 T	6.85	137.03 T
	Interior Girder	Negative Moment	HL-93	1.32	47.7 T	1.72	62.01 T
		Service II	3s2	3.2	115.33 T	4.16	149.93 T
			6at	1.58	104.58 T	2.06	135.95 T
			3as	3.16	94.75 T	4.11	123.94 T
			4as	2.76	95.34 T	3.59	123.94 T
			5as	2.77	105.2 T	3.6	136.76 T
			h20	4.62	92.36 T	6	120.07 T

Sumary of Load Rating

		Section	Live Load	Inventory		Operating	
	Exterior GIrder	Shear	HL-93	1.85	66.75 T	2.4	86.53 T
		Stiffened Panel	3s2	2.8	100.81 T	3.63	130.68 T
		w/in 6.3ft of piers	6at	1.7	111.87 T	2.2	145.02 T
		Strength I	3as	2.66	79.66 T	3.44	103.27 T
			4as	2.43	83.77 T	3.15	108.58 T
			5as	2.51	95.31 T	3.25	123.54 T
			h20	4.07	81.43 T	5.28	105.56 T
	Interior Girder	Shear	HL-93	1.7	61.33 T	2.21	79.5 T
		Stiffened Panel	3s2	2.57	92.62 T	3.34	120.06 T
		w/in 6.3ft of piers	6at	1.56	102.78 T	2.02	133.24 T
		Strength I	3as	2.44	73.19 T	3.16	94.88 T
			4as	2.23	76.96 T	2.89	99.76 T
			5as	2.3	87.56 T	2.99	113.51 T
			h20	3.74	74.82 T	4.85	96.99 T
	Exterior Girder	Shear	HL-93	1.92	69.04 T	2.49	89.5 T
		Unstiffened Panel	3s2	3.03	109.13 T	3.93	141.46 T
		6.3 ft from pier or	6at	1.8	118.75 T	2.33	153.93 T
		further	3as	2.63	78.96 T	3.41	102.36 T
		Strength I	4as	2.44	84.18 T	3.16	109.13 T
			5as	2.6	98.67 T	3.37	127.9 T
			h20	4.07	81.32 T	5.27	105.42 T
	Interior GIrder	Shear	HL-93	1.78	63.93 T	2.3	82.87 T
		Unstiffened Panel	3s2	2.81	101.05 T	3.64	130.99 T
		6.3 ft from pier or	6at	1.67	109.95 T	2.16	142.53 T
		further	3as	2.44	73.12 T	3.16	94.78 T
		Strength I	4as	2.26	77.95 T	2.93	101.05 T
			5as	2.4	91.36 T	3.12	118.43 T
			h20	3.77	75.30 T	4.88	97.61 T

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Project: Rockingham VT Bridge
Contractor: Cold River Bridges

Value Engineering Design: Calderwood Engineering
Design Computations by: Eric T. Calderwood, PE
Design Check Computations by: Rachael Joyce, EIT

Project Notes:

VTrans Structural Design Manual
4.3.2 Live Load Distribution: use controlling value of lever rule to det. amount of load on exterior beam. For interior and exterior beams, use controlling (larger) distribution factor calculated for one lane loaded, two lanes loaded or 3 or more loaded for flexure. Same for shear locations within span and at sprts. Controlling distribution factor will be larger of these.
For deflection, g shall be = max # lanes loaded / # beams * respective multipresence factor (m).
Calculate fatigue distribution factors similarly but with only one lane loaded.
5.1.1.1.1: Concrete, high performance class A for bridge decks placed on steel
5.1.2.6: Minimum Concrete Cover
5.2.1.1.1: Cast in Place Concrete Minimum deck thickness, paved deck, 8.5"
5.2.5: Minimum Reinforcement, #5 bars at 12" for reinforcing steel

$L_{pos} := (49\ ft + 3\ in) \cdot 2 + 33\ ft + 6\ in = 132\ ft$ total length of Positive Moment Girder section

$L_{neg} := 34\ ft \cdot 2 = 68\ ft$ total length of Negative Moment Girder section

Flange Transition locations:	49'-3"	
points of contraflexure:	83'-3"	
	116'-9"	(field splice)
	150'-9"	

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Distribution Factors:

Table 4.6.2.2.1-2 L for use in LL Distribution Factor Equations
+M: length of span for which moment is being calculated
-M (near interior sprts of continuous spans): average length of two adjacent spans
V: length of span for which shear is calculated
Rext: length of exterior span
Rint: avg length of two adjacent spans

$K_1 := 1.0$

$\gamma_c := 150\ pcf$

$f'_c := 4\ ksi$

$$E_c := 33000 \cdot K_1 \cdot \left(\left(\frac{\gamma_c}{\frac{kip}{ft^3}} \right)^{1.5} \right) \cdot \sqrt{f'_c \cdot ksi} \qquad E_c = 3834.25\ ksi$$

Beam geometry/ Area/ y/ Iox/ Ioy Positive Moment Region

$b_{bf} := 16.0\ in$

$t_{bf} := 1.125\ in \qquad A_{bf} := b_{bf} \cdot t_{bf} = 18\ in^2 \qquad y_{bf} := \frac{t_{bf}}{2} \qquad I_{oxbf} := \frac{b_{bf} \cdot t_{bf}^3}{12} \qquad I_{oybf} := \frac{t_{bf} \cdot b_{bf}^3}{12}$

$d_w := 35\ in$

$t_w := 0.50\ in \qquad A_w := d_w \cdot t_w = 17.5\ in^2 \qquad y_w := t_{bf} + \frac{d_w}{2} \qquad I_{oxw} := \frac{t_w \cdot d_w^3}{12} \qquad I_{oyw} := \frac{d_w \cdot t_w^3}{12}$

$b_{tf} := 16.0\ in$

$t_{tf} := 1.125\ in \qquad A_{tf} := b_{tf} \cdot t_{tf} = 18\ in^2 \qquad y_{tf} := t_{bf} + d_w + \frac{t_{tf}}{2} \qquad I_{oxtf} := \frac{b_{tf} \cdot t_{tf}^3}{12} \qquad I_{oytf} := \frac{t_{tf} \cdot b_{tf}^3}{12}$

$d_{beam} := t_{tf} + d_w + t_{bf} = 37.25\ in$

$A_g := b_{tf} \cdot t_{tf} + b_{bf} \cdot t_{bf} + d_w \cdot t_w = 53.5\ in^2$

$$y_{bar} := \frac{\left(A_{bf} \cdot y_{bf} + A_w \cdot y_w + A_{tf} \cdot y_{tf}\right)}{A_g} = 18.63\ in$$

$$I_x := I_{oxbf} + A_{bf} \cdot \left(y_{bf} - y_{bar}\right)^2 + I_{oxw} + A_w \cdot \left(y_w - y_{bar}\right)^2 + I_{oxtf} + A_{tf} \cdot \left(y_{tf} - y_{bar}\right)^2$$

$I_x = 13535.4\ in^4$

$I_y := I_{oybf} + I_{oyw} + I_{oytf}$

$I_y = 768.36\ in^4 \qquad S_{tf} := \frac{I_x}{\left(d_{beam} - y_{bar}\right)} = 726.73\ in^3 \qquad S_{bf} := \frac{I_x}{y_{bar}} = 726.73\ in^3$

$$I_{tbf} := \frac{b_{bf}^3 \cdot t_{bf}}{12} + \frac{d_w}{6} \cdot \frac{t_w^3}{12} = 384.06\ in^4 \qquad A_{tbf} := b_{bf} \cdot t_{bf} + \frac{d_w}{6} \cdot t_w = 20.92\ in^2$$

$$I_{ttf} := \frac{b_{tf}^3 \cdot t_{tf}}{12} + \frac{d_w}{6} \cdot \frac{t_w^3}{12} = 384.06\ in^4 \qquad A_{ttf} := b_{tf} \cdot t_{tf} + \frac{d_w}{6} \cdot t_w = 20.92\ in^2$$

$$r_{tbf} := \sqrt{\frac{I_{tbf}}{A_{tbf}}} = 4.29\ in \qquad r_{ttf} := \sqrt{\frac{I_{ttf}}{A_{ttf}}} = 4.29\ in$$

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Beam geometry/ Area/ y/ Iox/ Ioy Negative Moment Region (flange widths only change)

$b_{bfnm} := 18.375\ in$

$t_{bf} := 1.125\ in \quad A_{bfnm} := b_{bfnm} \cdot t_{bf} = 0.14\ ft^2 \quad y_{bfnm} := \frac{t_{bf}}{2} \quad I_{oxbfnm} := \frac{b_{bfnm} \cdot t_{bf}^3}{12} \quad I_{oybfnm} := \frac{t_{bf} \cdot b_{bfnm}^3}{12}$

$b_{tfnm} := 18.375\ in$

$t_{tf} := 1.125\ in \quad A_{tfnm} := b_{tfnm} \cdot t_{tf} = 0.14\ ft^2 \quad y_{tfnm} := t_{bf} + d_w + \frac{t_{tf}}{2} \quad I_{oxtfnm} := \frac{b_{tfnm} \cdot t_{tf}^3}{12} \quad I_{oytfnm} := \frac{t_{tf} \cdot b_{tfnm}^3}{12}$

$A_{gnm} := A_{bfnm} + A_w + A_{tfnm} = 58.84\ in^2$

$$y_{barnm} := \frac{\left(A_{bfnm} \cdot y_{bf} + A_w \cdot y_w + A_{tfnm} \cdot y_{tf}\right)}{A_{gnm}} = 18.63\ in$$

$$I_{xnm} := I_{oxbfnm} + A_{bfnm} \cdot \left(y_{bfnm} - y_{barnm}\right)^2 + I_{oxw} + A_w \cdot \left(y_w - y_{barnm}\right)^2 + I_{oxtfnm} + A_{tfnm} \cdot \left(y_{tfnm} - y_{barnm}\right)^2$$

$I_{xnm} = 15279.38\ in^4$

$I_{ynm} := I_{oybfnm} + I_{oyw} + I_{oytfnm}$

$I_{ynm} = 1163.64\ in^4 \quad S_{tfnm} := \frac{I_{xnm}}{\left(d_{beam} - y_{barnm}\right)} = 820.37\ in^3 \quad S_{bfnm} := \frac{I_{xnm}}{y_{barnm}} = 820.37\ in^3$

$I_{tbfnm} := \frac{b_{bfnm}^3 \cdot t_{bf}}{12} + \frac{d_w}{6} \cdot \frac{t_w^3}{12} = 581.7\ in^4 \quad A_{tbfnm} := b_{bfnm} \cdot t_{bf} + \frac{d_w}{6} \cdot t_w = 23.59\ in^2$

$I_{ttfnm} := \frac{b_{tfnm}^3 \cdot t_{tf}}{12} + \frac{d_w}{6} \cdot \frac{t_w^3}{12} = 581.7\ in^4 \quad A_{ttfnm} := b_{tfnm} \cdot t_{tf} + \frac{d_w}{6} \cdot t_w = 23.59\ in^2$

$r_{tbfnm} := \sqrt{\frac{I_{tbfnm}}{A_{tbfnm}}} = 4.97\ in \quad r_{ttfnm} := \sqrt{\frac{I_{ttfnm}}{A_{ttfnm}}} = 4.97\ in$

$t_{deck} := 9.0\ in \quad OH := 2\ ft + 7\ in = 2.58\ ft$

$skew := 30\ deg \quad OH_{ph} := 3\ ft + 10\ in = 3.83\ ft$ *Temporary overhang due to phase construction (at G2)*

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Moment Interior Beam
(Table 4.6.2.2.2b-1)

where,
S - beam spacing(ft)
L - span length of beam (ft)
Kg - longitudinal stiffness parameter (in^4)
(4.6.2.2.1-1) n - ratio of modulus of elasticicy of beam and deck, A-
ts- depth of concrete slab (in), eg-distance between cg of basic beam and deck (assume deck cg h/2)

$S := 10\ ft + 6\ in = 10.5\ ft$

$L_{APRCH} := 65.5\ ft \quad L_{MAIN} := 69\ ft \qquad L_{negM} := \frac{\langle L_{APRCH} + L_{MAIN} \rangle}{2} = 67.25\ ft$

$E_B := 29000\ ksi$

$E_D := E_c$

$n := \frac{E_B}{E_D} \qquad t_s := t_{deck}$

$e_g := \frac{d_{beam}}{2} + \frac{t_{deck}}{2} = 1.93\ ft$

$K_{gpos} := n \cdot \left(I_x + A_g \cdot e_g^{\ 2}\right) \qquad K_{gneg} := n \cdot \left(I_{xnm} + A_{gnm} \cdot e_g^{\ 2}\right)$

$K_{gpos} = 318762.27\ in^4 \qquad K_{gneg} = 353566.3\ in^4$

Moment Interior, Approach span, one lane loaded

$$g1_{MI1L} := 0.06 + \left(\frac{S}{14 \cdot ft}\right)^{0.4} \cdot \left(\frac{S}{L_{APRCH}}\right)^{0.3} \cdot \left(\frac{K_{gpos}}{12.0 \cdot \frac{in}{ft} \cdot L_{APRCH} \cdot t_s^{\ 3}}\right)^{0.1}$$

$g1_{MI1L} = 0.55$

Moment Interior, Approach span,
two or more lanes loaded

$$g1_{MI2L} := 0.075 + \left(\frac{S}{9.5\ ft}\right)^{0.6} \cdot \left(\frac{S}{L_{APRCH}}\right)^{0.2} \cdot \left(\frac{K_{gpos}}{12.0\ \frac{in}{ft} \cdot L_{APRCH} \cdot t_s^{\ 3}}\right)^{0.1}$$

$g1_{MI2L} = 0.77$

Moment Interior, Neg. Moment,
one lane loaded

$$g2_{MI1L} := 0.06 + \left(\frac{S}{14 \cdot ft}\right)^{0.4} \cdot \left(\frac{S}{L_{negM}}\right)^{0.3} \cdot \left(\frac{K_{gneg}}{12.0 \cdot \frac{in}{ft} \cdot L_{negM} \cdot t_s^{\ 3}}\right)^{0.1}$$

$g2_{MI1L} = 0.55$

Moment Interior, Neg. Mom,
two or more lanes loaded

$$g2_{MI2L} := 0.075 + \left(\frac{S}{9.5\ ft}\right)^{0.6} \cdot \left(\frac{S}{L_{negM}}\right)^{0.2} \cdot \left(\frac{K_{gneg}}{12.0\ \frac{in}{ft} \cdot L_{negM} \cdot t_s^{\ 3}}\right)^{0.1}$$

$g2_{MI2L} = 0.77$

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Moment Interior, Main span,
one lane loaded

$$g3_{MI1L} := 0.06 + \left(\frac{S}{14 \cdot ft}\right)^{0.4} \cdot \left(\frac{S}{L_{MAIN}}\right)^{0.3} \cdot \left(\frac{K_{gpos}}{12.0 \frac{in}{ft} \cdot L_{MAIN} \cdot t_s^{\,3}}\right)^{0.1}$$

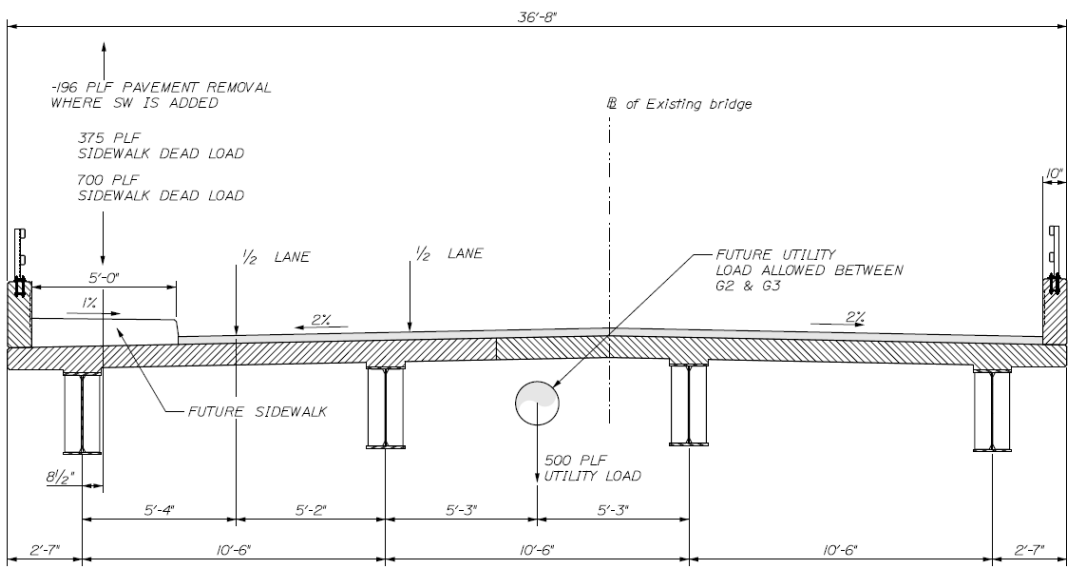
$$g3_{MI1L} = 0.54$$

Moment Interior, Main span, two or more lanes loaded

$$g3_{MI2L} := 0.075 + \left(\frac{S}{9.5\ ft}\right)^{0.6} \cdot \left(\frac{S}{L_{MAIN}}\right)^{0.2} \cdot \left(\frac{K_{gpos}}{12.0 \frac{in}{ft} \cdot L_{MAIN} \cdot t_s^{\,3}}\right)^{0.1}$$

$$g3_{MI2L} = 0.76$$

$$g_{MIcontrol} := \max\left(g3_{MI2L}, g3_{MI1L}, g2_{MI2L}, g2_{MI1L}, g1_{MI2L}, g1_{MI1L}\right) = 0.77$$



ADDITIONAL FUTURE LOADS

Alt Load #1 - additional loads shown with vehicular load shown in conjunction with sidewalk live loading a second truck load will not be applied in this case as the multi presence factor for a (3) lane loaded condition will make it not govern by inspection

Alt Load #2 - (not depicted in sketch) sidewalk live load will be neglected and the truck will be allowed to mount the curb

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Moment Exterior
(Table 4.6.2.2.2d-1)

one lane loaded, Lever Rule

same for approach spans, main span and negative moment regions

$$LE1_{MEL1} := \frac{0.5 \cdot (2 \cdot (S + OH - 2.83\ ft) - 6\ ft)}{S} = 0.69$$

Table 3.6.1.1.2-1, Multipresence factor (m)

$m_{1L} := 1.20$ $m_{2L} := 1.00$ $m_{3L} := 0.80$ Used for two lanes loaded + Sidewalk Live Load

$$g1_{MEL1} := m_{1L} \cdot LE1_{MEL1} = 0.83$$

$$g1_{alt1} := 0.5 \cdot \frac{(5\ ft + 2\ in)}{S} \cdot m_{2L} = 0.25$$

Exterior girder Live Load from Truck component concurrent with SW live load

$$g1_{alt2} := g1_{MEL1} = 0.83$$

loading with truck mounted on sidewalk one lane only

two or more lanes loaded: (for G4 fascia or G1 w/o sidewalk)

$$d_{eg4} := 2\ ft + 7\ in - 10\ in = 1.75\ ft$$

$$e_{g4} := 0.77 + \frac{d_{eg4}}{9.1\ ft} = 0.96$$

$$g1_{MEL2} := m_{2L} \cdot \langle e_{g4} \cdot g1_{MI2L} \rangle = 0.74$$

positive moment approach span

$$g2_{MEL2} := m_{2L} \cdot \langle e_{g4} \cdot g2_{MI2L} \rangle = 0.742$$

negative moment region

$$g3_{MEL2} := m_{2L} \cdot \langle e_{g4} \cdot g3_{MI2L} \rangle = 0.73$$

positive moment main span

two or more lanes loaded: (for G1 w/ sidewalk)

$$d_{eg1} := 2\ ft + 7\ in - 10\ in - 5\ ft = -3.25\ ft$$

de < -1.0 ft which is outside the range of applicability per section 4.6.2.2.2d therefor set de = -1.0 ft

$$d_{eg1} := -1.0\ ft$$

$$e_{g1} := 0.77 + \frac{d_{eg1}}{9.1\ ft} = 0.66$$

$$g2_{alt1} := m_{3L} \cdot \langle e_{g1} \cdot g1_{MI2L} \rangle = 0.406$$

$$g3_{alt1} := m_{3L} \cdot \langle e_{g1} \cdot g2_{MI2L} \rangle = 0.407$$

$$g4_{alt1} := m_{3L} \cdot \langle e_{g1} \cdot g3_{MI2L} \rangle = 0.401$$

Alternate Loadings (Sidewalk & Live Loads)

$$G1_{SWLL} := 375\ plf \cdot \frac{(S - 8.5\ in)}{S} = 349.7\ plf$$

$$G2_{SWLL} := 375\ plf - G1_{SWLL} = 25.3\ plf$$

Note that if G2swll is applied to interior girders it will cause the multipresence factor to decrease resulting in a lower total moment therefor G2swll will be ignored in calculations

It should be noted that according to the VTrans Structures Manual 2010 the rigid cross-section or pile distribution factor is not required for the design of exterior beams

4.3.2 Live Load Distribution

The LRFD Specifications provides the equations and tables for live load distribution factors. See LRFD Section 4.6.2.2. For typical beam bridges, distribution factors are provided for interior beam flexure (single lane, multiple lanes, and fatigue), Interior beam shear (single lane, multiple lanes, and fatigue). Use controlling value of the lever rule and AASHTO distribution formulas to determine the amount of live load carried by the exterior beam. LRFD C4.6.2.2.2d provides a formula for computation of an additional distribution factor for bridges that have diaphragms or cross-frames. Use of the rigid cross-section or pile-equation distribution factor is not required for design of exterior beams.

For the interior and exterior beams, the designer shall use the controlling (or larger) distribution factor calculated for one lane loaded, two lanes loaded or three or more lanes loaded for flexure. Do the same for shear for locations within the span and at the supports. The controlling distribution factor will be the larger of these.

When checking deflection, the distribution factor shall be the maximum number of lanes loaded divided by the number of beams and multiplied by the respective multiple-presence factor.

The designer shall also calculate the fatigue distribution factors similarly as above except only consider one lane loaded.

$N_b := 4$

Skew Adjustment factor neglected for Moment (as skew adjustment reduces moment this is a conservative approach)

$g_{pm} := \max\left(g1_{MEL2}, g3_{MEL2}, g1_{MEL1}, g3_{MI2L}, g3_{MI1L}, g1_{MI2L}, g1_{MI1L}\right) = 0.83$ Positive moment distribution

$g_{nm} := \max\left(g2_{MEL2}, g1_{MEL1}, g2_{MI1L}, g2_{MI2L}\right) = 0.83$ Negative moment distribution

$g_{posfatm} := \dfrac{\max\left(g1_{MEL1}, g1_{MI1L}, g3_{MI1L}\right)}{m_{1L}} = 0.69$ Positive moment fatigue distribution

$g_{negfatm} := \dfrac{\max\left(g1_{MEL1}, g2_{MI1L}\right)}{m_{1L}} = 0.69$ Negative moment fatigue distribution

$g_{alt1} := \max\left(g1_{alt1}, g2_{alt1}, g3_{alt1}, g4_{alt1}\right) = 0.407$ Vehicular load concurrent with SW LL

$g_{alt2} := g1_{alt2} = 0.83$ Vehicular load without SW LL

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Shear Interior Beam
(Table 4.6.2.2.3a-1)

Shear Interior, one lane loaded

$$g1_{VIL1} := 0.36 + \frac{S}{25.0\ ft}$$

$$g1_{VIL1} = 0.78$$

Shear Interior, two or more lanes loaded

$$g1_{VIL2} := 0.2 + \frac{S}{12\ ft} - \left(\frac{S}{35\ ft}\right)^{2.0}$$

$$g1_{VIL2} = 0.99$$

Shear Exterior Beam
(Table 4.6.2.2.3b-1)

one lane loaded, Lever Rule

$$g1_{VEL1} := m_{1L} \cdot LE1_{MEL1} = 0.83$$

also for alternate loading condition #2 with truck mounted on sidewalk

$$g1v_{alt1} := g1_{alt1} = 0.25$$

Concurrent with SW live Loading

two or more lanes loaded

$$d_e := OH - 10\ in = 1.75\ ft$$

$$e := 0.60 + \frac{d_e}{10\ ft} = 0.78$$

$$g1_{VEL2} := m_{2L} \cdot \left(e \cdot g1_{VIL2}\right) = 0.76$$

two or more lanes loaded: (for G1 w/ sidewalk)

$$d_{ev1} := 2\ ft + 7\ in - 10\ in - 5\ ft = -3.25\ ft$$

de < -1.0 ft which is outside the range of applicability per section 4.6.2.2.3b-1 therefor
set de = -1.0 ft

$$d_{ev1} := -1.0\ ft$$

$$e_{v1} := 0.60 + \frac{d_{ev1}}{10.0\ ft} = 0.5$$

$$g2v_{alt1} := m_{3L} \cdot \left(e_{v1} \cdot g1_{VIL2}\right) = 0.394$$

Skew Correction factor for Shear:

LRFD 4.6.2.2.3c-skewed bridges

$$Cor_{skapr} := 1 + 0.20 \cdot \left(\frac{\left(12 \cdot \frac{in}{ft} \cdot L_{APRCH} \cdot t_{deck}^{3} \right)}{K_{gpos}} \right)^{0.3} \cdot \tan(skew) = 1.138$$

$$Cor_{skneg} := 1 + 0.20 \cdot \left(\frac{\left(12 \cdot \frac{in}{ft} \cdot L_{negM} \cdot t_{deck}^{3} \right)}{K_{gneg}} \right)^{0.3} \cdot \tan(skew) = 1.135$$

$$Cor_{skmain} := 1 + 0.20 \cdot \left(\frac{\left(12 \cdot \frac{in}{ft} \cdot L_{MAIN} \cdot t_{deck}^{3} \right)}{K_{gpos}} \right)^{0.3} \cdot \tan(skew) = 1.14$$

$$Cor_{sk} := \max\left(Cor_{skapr}, Cor_{skmain}, Cor_{skneg}\right) = 1.14$$

Using highest calculated skew adjustment factor for shear

Controlling Shear Distibution Factor:

$$g_v := Cor_{sk} \cdot \max\left(g1_{VEL1}, g1_{VEL2}, g1_{VIL2}, g1_{VIL1}\right) = 1.12$$

$$g_{vfat} := Cor_{sk} \cdot \frac{\max\left(g1_{VEL1}, g1_{VIL1}\right)}{m_{1L}} = 0.79$$

$$g_{valt1} := Cor_{sk} \cdot \max\left(g1v_{alt1}, g2v_{alt1}\right) = 0.45$$

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Dead Load Computations:

115% of steel weight to account for connection plates, diaphragms, weldments, & 1/16" add'l thickness on plates

$$W_{stl} := \frac{A_g \cdot 490\ pcf \cdot 115\% \cdot L_{pos} + A_{gnm} \cdot 490\ pcf \cdot 115\% \cdot L_{neg}}{L_{pos} + L_{neg}} = 216.47\ plf$$

$$W_{stl} = 0.22\ klf$$

$$W_{extdeck} := \left(\frac{S}{2} + OH\right) \cdot t_{deck} \cdot 150\ pcf = 881.25\ plf$$

$$W_{extdeck} = 0.88\ klf$$

$$W_{intdeck} := S \cdot t_{deck} \cdot 150\ pcf = 1181.25\ plf$$

$$W_{intdeck} = 1.18\ klf$$

$$W_{extpvt} := \left(\frac{S}{2} + OH - 10\ in\right) \cdot 3.25\ in \cdot 145\ pcf = 274.9\ plf$$

$$W_{extpvt} = 0.27\ klf$$

$$W_{intpvt} := S \cdot 3.25\ in \cdot 145\ pcf = 412.34\ plf$$

$$W_{intpvt} = 0.41\ klf$$

$$W_{altpvtG1} := W_{extpvt} - 5\ ft \cdot 3.25\ in \cdot 145\ pcf \cdot \frac{(S - 8.5\ in)}{S} = 0.09\ klf$$

$$W_{utint} := \frac{500\ plf}{2} = 0.25\ klf$$

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60% of railing & Sidewalk load applied to exterior girders, steel railing taken at 25plf on top of concrete railing

$$W_{extrail} := 60\% \cdot 2 \cdot \frac{(10\ in \cdot (2\ ft + 3.25\ in) \cdot 150\ pcf + 25\ plf)}{2} = 185.31\ plf$$

$$W_{extrail} = 0.19\ klf$$

$$W_{intrail} := 40\% \cdot 2 \cdot \frac{(10\ in \cdot (2\ ft + 3.25\ in) \cdot 150\ pcf + 25\ plf)}{\langle N_b - 2 \rangle} = 123.54\ plf$$

$$W_{intrail} = 0.12\ klf$$

$$W_{altSWG1} := 60\% \cdot 1 \cdot 700\ plf = 420\ plf$$

$$W_{altSWG1} = 0.42\ klf$$

$$W_{altSWint} := 40\% \cdot 1 \cdot \frac{700\ plf}{2} = 140\ plf$$

$$W_{altSWint} = 0.14\ klf$$

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3S2 truck per VTrans Structures Mnl 2010 section 15.2 not distributed without impact single wheel line only

3S2 Truck

Distance	Vmax	Mmin	Mmax		No	Rmin	Rmax	
0.00	21.1	0.0	0.0		1	-2.4	21.1	
6.55	17.2	-15.7	124.9		2	-4.1	33.3	
13.10	13.5	-31.5	211.6		3	-4.1	33.3	
19.65	10.1	-47.2	251.6		4	-2.4	20.5	
26.20	6.9	-62.9	253.6					
32.75	7.0	-78.7	262.7					
39.30	10.9	-94.4	246.1					
45.85	14.8	-110.1	189.3					
52.40	18.5	-125.9	100.2					
58.95	21.9	-141.6	42.4					
65.50	26.8	-183.7	47.1					
72.40	23.2	-160.6	24.0					
79.30	19.4	-137.5	109.8					
86.20	15.5	-114.5	174.8					
93.10	11.7	-91.4	209.6					
100.00	8.4	-68.3	234.7					
106.90	8.8	-91.3	231.2					
113.80	12.6	-114.4	189.4					
120.70	16.5	-137.4	111.5					
127.60	20.3	-160.5	24.0					
134.50	26.1	-183.6	47.1					
141.05	22.7	-141.9	42.4					
147.60	19.0	-126.1	100.3					
154.15	15.1	-110.3	181.9					
160.70	11.5	-94.6	225.3					
167.25	8.0	-78.8	255.9					
173.80	5.9	-63.0	279.1					
180.35	9.3	-47.3	264.4		Vus3s2		22.832	kips
186.90	13.0	-31.5	204.7		Mmax=		279.1	k-ft
193.45	16.9	-15.8	117.7		Mmin=		-183.7	k-ft
200.00	20.5	0.0	0.0		Vmax=		26.8	kips

$M_{max3s2} = 279.13$ ft·kip

$M_{min3s2} = -183.71$ ft·kip

$M_{2neg3s2} = -160.62$ ft·kip

$V_{max3s2} = 26.79$ kip

$V_{us3s2} = 22.83$ kip

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6 Axle Trailer truck
per VTrans Structures Mnl 2010
section 15.2 not distributed
without impact - single wheel line
only

6 Axle Trailer

Distance	Vmax	Mmin	Mmax
0.00	35.7	0.0	0.0
6.55	28.9	-23.6	206.5
13.10	22.4	-47.3	351.8
19.65	16.5	-70.9	416.8
26.20	13.6	-94.5	425.5
32.75	19.5	-118.1	392.2
39.30	19.5	-141.8	308.6
45.85	24.6	-165.4	252.7
52.40	29.0	-189.0	132.7
58.95	32.6	-212.6	61.6
65.50	44.2	-371.4	68.5
72.40	37.9	-217.8	34.9
79.30	31.4	-186.5	197.0
86.20	25.3	-155.2	308.8
93.10	14.1	-123.9	363.4
100.00	10.7	-99.3	358.3
106.90	16.6	-132.8	300.1
113.80	22.0	-166.4	254.0
120.70	31.1	-199.9	147.1
127.60	34.6	-233.5	32.6
134.50	43.1	-365.6	63.9
141.05	36.8	-198.8	57.5
147.60	30.8	-171.2	188.0
154.15	24.8	-149.8	312.7
160.70	20.5	-128.4	380.9
167.25	16.4	-107.0	419.3
173.80	15.5	-85.6	423.0
180.35	19.6	-64.2	384.4
186.90	23.8	-42.8	311.7
193.45	28.2	-21.4	184.6
200.00	32.7	0.0	0.0

No	Rmin	Rmax
1	-3.6	35.7
2	-5.9	56.7
3	-5.5	56.6
4	-3.3	32.7

Vus6at	38.468	kips
Mmax	425.5	k-ft
Mmin	-371.4	k-ft
Vmax	44.2	kips

$M_{max6at} = 425.5$ ft·kip

$M_{min6at} = -371.43$ ft·kip

$M_{2neg6at} = -233.46$ ft·kip

$V_{max6at} = 44.25$ kip

$V_{us6at} = 38.47$ kip

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3 Axle Straight truck
per VTrans Structures Mnl 2010
section 15.2 not distributed
without impact single wheel line
only

3 Axle Straight

Distance	Vmax	Mmin	Mmax		No	Rmin	Rmax	
0.00	26.6	0.0	0.0		1	-2.5	26.6	
6.55	22.8	-16.1	149.6		2	-4.1	29.4	
13.10	19.2	-32.3	251.9		3	-4.1	29.5	
19.65	15.8	-48.4	309.5		4	-2.4	22.2	
26.20	12.5	-64.6	326.4					
32.75	11.5	-80.7	314.4					
39.30	14.6	-96.8	275.6					
45.85	17.4	-113.0	209.5					
52.40	19.9	-129.1	123.8					
58.95	22.0	-145.2	43.0					
65.50	27.4	-185.6	47.8					
72.40	24.7	-162.3	46.1					
79.30	21.7	-139.0	145.6					
86.20	18.4	-115.7	218.7					
93.10	14.9	-92.3	268.6					
100.00	11.5	-69.3	285.8					
106.90	12.5	-92.7	268.4					
113.80	15.8	-116.1	218.0					
120.70	18.9	-139.5	139.9					
127.60	21.4	-162.9	40.4					
134.50	28.2	-186.3	47.6					
141.05	26.2	-143.6	42.9					
147.60	23.8	-127.6	142.7					
154.15	21.1	-111.7	227.8					
160.70	18.1	-95.7	288.1					
167.25	14.8	-79.8	316.7					
173.80	11.3	-63.8	319.9					
180.35	12.7	-47.9	288.1		Vus3as		26.296	kips
186.90	16.3	-31.9	213.0		Mmax		326.4	k-ft
193.45	19.2	-16.0	125.8		Mmin		-186.3	k-ft
200.00	22.2	0.0	0.0		Vmax		28.2	kips

$M_{max3as} = 326.39\ ft{\cdot}kip$

$M_{min3as} = -186.35\ ft{\cdot}kip$

$M_{2neg3as} = -162.93\ ft{\cdot}kip$

$V_{max3as} = 28.25\ kip$

$V_{us3as} = 26.3\ kip$

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4 Axle Straight truck
per VTrans Structures Mnl 2010
section 15.2 not distributed
without impact single wheel line
only

4 Axle Straight

Distance	Vmax	Mmin	Mmax		No	Rmin	Rmax	
0.00	27.6	0.0	0.0		1	-2.8	27.6	
6.55	23.5	-18.3	153.6		2	-4.7	33.8	
13.10	19.4	-36.6	275.4		3	-4.7	33.8	
19.65	15.5	-54.9	349.4		4	-2.7	25.3	
26.20	11.9	-73.2	375.5					
32.75	13.0	-91.5	359.3					
39.30	16.6	-109.8	307.7					
45.85	19.9	-128.1	229.1					
52.40	22.8	-146.4	130.1					
58.95	25.5	-164.7	49.2					
65.50	29.4	-211.2	54.6					
72.40	26.0	-184.7	56.8					
79.30	22.3	-158.2	170.5					
86.20	18.4	-131.6	256.4					
93.10	14.4	-105.1	306.8					
100.00	10.6	-79.2	317.8					
106.90	14.1	-105.9	291.1					
113.80	17.9	-132.7	236.5					
120.70	21.5	-159.4	148.6					
127.60	24.6	-186.2	35.2					
134.50	30.9	-213.0	54.2					
141.05	28.3	-162.0	48.8					
147.60	25.2	-144.0	158.4					
154.15	21.9	-126.0	256.3					
160.70	18.2	-108.0	328.2					
167.25	14.3	-90.0	365.4					
173.80	10.3	-72.0	360.8					
180.35	14.2	-54.0	318.2		Vus4as		28.365	kips
186.90	18.3	-36.0	239.4		Mmax		375.5	k-ft
193.45	21.7	-18.0	142.3		Mmin		-213.0	k-ft
200.00	25.3	0.0	0.0		Vmax		30.9	kips

$M_{max4as} = 375.54$ ft·kip

$M_{min4as} = -212.96$ ft·kip

$M_{2neg4as} = -186.2$ ft·kip

$V_{max4as} = 30.89$ kip

$V_{us4as} = 28.36$ kip

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5 Axle Semi - per
VTrans Structures Manual 2010
section 15.2 35' truck unfactored
without dynamic load allowance
Single wheel line only

5 Axle Semi

Distance	Vmax	Mmin	Mmax		No	Rmin	Rmax	
0.00	24.8	0.0	0.0		1	-2.8	24.8	
6.55	20.5	-18.3	143.5		2	-4.7	36.0	
13.10	16.4	-36.6	249.1		3	-4.7	36.1	
19.65	12.5	-54.9	302.2		4	-2.8	23.5	
26.20	9.0	-73.1	312.8					
32.75	9.2	-91.4	316.1					
39.30	13.5	-109.7	288.2					
45.85	17.6	-128.0	219.4					
52.40	21.5	-146.3	118.6					
58.95	25.0	-164.6	49.1					
65.50	28.2	-211.1	54.5					
72.40	23.1	-184.6	27.8					
79.30	18.9	-158.1	132.2					
86.20	14.8	-131.5	210.9					
93.10	10.7	-105.0	254.1					
100.00	7.2	-79.0	278.8					
106.90	10.9	-105.7	270.7					
113.80	15.1	-132.4	220.8					
120.70	19.2	-159.2	132.4					
127.60	23.3	-185.9	27.6					
134.50	29.9	-212.6	54.2					
141.05	26.5	-163.3	48.7					
147.60	22.8	-145.2	119.5					
154.15	18.7	-127.0	216.0					
160.70	14.4	-108.9	275.5					
167.25	10.5	-90.7	306.7					
173.80	7.5	-72.6	328.4					
180.35	11.2	-54.4	308.3		Vus4as		26.656	kips
186.90	15.3	-36.3	238.4		Mmax		328.4	k-ft
193.45	19.6	-18.1	136.3		Mmin		-212.6	k-ft
200.00	23.5	0.0	0.0		Vmax		29.9	kips

$M_{max5as} = 328.4\ ft{\cdot}kip$

$M_{min5as} = -212.58\ ft{\cdot}kip$

$M_{2neg5as} = -185.87\ ft{\cdot}kip$

$V_{max5as} = 29.91\ kip$

$V_{us5as} = 26.66\ kip$

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H 20 load unfactored - undistributed without dynamic load allowance - single wheel line only

H 20

Distance	Vmax	Mmin	Mmax		No	Rmin	Rmax	
0.00	16.8	0.0	0.0		1	-1.7	16.8	
6.55	14.3	-10.8	95.5		2	-2.8	19.8	
13.10	11.9	-21.7	173.2		3	-2.8	19.8	
19.65	9.6	-32.5	220.1		4	-1.7	15.7	
26.20	7.5	-43.3	238.4					
32.75	8.5	-54.2	231.2					
39.30	10.5	-65.0	202.3					
45.85	12.3	-75.8	156.5					
52.40	13.8	-86.7	99.2					
58.95	15.2	-97.5	38.6					
65.50	17.8	-125.8	32.7					
72.40	15.8	-110.0	54.5					
79.30	13.7	-94.2	121.1					
86.20	11.5	-78.4	172.8					
93.10	9.1	-62.6	204.6					
100.00	6.9	-47.4	213.5					
106.90	9.1	-63.4	199.3					
113.80	11.3	-79.4	163.5					
120.70	13.3	-95.4	110.3					
127.60	14.9	-111.4	44.2					
134.50	18.4	-127.4	32.3					
141.05	17.0	-97.5	40.7					
147.60	15.3	-86.7	106.5					
154.15	13.4	-75.8	164.4					
160.70	11.3	-65.0	208.3					
167.25	9.1	-54.2	233.1					
173.80	6.9	-43.3	234.5					
180.35	9.3	-32.5	208.9		Vush20	17.022	kips	
186.90	11.7	-21.7	153.7		Mmax	238.4	k-ft	
193.45	13.7	-10.8	89.8		Mmin	-127.4	k-ft	
200.00	15.7	0.0	0.0		Vmax	18.4	kips	

$M_{maxh20} = 238.4$ ft·kip

$M_{minh20} = -127.44$ ft·kip

$M_{2negh20} = -111.43$ ft·kip

$V_{maxh20} = 18.42$ kip

$V_{ush20} = 17.02$ kip

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HS 20 load unfactored - undistributed without dynamic load allowance single LANE only

3.6.1.2.2 truck definition

HS20 Truck

Distance	Vmax	Mmin	Mmax	No	Rmin	Rmax	
0.00	52.9	0.0	0.0	1	-5.6	52.9	
6.55	44.4	-37.0	290.7	2	-9.5	69.8	
13.10	36.2	-74.0	523.8	3	-9.4	69.8	
19.65	28.4	-111.0	653.2	4	-5.6	54.4	
26.20	21.3	-148.0	687.4				
32.75	27.8	-185.0	679.1				
39.30	35.6	-222.0	611.8				
45.85	42.7	-259.0	469.8				
52.40	49.2	-296.0	270.2				
58.95	55.1	-333.0	99.5				
65.50	60.1	-424.8	110.5				
72.40	49.7	-371.4	81.9				
79.30	41.8	-318.0	314.8				
86.20	33.7	-264.7	482.6				
93.10	25.6	-211.3	572.6				
100.00	22.2	-160.2	611.5				
106.90	30.3	-214.4	589.1				
113.80	38.4	-268.5	485.8				
120.70	46.1	-322.7	309.7				
127.60	52.8	-376.8	71.0				
134.50	61.3	-431.0	109.0				
141.05	55.4	-328.0	98.1				
147.60	48.7	-291.6	270.6				
154.15	41.4	-255.1	468.4				
160.70	33.5	-218.7	604.4	Vushs20		55.61	kips
167.25	25.1	-182.2	665.7				
173.80	22.6	-145.8	698.2				
180.35	30.5	-109.3	652.5				
186.90	38.9	-72.9	509.1	Mmax=		698.2	k-ft
193.45	46.5	-36.4	304.6	Mmin=		-431.0	k-ft
200.00	54.4	0.0	0.0	Vmax=		61.3	kips

$M_{maxhs20} = 698.16$ ft·kip

$M_{minhs20} = -430.97$ ft·kip

$M_{2neghs20} = -376.82$ ft·kip

$V_{maxhs20} = 61.3$ kip

$V_{ushs20} = 55.61$ kip

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Negative Moment Truck Train load
unfactored - undistributed
without dynamic load allowance
(90% of HS-20 truck train figured)
single LANE only

3.6.1.3 90% of two HS 20 trucks with 14' axle spacing and 50' from the rear axle of the front truck to the front axle of the rear truck.

Neg Moment Truck Train

Distance	Vmax	Mmin	Mmax		No	Rmin	Rmax	
0.00	47.6	0.0	0.0		1	-3.7	47.6	
6.55	39.9	-24.3	261.6		2	-8.6	70.1	
13.10	32.6	-48.6	471.4		3	-8.5	70.0	
19.65	25.6	-73.0	587.9		4	-3.7	49.6	
26.20	19.1	-97.3	618.6					
32.75	26.3	-121.6	611.2					
39.30	33.1	-145.9	550.7					
45.85	39.1	-170.3	422.8					
52.40	44.3	-251.0	243.2					
58.95	49.6	-414.9	89.7					
65.50	54.3	-634.1	99.7					
72.40	47.6	-427.3	97.2					
79.30	42.2	-286.2	261.8					
86.20	36.2	-238.2	371.9					
93.10	29.8	-190.2	429.3					
100.00	23.1	-144.5	457.3					
106.90	27.9	-193.3	450.2					
113.80	33.6	-242.1	392.3					
120.70	39.2	-290.9	280.7					
127.60	44.1	-429.0	110.8					
134.50	56.1	-636.9	98.1					
141.05	51.7	-417.7	88.3					
147.60	46.7	-253.3	249.4					
154.15	41.0	-167.7	426.6					
160.70	34.7	-143.8	547.2		Vusnmtt=		51.865	kips
167.25	27.6	-119.8	607.2					
173.80	21.0	-95.8	640.6					
180.35	28.2	-71.9	596.1					
186.90	35.6	-47.9	466.3		Mmax=		640.6	k-ft
193.45	42.5	-24.0	278.4		Mmin=		-636.9	k-ft
200.00	49.6	0.0	0.0		Vmax=		56.1	kips

$M_{maxnmtt} = 640.58$ ft·kip

$M_{minnmtt} = -636.91$ ft·kip

$M_{2negnmtt} = -429.02$ ft·kip

$V_{maxnmtt} = 56.05$ kip

$V_{usnmtt} = 51.87$ kip

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Design Tandem Load,
Unfactored, Undistributed, with
no dynamic load allowance
single LANE only

LRFD 3.6.1.2.3

Tandem

Distance	Vmax	Mmin	Mmax		No	Rmin	Rmax	
0.00	45.6	0.0	0.0		1	-4.3	45.6	
6.55	39.4	-28.1	258.0		2	-7.2	50.1	
13.10	33.3	-56.2	436.0		3	-7.2	50.0	
19.65	27.4	-84.3	553.9		4	-4.3	41.8	
26.20	21.8	-112.4	617.4					
32.75	22.6	-140.5	613.1					
39.30	28.2	-168.7	549.7					
45.85	33.5	-196.8	438.1					
52.40	38.3	-224.9	291.1					
58.95	42.5	-253.0	123.6					
65.50	47.4	-327.1	83.1					
72.40	43.0	-286.0	125.8					
79.30	38.0	-244.9	290.4					
86.20	32.5	-203.8	425.4					
93.10	26.7	-162.7	515.3					
100.00	20.9	-121.6	550.2					
106.90	23.3	-161.2	526.0					
113.80	29.1	-202.0	444.4					
120.70	34.8	-242.7	312.7					
127.60	40.2	-283.4	143.9					
134.50	48.1	-324.1	83.9					
141.05	44.9	-250.5	110.9					
147.60	40.9	-222.7	269.6					
154.15	36.5	-194.9	415.4					
160.70	31.5	-167.0	532.4		Vustan=		43.407	kips
167.25	26.1	-139.2	606.7					
173.80	20.4	-111.4	626.7					
180.35	23.9	-83.5	582.6					
186.90	29.6	-55.7	466.8		Mmax=		626.7	k-ft
193.45	35.6	-27.8	273.8		Mmin=		-327.1	k-ft
200.00	41.8	0.0	0.0		Vmax=		48.1	kips

$M_{maxtan} = 626.66$ ft·kip

$M_{mintan} = -327.1$ ft·kip

$M_{2negtan} = -286$ ft·kip

$V_{maxtan} = 48.12$ kip

$V_{ustan} = 43.41$ kip

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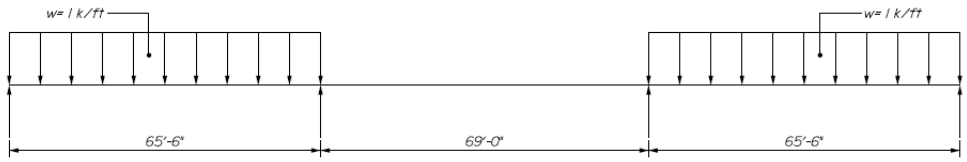
Uniform load Maximixed for Positive Moment approach spans govern by inspection therefor spans 1 & 3 loaded, span 2 not loaded



Uniform load positioned for maximum positive moment

Uniform load for Maximum Positive Moment (sp 1 & 3 Loaded)								
Distance	Vmax	Mmin	Mmax		No	Rmin	Rmax	
0.00	29.6	0.0	0.0		1	0.0	29.6	
6.55	23.0	0.0	172.3		2	0.0	35.9	
13.10	16.5	0.0	301.7		3	0.0	35.9	
19.65	9.9	0.0	388.1		4	0.0	29.6	
26.20	3.4	0.0	431.7					
32.75	3.2	0.0	432.4					
39.30	9.7	0.0	390.1					
45.85	16.3	0.0	305.0					
52.40	22.8	0.0	176.9					
58.95	29.4	0.0	6.0					
65.50	35.9	-207.8	0.0					
72.40	0.0	-207.8	0.0					
79.30	0.0	-207.8	0.0					
86.20	0.0	-207.8	0.0					
93.10	0.0	-207.8	0.0					
100.00	0.0	-207.8	0.0					
106.90	0.0	-207.8	0.0					
113.80	0.0	-207.8	0.0					
120.70	0.0	-207.8	0.0					
127.60	0.0	-207.8	0.0					
134.50	35.9	-207.8	0.0					
141.05	29.4	0.0	6.0					
147.60	22.8	0.0	176.9					
154.15	16.3	0.0	305.0					
160.70	9.7	0.0	390.1					
167.25	3.2	0.0	432.4		Vus13=		29.621	kips
173.80	3.4	0.0	431.7					
180.35	9.9	0.0	388.1					
186.90	16.5	0.0	301.7		Mmax=		432.4	k-ft
193.45	23.0	0.0	172.3		Mmin=		-207.8	k-ft
200.00	29.6	0.0	0.0		Vmax=		35.9	kips

$M_{13max} = 432.36$ ft·kip

$M_{13min} = -207.85$ ft·kip

$V_{13max} = 35.92$ kip

$M_{2neg13} := M_{13min} = -207.85$ ft·kip

$V_{us13} = 29.62$ kip

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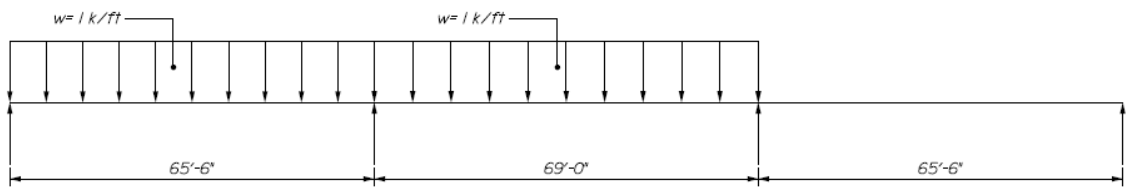
Uniform load Maximized for Negative Moment, spans 1 & 2 loaded, span 3 unloaded



Uniform load positioned for maximum negative moment

Uniform load for Maximum Negative Moment (sp 1 & 2 Loaded)							
Distance	Vmax	Mmin	Mmax		No	Rmin	Rmax
0.00	24.8	0.0	0.0		1	0.0	24.8
6.55	18.2	0.0	140.8		2	0.0	80.3
13.10	11.7	0.0	238.7		3	0.0	32.0
19.65	5.1	0.0	293.7		4	-2.6	0.0
26.20	1.4	0.0	305.8				
32.75	8.0	0.0	275.0				
39.30	14.5	0.0	201.3				
45.85	21.1	0.0	84.7				
52.40	27.6	-74.8	0.0				
58.95	34.2	-277.2	0.0				
65.50	40.7	-522.5	0.0				
72.40	32.7	-273.2	0.0				
79.30	25.8	-71.4	0.0				
86.20	18.9	0.0	82.7				
93.10	12.0	0.0	189.3				
100.00	5.1	0.0	248.2				
106.90	1.8	0.0	259.5				
113.80	8.7	0.0	223.3				
120.70	15.6	0.0	139.4				
127.60	22.5	0.0	7.8				
134.50	2.6	-171.3	0.0				
141.05	2.6	-154.1	0.0				
147.60	2.6	-137.0	0.0				
154.15	2.6	-119.9	0.0				
160.70	2.6	-102.8	0.0		Vus12=	34.426	kips
167.25	2.6	-85.6	0.0		Vsp12=	21.8	kips
173.80	2.6	-68.5	0.0		Mspmin12	-30.5	k-ft
180.35	2.6	-51.4	0.0		Mspmax12=	187.4	k-ft
186.90	2.6	-34.3	0.0		Mmax=	305.8	k-ft
193.45	2.6	-17.1	0.0		Mmin=	-522.5	k-ft
200.00	2.6	0.0	0.0		Vmax=	40.7	kips

$M_{12max} = 305.82$ ft·kip

$M_{12min} = -522.54$ ft·kip

$V_{us12} = 34.43$ kip

$V_{12max} = 40.73$ kip

$M_{2neg12} = -277.22$ ft·kip

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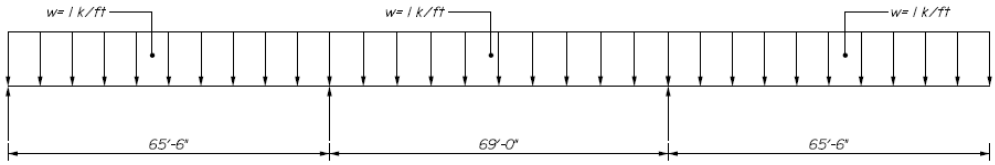
Uniform load all spans loaded



Uniform load positioned for maximum negative moment

Uniform load (spans 1,2 & 3 Loaded)								
Distance	Vmax	Mmin	Mmax		No	Rmin	Rmax	
0.00	25.9	0.0	0.0		1	0.0	25.9	
6.55	19.3	0.0	148.0		2	0.0	74.1	
13.10	12.8	0.0	253.1		3	0.0	74.1	
19.65	6.2	0.0	315.2		4	0.0	25.9	
26.20	0.3	0.0	334.5					
32.75	6.9	0.0	310.9					
39.30	13.4	0.0	244.3					
45.85	20.0	0.0	134.9					
52.40	26.5	-17.4	0.0					
58.95	33.1	-212.7	0.0					
65.50	39.6	-450.8	0.0					
72.40	27.6	-236.6	0.0					
79.30	20.7	-69.9	0.0					
86.20	13.8	0.0	49.1					
93.10	6.9	0.0	120.5					
100.00	0.0	0.0	144.3					
106.90	6.9	0.0	120.5					
113.80	13.8	0.0	49.1					
120.70	20.7	-69.9	0.0					
127.60	27.6	-236.6	0.0					
134.50	39.6	-450.8	0.0					
141.05	33.1	-212.7	0.0					
147.60	26.5	-17.4	0.0					
154.15	20.0	0.0	134.9					
160.70	13.4	0.0	244.3					
167.25	6.9	0.0	310.9		Vus123=		33.331	kips
173.80	0.3	0.0	334.5		Vsp123=		16.8	kips
180.35	6.2	0.0	315.2		Msp123=		-1.8	k-ft
186.90	12.8	0.0	253.1		Mmax=		334.5	k-ft
193.45	19.3	0.0	148.0		Mmin=		-450.8	k-ft
200.00	25.9	0.0	0.0		Vmax=		39.6	kips

$M_{123max} = 334.5$ ft·kip $\quad V_{123max} = 39.63$ kip $\quad V_{us123} = 33.33$ kip

$M_{123min} = -450.83$ ft·kip $\quad M_{2neg123} = -236.58$ ft·kip

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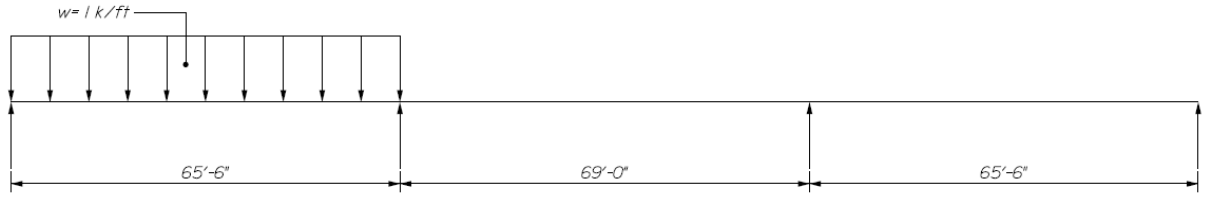
Uniform load Span #1 only loaded (max fluid load positive moment)



Uniform load span one only loaded

Uniform load (span 1 only Loaded)								
Distance	Vmax	Mmin	Mmax		No	Rmin	Rmax	
0.00	28.5	0.0	0.0		1	0.0	28.5	
6.55	21.9	0.0	165.1		2	0.0	42.1	
13.10	15.4	0.0	287.3		3	-6.2	0.0	
19.65	8.8	0.0	366.6		4	0.0	1.1	
26.20	2.3	0.0	403.0					
32.75	4.3	0.0	396.5					
39.30	10.8	0.0	347.1					
45.85	17.4	0.0	254.8					
52.40	23.9	0.0	119.6					
58.95	30.5	-58.5	0.0					
65.50	37.0	-279.6	0.0					
72.40	5.1	-244.4	0.0					
79.30	5.1	-209.3	0.0					
86.20	5.1	-174.2	0.0					
93.10	5.1	-139.1	0.0					
100.00	5.1	-103.9	0.0					
106.90	5.1	-68.8	0.0					
113.80	5.1	-33.7	0.0					
120.70	5.1	0.0	1.5					
127.60	5.1	0.0	36.6					
134.50	1.1	0.0	71.7					
141.05	1.1	0.0	64.5					
147.60	1.1	0.0	57.4					
154.15	1.1	0.0	50.2					
160.70	1.1	0.0	43.0					
167.25	1.1	0.0	35.9		Vus=		30.716	kips
173.80	1.1	0.0	28.7		Vsp=		5.1	kips
180.35	1.1	0.0	21.5		Msp1=		-189.2	k-ft
186.90	1.1	0.0	14.3		Mmax=		403.0	k-ft
193.45	1.1	0.0	7.2		Mmin=		-279.6	k-ft
200.00	1.1	0.0	0.0		Vmax=		37.0	kips

$M_{1max} = 403.01$ ft·kip

$M_{1min} = -279.56$ ft·kip

$V_{1max} = 37.02$ kip

$M_{2neg1} = 0$ ft·kip

$V_{us1} = 30.72$ kip

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Service Load Dead Load Moments
Maximum Positive Moments

$M1_{fluidint} := \frac{W_{intdeck}}{1\ klf} \cdot M_{123max} = 395.13\ ft{\cdot}kip$

$M1_{fluidext} := \frac{W_{extdeck}}{1\ klf} \cdot M_{123max} = 294.78\ ft{\cdot}kip$

$M1_{beam} := \frac{W_{stl}}{1\ klf} \cdot M_{123max} = 72.41\ ft{\cdot}kip$

$M1_{railint} := \frac{W_{intrail}}{1\ klf} \cdot M_{123max} = 41.32\ ft{\cdot}kip$

$M1_{railext} := \frac{W_{extrail}}{1\ klf} \cdot M_{123max} = 61.99\ ft{\cdot}kip$

$M1_{pvtint} := \frac{W_{intpvt}}{1\ klf} \cdot M_{123max} = 137.93\ ft{\cdot}kip$

$M1_{pvtext} := \frac{W_{extpvt}}{1\ klf} \cdot M_{123max} = 91.95\ ft{\cdot}kip$

$M1_{swdlext} := \frac{W_{altSWG1}}{1\ klf} \cdot M_{123max} = 140.49\ ft{\cdot}kip$

$M1_{swdlint} := \frac{W_{altSWint}}{1\ klf} \cdot M_{123max} = 46.83\ ft{\cdot}kip$

$M1_{altpvtg1} := \frac{W_{altpvtG1}}{1\ klf} \cdot M_{123max} = 30.7\ ft{\cdot}kip$

$M1_{utint} := \frac{W_{utint}}{1\ klf} \cdot M_{123max} = 83.62\ ft{\cdot}kip$

$IM := 33\%$ Dynamic Load Allowance

Strength I load Factors

$\gamma_{strIL} := 1.75$ $\gamma_{strIdc} := 1.25$ $\gamma_{strIdw} := 1.50$

Service II load Factors

$\gamma_{svcIIL} := 1.30$ $\gamma_{svcIIdc} := 1.00$ $\gamma_{svcIIdw} := 1.00$

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Capacity of Positive Moment Regions - Strength Capacity

Exterior Girders - Composite properties:

$$A_{deckexLT} := \left(\frac{S}{2} + OH\right) \cdot t_{deck} \cdot \frac{E_D}{3 \cdot E_B} = 0.26\ ft^2$$

$$A_{deckexST} := \left(\frac{S}{2} + OH\right) \cdot t_{deck} \cdot \frac{E_D}{E_B} = 0.78\ ft^2$$

$$y_{exlt} := \frac{\left(A_{deckexLT} \cdot \left(\frac{t_{deck}}{2} + d_{beam}\right) + A_g \cdot y_{bar}\right)}{\left(A_g + A_{deckexLT}\right)} = 28.12\ in$$

$$y_{exst} := \frac{\left(A_{deckexST} \cdot \left(\frac{t_{deck}}{2} + d_{beam}\right) + A_g \cdot y_{bar}\right)}{\left(A_g + A_{deckexST}\right)} = 34.27\ in$$

$$d_{tot} := t_{deck} + t_{tf} + d_w + t_{bf} = 46.25\ in$$

$$I_{extLT} := t_{deck}^{\ 3} \cdot \left(\frac{S}{2} + OH\right) \cdot \frac{E_D}{3 \cdot E_B} + A_{deckexLT} \cdot \left(d_{tot} - \frac{t_{deck}}{2} - y_{exlt}\right)^2 + I_x + A_g \cdot \left(y_{exlt} - y_{bar}\right)^2$$

$$I_{extLT} = 28305.42\ in^4$$

$$S_{extfLT} := \frac{I_{extLT}}{\left(d_{beam} - y_{exlt}\right)} = 3101.05\ in^3 \qquad S_{exbfLT} := \frac{I_{extLT}}{y_{exlt}} = 1006.51\ in^3$$

$$I_{extST} := t_{deck}^{\ 3} \cdot \left(\frac{S}{2} + OH\right) \cdot \frac{E_D}{E_B} + A_{deckexST} \cdot \left(d_{tot} - \frac{t_{deck}}{2} - y_{exst}\right)^2 + I_x + A_g \cdot \left(y_{exst} - y_{bar}\right)^2$$

$$I_{extST} = 41948.89\ in^4$$

$$S_{extfST} := \frac{I_{extST}}{\left(d_{beam} - y_{exst}\right)} = 14067.21\ in^3 \qquad S_{exbfST} := \frac{I_{extST}}{y_{exst}} = 1224.14\ in^3$$

Interior Girders - Composite properties:

$$A_{deckinLT} := S \cdot t_{deck} \cdot \frac{E_D}{3 \cdot E_B} = 0.35\ ft^2$$

$$A_{deckinST} := S \cdot t_{deck} \cdot \frac{E_D}{E_B} = 1.04\ ft^2$$

$$y_{inlt} := \frac{\left(A_{deckinLT} \cdot \left(\frac{t_{deck}}{2} + d_{beam}\right) + A_g \cdot y_{bar}\right)}{\left(A_g + A_{deckinLT}\right)} = 29.79\ in$$

$$y_{inst} := \frac{\left(A_{deckinST} \cdot \left(\frac{t_{deck}}{2} + d_{beam}\right) + A_g \cdot y_{bar}\right)}{\left(A_g + A_{deckinST}\right)} = 35.67\ in$$

$$d_{tot} = 46.25\ in$$

$$I_{intLT} := t_{deck}^3 \cdot S \cdot \frac{E_D}{3 \cdot E_B} + A_{deckinLT} \cdot \left(d_{tot} - \frac{t_{deck}}{2} - y_{inlt}\right)^2 + I_x + A_g \cdot \left(y_{inlt} - y_{bar}\right)^2$$

$$I_{intLT} = 31401.6\ in^4$$

$$S_{intflLT} := \frac{I_{intLT}}{\left(d_{beam} - y_{inlt}\right)} = 4211.53\ in^3 \qquad S_{inbflLT} := \frac{I_{intLT}}{y_{inlt}} = 1053.96\ in^3$$

$$I_{intST} := t_{deck}^3 \cdot S \cdot \frac{E_D}{E_B} + A_{deckinST} \cdot \left(d_{tot} - \frac{t_{deck}}{2} - y_{inst}\right)^2 + I_x + A_g \cdot \left(y_{inst} - y_{bar}\right)^2$$

$$I_{intST} = 46765.86\ in^4$$

$$S_{intfST} := \frac{I_{intST}}{\left(d_{beam} - y_{inst}\right)} = 29569.42\ in^3 \qquad S_{inbfST} := \frac{I_{intST}}{y_{inst}} = 1311.13\ in^3$$

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Calculation of yield moment at
Strength I condition Exterior Girder:

Appendix D6.2.2 Composite Sections in Positive Flexure

$F_y := 50$ ksi

$M_{D1ext} := \gamma_{strIdc} \cdot (M1_{fluidext} + M1_{beam}) = 458.98$ ft·kip

$M_{D2ext} := \gamma_{strIdw} \cdot M1_{pvtext} + \gamma_{strIdc} \cdot (M1_{railext} + M1_{swdlext}) = 391.02$ ft·kip

$$M_{ADexttf} := S_{extfST} \cdot \left(F_y - \frac{M_{D1ext}}{S_{tf}} - \frac{M_{D2ext}}{S_{extfLT}}\right) = 47955.18 \text{ ft·kip}$$

$$M_{ADextbf} := S_{exbfST} \cdot \left(F_y - \frac{M_{D1ext}}{S_{bf}} - \frac{M_{D2ext}}{S_{exbfLT}}\right) = 3851.89 \text{ ft·kip}$$

$M_{ADext} := min(M_{ADexttf}, M_{ADextbf}) = 3851.89$ ft·kip

By inspection Bottom flange governs yield moment calculations in the composite positive moment section.

$M_{yext} := M_{ADext} + M_{D1ext} + M_{D2ext} = 4701.9$ ft·kip

D6.2.2-2

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Check Plastic Moment:

Appendix D6.1-1 Composite Sections in Positive Flexure

$$P_{Se} := 0.85 \cdot f'_c \cdot \left(\frac{S}{2} + OH\right) \cdot t_{deck} = 2876.4 \text{ kip}$$

$$P_C := F_y \cdot A_{tf} = 900 \text{ kip}$$

per Appendix Pc stands for Compression flange

$$P_W := F_y \cdot A_w = 875 \text{ kip}$$

$$P_T := F_y \cdot A_{bf} = 900 \text{ kip}$$

per Appendix Pt stands for Tension flange

$$\text{Case} := \begin{array}{l} \text{if } \langle P_T + P_W \rangle > \langle P_C + P_{Se} \rangle \\ \quad \| \; 1 \\ \text{else if } \langle P_T + P_W + P_C \rangle > \langle P_{Se} \rangle \\ \quad \| \; 2 \\ \text{else} \\ \quad \| \; 3 \end{array} = 3$$

The Plastic Neutral Axis is in the concrete deck this is not unexpected, the reinforcing steel is neglected as part of the section for the sake of simplicity and conservatism.

$$Y_{pexbar} := t_{deck} \cdot \frac{\langle P_C + P_W + P_T \rangle}{P_{Se}} = 8.37 \text{ in}$$

$$d_{tfe} := t_{deck} - Y_{pexbar} + \frac{t_{tf}}{2} = 1.19 \text{ in}$$

$$d_{we} := d_{tfe} + \frac{t_{tf}}{2} + \frac{d_w}{2} = 19.26 \text{ in}$$

$$d_{bfe} := d_{we} + \frac{d_w}{2} + \frac{t_{bf}}{2} = 37.32 \text{ in}$$

$$M_{pex} := Y_{pexbar}^{\;2} \cdot \frac{P_{Se}}{2 \cdot t_{deck}} + \langle P_C \cdot d_{tfe} + P_W \cdot d_{we} + P_T \cdot d_{bfe} \rangle = 5225.18 \text{ ft}\cdot\text{kip}$$

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Nominal Flexural resistance per LRFD 6.10.7.1.2

$D_{pex} := Y_{pexbar} = 8.37$ in

$D_{tot} := t_{deck} + d_{beam} = 46.25$ in

$\frac{D_{pex}}{D_{tot}} = 0.18$

Dp/Dtot > 0.1 therefor full plastic moment cannot be reached

$M_{nex} := M_{pex} \cdot \left(1.07 - 0.7 \cdot \frac{D_{pex}}{D_{tot}}\right) = 4929.03$ ft·kip

6.10.7.1.2-2

$\varphi_f := 1.00$

Resistance Factor from LRFD 6.5.4.2

$M_{rex} := \varphi_f \cdot min\left(M_{nex}, 1.3 \cdot M_{yext}\right) = 4929.03$ ft·kip

Nominal moment capacity must be less than 1.3x the yield moment per 6.10.7.1.2-3

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Calculation of yield moment at
Strength I condition Interior Girder:

Appendix D6.2.2 Composite Sections in Positive Flexure

$F_y := 50$ ksi

$M_{D1int} := \gamma_{strIdc} \cdot \langle M1_{fluidint} + M1_{beam} \rangle = 584.42$ ft·kip

$M_{D2int} := \gamma_{strIdw} \cdot \langle M1_{pvtint} + M1_{utint} \rangle + \gamma_{strIdc} \cdot \langle M1_{railint} + M1_{swdlint} \rangle = 442.52$ ft·kip

$M_{ADinttf} := S_{intfST} \cdot \left(F_y - \frac{M_{D1int}}{S_{tf}} - \frac{M_{D2int}}{S_{intfLT}} \right) = 96320.07$ ft·kip

$M_{ADintbf} := S_{inbfST} \cdot \left(F_y - \frac{M_{D1int}}{S_{bf}} - \frac{M_{D2int}}{S_{inbfLT}} \right) = 3858.16$ ft·kip

$M_{ADint} := min \langle M_{ADinttf}, M_{ADintbf} \rangle = 3858.16$ ft·kip

$M_{yint} := M_{ADint} + M_{D1int} + M_{D2int} = 4885.1$ ft·kip

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Check Plastic Moment:

Appendix D6.1-1 Composite Sections in Positive Flexure

$P_{Si} := 0.85 \cdot f'_c \cdot S \cdot t_{deck} = 3855.6$ kip

$P_C := F_y \cdot A_{tf} = 900$ kip

per Appendix Pc stands for Compression flange

$P_W := F_y \cdot A_w = 875$ kip

$P_T := F_y \cdot A_{bf} = 900$ kip

per Appendix Pt stands for Tension flange

$$Case := \begin{cases} 1 & \text{if } \langle P_T + P_W \rangle > \langle P_C + P_{Si} \rangle \\ 2 & \text{else if } \langle P_T + P_W + P_C \rangle > \langle P_{Si} \rangle \\ 3 & \text{else} \end{cases} = 3$$

The Plastic Neutral Axis is in the concrete deck this is not unexpected, the reinforcing steel is neglected as part of the section for the sake of simplicity and conservatism.

$$Y_{pinbar} := t_{deck} \cdot \frac{\langle P_C + P_W + P_T \rangle}{P_{Si}} = 6.24 \text{ in}$$

$$d_{tfi} := t_{deck} - Y_{pinbar} + \frac{t_{tf}}{2} = 3.32 \text{ in}$$

$$d_{wi} := d_{tfi} + \frac{t_{tf}}{2} + \frac{d_w}{2} = 21.38 \text{ in}$$

$$d_{bfi} := d_{wi} + \frac{d_w}{2} + \frac{t_{bf}}{2} = 39.44 \text{ in}$$

$$M_{pin} := Y_{pinbar}^{\ 2} \cdot \frac{P_{Si}}{2 \cdot t_{deck}} + \langle P_C \cdot d_{tfi} + P_W \cdot d_{wi} + P_T \cdot d_{bfi} \rangle = 5462.11 \text{ ft·kip}$$

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Nominal Flexural resistance per LRFD 6.10.7.1.2

$D_{pin} := Y_{pinbar} = 6.24$ in

$D_{tot} := t_{deck} + d_{beam} = 46.25$ in

$\frac{D_{pin}}{D_{tot}} = 0.14$

Dp/Dtot > 0.1 therefor full plastic moment cannot be reached

$M_{nin} := M_{pin} \cdot \left(1.07 - 0.7 \cdot \frac{D_{pin}}{D_{tot}}\right) = 5328.25$ ft·kip

$\varphi_f := 1.00$

Resistance Factor from LRFD 6.5.4.2

$M_{rin} := \varphi_f \cdot min\left(M_{nin}, 1.3 \cdot M_{yint}\right) = 5328.25$ ft·kip

Nominal moment capacity must be less than 1.3x the yield moment per 6.10.7.1.2-3

Check Negative Moment Capacity
of exterior girders:

Check Local Buckling per 6.10.8.2.2

$\lambda_f := \frac{b_{bfnm}}{2 \cdot t_{bf}} = 8.17$ *flange slenderness ratio 6.10.8.2.2-3*

$D_c := y_{bar} = 18.63\ \text{in}$ $\lambda_{rw} := 5.7 \cdot \sqrt{\left(\frac{E_B}{F_y}\right)} = 137.27$ *6.10.6.2.3-1 to check load shedding factor - ie determination of web compactness*

$$R_b := \begin{cases} 1 & \text{if } \frac{2 \cdot D_c}{t_w} < \lambda_{rw} \\ \text{"load shedding factor must be calculated"} & \text{else} \end{cases} = 1$$

$R_h := 1$ *Section is not Hybrid, all plates are grade 50, therefor 6.10.1.10*

$F_{nclb} := R_b \cdot R_h \cdot F_y = 50\ \text{ksi}$ *Because the flange slenderness ratio is less than the compact flange slenderness ratio of 9.2 per C6.10.8.2.2-1*

Check Lateral torsional buckling resistance:
Cb taken as 1.0

$F_{yc} := F_y = 50\ \text{ksi}$

$F_{yr} := 0.7 \cdot F_{yc} = 35\ \text{ksi}$

$L_p := 1 \cdot r_{tbfnm} \cdot \sqrt{\frac{E_B}{F_y}} = 9.97\ \text{ft}$ *Unbraced length to achieve full yield stress of the flange*

$L_r := \pi \cdot r_{tbfnm} \cdot \sqrt{\frac{E_B}{F_y}} = 31.31\ \text{ft}$ *Unbraced length to achieve nominal initial yielding - 70% of yield strength*

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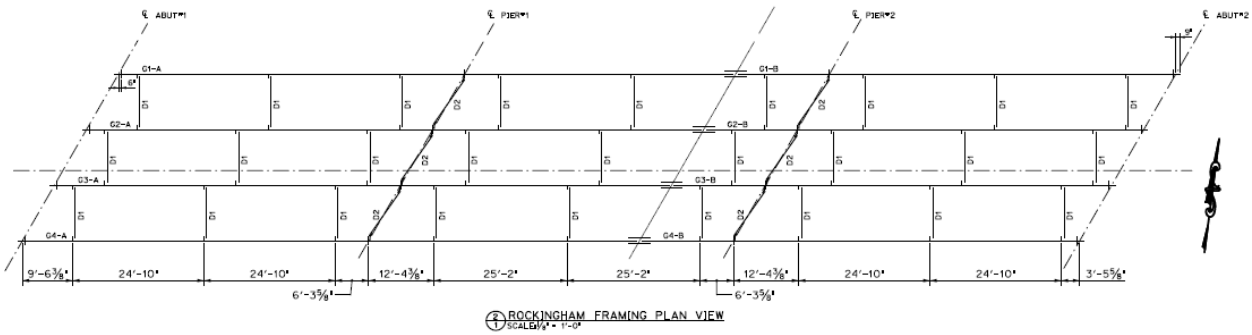

$L_{bpierext} := 12\ ft + 4.375\ in = 12.365\ ft$ *at pier locations (exterior girders only)*

$$F1_{ltbext} := \begin{cases} R_b \cdot R_h \cdot F_{yc} & \text{if } L_{bpierext} < L_p \\ \left(1 - \left(1 - \frac{F_{yr}}{R_h \cdot F_{yc}}\right) \cdot \left(\frac{L_{bpierext} - L_p}{L_r - L_p}\right)\right) \cdot R_b \cdot R_h \cdot F_{yc} & \text{else if } L_{bpierext} < L_r \\ \frac{\left(R_b \cdot \pi^2 \cdot E_B\right)}{\left(\frac{L_{bpierext}}{r_{tbf}}\right)^2} & \text{else} \end{cases} = 48.31\ ksi$$

$F1_{ncext} := min\left(F1_{ltbext}, F_{nclb}\right) = 48.31\ ksi$ $\quad F1_{nt} := R_h \cdot F_y = 50\ ksi$

$F1_{rcext} := \varphi_f \cdot F1_{ncext} = 48.31\ ksi$ $\quad F1_{rt} := \varphi_f \cdot F1_{nt} = 50\ ksi$

$L_{bpierint} := 6\ ft + 3.625\ in = 6.302\ ft$ *at pier locations (interior girders only)*

$$F1_{ltbint} := \begin{cases} R_b \cdot R_h \cdot F_{yc} & \text{if } L_{bpierint} < L_p \\ \left(1 - \left(1 - \frac{F_{yr}}{R_h \cdot F_{yc}}\right) \cdot \left(\frac{L_{bpierext} - L_p}{L_r - L_p}\right)\right) \cdot R_b \cdot R_h \cdot F_{yc} & \text{else if } L_{bpierint} < L_r \\ \frac{\left(R_b \cdot \pi^2 \cdot E_B\right)}{\left(\frac{L_{bpierext}}{r_{tbf}}\right)^2} & \text{else} \end{cases} = 50\ ksi$$

$F1_{ncint} := min\left(F1_{ltbint}, F_{nclb}\right) = 50\ ksi$ $\qquad$ $F1_{nt} := R_h \cdot F_y = 50\ ksi$

$F1_{rcint} := \varphi_f \cdot F1_{ncint} = 50\ ksi$ $\qquad$ $F1_{rt} := \varphi_f \cdot F1_{nt} = 50\ ksi$

$L_{2bpier} := 25\ ft + 2\ in = 25.17\ ft$

adjacent to next Cross frame at pier locations - interior or exterior

$$F2_{ltb} := \begin{cases} R_b \cdot R_h \cdot F_{yc} & \text{if } L_{2bpier} < L_p \\ \left(1 - \left(1 - \frac{F_{yr}}{R_h \cdot F_{yc}}\right) \cdot \left(\frac{L_{2bpier} - L_p}{L_r - L_p}\right)\right) \cdot R_b \cdot R_h \cdot F_{yc} & \text{else if } L_{2bpier} < L_r \\ \frac{\left(R_b \cdot \pi^2 \cdot E_B\right)}{\left(\frac{L_{2bpier}}{r_{tbf}}\right)^2} & \text{else} \end{cases} = 39.32\ ksi$$

$F2_{nc} := min\left(F2_{ltb}, F_{nclb}\right)$

$F2_{rc} := \varphi_f \cdot F2_{nc} = 39.32\ ksi$

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Service II capacity of girder flanges

$F_{svcIIpos} := 0.95 \cdot F_y = 47.5$ ksi

Per LRFD 6.10.4.2.2 for both top flanges and bottom flanges where deck is composite with steel

$F_{svcIIneg} := 0.80 \cdot F_y = 40$ ksi

Per LRFD 6.10.4.2.2 for both top flanges and bottom flanges where deck is not composite with steel (negative moment region)

$C_{s2pos} := F_{svcIIpos} = 47.5$ ksi

$C_{s2neg} := -F_{svcIIneg} = -40$ ksi

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Shear computations: (vertical shear)

Nominal resistance of Unstiffened webs per 6.10.9.2

$D := d_w = 35$ in $\qquad F_{yw} := F_y = 50$ ksi

$V_p := 0.58 \cdot t_w \cdot D \cdot F_{yw} = 507.5$ kip

$k_u := 5$ *for unstiffened panels per 6.10.9.2*

$\frac{D}{t_w} = 70$ $\qquad \varphi_v := 1.0$ *Per 6.5.4.2 for Shear*

$1.12 \cdot \sqrt{\frac{E_B \cdot k_u}{F_{yw}}} = 60.31 \qquad 1.40 \cdot \sqrt{\frac{E_B \cdot k_u}{F_{yw}}} = 75.39$

Because D/tw < 75.39 & > 60.31:

$$C_u := \frac{1.12}{\frac{D}{t_w}} \cdot \sqrt{\frac{E_B \cdot k_u}{F_{yw}}} = 0.86$$

$V_{nu} := C_u \cdot V_p = 437.28$ kip $\qquad V_{ru} := \varphi_v \cdot V_{nu} = 437.28$ kip *for unstiffened regions*

For interior girders near interior supports with connection plates w/in 75.625" of Bearing Stiffener $\qquad d_o := 75.625$ in

$$k_s := 5 + \frac{5}{\left(\frac{d_o}{D}\right)^2} = 6.07$$ *6.10.9.3.2-7*

$1.12 \cdot \sqrt{\frac{E_B \cdot k_s}{F_{yw}}} = 66.46 \qquad 1.40 \cdot \sqrt{\frac{E_B \cdot k_s}{F_{yw}}} = 83.08$

Because D/tw between 66.46 & 83.08 (D/tw =80) use eqn: 6.10.9.3.2-5 for C

$$C_s := \frac{1.12}{\frac{D}{t_w}} \cdot \sqrt{\frac{E_B \cdot k_s}{F_{yw}}} = 0.95$$

$V_{ns} := C_s \cdot V_p = 481.84$ kip $\qquad V_{rs} := \varphi_v \cdot V_{ns} = 481.84$ kip *For Stiffened Regions at adjacent to piers*

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The Following Computations are the load calculation portion of the load rating, all the computations prior to this are the capacity portion of the load rating - for simplicity it makes sense for us to summarize the capacities as we are doing the load rating.

The general load rating formula is as follows:

[Capacity - factored Dead Loads]/factored live load with impact = Rating Factor

Rating factors for Inventory ratings use a live load factor of 1.75 for strength conditions, and 1.30 for service II conditions

Rating factors for Operating ratings use a live load factor of 1.35 for strength and 1.00 for service II conditions

to get the load rating in Tons for either operating or inventory multiply the rating factor by the weight of the design vehicle used to calculate the specific rating factor in tons. LRFR 6A.4.2.1-1

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Flexural Design Load Rating: Calculation of Maximum Moments factor of 2 applied to those trucks where reactions were determined using a single wheelline

Positive Moments - Unfactored

$$M1_{HL93} := g_{pm} \cdot \left((100\% + IM) \cdot \max\left(M_{maxhs20}, M_{maxtan}\right) + \left(\frac{0.64 \cdot klf}{1\ klf}\right) \cdot \max\left(M_{13max}, M_{123max}\right) \right)$$

$M1_{HL93} = 999.11\ ft{\cdot}kip$

$M1_{3s2} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{max3s2} = 615.49\ ft{\cdot}kip$

$M1_{6at} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{max6at} = 938.23\ ft{\cdot}kip$

$M1_{3as} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{max3as} = 719.7\ ft{\cdot}kip$

$M1_{4as} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{max4as} = 828.07\ ft{\cdot}kip$

$M1_{5as} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{max5as} = 724.12\ ft{\cdot}kip$

$M1_{h20} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{maxh20} = 525.68\ ft{\cdot}kip$

$C_{fep} := M_{rex} = 4929.03\ ft{\cdot}kip$

$C_{fip} := M_{rin} = 5328.25\ ft{\cdot}kip$

$\gamma_{strop} := 1.35$

Positive Moment Load Factors
Exterior Girders:

$$RF_{fepinvHL93} := \frac{C_{fep} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railext} + M1_{swdlext} + M1_{fluidext}) - \gamma_{strIdw} \cdot (M1_{altpvtg1})}{\gamma_{strIL} \cdot M1_{HL93}} = 2.385$$

$invratHL93e := 36\ tonf \cdot RF_{fepinvHL93} = 85.88\ tonf$

$operatHL93e := 36\ tonf \cdot RF_{fepopHL93} = 111.32\ tonf$

$$RF_{fepopHL93} := RF_{fepinvHL93} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.09$$

$$RF_{fepinv3s2} := \frac{C_{fep} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railext} + M1_{swdlext} + M1_{fluidext}) - \gamma_{strIdw} \cdot (M1_{altpvtg1})}{\gamma_{strIL} \cdot M1_{3s2}} = 3.872$$

$invrat3s2e := 36\ tonf \cdot RF_{fepinv3s2} = 139.4\ tonf$

$operat3s2e := 36\ tonf \cdot RF_{fepop3s2} = 180.71\ tonf$

$$RF_{fepop3s2} := RF_{fepinv3s2} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 5.02$$

$$RF_{fepinv6at} := \frac{C_{fep} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railext} + M1_{swdlext} + M1_{fluidext}) - \gamma_{strIdw} \cdot (M1_{altpvtg1})}{\gamma_{strIL} \cdot M1_{6at}} = 2.54$$

$invrat6ate := 66\ tonf \cdot RF_{fepinv6at} = 167.66\ tonf$

$operat6ate := 66\ tonf \cdot RF_{fepop6at} = 217.33\ tonf$

$$RF_{fepop6at} := RF_{fepinv6at} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.29$$

$$RF_{fepinv3as} := \frac{C_{fep} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railext} + M1_{swdlext} + M1_{fluidext}) - \gamma_{strIdw} \cdot (M1_{altpvtg1})}{\gamma_{strIL} \cdot M1_{3as}} = 3.312$$

$invrat3ase := 30\ tonf \cdot RF_{fepinv3as} = 99.35\ tonf$

$operat3ase := 30\ tonf \cdot RF_{fepop3as} = 128.79\ tonf$

$$RF_{fepop3as} := RF_{fepinv3as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.29$$

$$RF_{fepinv4as} := \frac{C_{fep} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railext} + M1_{swdlext} + M1_{fluidext}) - \gamma_{strIdw} \cdot (M1_{altpvtg1})}{\gamma_{strIL} \cdot M1_{4as}} = 2.878$$

$invrat4ase := 34.5\ tonf \cdot RF_{fepinv4as} = 99.3\ tonf$

$operat4ase := 34.5\ tonf \cdot RF_{fepop4as} = 128.72\ tonf$

$$RF_{fepop4as} := RF_{fepinv4as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.73$$

$$RF_{fepinv5as} := \frac{C_{fep} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railext} + M1_{swdlext} + M1_{fluidext}) - \gamma_{strIdw} \cdot (M1_{altpvtg1})}{\gamma_{strIL} \cdot M1_{5as}} = 3.291$$

$invrat5ase := 38\ tonf \cdot RF_{fepinv5as} = 125.07\ tonf$

$operat5ase := 38\ tonf \cdot RF_{fepop5as} = 162.13\ tonf$

$$RF_{fepop5as} := RF_{fepinv5as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.27$$

$$RF_{fepinvh20} := \frac{C_{fep} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railext} + M1_{swdlext} + M1_{fluidext}) - \gamma_{strIdw} \cdot (M1_{altpvtg1})}{\gamma_{strIL} \cdot M1_{h20}} = 4.534$$

$invratH20e := 20\ tonf \cdot RF_{fepinvh20} = 90.68\ tonf$

$operatH20e := 20\ tonf \cdot RF_{fepoph20} = 117.54\ tonf$

$$RF_{fepoph20} := RF_{fepinvh20} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 5.88$$

$INV_{posmomex} := min(invratHL93e, invrat3s2e, invrat6ate, invrat3ase, invrat4ase, invrat5ase, invratH20e)$

$OPER_{posmomex} := min(operatHL93e, operat3s2e, operat6ate, operat3ase, operat4ase, operat5ase, operatH20e)$

$INV_{posmomex} = 85.88\ tonf$ $OPER_{posmomex} = 111.32\ tonf$

Controlling Positive flexure ratings - exterior

CALDERWOOD ENGINEERING
222 RIVER ROAD
RICHMOND, ME 04357
PH. (207) 737-2007 FAX (207) 737-2008

Positive Moment Load Factors
Interior Girders:

$$RF_{fipinvHL93} := \frac{C_{fip} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railint} + M1_{swdlint} + M1_{fluidint}) - \gamma_{strIdw} \cdot (M1_{pvtint} + M1_{utint})}{\gamma_{strIL} \cdot M1_{HL93}} = 2.46$$

$invratHL93i := 36\ tonf \cdot RF_{fipinvHL93} = 88.56\ tonf$

$operatHL93i := 36\ tonf \cdot RF_{fipopHL93} = 114.8\ tonf$

$$RF_{fipopHL93} := RF_{fipinvHL93} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.19$$

$$RF_{fipinv3s2} := \frac{C_{fip} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railint} + M1_{swdlint} + M1_{fluidint}) - \gamma_{strIdw} \cdot (M1_{pvtint} + M1_{utint})}{\gamma_{strIL} \cdot M1_{3s2}} = 3.993$$

$invrat3s2i := 36\ tonf \cdot RF_{fipinv3s2} = 143.76\ tonf$

$operat3s2i := 36\ tonf \cdot RF_{fipop3s2} = 186.36\ tonf$

$$RF_{fipop3s2} := RF_{fipinv3s2} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 5.18$$

$$RF_{fipinv6at} := \frac{C_{fip} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railint} + M1_{swdlint} + M1_{fluidint}) - \gamma_{strIdw} \cdot (M1_{pvtint} + M1_{utint})}{\gamma_{strIL} \cdot M1_{6at}} = 2.62$$

$invrat6ati := 66\ tonf \cdot RF_{fipinv6at} = 172.9\ tonf$

$operat6ati := 66\ tonf \cdot RF_{fipop6at} = 224.13\ tonf$

$$RF_{fipop6at} := RF_{fipinv6at} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.4$$

$$RF_{fipinv3as} := \frac{C_{fip} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railint} + M1_{swdlint} + M1_{fluidint}) - \gamma_{strIdw} \cdot (M1_{pvtint} + M1_{utint})}{\gamma_{strIL} \cdot M1_{3as}} = 3.415$$

$invrat3asi := 30\ tonf \cdot RF_{fipinv3as} = 102.46\ tonf$

$operat3asi := 30\ tonf \cdot RF_{fipop3as} = 132.81\ tonf$

$$RF_{fipop3as} := RF_{fipinv3as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.43$$

$$RF_{fipinv4as} := \frac{C_{fip} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railint} + M1_{swdlint} + M1_{fluidint}) - \gamma_{strIdw} \cdot (M1_{pvtint} + M1_{utint})}{\gamma_{strIL} \cdot M1_{4as}} = 2.968$$

$invrat4asi := 34.5\ tonf \cdot RF_{fipinv4as} = 102.4\ tonf$

$operat4asi := 34.5\ tonf \cdot RF_{fipop4as} = 132.75\ tonf$

$$RF_{fipop4as} := RF_{fipinv4as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.85$$

$$RF_{fipinv5as} := \frac{C_{fip} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railint} + M1_{swdlint} + M1_{fluidint}) - \gamma_{strIdw} \cdot (M1_{pvtint} + M1_{utint})}{\gamma_{strIL} \cdot M1_{5as}} = 3.394$$

$invrat5asi := 38\ tonf \cdot RF_{fipinv5as} = 128.98\ tonf$

$operat5asi := 38\ tonf \cdot RF_{fipop5as} = 167.2\ tonf$

$$RF_{fipop5as} := RF_{fipinv5as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.4$$

$$RF_{fipinvh20} := \frac{C_{fip} - \gamma_{strIdc} \cdot (M1_{beam} + M1_{railint} + M1_{swdlint} + M1_{fluidint}) - \gamma_{strIdw} \cdot (M1_{pvtint} + M1_{utint})}{\gamma_{strIL} \cdot M1_{h20}} = 4.676$$

$invratH20i := 20\ tonf \cdot RF_{fipinvh20} = 93.51\ tonf$

$operatH20i := 20\ tonf \cdot RF_{fipoph20} = 121.22\ tonf$

$$RF_{fipoph20} := RF_{fipinvh20} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 6.06$$

$INV_{posmomin} := min(invratHL93i, invrat3s2i, invrat6ati, invrat3asi, invrat4asi, invrat5asi, invratH20i)$

$OPER_{posmomin} := min(operatHL93i, operat3s2i, operat6ati, operat3asi, operat4asi, operat5asi, operatH20i)$

$INV_{posmomin} = 88.56\ tonf$ $OPER_{posmomin} = 114.8\ tonf$

Controlling Positive flexure ratings - interior

CALDERWOOD ENGINEERING
222 RIVER ROAD
RICHMOND, ME 04357
PH. (207) 737-2007 FAX (207) 737-2008

Negative Moments: Dead & Live
Loads at pier CL brg

$M2_{fluidint} := \frac{W_{intdeck}}{1\ klf} \cdot M_{123min} = -532.54\ ft{\cdot}kip$

$M2_{fluidext} := \frac{W_{extdeck}}{1\ klf} \cdot M_{123min} = -397.29\ ft{\cdot}kip$

$M2_{beam} := \frac{W_{stl}}{1\ klf} \cdot M_{123min} = -97.59\ ft{\cdot}kip$

$M2_{railint} := \frac{W_{intrail}}{1\ klf} \cdot M_{123min} = -55.7\ ft{\cdot}kip$

$M2_{railext} := \frac{W_{extrail}}{1\ klf} \cdot M_{123min} = -83.54\ ft{\cdot}kip$

$M2_{pvtint} := \frac{W_{intpvt}}{1\ klf} \cdot M_{123min} = -185.9\ ft{\cdot}kip$

$M2_{pvtext} := \frac{W_{extpvt}}{1\ klf} \cdot M_{123min} = -123.93\ ft{\cdot}kip$

$M2_{swdlext} := \frac{W_{altSWG1}}{1\ klf} \cdot M_{123min} = -189.35\ ft{\cdot}kip$

$M2_{swdlint} := \frac{W_{altSWint}}{1\ klf} \cdot M_{123min} = -63.12\ ft{\cdot}kip$

$M2_{altpvtg1} := \frac{W_{altpvtG1}}{1\ klf} \cdot M_{123min} = -41.38\ ft{\cdot}kip$

$M2_{utint} := \frac{W_{utint}}{1\ klf} \cdot M_{123min} = -112.71\ ft{\cdot}kip$

$$M2_{HL93} := g_{nm} \cdot \left((100\% + IM) \cdot min\left(M_{minhs20}, M_{minnmtt}\right) + \frac{0.64 \cdot klf}{1\ klf} \cdot min\left(M_{123min}, M_{12min}\right) \right)$$

$M2_{HL93} = -979.42\ ft{\cdot}kip$

$M2_{3s2} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{min3s2} = -405.08\ ft{\cdot}kip$

$M2_{6at} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{min6at} = -819\ ft{\cdot}kip$

$M2_{3as} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{min3as} = -410.89\ ft{\cdot}kip$

$M2_{4as} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{min4as} = -469.58\ ft{\cdot}kip$

$M2_{5as} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{min5as} = -468.75\ ft{\cdot}kip$

$M2_{h20} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{minh20} = -281.01\ ft{\cdot}kip$

$C_{fen} := -F1_{rcext} = -48.31\ ksi$

$C_{fin} := -F1_{rcint} = -50\ ksi$

For negative moment capacity capacity is clearly controlled by the compression flange, tensile flange "stresses" need not be checked

Negative Moment Load Factors
Exterior Girders at piers:

$$RF_{feninvHL93} := \frac{C_{fen} - \gamma_{strIdc} \cdot \frac{(M2_{beam} + M2_{railext} + M2_{fluidext} + M2_{swdlext})}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M2_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{HL93}}{S_{bfnm}}} = 1.331$$

$invratHL93ne := 36\ tonf \cdot RF_{feninvHL93} = 47.91\ tonf$

$operatHL93ne := 36\ tonf \cdot RF_{fenopHL93} = 62.11\ tonf$

$$RF_{fenopHL93} := RF_{feninvHL93} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 1.73$$

$$RF_{feninv3s2} := \frac{C_{fen} - \gamma_{strIdc} \cdot \frac{(M2_{beam} + M2_{railext} + M2_{fluidext} + M2_{swdlext})}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M2_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{3s2}}{S_{bfnm}}} = 3.218$$

$invrat3s2ne := 36\ tonf \cdot RF_{feninv3s2} = 115.85\ tonf$

$operat3s2ne := 36\ tonf \cdot RF_{fenop3s2} = 150.17\ tonf$

$$RF_{fenop3s2} := RF_{feninv3s2} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.17$$

$$RF_{feninv6at} := \frac{C_{fen} - \gamma_{strIdc} \cdot \frac{(M2_{beam} + M2_{railext} + M2_{fluidext} + M2_{swdlext})}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M2_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{6at}}{S_{bfnm}}} = 1.592$$

$invrat6atne := 66\ tonf \cdot RF_{feninv6at} = 105.05\ tonf$

$operat6atne := 66\ tonf \cdot RF_{fenop6at} = 136.17\ tonf$

$$RF_{fenop6at} := RF_{feninv6at} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.06$$

$$RF_{feninv3as} := \frac{C_{fen} - \gamma_{strIdc} \cdot \frac{(M2_{beam} + M2_{railext} + M2_{fluidext} + M2_{swdlext})}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M2_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{3as}}{S_{bfnm}}} = 3.172$$

$invrat3asne := 30\ tonf \cdot RF_{feninv3as} = 95.17\ tonf$

$operat3asne := 30\ tonf \cdot RF_{fenop3as} = 123.37\ tonf$

$$RF_{fenop3as} := RF_{feninv3as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.11$$

$$RF_{feninv4as} := \frac{C_{fen} - \gamma_{strIdc} \cdot \frac{(M2_{beam} + M2_{railext} + M2_{fluidext} + M2_{swdlext})}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M2_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{4as}}{S_{bfnm}}} = 2.776$$

$invrat4asne := 34.5\ tonf \cdot RF_{feninv4as} = 95.77\ tonf$

$operat4asne := 34.5\ tonf \cdot RF_{fenop4as} = 124.15\ tonf$

$$RF_{fenop4as} := RF_{feninv4as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.6$$

$$RF_{feninv5as} := \frac{C_{fen} - \gamma_{strIdc} \cdot \frac{(M2_{beam} + M2_{railext} + M2_{fluidext} + M2_{swdlext})}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M2_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{5as}}{S_{bfnm}}} = 2.781$$

$invrat5asne := 38\ tonf \cdot RF_{feninv5as} = 105.67\ tonf$

$operat5asne := 38\ tonf \cdot RF_{fenop5as} = 136.98\ tonf$

$$RF_{fenop5as} := RF_{feninv5as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.6$$

$$RF_{feninvh20} := \frac{C_{fen} - \gamma_{strIdc} \cdot \frac{(M2_{beam} + M2_{railext} + M2_{fluidext} + M2_{swdlext})}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M2_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{h20}}{S_{bfnm}}} = 4.639$$

$invrath20ne := 20\ tonf \cdot RF_{feninv5as} = 55.62\ tonf$

$operath20ne := 20\ tonf \cdot RF_{fenop5as} = 72.1\ tonf$

$$RF_{fenoph20} := RF_{feninvh20} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 6.01$$

$INV_{negmomex} := min(invratHL93ne, invrat3s2ne, invrat6atne, invrat3asne, invrat4asne, invrat5asne, invrath20ne)$

$OPER_{negmomex} := min(operatHL93ne, operat3s2ne, operat6atne, operat3asne, operat4asne, operat5asne, operath20ne)$

$INV_{negmomex} = 47.91\ tonf$

$OPER_{negmomex} = 62.11\ tonf$

Controlling negative flexure ratings - exterior

Negative Moment Load Factors
Interior Girders at piers:

$$RF_{fininvHL93} := \frac{C_{fin} - \gamma_{strIdc} \cdot \frac{\langle M2_{beam} + M2_{railint} + M2_{fluidint} + M2_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{\langle M2_{pvtint} + M2_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{HL93}}{S_{bfnm}}} = 1.187$$

$invratHL93ni := 36\ tonf \cdot RF_{fininvHL93} = 42.72\ tonf$

$operatHL93ni := 36\ tonf \cdot RF_{finopHL93} = 55.38\ tonf$

$$RF_{finopHL93} := RF_{fininvHL93} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 1.54$$

$$RF_{fininv3s2} := \frac{C_{fin} - \gamma_{strIdc} \cdot \frac{\langle M2_{beam} + M2_{railint} + M2_{fluidint} + M2_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{\langle M2_{pvtint} + M2_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{3s2}}{S_{bfnm}}} = 2.869$$

$invrat3s2ni := 36\ tonf \cdot RF_{fininv3s2} = 103.3\ tonf$

$operat3s2ni := 36\ tonf \cdot RF_{finop3s2} = 133.91\ tonf$

$$RF_{finop3s2} := RF_{fininv3s2} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.72$$

$$RF_{fininv6at} := \frac{C_{fin} - \gamma_{strIdc} \cdot \frac{\langle M2_{beam} + M2_{railint} + M2_{fluidint} + M2_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{\langle M2_{pvtint} + M2_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{6at}}{S_{bfnm}}} = 1.419$$

$invrat6atni := 66\ tonf \cdot RF_{fininv6at} = 93.67\ tonf$

$operat6atni := 66\ tonf \cdot RF_{finop6at} = 121.42\ tonf$

$$RF_{finop6at} := RF_{fininv6at} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 1.84$$

$$RF_{fininv3as} := \frac{C_{fin} - \gamma_{strIdc} \cdot \frac{\langle M2_{beam} + M2_{railint} + M2_{fluidint} + M2_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{\langle M2_{pvtint} + M2_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{3as}}{S_{bfnm}}} = 2.829$$

$invrat3asni := 30\ tonf \cdot RF_{fininv3as} = 84.87\ tonf$

$operat3asni := 30\ tonf \cdot RF_{finop3as} = 110.01\ tonf$

$$RF_{finop3as} := RF_{fininv3as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.67$$

$$RF_{fininv4as} := \frac{C_{fin} - \gamma_{strIdc} \cdot \frac{\langle M2_{beam} + M2_{railint} + M2_{fluidint} + M2_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{\langle M2_{pvtint} + M2_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{4as}}{S_{bfnm}}} = 2.475$$

$invrat4asni := 34.5\ tonf \cdot RF_{fininv4as} = 85.4\ tonf$

$operat4asni := 34.5\ tonf \cdot RF_{finop4as} = 110.7\ tonf$

$$RF_{finop4as} := RF_{fininv4as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.21$$

$$RF_{fininv5as} := \frac{C_{fin} - \gamma_{strIdc} \cdot \frac{(M2_{beam} + M2_{railint} + M2_{fluidint} + M2_{swdlint})}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{(M2_{pvtint} + M2_{utint})}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{5as}}{S_{bfnm}}} = 2.48$$

$invrat5asni := 38\ tonf \cdot RF_{fininv5as} = 94.23\ tonf$

$operat5asni := 38\ tonf \cdot RF_{finop5as} = 122.15\ tonf$

$RF_{finop5as} := RF_{fininv5as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.21$

$$RF_{fininvh20} := \frac{C_{fin} - \gamma_{strIdc} \cdot \frac{(M2_{beam} + M2_{railint} + M2_{fluidint} + M2_{swdlint})}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{(M2_{pvtint} + M2_{utint})}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M2_{h20}}{S_{bfnm}}} = 4.136$$

$invrath20ni := 20\ tonf \cdot RF_{fininv5as} = 49.59\ tonf$

$operath20ni := 20\ tonf \cdot RF_{finop5as} = 64.29\ tonf$

$RF_{finoph20} := RF_{fininvh20} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 5.36$

$INV_{negmomin} := min(invratHL93ni, invrat3s2ni, invrat6atni, invrat3asni, invrat4asni, invrat5asni, invrath20ni)$

$OPER_{negmomin} := min(operatHL93ni, operat3s2ni, operat6atni, operat3asni, operat4asni, operat5asni, operath20ni)$

$INV_{negmomin} = 42.72\ tonf$

$OPER_{negmomin} = 55.38\ tonf$

Controlling negative flexure ratings - interior

CALDERWOOD ENGINEERING
222 RIVER ROAD
RICHMOND, ME 04357
PH. (207) 737-2007 FAX (207) 737-2008

Negative Moments: Dead & Live
Loads at pier CL brg

$M3_{fluidint} := \frac{W_{intdeck}}{1\ klf} \cdot M_{2neg123} = -279.46\ ft{\cdot}kip$

$M3_{fluidext} := \frac{W_{extdeck}}{1\ klf} \cdot M_{2neg123} = -208.49\ ft{\cdot}kip$

$M3_{beam} := \frac{W_{stl}}{1\ klf} \cdot M_{2neg123} = -51.21\ ft{\cdot}kip$

$M3_{railint} := \frac{W_{intrail}}{1\ klf} \cdot M_{2neg123} = -29.23\ ft{\cdot}kip$

$M3_{railext} := \frac{W_{extrail}}{1\ klf} \cdot M_{2neg123} = -43.84\ ft{\cdot}kip$

$M3_{pvtint} := \frac{W_{intpvt}}{1\ klf} \cdot M_{2neg123} = -97.55\ ft{\cdot}kip$

$M3_{pvtext} := \frac{W_{extpvt}}{1\ klf} \cdot M_{2neg123} = -65.04\ ft{\cdot}kip$

$M3_{swdlext} := \frac{W_{altSWG1}}{1\ klf} \cdot M_{2neg123} = -99.37\ ft{\cdot}kip$

$M3_{swdlint} := \frac{W_{altSWint}}{1\ klf} \cdot M_{2neg123} = -33.12\ ft{\cdot}kip$

$M3_{altpvtg1} := \frac{W_{altpvtG1}}{1\ klf} \cdot M_{2neg123} = -21.72\ ft{\cdot}kip$

$M3_{utint} := \frac{W_{utint}}{1\ klf} \cdot M_{2neg123} = -59.15\ ft{\cdot}kip$

$$M3_{HL93} := g_{nm} \cdot \left((100\% + IM) \cdot min\left(M_{2neghs20}, M_{2negnmtt}\right) + \frac{0.64 \cdot klf}{1\ klf} \cdot min\left(M_{2neg123}, M_{2neg12}\right) \right)$$

$M3_{HL93} = -620.07\ ft{\cdot}kip$

$M3_{3s2} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{2neg3s2} = -354.18\ ft{\cdot}kip$

$C_{f2n} := -F2_{rc} = -39.32\ ksi$

$M3_{6at} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{2neg6at} = -514.79\ ft{\cdot}kip$

$M3_{3as} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{2neg3as} = -359.27\ ft{\cdot}kip$

$M3_{4as} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{2neg4as} = -410.58\ ft{\cdot}kip$

$M3_{5as} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{2neg5as} = -409.85\ ft{\cdot}kip$

$M3_{h20} := 2 \cdot g_{pm} \cdot (100\% + IM) \cdot M_{2negh20} = -245.7\ ft{\cdot}kip$

For negative moment capacity capacity is clearly controlled by the compression flange, tensile flange "stresses" need not be checked

Negative Moment Load Factors
Exterior Girders at 1st diaphragm
back from pier:

$$RF2_{feninvHL93} := \frac{C_{f2n} - \gamma_{strIdc} \cdot \frac{\langle M3_{beam} + M3_{railext} + M3_{fluidext} + M3_{swdlext} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M3_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{HL93}}{S_{bfnm}}} = 1.983$$

$invratHL93n2e := 36\ tonf \cdot RF2_{feninvHL93} = 71.38\ tonf$

$operatHL93n2e := 36\ tonf \cdot RF2_{fenopHL93} = 92.54\ tonf$

$$RF2_{fenopHL93} := RF2_{feninvHL93} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.57$$

$$RF2_{feninv3s2} := \frac{C_{f2n} - \gamma_{strIdc} \cdot \frac{\langle M3_{beam} + M3_{railext} + M3_{fluidext} + M3_{swdlext} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M3_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{3s2}}{S_{bfnm}}} = 3.472$$

$invrat3s2n2e := 36\ tonf \cdot RF2_{feninv3s2} = 124.97\ tonf$

$operat3s2n2e := 36\ tonf \cdot RF2_{fenop3s2} = 162\ tonf$

$$RF2_{fenop3s2} := RF2_{feninv3s2} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.5$$

$$RF2_{feninv6at} := \frac{C_{f2n} - \gamma_{strIdc} \cdot \frac{\langle M3_{beam} + M3_{railext} + M3_{fluidext} + M3_{swdlext} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M3_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{6at}}{S_{bfnm}}} = 2.388$$

$invrat6atn2e := 66\ tonf \cdot RF2_{feninv6at} = 157.64\ tonf$

$operat6atn2e := 66\ tonf \cdot RF2_{fenop6at} = 204.34\ tonf$

$$RF2_{fenop6at} := RF2_{feninv6at} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.1$$

$$RF2_{feninv3as} := \frac{C_{f2n} - \gamma_{strIdc} \cdot \frac{\langle M3_{beam} + M3_{railext} + M3_{fluidext} + M3_{swdlext} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M3_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{3as}}{S_{bfnm}}} = 3.422$$

$invrat3asn2e := 30\ tonf \cdot RF2_{feninv3as} = 102.67\ tonf$

$operat3asn2e := 30\ tonf \cdot RF2_{fenop3as} = 133.09\ tonf$

$$RF2_{fenop3as} := RF2_{feninv3as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.44$$

$$RF2_{feninv4as} := \frac{C_{f2n} - \gamma_{strIdc} \cdot \frac{\langle M3_{beam} + M3_{railext} + M3_{fluidext} + M3_{swdlext} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M3_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{4as}}{S_{bfnm}}} = 2.995$$

$invrat4asn2e := 34.5\ tonf \cdot RF_{feninv4as} = 95.77\ tonf$

$operat4asn2e := 34.5\ tonf \cdot RF_{fenop4as} = 124.15\ tonf$

$$RF2_{fenop4as} := RF2_{feninv4as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.88$$

$$RF2_{feninv5as} := \frac{C_{f2n} - \gamma_{strIdc} \cdot \frac{(M3_{beam} + M3_{railext} + M3_{fluidext} + M3_{swdlext})}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M3_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{5as}}{S_{bfnm}}} = 3$$

$invrat5asn2e := 38\ tonf \cdot RF2_{feninv5as} = 114\ tonf$

$operat5asn2e := 38\ tonf \cdot RF2_{fenop5as} = 147.78\ tonf$

$$RF2_{fenop5as} := RF2_{feninv5as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.89$$

$$RF2_{feninvh20} := \frac{C_{fen} - \gamma_{strIdc} \cdot \frac{(M3_{beam} + M3_{railext} + M3_{fluidext} + M3_{swdlext})}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{M3_{altpvtg1}}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{h20}}{S_{bfnm}}} = 6.435$$

$invrath20n2e := 20\ tonf \cdot RF2_{feninvh20} = 128.69\ tonf$

$operath20n2e := 20\ tonf \cdot RF2_{fenoph20} = 166.82\ tonf$

$$RF2_{fenoph20} := RF2_{feninvh20} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 8.34$$

$INV_{neg2ex} := min(invratHL93n2e, invrat3s2n2e, invrat6atn2e, invrat3asn2e, invrat4asn2e, invrat5asn2e, invrath20n2e)$

$OPER_{neg2ex} := min(operatHL93n2e, operat3s2n2e, operat6atn2e, operat3asn2e, operat4asn2e, operat5asn2e, operath20n2e)$

$INV_{neg2ex} = 71.38\ tonf$

$OPER_{neg2ex} = 92.54\ tonf$

Controlling negative flexure ratings - exterior at 1st diaphragm back from pier

Negative Moment Load Factors
Interior Girders at 1st diaphragm
back from piers:

$$RF2_{fininvHL93} := \frac{C_{f2n} - \gamma_{strIdc} \cdot \frac{\langle M3_{beam} + M3_{railint} + M3_{fluidint} + M3_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{\langle M3_{pvtint} + M3_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{HL93}}{S_{bfnm}}} = 1.808$$

$invratHL93n2i := 36\ tonf \cdot RF2_{fininvHL93} = 65.08\ tonf$

$operatHL93n2i := 36\ tonf \cdot RF2_{finopHL93} = 84.36\ tonf$

$$RF2_{finopHL93} := RF2_{fininvHL93} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.34$$

$$RF2_{fininv3s2} := \frac{C_{f2n} - \gamma_{strIdc} \cdot \frac{\langle M3_{beam} + M3_{railint} + M3_{fluidint} + M3_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{\langle M3_{pvtint} + M3_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{3s2}}{S_{bfnm}}} = 3.165$$

$invrat3s2n2i := 36\ tonf \cdot RF2_{fininv3s2} = 113.93\ tonf$

$operat3s2n2i := 36\ tonf \cdot RF2_{finop3s2} = 147.69\ tonf$

$$RF2_{finop3s2} := RF2_{fininv3s2} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.1$$

$$RF2_{fininv6at} := \frac{C_{f2n} - \gamma_{strIdc} \cdot \frac{\langle M3_{beam} + M3_{railint} + M3_{fluidint} + M3_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{\langle M3_{pvtint} + M3_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{6at}}{S_{bfnm}}} = 2.177$$

$invrat6atn2i := 66\ tonf \cdot RF2_{fininv6at} = 143.71\ tonf$

$operat6atn2i := 66\ tonf \cdot RF2_{finop6at} = 186.29\ tonf$

$$RF2_{finop6at} := RF2_{fininv6at} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.82$$

$$RF2_{fininv3as} := \frac{C_{f2n} - \gamma_{strIdc} \cdot \frac{\langle M3_{beam} + M3_{railint} + M3_{fluidint} + M3_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{\langle M3_{pvtint} + M3_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{3as}}{S_{bfnm}}} = 3.12$$

$invrat3asn2i := 30\ tonf \cdot RF2_{fininv3as} = 93.6\ tonf$

$operat3asn2i := 30\ tonf \cdot RF2_{finop3as} = 121.33\ tonf$

$$RF2_{finop3as} := RF2_{fininv3as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.04$$

$$RF2_{fininv4as} := \frac{C_{f2n} - \gamma_{strIdc} \cdot \frac{\langle M3_{beam} + M3_{railint} + M3_{fluidint} + M3_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strIdw} \cdot \frac{\langle M3_{pvtint} + M3_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{4as}}{S_{bfnm}}} = 2.73$$

$invrat4asn2i := 34.5\ tonf \cdot RF_{fininv4as} = 85.4\ tonf$

$operat4asn2i := 34.5\ tonf \cdot RF_{finop4as} = 110.7\ tonf$

$$RF2_{finop4as} := RF2_{fininv4as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.54$$

$$RF2_{fininv5as} := \frac{C_{f2n} - \gamma_{strldc} \cdot \frac{\langle M3_{beam} + M3_{railint} + M3_{fluidint} + M3_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strldw} \cdot \frac{\langle M3_{pvtint} + M3_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{5as}}{S_{bfnm}}} = 2.735$$

$invrat5asn2i := 38\ tonf \cdot RF_{fininv5as} = 94.23\ tonf$

$operat5asn2i := 38\ tonf \cdot RF_{finop5as} = 122.15\ tonf$

$$RF2_{finop5as} := RF2_{fininv5as} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.55$$

$$RF2_{fininvh20} := \frac{C_{f2n} - \gamma_{strldc} \cdot \frac{\langle M3_{beam} + M3_{railint} + M3_{fluidint} + M3_{swdlint} \rangle}{S_{bfnm}} - \gamma_{strldw} \cdot \frac{\langle M3_{pvtint} + M3_{utint} \rangle}{S_{bfnm}}}{\gamma_{strIL} \cdot \frac{M3_{h20}}{S_{bfnm}}} = 4.562$$

$invrath20n2i := 20\ tonf \cdot RF2_{fininvh20} = 91.24\ tonf$

$operath20n2i := 20\ tonf \cdot RF2_{finoph20} = 118.27\ tonf$

$$RF2_{finoph20} := RF2_{fininvh20} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 5.91$$

$INV_{neg2in} := min(invratHL93n2i, invrat3s2n2i, invrat6atn2i, invrat3asn2i, invrat4asn2i, invrat5asn2i, invrath20n2i)$

$OPER_{neg2in} := min(operatHL93n2i, operat3s2n2i, operat6atn2i, operat3asn2i, operat4asn2i, operat5asn2i, operath20n2i)$

$INV_{neg2in} = 65.08\ tonf$

$OPER_{neg2in} = 84.36\ tonf$

Controlling negative flexure ratings - interior at 1st diaphragm back

CALDERWOOD ENGINEERING
222 RIVER ROAD
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Positive Moment Dead Load
Stresses Svc II

$$f_{besIIpos} := \gamma_{svcIIdc} \cdot \left(\frac{\langle M1_{beam} + M1_{fluidext} \rangle}{S_{bf}} + \frac{\langle M1_{railext} + M1_{swdlext} \rangle}{S_{exbfLT}} \right) + \frac{\gamma_{svcIIdw} \cdot \langle M1_{altpvtg1} \rangle}{S_{exbfLT}} = 8.843 \text{ ksi}$$

$$f_{tesIIpos} := \gamma_{svcIIdc} \cdot \left(\frac{\langle M1_{beam} + M1_{fluidext} \rangle}{S_{tf}} + \frac{\langle M1_{railext} + M1_{swdlext} \rangle}{S_{extfLT}} \right) + \frac{\gamma_{svcIIdw} \cdot \langle M1_{altpvtg1} \rangle}{S_{extfLT}} = 6.965 \text{ ksi}$$

$$f_{bisIIpos} := \gamma_{svcIIdc} \cdot \left(\frac{\langle M1_{beam} + M1_{fluidint} \rangle}{S_{bf}} + \frac{\langle M1_{railint} + M1_{swdlint} \rangle}{S_{exbfLT}} \right) + \frac{\gamma_{svcIIdw} \cdot \langle M1_{pvtint} + M1_{utint} \rangle}{S_{exbfLT}} = 11.41 \text{ ksi}$$

$$f_{tisIIpos} := \gamma_{svcIIdc} \cdot \left(\frac{\langle M1_{beam} + M1_{fluidint} \rangle}{S_{tf}} + \frac{\langle M1_{railint} + M1_{swdlint} \rangle}{S_{extfLT}} \right) + \frac{\gamma_{svcIIdw} \cdot \langle M1_{pvtint} + M1_{utint} \rangle}{S_{extfLT}} = 8.92 \text{ ksi}$$

$$f_{besIIneg} := \frac{\gamma_{svcIIdc} \cdot \langle M2_{beam} + M2_{fluidext} + M2_{railext} + M2_{swdlext} \rangle + \gamma_{svcIIdw} \cdot \langle M2_{altpvtg1} \rangle}{S_{bfnm}} = -11.836 \text{ ksi}$$

$$f_{besIIneg} := \frac{\gamma_{svcIIdc} \cdot \langle M2_{beam} + M2_{fluidext} + M2_{railext} + M2_{swdlext} \rangle + \gamma_{svcIIdw} \cdot \langle M2_{altpvtg1} \rangle}{S_{tfnm}} = -11.836 \text{ ksi}$$

$$f_{bisIIneg} := \frac{\gamma_{svcIIdc} \cdot \langle M2_{beam} + M2_{fluidint} + M2_{railint} + M2_{swdlint} \rangle + \gamma_{svcIIdw} \cdot \langle M2_{pvtint} + M2_{utint} \rangle}{S_{bfnm}} = -15.323 \text{ ksi}$$

$$f_{bisIIneg} := \frac{\gamma_{svcIIdc} \cdot \langle M2_{beam} + M2_{fluidint} + M2_{railint} + M2_{swdlint} \rangle + \gamma_{svcIIdw} \cdot \langle M2_{pvtint} + M2_{utint} \rangle}{S_{tfnm}} = -15.323 \text{ ksi}$$

Capacities - Service II:

$C_{s2pos} := F_{svcIIpos} = 47.5$ ksi Positive moment Capacity Svc II

$C_{s2neg} := -F_{svcIIneg} = -40$ ksi Negative moment Capacity Svc II

$\gamma_{svcIILop} := 1.0$ $\gamma_{svcIIL} = 1.3$

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Positive Moment Load Factors
Exterior Girders:

Positive moment region governed by bottom flange stress for Svc II limit state by inspection

$$RF_{es2invHL93p} := \frac{C_{s2pos} - f_{besIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{HL93}}{S_{exbfST}}} = 3.04$$

$$RF_{es2opHL93p} := RF_{es2invHL93p} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 3.95$$

$$invsvcHL93pe := RF_{es2invHL93p} \cdot 36\ tonf = 109.3\ tonf$$

$$opsvcrHL93pe := RF_{es2opHL93p} \cdot 36\ tonf = 142.09\ tonf$$

$$RF_{es2inv3s2p} := \frac{C_{s2pos} - f_{besIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{3s2}}{S_{exbfST}}} = 4.93$$

$$RF_{es2op3s2p} := RF_{es2inv3s2p} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 6.41$$

$$invsvc3s2pe := RF_{es2inv3s2p} \cdot 36\ tonf = 177.42\ tonf$$

$$opsvcr3s2pe := RF_{es2op3s2p} \cdot 36\ tonf = 230.65\ tonf$$

$$RF_{es2inv6atp} := \frac{C_{s2pos} - f_{besIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{6at}}{S_{exbfST}}} = 3.23$$

$$RF_{es2op6atp} := RF_{es2inv6atp} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 4.2$$

$$invsvc6atpe := RF_{es2inv6atp} \cdot 66\ tonf = 213.39\ tonf$$

$$opsvcr6atpe := RF_{es2op6atp} \cdot 66\ tonf = 277.4\ tonf$$

$$RF_{es2inv3asp} := \frac{C_{s2pos} - f_{besIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{3as}}{S_{exbfST}}} = 4.21$$

$$RF_{es2op3asp} := RF_{es2inv3asp} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 5.48$$

$$invsvc3aspe := RF_{es2inv3asp} \cdot 30\ tonf = 126.45\ tonf$$

$$opsvcr3aspe := RF_{es2op3asp} \cdot 30\ tonf = 164.38\ tonf$$

$$RF_{es2inv4asp} := \frac{C_{s2pos} - f_{besIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{4as}}{S_{exbfST}}} = 3.66$$

$$RF_{es2op4asp} := RF_{es2inv4asp} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 4.76$$

$$invsvc4aspe := RF_{es2inv4asp} \cdot 34.5\ tonf = 126.38\ tonf$$

$$opsvcr4aspe := RF_{es2op4asp} \cdot 34.5\ tonf = 164.3\ tonf$$

$$RF_{es2inv5asp} := \frac{C_{s2pos} - f_{besIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{5as}}{S_{exbfST}}} = 4.19$$

$$RF_{es2op5asp} := RF_{es2inv5asp} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 5.45$$

$$invsvc5aspe := RF_{es2inv5asp} \cdot 38\ tonf = 159.19\ tonf$$

$$opsvcr5aspe := RF_{es2op5asp} \cdot 38\ tonf = 206.94\ tonf$$

$$RF_{es2invh20p} := \frac{C_{s2pos} - f_{besIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{h20}}{S_{exbfST}}} = 5.77$$

$$RF_{es2oph20p} := RF_{es2invh20p} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 7.5$$

$$invsvch20pe := RF_{es2invh20p} \cdot 20\ tonf = 115.41\ tonf$$

$$opsvcrh20pe := RF_{es2oph20p} \cdot 20\ tonf = 150.03\ tonf$$

$$INV_{possvcIIe} := min(invsvcHL93pe, invsvc3s2pe, invsvc6atpe, invsvc3aspe, invsvc4aspe, invsvc5aspe, invsvch20pe)$$

$$OPER_{possvcIIe} := min(opsvcrHL93pe, opsvcr3s2pe, opsvcr6atpe, opsvcr3aspe, opsvcr4aspe, opsvcr5aspe, opsvcrh20pe)$$

$$INV_{possvcIIe} = 109.3\ tonf$$

$$OPER_{possvcIIe} = 142.09\ tonf$$

Controlling positive flexure
Svc II load ratings - exterior

Positive Moment Load Factors
Interior Girders:

Positive moment region governed by bottom flange stress for Svc II limit state by inspection

$$RF_{is2invHL93p} := \frac{C_{s2pos} - f_{bisIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{HL93}}{S_{inbfST}}} = 3.04$$

$$RF_{is2opHL93p} := RF_{is2invHL93p} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 3.95$$

$$invsvcHL93pi := RF_{is2invHL93p} \cdot 36\ tonf = 109.29\ tonf$$

$$opsvcrHL93pi := RF_{is2opHL93p} \cdot 36\ tonf = 142.07\ tonf$$

$$RF_{is2inv3s2p} := \frac{C_{s2pos} - f_{bisIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{3s2}}{S_{inbfST}}} = 4.93$$

$$RF_{is2op3s2p} := RF_{is2inv3s2p} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 6.41$$

$$invsvc3s2pi := RF_{is2inv3s2p} \cdot 36\ tonf = 177.4\ tonf$$

$$opsvcr3s2pi := RF_{is2op3s2p} \cdot 36\ tonf = 230.62\ tonf$$

$$RF_{is2inv6atp} := \frac{C_{s2pos} - f_{bisIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{6at}}{S_{inbfST}}} = 3.23$$

$$RF_{is2op6atp} := RF_{is2inv6atp} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 4.2$$

$$invsvc6atpi := RF_{is2inv6atp} \cdot 66\ tonf = 213.36\ tonf$$

$$opsvcr6atpi := RF_{is2op6atp} \cdot 66\ tonf = 277.37\ tonf$$

$$RF_{is2inv3asp} := \frac{C_{s2pos} - f_{bisIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{3as}}{S_{inbfST}}} = 4.21$$

$$RF_{is2op3asp} := RF_{is2inv3asp} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 5.48$$

$$invsvc3aspi := RF_{is2inv3asp} \cdot 30\ tonf = 126.43\ tonf$$

$$opsvcr3aspi := RF_{is2op3asp} \cdot 30\ tonf = 164.36\ tonf$$

$$RF_{is2inv4asp} := \frac{C_{s2pos} - f_{bisIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{4as}}{S_{inbfST}}} = 3.66$$

$$RF_{is2op4asp} := RF_{is2inv4asp} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 4.76$$

$$invsvc4aspi := RF_{is2inv4asp} \cdot 34.5\ tonf = 126.37\ tonf$$

$$opsvcr4aspi := RF_{is2op4asp} \cdot 34.5\ tonf = 164.28\ tonf$$

$$RF_{is2inv5asp} := \frac{C_{s2pos} - f_{bisIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{5as}}{S_{inbfST}}} = 4.19$$

$$RF_{is2op5asp} := RF_{is2inv5asp} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 5.45$$

$$invsvc5aspi := RF_{is2inv5asp} \cdot 38\ tonf = 159.17\ tonf$$

$$opsvcr5aspi := RF_{is2op5asp} \cdot 38\ tonf = 206.92\ tonf$$

$$RF_{is2invh20p} := \frac{C_{s2pos} - f_{bisIIpos}}{\gamma_{svcIIL} \cdot \frac{M1_{h20}}{S_{inbfST}}} = 5.77$$

$$RF_{is2oph20p} := RF_{is2invh20p} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 7.5$$

$$invsvch20pi := RF_{is2invh20p} \cdot 20\ tonf = 115.39\ tonf$$

$$opsvcrh20pi := RF_{is2oph20p} \cdot 20\ tonf = 150.01\ tonf$$

$$INV_{possvcIIi} := min(invsvcHL93pi, invsvc3s2pi, invsvc6atpi, invsvc3aspi, invsvc4aspi, invsvc5aspi, invsvch20pi)$$

$$OPER_{possvcIIi} := min(opsvcrHL93pi, opsvcr3s2pi, opsvcr6atpi, opsvcr3aspi, opsvcr4aspi, opsvcr5aspi, opsvcrh20pi)$$

$$INV_{possvcIIi} = 109.29\ tonf$$

$$OPER_{possvcIIi} = 142.07\ tonf$$

Controlling positive flexure
Svc II load ratings - interior

Negative Moment Load Factors
Exterior Girders:

Negative moment region the same for top and bottom flange stress for Svc II limit state by inspection

$$RF_{es2invHL93n} := \frac{C_{s2neg} - f_{besIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{HL93}}{S_{bfnm}}} = 1.51$$

$$RF_{es2opHL93n} := RF_{es2invHL93n} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 1.97$$

$$invsvcHL93ne := RF_{es2invHL93n} \cdot 36\ tonf = 54.44\ tonf$$

$$opsvcrHL93ne := RF_{es2opHL93n} \cdot 36\ tonf = 70.77\ tonf$$

$$RF_{es2inv3s2n} := \frac{C_{s2neg} - f_{besIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{3s2}}{S_{bfnm}}} = 3.66$$

$$RF_{es2op3s2n} := RF_{es2inv3s2n} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 4.75$$

$$invsvc3s2ne := RF_{es2inv3s2n} \cdot 36\ tonf = 131.63\ tonf$$

$$opsvcr3s2ne := RF_{es2op3s2n} \cdot 36\ tonf = 171.12\ tonf$$

$$RF_{es2inv6atn} := \frac{C_{s2neg} - f_{besIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{6at}}{S_{bfnm}}} = 1.81$$

$$RF_{es2op6atn} := RF_{es2inv6atn} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 2.35$$

$$invsvc6atne := RF_{es2inv6atn} \cdot 66\ tonf = 119.35\ tonf$$

$$opsvcr6atne := RF_{es2op6atn} \cdot 66\ tonf = 155.16\ tonf$$

$$RF_{es2inv3asn} := \frac{C_{s2neg} - f_{besIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{3as}}{S_{bfnm}}} = 3.6$$

$$RF_{es2op3asn} := RF_{es2inv3asn} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 4.69$$

$$invsvc3asne := RF_{es2inv3asn} \cdot 30\ tonf = 108.14\ tonf$$

$$opsvcr3asne := RF_{es2op3asn} \cdot 30\ tonf = 140.58\ tonf$$

$$RF_{es2inv4asn} := \frac{C_{s2neg} - f_{besIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{4as}}{S_{bfnm}}} = 3.15$$

$$RF_{es2op4asn} := RF_{es2inv4asn} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 4.1$$

$$invsvc4asne := RF_{es2inv4asn} \cdot 34.5\ tonf = 108.81\ tonf$$

$$opsvcr4asne := RF_{es2op4asn} \cdot 34.5\ tonf = 141.46\ tonf$$

$$RF_{es2inv5asn} := \frac{C_{s2neg} - f_{besIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{5as}}{S_{bfnm}}} = 3.16$$

$$RF_{es2op5asn} := RF_{es2inv5asn} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 4.11$$

$$invsvc5asne := RF_{es2inv5asn} \cdot 38\ tonf = 120.07\ tonf$$

$$opsvcr5asne := RF_{es2op5asn} \cdot 38\ tonf = 156.09\ tonf$$

$$RF_{es2invh20n} := \frac{C_{s2neg} - f_{besIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{h20}}{S_{bfnm}}} = 5.27$$

$$RF_{es2oph20n} := RF_{es2invh20n} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 6.85$$

$$invsvch20ne := RF_{es2invh20n} \cdot 20\ tonf = 105.41\ tonf$$

$$opsvcrh20ne := RF_{es2oph20n} \cdot 20\ tonf = 137.03\ tonf$$

$$INV_{negsvcIIe} := min(invsvcHL93ne, invsvc3s2ne, invsvc6atne, invsvc3asne, invsvc4asne, invsvc5asne, invsvch20ne)$$

$$OPER_{negsvcIIe} := min(opsvcrHL93ne, opsvcr3s2ne, opsvcr6atne, opsvcr3asne, opsvcr4asne, opsvcr5asne, opsvcrh20ne)$$

$$INV_{negsvcIIe} = 54.44\ tonf$$

$$OPER_{negsvcIIe} = 70.77\ tonf$$

Controlling negative flexure
Svc II load ratings - exterior girder

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Negative Moment Load Factors
Interior Girders:

Negative moment region the same for top and bottom flange stress for Svc II limit state by inspection

$$RF_{is2invHL93n} := \frac{C_{s2neg} - f_{bisIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{HL93}}{S_{bfnm}}} = 1.32$$

$$RF_{is2opHL93n} := RF_{is2invHL93n} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 1.72$$

$$invsvcHL93ni := RF_{is2invHL93n} \cdot 36\ tonf = 47.7\ tonf$$

$$opsvcrHL93ni := RF_{is2opHL93n} \cdot 36\ tonf = 62.01\ tonf$$

$$RF_{is2inv3s2n} := \frac{C_{s2neg} - f_{bisIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{3s2}}{S_{bfnm}}} = 3.2$$

$$RF_{is2op3s2n} := RF_{is2inv3s2n} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 4.16$$

$$invsvc3s2ni := RF_{is2inv3s2n} \cdot 36\ tonf = 115.33\ tonf$$

$$opsvcr3s2ni := RF_{is2op3s2n} \cdot 36\ tonf = 149.93\ tonf$$

$$RF_{is2inv6atn} := \frac{C_{s2neg} - f_{bisIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{6at}}{S_{bfnm}}} = 1.58$$

$$RF_{is2op6atn} := RF_{is2inv6atn} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 2.06$$

$$invsvc6atni := RF_{is2inv6atn} \cdot 66\ tonf = 104.58\ tonf$$

$$opsvcr6atni := RF_{is2op6atn} \cdot 66\ tonf = 135.95\ tonf$$

$$RF_{is2inv3asn} := \frac{C_{s2neg} - f_{bisIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{3as}}{S_{bfnm}}} = 3.16$$

$$RF_{is2op3asn} := RF_{is2inv3asn} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 4.11$$

$$invsvc3asni := RF_{is2inv3asn} \cdot 30\ tonf = 94.75\ tonf$$

$$opsvcr3asni := RF_{is2op3asn} \cdot 30\ tonf = 123.17\ tonf$$

$$RF_{is2inv4asn} := \frac{C_{s2neg} - f_{bisIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{4as}}{S_{bfnm}}} = 2.76$$

$$RF_{is2op4asn} := RF_{is2inv4asn} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 3.59$$

$$invsvc4asni := RF_{is2inv4asn} \cdot 34.5\ tonf = 95.34\ tonf$$

$$opsvcr4asni := RF_{is2op4asn} \cdot 34.5\ tonf = 123.94\ tonf$$

$$RF_{is2inv5asn} := \frac{C_{s2neg} - f_{bisIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{5as}}{S_{bfnm}}} = 2.77$$

$$RF_{is2op5asn} := RF_{is2inv5asn} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 3.6$$

$$invsvc5asni := RF_{is2inv5asn} \cdot 38\ tonf = 105.2\ tonf$$

$$opsvcr5asni := RF_{is2op5asn} \cdot 38\ tonf = 136.76\ tonf$$

$$RF_{is2invh20n} := \frac{C_{s2neg} - f_{bisIIneg}}{\gamma_{svcIIL} \cdot \frac{M2_{h20}}{S_{bfnm}}} = 4.62$$

$$RF_{is2oph20n} := RF_{is2invh20n} \cdot \frac{\gamma_{svcIIL}}{\gamma_{svcIILop}} = 6$$

$$invsvch20ni := RF_{is2invh20n} \cdot 20\ tonf = 92.36\ tonf$$

$$opsvcrh20ni := RF_{is2oph20n} \cdot 20\ tonf = 120.07\ tonf$$

$$INV_{negsvcIIi} := min(invsvcHL93ni, invsvc3s2ni, invsvc6atni, invsvc3asni, invsvc4asni, invsvc5asni, invsvch20ni)$$

$$OPER_{negsvcIIi} := min(opsvcrHL93ni, opsvcr3s2ni, opsvcr6atni, opsvcr3asni, opsvcr4asni, opsvcr5asni, opsvcrh20ni)$$

$$INV_{negsvcIIi} = 47.7\ tonf$$

$$OPER_{negsvcIIi} = 62.01\ tonf$$

Controlling negative flexure
Svc II load ratings - interior girder

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Strength I Live Load Shear at CL brg
Piers:

$$V_{hl93} := g_v \cdot \left((100\% + IM) \cdot \max\left(V_{maxhs20}, V_{maxnmtt}\right) + \frac{0.64\ klf}{1\ klf} \cdot \left(\max\left(V_{123max}, V_{12max}\right)\right) \right) = 120.81\ kip$$

$$V_{3s2} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{max3s2} = 79.99\ kip$$
$$V_{6at} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{max6at} = 132.15\ kip$$
$$V_{3as} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{max3as} = 84.36\ kip$$
$$V_{4as} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{max4as} = 92.26\ kip$$
$$V_{5as} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{max5as} = 89.31\ kip$$
$$V_{h20} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{maxh20} = 55.01\ kip$$

$$V_{dcext} := \frac{W_{stl} + W_{extdeck} + W_{altSWG1} + W_{extrail}}{1\ klf} \cdot V_{123max} = 67.5\ kip$$

$$V_{dwext} := \frac{W_{altpvtG1}}{1\ klf} \cdot V_{123max} = 3.64\ kip$$

$$V_{dcint} := \frac{W_{stl} + W_{intdeck} + W_{altSWint} + W_{intrail}}{1\ klf} \cdot V_{123max} = 65.84\ kip$$

$$V_{dwint} := \frac{W_{intpvt} + W_{utint}}{1\ klf} \cdot V_{123max} = 26.25\ kip$$

Strength I shear Load Ratings-
Exterior Girder - stiffened section at piers:

$C_{sv} := V_{rs} = 481.84$ kip

$RF_{vinvhl93e} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcext} - \gamma_{strIdw} \cdot V_{dwext}}{\gamma_{strIL} \cdot V_{hl93}} = 1.85$ $\quad RF_{vophl93e} := RF_{vinvhl93e} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.4$

$invrvhl93es := RF_{vinvhl93e} \cdot 36$ tonf $= 66.75$ tonf
$oprvhl93es := RF_{vophl93e} \cdot 36$ tonf $= 86.53$ tonf

$RF_{vinv3s2e} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcext} - \gamma_{strIdw} \cdot V_{dwext}}{\gamma_{strIL} \cdot V_{3s2}} = 2.8$ $\quad RF_{vop3s2e} := RF_{vinv3s2e} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.63$

$invrv3s2es := RF_{vinv3s2e} \cdot 36$ tonf $= 100.81$ tonf
$oprv3s2es := RF_{vop3s2e} \cdot 36$ tonf $= 130.68$ tonf

$RF_{vinv6ate} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcext} - \gamma_{strIdw} \cdot V_{dwext}}{\gamma_{strIL} \cdot V_{6at}} = 1.7$ $\quad RF_{vop6ate} := RF_{vinv6ate} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.2$

$invrv6ates := RF_{vinv6ate} \cdot 66$ tonf $= 111.87$ tonf
$oprv6ates := RF_{vop6ate} \cdot 66$ tonf $= 145.02$ tonf

$RF_{vinv3ase} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcext} - \gamma_{strIdw} \cdot V_{dwext}}{\gamma_{strIL} \cdot V_{3as}} = 2.66$ $\quad RF_{vop3ase} := RF_{vinv3ase} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.44$

$invrv3ases := RF_{vinv3ase} \cdot 30$ tonf $= 79.66$ tonf
$oprv3ases := RF_{vop3ase} \cdot 30$ tonf $= 103.27$ tonf

$RF_{vinv4ase} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcext} - \gamma_{strIdw} \cdot V_{dwext}}{\gamma_{strIL} \cdot V_{4as}} = 2.43$ $\quad RF_{vop4ase} := RF_{vinv4ase} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.15$

$invrv4ases := RF_{vinv4ase} \cdot 34.5$ tonf $= 83.77$ tonf
$oprv4ases := RF_{vop4ase} \cdot 34.5$ tonf $= 108.58$ tonf

$RF_{vinv5ase} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcext} - \gamma_{strIdw} \cdot V_{dwext}}{\gamma_{strIL} \cdot V_{5as}} = 2.51$ $\quad RF_{vop5ase} := RF_{vinv5ase} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.25$

$invrv5ases := RF_{vinv5ase} \cdot 38$ tonf $= 95.31$ tonf
$oprv5ases := RF_{vop5ase} \cdot 38$ tonf $= 123.54$ tonf

$RF_{vinvh20e} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcext} - \gamma_{strIdw} \cdot V_{dwext}}{\gamma_{strIL} \cdot V_{h20}} = 4.07$ $\quad RF_{voph20e} := RF_{vinvh20e} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 5.28$

$invrvh20es := RF_{vinvh20e} \cdot 20$ tonf $= 81.43$ tonf
$oprvh20es := RF_{voph20e} \cdot 20$ tonf $= 105.56$ tonf

$INV_{shearpierext} := min(invrvhl93es, invrv3s2es, invrv6ates, invrv3ases, invrv4ases, invrv5ases, invrvh20es)$

$OPER_{shearpierext} := min(oprvhl93es, oprv3s2es, oprv6ates, oprv3ases, oprv4ases, oprv5ases, oprvh20es)$

$INV_{shearpierext} = 66.75$ tonf $\quad OPER_{shearpierext} = 86.53$ tonf

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Strength I shear Load Ratings-
Interior Girder - stiffened section at piers:

$$RF_{vinvhl93i} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcint} - \gamma_{strIdw} \cdot V_{dwint}}{\gamma_{strIL} \cdot V_{hl93}} = 1.7 \qquad RF_{vophl93i} := RF_{vinvhl93i} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.21$$

$$invrvhl93is := RF_{vinvhl93i} \cdot 36\ tonf = 61.33\ tonf$$
$$oprvhl93is := RF_{vophl93i} \cdot 36\ tonf = 79.5\ tonf$$

$$RF_{vinv3s2i} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcint} - \gamma_{strIdw} \cdot V_{dwint}}{\gamma_{strIL} \cdot V_{3s2}} = 2.57 \qquad RF_{vop3s2i} := RF_{vinv3s2i} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.34$$

$$invrv3s2is := RF_{vinv3s2i} \cdot 36\ tonf = 92.62\ tonf$$
$$oprv3s2is := RF_{vop3s2i} \cdot 36\ tonf = 120.06\ tonf$$

$$RF_{vinv6ati} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcint} - \gamma_{strIdw} \cdot V_{dwint}}{\gamma_{strIL} \cdot V_{6at}} = 1.56 \qquad RF_{vop6ati} := RF_{vinv6ati} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.02$$

$$invrv6atis := RF_{vinv6ati} \cdot 66\ tonf = 102.78\ tonf$$
$$oprv6atis := RF_{vop6ati} \cdot 66\ tonf = 133.24\ tonf$$

$$RF_{vinv3asi} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcint} - \gamma_{strIdw} \cdot V_{dwint}}{\gamma_{strIL} \cdot V_{3as}} = 2.44 \qquad RF_{vop3asi} := RF_{vinv3asi} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.16$$

$$invrv3asis := RF_{vinv3asi} \cdot 30\ tonf = 73.19\ tonf$$
$$oprv3asis := RF_{vop3asi} \cdot 30\ tonf = 94.88\ tonf$$

$$RF_{vinv4asi} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcint} - \gamma_{strIdw} \cdot V_{dwint}}{\gamma_{strIL} \cdot V_{4as}} = 2.23 \qquad RF_{vop4asi} := RF_{vinv4asi} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.89$$

$$invrv4asis := RF_{vinv4asi} \cdot 34.5\ tonf = 76.96\ tonf$$
$$oprv4asis := RF_{vop4asi} \cdot 34.5\ tonf = 99.76\ tonf$$

$$RF_{vinv5asi} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcint} - \gamma_{strIdw} \cdot V_{dwint}}{\gamma_{strIL} \cdot V_{5as}} = 2.3 \qquad RF_{vop5asi} := RF_{vinv5asi} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.99$$

$$invrv5asis := RF_{vinv5asi} \cdot 38\ tonf = 87.56\ tonf$$
$$oprv5asis := RF_{vop5asi} \cdot 38\ tonf = 113.51\ tonf$$

$$RF_{vinvh20i} := \frac{C_{sv} - \gamma_{strIdc} \cdot V_{dcint} - \gamma_{strIdw} \cdot V_{dwint}}{\gamma_{strIL} \cdot V_{h20}} = 3.74 \qquad RF_{voph20i} := RF_{vinvh20i} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.85$$

$$invrvh20is := RF_{vinvh20i} \cdot 20\ tonf = 74.82\ tonf$$
$$oprvh20is := RF_{voph20i} \cdot 20\ tonf = 96.99\ tonf$$

$$INV_{shearpierint} := min(invrvhl93is, invrv3s2is, invrv6atis, invrv3asis, invrv4asis, invrv5asis, invrvh20is)$$
$$OPER_{shearpierint} := min(oprvhl93is, oprv3s2is, oprv6atis, oprv3asis, oprv4asis, oprv5asis, oprvh20is)$$

$$INV_{shearpierint} = 61.33\ tonf \qquad OPER_{shearpierint} = 79.5\ tonf$$

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Strength I Live Load Maximum
Shear at Unstiffened sections:

$$Vu_{hl93} := g_v \cdot \left((100\% + IM) \cdot \max\left\langle V_{ushs20}, V_{usnmtt} \right\rangle + \frac{0.64\ klf}{1\ klf} \cdot \left\langle \max\left\langle V_{us123}, V_{us12} \right\rangle \right\rangle \right) = 107.78\ kip$$

$$Vu_{3s2} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{us3s2} = 68.19\ kip$$

$$Vu_{6at} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{us6at} = 114.89\ kip$$

$$Vu_{3as} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{us3as} = 78.53\ kip$$

$$Vu_{4as} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{us4as} = 84.71\ kip$$

$$Vu_{5as} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{us5as} = 79.61\ kip$$

$$Vu_{h20} := 2 \cdot g_v \cdot (100\% + IM) \cdot V_{ush20} = 50.84\ kip$$

$$Vu_{dcext} := \frac{W_{stl} + W_{extdeck} + W_{altSWG1} + W_{extrail}}{1\ klf} \cdot V_{us123} = 56.76\ kip$$

$$Vu_{dwext} := \frac{W_{altpvtG1}}{1\ klf} \cdot V_{us123} = 3.06\ kip$$

$$Vu_{dcint} := \frac{W_{stl} + W_{intdeck} + W_{altSWint} + W_{intrail}}{1\ klf} \cdot V_{us123} = 55.37\ kip$$

$$Vu_{dwint} := \frac{W_{intpvt} + W_{utint}}{1\ klf} \cdot V_{us123} = 22.08\ kip$$

Strength I shear Load Ratings-
Exterior Girder - unstiffened sections: $C_{uv} := V_{ru} = 437.28$ kip

$$RF_{vinvhl93ue} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcext} - \gamma_{strIdw} \cdot Vu_{dwext}}{\gamma_{strIL} \cdot Vu_{hl93}} = 1.92 \qquad RF_{vophl93ue} := RF_{vinvhl93ue} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.49$$

$invrvhl93eu := RF_{vinvhl93ue} \cdot 36$ tonf $= 69.04$ tonf
$oprvhl93eu := RF_{vophl93ue} \cdot 36$ tonf $= 89.5$ tonf

$$RF_{vinv3s2ue} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcext} - \gamma_{strIdw} \cdot Vu_{dwext}}{\gamma_{strIL} \cdot Vu_{3s2}} = 3.03 \qquad RF_{vop3s2ue} := RF_{vinv3s2ue} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.93$$

$invrv3s2eu := RF_{vinv3s2ue} \cdot 36$ tonf $= 109.13$ tonf
$oprv3s2eu := RF_{vop3s2ue} \cdot 36$ tonf $= 141.46$ tonf

$$RF_{vinv6atue} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcext} - \gamma_{strIdw} \cdot Vu_{dwext}}{\gamma_{strIL} \cdot Vu_{6at}} = 1.8 \qquad RF_{vop6atue} := RF_{vinv6atue} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.33$$

$invrv6ateu := RF_{vinv6atue} \cdot 66$ tonf $= 118.75$ tonf
$oprv6ateu := RF_{vop6atue} \cdot 66$ tonf $= 153.93$ tonf

$$RF_{vinv3asue} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcext} - \gamma_{strIdw} \cdot Vu_{dwext}}{\gamma_{strIL} \cdot Vu_{3as}} = 2.63 \qquad RF_{vop3asue} := RF_{vinv3asue} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.41$$

$invrv3aseu := RF_{vinv3asue} \cdot 30$ tonf $= 78.96$ tonf
$oprv3aseu := RF_{vop3asue} \cdot 30$ tonf $= 102.36$ tonf

$$RF_{vinv4asue} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcext} - \gamma_{strIdw} \cdot Vu_{dwext}}{\gamma_{strIL} \cdot Vu_{4as}} = 2.44 \qquad RF_{vop4asue} := RF_{vinv4asue} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.16$$

$invrv4aseu := RF_{vinv4asue} \cdot 34.5$ tonf $= 84.18$ tonf
$oprv4aseu := RF_{vop4asue} \cdot 34.5$ tonf $= 109.13$ tonf

$$RF_{vinv5asue} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcext} - \gamma_{strIdw} \cdot Vu_{dwext}}{\gamma_{strIL} \cdot Vu_{5as}} = 2.6 \qquad RF_{vop5asue} := RF_{vinv5asue} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.37$$

$invrv5aseu := RF_{vinv5asue} \cdot 38$ tonf $= 98.67$ tonf
$oprv5aseu := RF_{vop5asue} \cdot 38$ tonf $= 127.9$ tonf

$$RF_{vinvh20ue} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcext} - \gamma_{strIdw} \cdot Vu_{dwext}}{\gamma_{strIL} \cdot Vu_{h20}} = 4.07 \qquad RF_{voph20ue} := RF_{vinvh20ue} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 5.27$$

$invrvh20eu := RF_{vinvh20ue} \cdot 20$ tonf $= 81.32$ tonf
$oprvh20eu := RF_{voph20ue} \cdot 20$ tonf $= 105.42$ tonf

$INV_{shearunstext} := min(invrvhl93eu, invrv3s2eu, invrv6ateu, invrv3aseu, invrv4aseu, invrv5aseu, invrvh20eu)$
$OPER_{shearunstext} := min(oprvhl93eu, oprv3s2eu, oprv6ateu, oprv3aseu, oprv4aseu, oprv5aseu, oprvh20eu)$

$INV_{shearunstext} = 69.04$ tonf $\qquad OPER_{shearunstext} = 89.5$ tonf

Strength I shear Load Ratings-
Interior Girder - unstiffened
sections:

$$RF_{vinvhl93ui} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcint} - \gamma_{strIdw} \cdot Vu_{dwint}}{\gamma_{strIL} \cdot Vu_{hl93}} = 1.78 \qquad RF_{vophl93ui} := RF_{vinvhl93ui} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.3$$

$$invrvhl93iu := RF_{vinvhl93ui} \cdot 36\ tonf = 63.93\ tonf$$
$$oprvhl93iu := RF_{vophl93ui} \cdot 36\ tonf = 82.87\ tonf$$

$$RF_{vinv3s2ui} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcint} - \gamma_{strIdw} \cdot Vu_{dwint}}{\gamma_{strIL} \cdot Vu_{3s2}} = 2.81 \qquad RF_{vop3s2ui} := RF_{vinv3s2ui} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.64$$

$$invrv3s2iu := RF_{vinv3s2ui} \cdot 36\ tonf = 101.05\ tonf$$
$$oprv3s2iu := RF_{vop3s2ui} \cdot 36\ tonf = 130.99\ tonf$$

$$RF_{vinv6atui} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcint} - \gamma_{strIdw} \cdot Vu_{dwint}}{\gamma_{strIL} \cdot Vu_{6at}} = 1.67 \qquad RF_{vop6atui} := RF_{vinv6atui} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.16$$

$$invrv6atiu := RF_{vinv6atui} \cdot 66\ tonf = 109.95\ tonf$$
$$oprv6atiu := RF_{vop6atui} \cdot 66\ tonf = 142.53\ tonf$$

$$RF_{vinv3asui} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcint} - \gamma_{strIdw} \cdot Vu_{dwint}}{\gamma_{strIL} \cdot Vu_{3as}} = 2.44 \qquad RF_{vop3asui} := RF_{vinv3asui} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.16$$

$$invrv3asiu := RF_{vinv3asui} \cdot 30\ tonf = 73.12\ tonf$$
$$oprv3asiu := RF_{vop3asui} \cdot 30\ tonf = 94.78\ tonf$$

$$RF_{vinv4asui} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcint} - \gamma_{strIdw} \cdot Vu_{dwint}}{\gamma_{strIL} \cdot Vu_{4as}} = 2.26 \qquad RF_{vop4asui} := RF_{vinv4asui} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 2.93$$

$$invrv4asiu := RF_{vinv4asui} \cdot 34.5\ tonf = 77.95\ tonf$$
$$oprv4asiu := RF_{vop4asui} \cdot 34.5\ tonf = 101.05\ tonf$$

$$RF_{vinv5asui} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcint} - \gamma_{strIdw} \cdot Vu_{dwint}}{\gamma_{strIL} \cdot Vu_{5as}} = 2.4 \qquad RF_{vop5asui} := RF_{vinv5asui} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 3.12$$

$$invrv5asiu := RF_{vinv5asui} \cdot 38\ tonf = 91.36\ tonf$$
$$oprv5asiu := RF_{vop5asui} \cdot 38\ tonf = 118.43\ tonf$$

$$RF_{vinvh20ui} := \frac{C_{uv} - \gamma_{strIdc} \cdot Vu_{dcint} - \gamma_{strIdw} \cdot Vu_{dwint}}{\gamma_{strIL} \cdot Vu_{h20}} = 3.77 \qquad RF_{voph20ui} := RF_{vinvh20ui} \cdot \frac{\gamma_{strIL}}{\gamma_{strop}} = 4.88$$

$$invrvh20iu := RF_{vinvh20ui} \cdot 20\ tonf = 75.3\ tonf$$
$$oprvh20iu := RF_{voph20ui} \cdot 20\ tonf = 97.61\ tonf$$

$$INV_{shearunstint} := min(invrvhl93iu, invrv3s2iu, invrv6atiu, invrv3asiu, invrv4asiu, invrv5asiu, invrvh20iu)$$
$$OPER_{shearunstint} := min(oprvhl93iu, oprv3s2iu, oprv6atiu, oprv3asiu, oprv4asiu, oprv5asiu, oprvh20iu)$$

$$INV_{shearunstint} = 63.93\ tonf \qquad OPER_{shearunstint} = 82.87\ tonf$$