

AASHTOWare BrDR 7.5.0

Concrete Shear LRFR Rating Iteration Tutorial

MBE 2023 Spec Interim Update – Shear Rating Iteration Example

BrDR Training

MBE 2023 Spec Interim Shear Rating Iteration Example

This example illustrates the effects of using concurrent load effects, iterative shear rating and Modified Compression Field Theory (MCFT) control options for Load and Resistance Factor Rating (LRFR) shear rating of concrete structures (prestressed, post tensioned and reinforced) based on the MBE 3rd edition, 2023 specification interim update.

Topics Covered

- Concurrent forces considered for non-iterative shear rating
- Control option added to consider iterative shear rating
- Control option added to consider modifying MCFT theta
- Control option added to consider modifying MCFT size effect
- MBE 2023 specification interim update for reinforced concrete box culverts

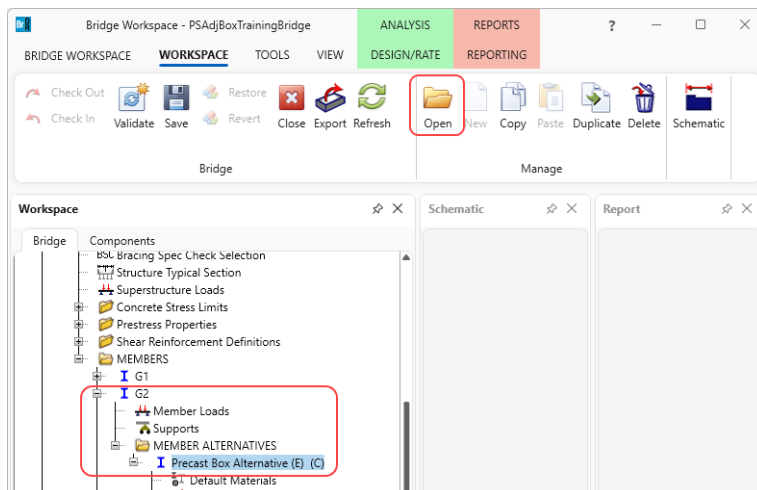
This tutorial uses the bridge from prestressed concrete structure tutorial PS3. From the **Bridge Explorer** import the bridge given with the PS3 tutorial.

Concurrent forces considered for non-iterative shear rating

This section discusses the effects of using concurrent forces for LRFR shear rating of concrete bridges without any iterations. This is applicable to all concrete structures, i.e., reinforced concrete, prestressed concrete, post tensioned concrete and reinforced concrete box culverts.

Member Alternative Description – Control options

Navigate to the member alternative Precast Box Alternative of member **G2**, double click on it (or click the **Open** button from the **WORKSPACE** ribbon) to open its **Member Alternative Description** window. Navigate to the **Control options** tab as shown below.



Uncheck the **Ignore design & legal load shear** and **Ignore long. reinf. in rating** for this example.

Member Alternative Description

Member alternative: Precast Box Alternative

Description Specs Factors Engine Import Control options

LRFD

- Points of interest
 - ☒ Generate at tenth points except supports
 - ☒ Generate at support points
 - ☒ Generate at support face & critical shear points
 - ☒ Generate at section change points
 - ☒ Generate at user-defined points
- Shear computation method
 - ☐ Ignore
 - ☒ General procedure
 - ☐ General procedure - Appendix B5

LRFR

- Points of interest
 - ☒ Generate at tenth points except supports
 - ☒ Generate at support points
 - ☒ Generate at support face & critical shear points
 - ☒ Generate at section change points
 - ☒ Generate at user-defined points
- Shear computation method
 - ☐ Ignore
 - ☐ Use AASHTO 1979 interim code
 - ☒ Use current AASHTO

LRFR

- ☒ Use gross section properties
- ☐ Use transformed section properties
- Multi-span analysis
 - ☒ Continuous
 - ☐ Continuous and simple
- ☐ Ignore design & legal load shear
- ☒ Ignore permit load shear
- ☐ Consider legal load tensile concrete stress
- ☐ Consider splitting resistance article
- ☒ Ignore tensile rating in top of beam
- ☐ Consider deck reinf. development length
- ☐ Consider permit load tensile steel stress
- ☐ Ignore long. reinf. in rating
- Distribution factor application method
 - ☐ By axle
 - ☒ By POI
- ☐ Allow negative epsilon in general shear method
- ☐ Allow moment redistribution
- ☐ Consider iterative shear rating
- ☐ Modify MCFT theta
- ☐ Modify MCFT size effect

OK Apply Cancel

Click **OK** to apply the data and close the window.

LRFR Rating

Perform an LRFR rating of the member alternative using the analysis settings shown below.

Analysis Settings

☐ Design review ☒ Rating

Rating method: LRFR

Analysis type: Line Girder

Lane / Impact loading type: As Requested

Apply preference setting: None

Vehicles Output Engine Description

Traffic direction: Both directions

Refresh Temporary vehicles Advanced

Vehicle selection

- Vehicles
 - Standard
 - EV2
 - EV3
 - H 15-44
 - H 20-44
 - HL-93 (SI)
 - HL-93 (US)
 - HS 15-44
 - HS 20 (SI)
 - HS 20-44
 - Lane-Type Legal Load
 - LRFD Fatigue Truck (SI)
 - LRFD Fatigue Truck (US)
 - NRL
 - SU4
 - SU5
 - SU6
 - SU7
 - Type 3
 - Type 3-3
 - Type 3S2
 - Agency
 - User defined
 - Temporary

Add to >>

Remove from <<

Vehicle summary

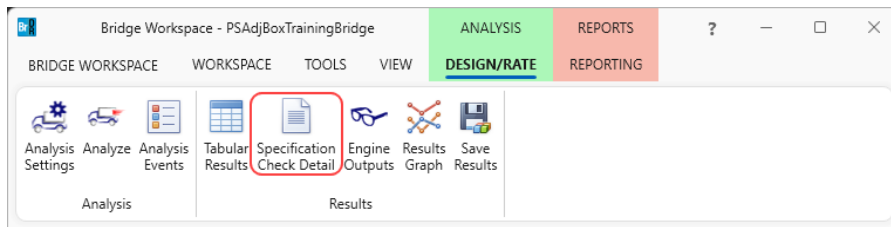
- Rating vehicles
 - LRFR
 - Design load rating
 - Inventory
 - HL-93 (US)
 - Operating
 - HL-93 (US)
 - Fatigue
 - LRFD Fatigue Truck (US)
 - Legal load rating
 - Routine
 - Specialized hauling
 - Permit load rating

Reset Clear Open template Save template OK Apply Cancel

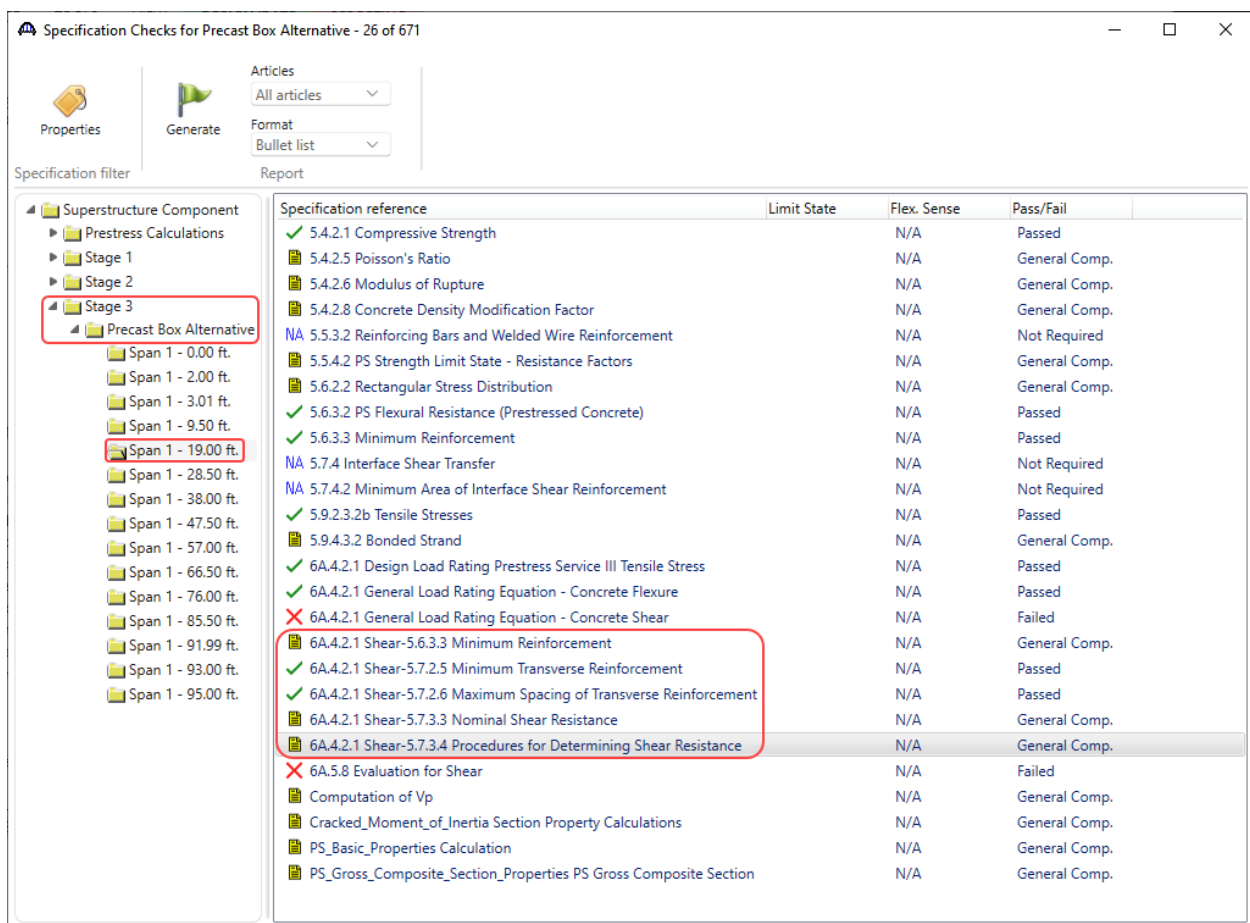
MBE 2023 Spec Interim Update - Shear Rating Iteration Example

Specification Check Detail

When the rating is finished, the specification check detail can be reviewed by clicking the **Specification Check Detail** button from the **Results** group of the **DESIGN/RATE** ribbon.



The window shown below will open. Navigate to the **Stage 3** specification check detail for the analyzed member alternative and select the **Span 1 – 19.00 ft** point of interest.



The highlighted articles for MBE 6A.4.2.1 shear rating are available for an LRFR shear rating of concrete structures. These articles along with 6A.5.8 Evaluation of Shear and 6A.4.2.1 General Load Rating Equation – Concrete Shear articles, use the concurrent load effects to compute the shear capacity and rating factors.

Following sections highlight the MBE 3rd edition 2023 spec interim implementation for an LRFR analysis.

MBE 2023 Spec Interim Update - Shear Rating Iteration Example

Article 6A.4.2.1 Shear-5.6.3.3 Minimum Reinforcement computes the cracking moment (M_{cr}) for each load case as shown below.

A new column – “Governing Action” has been added to indicate the primary action considered. For example, in 2022 interim, rating factors were computed using the envelope moment and shear values. In 2023 interim, shear concurrent actions with maximum (Max M) and minimum (Min M) moment, moment concurrent actions with maximum (Max V) and minimum (Min V) shear are being considered for load rating.

Spec Check Detail for 6A.4.2.1 Shear-5.6.3.3 Minimum Reinforcement

6A.4.2.1 Shear - 5 Concrete Structures
 6A.4.2.1 Shear - 5.6 Design for Flexural and Axial Effects - 8 Regions
 6A.4.2.1 Shear - 5.6.3 Flexural Members
 6A.4.2.1 Shear - 5.6.3.3 Minimum Reinforcement
 (AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)

PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3

Cross Section Properties for Prestress box beam with Rectangular void

Name: BIII-48 Girder f'_c = 5.00 (ksi) Girder f'_{ci} = 4.00 (ksi)

Beam Height = 39.00 (in) Side Wall Thickness = 5.00 (in)
 Top Slab Width = 47.25 (in)
 Top Slab Thick = 5.50 (in)
 Bottom Slab Width = 48.00 (in)
 Bottom Slab Thick = 5.50 (in)
 Shear Key Top = 6.00 (in)
 Shear Key Height = 6.00 (in)
 Shear Key Depth = 0.75 (in)
 B1 = 3.00 (in)
 B2 = 3.00 (in)
 B3 = 3.00 (in)
 B4 = 3.00 (in)

Slab f'_c = 0.00 (ksi)
 Effective Slab Width = 0.00 (in) Haunch Width = 0.00 (in)
 Effective Slab Thickness = 0.00 (in) Haunch Thickness = 0.00 (in)

Input:
 fr beam = 0.54 ksi
 ScTop = -8569.07 in³ Mdnc = 8812.35 kip-in
 ScBot = 8734.21 in³ SncBot = 8734.21 in³
 Gamma1 = 1.60
 Gamma2 = 1.10
 Gamma3 = 1.00 (Prestressed Concrete)
 Gamma3 = 0.67 (Reinforced Concrete)

$M_{cr} = \text{Gamma3} * [(\text{gamma1} * \text{fr} + \text{Gamma2} * \text{f}_{cpe}) * \text{Sc} - \text{Mdnc} * (\text{Sc} / \text{Snc} - 1)]$ (5.6.3.3-1)
 Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
 Otherwise the Resistance is computed as per the Specification.

Limit State	Load Comb	f_{cpe} ksi	f_r ksi	Gamma3	Governing Action	M_u kip-in	V_u kip	Sc in ³	M_{cr} kip-in
STR-I	1, DesInv	2.22	0.54	1.00	Max M	33228.57	127.29	8734.21	28801.18
STR-I	1, DesInv	2.22	0.54	1.00	Min M	11318.68	37.57	8734.21	28801.18
STR-I	1, DesInv	2.22	0.54	1.00	Max V	32064.13	128.56	8734.21	28801.18
STR-I	1, DesInv	2.22	0.54	1.00	Min V	22779.24	25.01	8734.21	28801.18
STR-I	1, DesOp	2.22	0.54	1.00	Max M	28220.60	106.78	8734.21	28801.18
STR-I	1, DesOp	2.22	0.54	1.00	Min M	11318.68	37.57	8734.21	28801.18
STR-I	1, DesOp	2.22	0.54	1.00	Max V	27322.31	107.77	8734.21	28801.18
STR-I	1, DesOp	2.22	0.54	1.00	Min V	20159.68	27.88	8734.21	28801.18
STR-I	2, DesInv	2.22	0.54	1.00	Max M	29541.81	111.12	8734.21	28801.18
STR-I	2, DesInv	2.22	0.54	1.00	Min M	11318.68	37.57	8734.21	28801.18
STR-I	2, DesInv	2.22	0.54	1.00	Max V	28377.37	112.39	8734.21	28801.18
STR-I	2, DesInv	2.22	0.54	1.00	Min V	23878.56	23.80	8734.21	28801.18
STR-I	2, DesOp	2.22	0.54	1.00	Max M	25376.52	94.31	8734.21	28801.18
STR-I	2, DesOp	2.22	0.54	1.00	Min M	11318.68	37.57	8734.21	28801.18
STR-I	2, DesOp	2.22	0.54	1.00	Max V	24478.24	95.29	8734.21	28801.18
STR-I	2, DesOp	2.22	0.54	1.00	Min V	21007.73	26.95	8734.21	28801.18
SER-III	1, DesInv	2.22	0.54	1.00	Max M	18828.30	70.27	8734.21	28801.18
SER-III	1, DesInv	2.22	0.54	1.00	Min M	8812.35	29.26	8734.21	28801.18
SER-III	1, DesInv	2.22	0.54	1.00	Max V	18295.99	70.86	8734.21	28801.18
SER-III	1, DesInv	2.22	0.54	1.00	Min V	14051.47	23.52	8734.21	28801.18
SER-III	2, DesInv	2.22	0.54	1.00	Max M	17142.93	62.88	8734.21	28801.18
SER-III	2, DesInv	2.22	0.54	1.00	Min M	8812.35	29.26	8734.21	28801.18
SER-III	2, DesInv	2.22	0.54	1.00	Max V	16610.61	63.46	8734.21	28801.18
SER-III	2, DesInv	2.22	0.54	1.00	Min V	14554.01	22.97	8734.21	28801.18

Load Combination Legend:

Code	Vehicle
1	HL-93 (US) - Truck + Lane
2	HL-93 (US) - Tandem + Lane

Figure 1 - 6A.4.2.1 Shear-5.6.3.3 Minimum Reinforcement

Note: Article “LRFD 5.6.3.3 Minimum Reinforcement” will only be applicable for determining M_{cr} for flexural resistance using the envelope moment.

MBE 2023 Spec Interim Update - Shear Rating Iteration Example

Spec Check Detail for 6A.4.2.1 Shear-5.7.3.4 Procedures for Determining Shear Resistance

6A.4.2.1 Shear - 5 Concrete Structures
 6A.4.2.1 Shear - 5.7 Shear and Torsion
 6A.4.2.1 Shear - 5.7.3 Sectional Design Model
6A.4.2.1 Shear - 5.7.3.4 Procedures for Determining Shear Resistance
 (AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)
 PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3

Calculation of Beta/Theta

$E_s = 0.000$ (kips/in²)
 $\phi_t = 0.900$
 $f'_c = 5.000$ (kips/in²)
 $f_{pc} = 0.957$ (kips/in²)
 $f_y = 60.000$ (kips/in²)
 Agg diam = 1.000 (in)
 $V_p = 0.000$ (kips)
 $E_p = 28500.000$ (kips/in²)
 $A_s(\text{pos}) = 0.000$ (in²) (used for Positive Mu)
 $A_s(\text{neg}) = 0.000$ (in²) (used for Negative Mu)
 $A_{st}(\text{pos}) = 4.284$ (in²) (used for Positive Mu)
 $A_{st}(\text{neg}) = 0.306$ (in²) (used for Negative Mu)
 $f_{po} = 189.000$ (kips/in²)
 $E_c = 4592.232$ (kips/in²)

Beta Calc (used in table below) :

(1) - Beta = $4.8 / (1 + 750 \text{ EpsilonS})$
 (2) - Beta = $(4.8 / (1 + 750 \text{ EpsilonS})) * (51 / (39 + sxe))$
 where:
 $sxe = sx * (1.38 / (ag + 0.63))$

Mu_calc = Max(Mu, |Vu - Vp| * dv)

Modify MCF Theta: No

Modify MCF Size Effect: No

$f_{pc} / f'_c = 0.19$

Limit State	Load Comb	Epsilon	Theta	Beta	Governing Action	Mu (kip-in)	Mu Calc (kip-in)	Vu (kips)	Nu (kips)	bv (in)	dv (in)	Sx (in)	Sxe (in)	Beta Calc	Act (in ²)	Av (in ²)	As (in ²)
STR-I	1, DesInv	0.002471	37.65	1.68	Max M	33228.57	33228.57	127.29	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	1, DesInv	0.000000	29.00	4.80	Min M	11318.68	11318.68	37.57	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	1, DesInv	0.002199	36.70	1.81	Max V	32064.13	32064.13	128.56	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	1, DesInv	0.000000	29.00	4.80	Min V	22779.24	22779.24	25.01	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	1, DesOp	0.001052	32.11	2.64	Max M	28220.60	28220.60	106.78	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	1, DesOp	0.000000	29.00	4.80	Min M	11318.68	11318.68	37.57	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	1, DesOp	0.000879	32.08	2.89	Max V	27322.31	27322.31	107.77	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	1, DesOp	0.000000	29.00	4.80	Min V	20159.68	20159.68	27.88	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesInv	0.001444	34.06	2.30	Max M	29541.81	29541.81	111.12	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesInv	0.000000	29.00	4.80	Min M	11318.68	11318.68	37.57	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesInv	0.001172	33.10	2.55	Max V	28377.37	28377.37	112.39	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesInv	0.000000	29.00	4.80	Min V	23878.56	23878.56	23.80	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000296	30.04	3.93	Max M	25376.52	25376.52	94.31	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000000	29.00	4.80	Min M	11318.68	11318.68	37.57	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000087	29.30	4.51	Max V	24478.24	24478.24	95.29	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000000	29.00	4.80	Min V	21007.73	21007.73	26.95	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000000	29.00	4.80	Max M	18528.30	18528.30	70.27	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000000	29.00	4.80	Min M	8812.35	8812.35	29.26	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000000	29.00	4.80	Max V	18295.99	18295.99	70.86	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000000	29.00	4.80	Min V	14051.47	14051.47	23.52	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000000	29.00	4.80	Max M	17142.93	17142.93	62.88	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000000	29.00	4.80	Min M	8812.35	8812.35	29.26	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000000	29.00	4.80	Max V	16610.61	16610.61	63.46	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00
STR-I	2, DesOp	0.000000	29.00	4.80	Min V	14554.01	14554.01	22.97	0.00	10.00	33.77	33.77	--	(1)	413.00	0.40	0.00

Load Combination Legend:

Code	Vehicle
1	HL-93 (US) - Truck + Lane
2	HL-93 (US) - Tandem + Lane

Figure 2 - 6A.4.2.1 Shear-5.7.3.4 Procedures for Determining Shear Resistance

Spec Check Detail for 6A.4.2.1 Shear-5.7.2.5 Minimum Transverse Reinforcement

6A.4.2.1 Shear - 5 Concrete Structures
 6A.4.2.1 Shear - 5.7 Shear and Torsion
 6A.4.2.1 Shear - 5.7.2 General Requirements
6A.4.2.1 Shear - 5.7.2.5 Minimum Transverse Reinforcement
 (AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)
 PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3

Check

$V_u > 0.5 * \phi_t * (V_c + V_p)$ (5.7.2.3 - 1)
 $Av \geq 0.0316 * \lambda_{mbda} * \text{SQRT}(f'_c) * b_v * s / f_y$ (5.7.2.5 - 1)
 $f'_c = 5.000\text{kpsi}$
 $f_y = 60.000\text{kpsi}$
 $\phi_t = 0.900$
 $\lambda_{mbda} = 1.000$

Note: f_y = Yield strength of transverse reinforcement (ksi) <= 100 ksi.

Limit State	Load Comb	Vc (kip)	Vp (kip)	Governing Action	Vu (kip)	Vu> 0.5*phi*(Vc+Vp)	s (in)	bv (in)	Av Provided(in ²)	>= 0.0316 * lambda * SQRT(f'c) * bv * s / f_y	Pass/Fail
STR-I	1, DesInv	40.13	0.00	Max M	127.29	Yes	12.00	10.00	0.40	0.14	Pass
STR-I	1, DesInv	114.52	0.00	Min M	37.57	No	12.00	10.00	0.40	n/a	Pass
STR-I	1, DesInv	43.22	0.00	Max V	128.56	Yes	12.00	10.00	0.40	0.14	Pass
STR-I	1, DesInv	114.52	0.00	Min V	25.01	No	12.00	10.00	0.40	n/a	Pass
STR-I	1, DesOp	62.05	0.00	Max M	106.78	Yes	12.00	10.00	0.40	0.14	Pass
STR-I	1, DesOp	114.52	0.00	Min M	37.57	No	12.00	10.00	0.40	n/a	Pass
STR-I	1, DesOp	69.03	0.00	Max V	107.77	Yes	12.00	10.00	0.40	0.14	Pass
STR-I	1, DesOp	114.52	0.00	Min V	27.88	No	12.00	10.00	0.40	n/a	Pass
STR-I	2, DesInv	54.97	0.00	Max M	111.12	Yes	12.00	10.00	0.40	0.14	Pass
STR-I	2, DesInv	114.52	0.00	Min M	37.57	No	12.00	10.00	0.40	n/a	Pass
STR-I	2, DesInv	60.94	0.00	Max V	112.39	Yes	12.00	10.00	0.40	0.14	Pass
STR-I	2, DesInv	114.52	0.00	Min V	23.80	No	12.00	10.00	0.40	n/a	Pass
STR-I	2, DesOp	92.69	0.00	Max M	94.31	Yes	12.00	10.00	0.40	0.14	Pass
STR-I	2, DesOp	114.52	0.00	Min M	37.57	No	12.00	10.00	0.40	n/a	Pass
STR-I	2, DesOp	107.53	0.00	Max V	95.29	Yes	12.00	10.00	0.40	0.14	Pass
STR-I	2, DesOp	114.52	0.00	Min V	26.95	No	12.00	10.00	0.40	n/a	Pass
STR-III	1, DesInv	114.52	0.00	Max M	70.27	Yes	12.00	10.00	0.40	0.14	Pass
STR-III	1, DesInv	114.52	0.00	Min M	29.26	No	12.00	10.00	0.40	n/a	Pass
STR-III	1, DesInv	114.52	0.00	Max V	70.86	Yes	12.00	10.00	0.40	0.14	Pass
STR-III	1, DesInv	114.52	0.00	Min V	23.52	No	12.00	10.00	0.40	n/a	Pass
STR-III	2, DesInv	114.52	0.00	Max M	62.88	Yes	12.00	10.00	0.40	0.14	Pass
STR-III	2, DesInv	114.52	0.00	Min M	29.26	No	12.00	10.00	0.40	n/a	Pass
STR-III	2, DesInv	114.52	0.00	Max V	63.46	Yes	12.00	10.00	0.40	0.14	Pass
STR-III	2, DesInv	114.52	0.00	Min V	22.97	No	12.00	10.00	0.40	n/a	Pass

Load Combination Legend:

Code	Vehicle
1	HL-93 (US) - Truck + Lane
2	HL-93 (US) - Tandem + Lane

Figure 3 - 6A.4.2.1 Shear-5.7.2.5 Minimum Transverse Reinforcement

MBE 2023 Spec Interim Update - Shear Rating Iteration Example

Spec Check Detail for 6A.4.2.1 Shear-5.7.2.6 Maximum Spacing of Transverse Reinforcement

6A.4.2.1 Shear - 5 Concrete Structures
 6A.4.2.1 Shear - 5.7 Shear and Torsion
 6A.4.2.1 Shear - 5.7.2 General Requirements
 6A.4.2.1 Shear - 5.7.2.6 Maximum Spacing of Transverse Reinforcement
 (AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)

PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3

Calculation of Shear Stress on the concrete
 $V_u > 0.5\phi V_p + (V_c + V_p)$ (5.8.2.4-1)
 $\phi = 0.9000$
 $f'_c = 5.000\text{ksi}$

Limit State	Load Comb	Vc (kip)	Vp (kip)	Governing Action	Vu (kip)	Vu > 0.5*phi*(Vc+Vp)	bv (in)	dv (in)	Vu (ksi)	Vu < 0.125*f'c	s (in)	Spacing criteria	Status
STR-I	1, DesInv	40.13	0.00	Max M	127.29	TRUE	10.00	33.77	0.42	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
STR-I	1, DesInv	114.52	0.00	Min M	37.57	FALSE	NA	NA	NA	NA	NA	n/a	Pass
STR-I	1, DesInv	43.22	0.00	Max V	128.56	TRUE	10.00	33.77	0.42	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
STR-I	1, DesInv	114.52	0.00	Min V	25.01	FALSE	NA	NA	NA	NA	NA	n/a	Pass
STR-I	1, DesOp	63.03	0.00	Max M	106.78	TRUE	10.00	33.77	0.35	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
STR-I	1, DesOp	114.52	0.00	Min M	37.57	FALSE	NA	NA	NA	NA	NA	n/a	Pass
STR-I	1, DesOp	69.03	0.00	Max V	107.77	TRUE	10.00	33.77	0.35	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
STR-I	1, DesOp	114.52	0.00	Min V	27.88	FALSE	NA	NA	NA	NA	NA	n/a	Pass
STR-I	2, DesInv	54.97	0.00	Max M	111.12	TRUE	10.00	33.77	0.37	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
STR-I	2, DesInv	114.52	0.00	Min M	37.57	FALSE	NA	NA	NA	NA	NA	n/a	Pass
STR-I	2, DesInv	60.94	0.00	Max V	112.39	TRUE	10.00	33.77	0.37	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
STR-I	2, DesInv	114.52	0.00	Min V	23.80	FALSE	NA	NA	NA	NA	NA	n/a	Pass
STR-I	2, DesOp	93.69	0.00	Max M	94.31	TRUE	10.00	33.77	0.31	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
STR-I	2, DesOp	114.52	0.00	Min M	37.57	FALSE	NA	NA	NA	NA	NA	n/a	Pass
STR-I	2, DesOp	107.53	0.00	Max V	95.29	TRUE	10.00	33.77	0.31	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
STR-I	2, DesOp	114.52	0.00	Min V	26.95	FALSE	NA	NA	NA	NA	NA	n/a	Pass
SER-III	1, DesInv	114.52	0.00	Max M	70.27	TRUE	10.00	33.77	0.23	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
SER-III	1, DesInv	114.52	0.00	Min M	29.26	FALSE	NA	NA	NA	NA	NA	n/a	Pass
SER-III	1, DesInv	114.52	0.00	Max V	70.86	TRUE	10.00	33.77	0.23	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
SER-III	1, DesInv	114.52	0.00	Min V	23.52	FALSE	NA	NA	NA	NA	NA	n/a	Pass
SER-III	2, DesInv	114.52	0.00	Max M	62.08	TRUE	10.00	33.77	0.21	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
SER-III	2, DesInv	114.52	0.00	Min M	29.26	FALSE	NA	NA	NA	NA	NA	n/a	Pass
SER-III	2, DesInv	114.52	0.00	Max V	63.46	TRUE	10.00	33.77	0.21	TRUE	12.00	s <= Min(0.8*dv, 24	Pass
SER-III	2, DesInv	114.52	0.00	Min V	22.97	FALSE	NA	NA	NA	NA	NA	n/a	Pass

Load Combination Legend:

Code	Vehicle
1	HL-93 (US) - Truck + Lane
2	HL-93 (US) - Tandem + Lane

Figure 4 - 6A.4.2.1 Shear-5.7.2.6 Maximum Spacing of Transverse Reinforcement

Spec Check Detail for 6A.4.2.1 Shear-5.7.3.3 Nominal Shear Resistance

6A.4.2.1 Shear - 5 Concrete Structures
 6A.4.2.1 Shear - 5.7 Shear and Torsion
 6A.4.2.1 Shear - 5.7.3 Sectional Design Model
 6A.4.2.1 Shear - 5.7.3.3 Nominal Shear Resistance
 (AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)

PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3

Calculation of Shear Resistance Vr

Vc = 0.0316 * Beta * lambda * SQRT(f'c) * bv * dv (5.7.3.3-3)

Av1 * fy1 * dv (cot(theta) + cot(alpha1)) * sin(alpha1)
 Vs1 = ----- * lambda_duct (5.7.3.3-4)

Vs2 = Av2 * fy2 * sin(alpha2) * lambda_duct (5.7.3.3-6)
 Vs2Max = 0.095 * lambda * SQRT(f'c) * bv * dv (5.7.3.3-6)
 Vs = Vs1 + min(Vs2, Vs2Max)

Post tensioned = FALSE
 lambda_duct = 1.0000

Vn1 = Vc + Vs + Vp (5.7.3.3-1)
 Vn2 = 0.25 * f'c * bv * dv + Vp (5.7.3.3-2)
 Vn = min(Vn1, Vn2)
 Vr = phi * Vn (5.7.2.1-1)

where:

Vc: Resistance due to concrete.
 Vs1: Resistance due to stirrups.
 Vs2: Resistance due to only center 3/4 of sloped portion of the longitudinal bars. (Article 5.7.3.3)
 Vp: Resistance due to prestressing.
 Vs1: Resistance due to force in inclined bars.
 *Note: Vr includes the value Vs1
 Av1: Area of stirrups.
 fy1: Yield Strength of stirrups.
 alpha1: Angle of inclination of stirrups.
 Av2: Area of bent up longitudinal rebars.
 fy2: Yield Strength of bent up longitudinal rebars.
 alpha2: Angle of inclination of bent up longitudinal rebars.

Input:

phi = 0.900
 f'c = 5.000 (ksi)
 fy1 = 60.000 (ksi)
 alpha1 = 90.000 (Degrees)
 lambda = 1.000
 Consider inclined forces option: No
 Consider sloped portion of longitudinal rebar option: No
 Consider iterative shear rating option (applies only to General and GeneralAppB shear computation methods): No
 Consider MCFT theta option: No
 Shear computation method: General
 Iteration required: No

Figure 5 - 6A.4.2.1 Shear-5.7.3.3 Nominal Shear Resistance Part 1

MBE 2023 Spec Interim Update - Shear Rating Iteration Example

Limit State	Load Combo	Governing Action	Mu (kip-in)	MuDL (kip-in)	MuLL (kip-in)	Vu (kip)	VuDL (kip)	VuLL (kip)	Mu (kip)	bw (in)	dw (in)	s (in)	Av1 (in^2)	Beta	cot (Theta)	Epsilon
STR-I	1, DesInv	Max M	33228.57	11318.68	21909.89	127.29	37.57	89.71	0.00	10.00	33.77	12.00	0.40	1.682	1.296	0.002471
STR-I	1, DesInv	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
STR-I	1, DesInv	Max V	32064.13	11318.68	20745.45	128.56	37.57	90.99	0.00	10.00	33.77	12.00	0.40	1.612	1.342	0.002199
STR-I	1, DesInv	Min V	22779.24	11318.68	11460.56	25.01	37.57	-12.57	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
STR-I	1, DesOp	Max M	28220.60	11318.68	16901.91	106.78	37.57	69.21	0.00	10.00	33.77	12.00	0.40	2.643	1.551	0.001088
STR-I	1, DesOp	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
STR-I	1, DesOp	Max V	27322.31	11318.68	16003.63	107.77	37.57	70.19	0.00	10.00	33.77	12.00	0.40	2.893	1.586	0.000879
STR-I	1, DesOp	Min V	20159.68	11318.68	8841.00	27.88	37.57	-9.69	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
STR-I	2, DesInv	Max M	29541.81	11318.68	18223.13	111.12	37.57	73.54	0.00	10.00	33.77	12.00	0.40	2.304	1.479	0.001444
STR-I	2, DesInv	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
STR-I	2, DesInv	Max V	28377.37	11318.68	17058.69	112.39	37.57	74.82	0.00	10.00	33.77	12.00	0.40	2.554	1.534	0.001172
STR-I	2, DesInv	Min V	23878.56	11318.68	12559.88	23.80	37.57	-13.77	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
STR-I	2, DesOp	Max M	25376.52	11318.68	14057.84	94.31	37.57	56.73	0.00	10.00	33.77	12.00	0.40	3.927	1.729	0.002296
STR-I	2, DesOp	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
STR-I	2, DesOp	Max V	24478.24	11318.68	13159.56	95.29	37.57	57.72	0.00	10.00	33.77	12.00	0.40	4.507	1.782	0.000887
STR-I	2, DesOp	Min V	21007.73	11318.68	9689.05	26.95	37.57	-10.62	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
SER-III	1, DesInv	Max M	18928.30	8812.35	10015.95	70.27	29.26	41.01	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
SER-III	1, DesInv	Min M	8812.35	8812.35	0.00	29.26	29.26	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
SER-III	1, DesInv	Max V	18295.99	8812.35	9483.63	70.86	29.26	41.59	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
SER-III	1, DesInv	Min V	14051.47	8812.35	5239.11	23.52	29.26	-5.74	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
SER-III	2, DesInv	Max M	17142.93	8812.35	8330.57	62.88	29.26	33.62	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
SER-III	2, DesInv	Min M	8812.35	8812.35	0.00	29.26	29.26	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
SER-III	2, DesInv	Max V	14610.61	8812.35	7799.26	63.46	29.26	34.20	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000
SER-III	2, DesInv	Min V	14554.01	8812.35	5741.66	22.97	29.26	-6.30	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000

Load Combination Legend:

Code	Vehicle
1	HL-93 (US) - Truck + Lane
2	HL-93 (US) - Tandem + Lane

Figure 6 - 6A.4.2.1 Shear-5.7.3.3 Nominal Shear Resistance Part 2

Vc (kip)	Vs1 (kip)	Vs2 (kip)	Vs2Max (kip)	Vp (kip)	Vrs1 (kip)	Vn1 (kip)	Vn2 (kip)	Phi	Override Vn (kip)	Vr (kip)
40.13	87.53	0.00	71.73	0.00	0.00	127.67	422.06	---	---	114.90
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
43.22	90.61	0.00	71.73	0.00	0.00	133.83	422.06	---	---	120.45
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
63.05	104.75	0.00	71.73	0.00	0.00	167.80	422.06	---	---	151.02
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
69.03	107.76	0.00	71.73	0.00	0.00	176.78	422.06	---	---	159.11
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
54.97	99.91	0.00	71.73	0.00	0.00	154.88	422.06	---	---	139.39
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
60.94	103.58	0.00	71.73	0.00	0.00	164.51	422.06	---	---	148.06
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
93.69	116.79	0.00	71.73	0.00	0.00	210.48	422.06	---	---	189.43
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
107.53	120.32	0.00	71.73	0.00	0.00	227.86	422.06	---	---	205.07
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71
114.52	121.83	0.00	71.73	0.00	0.00	236.35	422.06	---	---	212.71

Figure 7 - 6A.4.2.1 Shear-5.7.3.3 Nominal Shear Resistance Part 3

In 2022 interim, the load cases shown in the LL column are only envelope shear actions.

Spec Check Detail for 6A.4.2.1 General Load Rating Equation - Concrete Shear

6A Load and Resistance Factor Rating
 6A.4 Load Rating Procedures
 6A.4.2 General Load Rating Equation
 6A.4.2.1 Concrete Shear General
 (AASHTO Manual for Bridge Evaluation, Third Edition with 2022 Interims)
 PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3

Shear Rating Factor Calculations

Input:

Condition Factor = 1.0000
 System Factor = 1.0000
 DC Shear (Max) = 25.2718 (kip)
 DC Shear (Min) = 25.2718 (kip)
 DW Shear (Max) = 3.9900 (kip)
 DW Shear (Min) = 3.9900 (kip)
 DW-S Shear (Max) = 0.0000 (kip)
 DW-S Shear (Min) = 0.0000 (kip)

Ignore design & legal shear: False
 Ignore permit shear: True

Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
 Otherwise the Resistance is computed as per the Specification.

Load	Load Combo	Limit State	LL (kip)	Adj. LL (kip)	DC	DW	DW-S	LL	Phi	Override Vn (kip)	Phi	Vn (kip)	RF	Capacity (Ton)
DesignInv	1	STR-I	51.99	---	1.25	1.50	1.50	1.75	0.90	127.44	---	---	0.848	30.51
DesignInv	1	STR-I	-7.18	---	1.25	1.50	1.50	1.75	0.90	-236.35	---	---	19.917	717.02
DesignOp	1	STR-I	51.99	---	1.25	1.50	1.50	1.35	0.90	167.47	---	---	1.612	58.03
DesignOp	1	STR-I	-7.18	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	25.819	929.47
DesignInv	2	STR-I	42.75	---	1.25	1.50	1.50	1.75	0.90	154.53	---	---	1.357	48.94
DesignInv	2	STR-I	-7.87	---	1.25	1.50	1.50	1.75	0.90	-236.35	---	---	18.174	654.26
DesignOp	2	STR-I	42.75	---	1.25	1.50	1.50	1.35	0.90	209.88	---	---	2.622	94.38
DesignOp	2	STR-I	-7.87	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	23.559	848.12

Load Combination Legend:

Code	Vehicle
1	HL-93 (US) - Truck + Lane

Figure 8 - 6A.4.2.1 General Load Rating Equation - Concrete Shear MBE 3rd edition, 2022 interim

MBE 2023 Spec Interim Update - Shear Rating Iteration Example

In 2023 interim, the LL values shown for governing action Max V and Min V are the envelope shear values. For governing action Max M and Min M, shear concurrent with moment are considered. This results in new load cases.

Spec Check Detail for 6A.4.2.1 General Load Rating Equation - Concrete Shear

6A Load and Resistance Factor Rating
 6A.4 Load Rating Procedures
 6A.4.2 General Load-Rating Equation
 6A.4.2.1 Concrete Shear General
 (AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interim)

PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3

Shear Rating Factor Calculations

Input:

Condition Factor = 1.0000
 System Factor = 1.0000

DC Shear (Max) = 25.2718 (kip)
 DC Shear (Min) = 25.2718 (kip)
 DW Shear (Max) = 3.9900 (kip)
 DW Shear (Min) = 0.0000 (kip)
 DW-WS Shear (Max) = 0.0000 (kip)
 DW-WS Shear (Min) = 0.0000 (kip)

Ignore design a legal shear: False
 Ignore permit shear: True

Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity. Otherwise the Resistance is computed as per the Specification.

Load	Load Combo	Limit State	Governing Action	LL (kip)	Adj. LL (kip)	Load Factors				Phi	Vn (kip)	-- Override --		RF	Capacity (Ton)
						DC	DW	DW-WS	LL			Phi	Vn (kip)		
DesignInv	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.75	0.90	127.67	---	---	0.862	31.03
DesignInv	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.75	0.90	133.83	---	---	0.911	32.79
DesignInv	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.75	0.90	-236.35	---	---	19.917	717.02
DesignOp	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.35	0.90	167.50	---	---	1.639	59.01
DesignOp	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.35	0.90	176.78	---	---	1.731	62.33
DesignOp	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	25.819	929.47
DesignInv	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.75	0.90	154.88	---	---	1.384	49.84
DesignInv	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.75	0.90	164.51	---	---	1.477	53.16
DesignInv	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.75	0.90	-236.35	---	---	18.174	654.26
DesignOp	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.35	0.90	210.48	---	---	2.677	96.36
DesignOp	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.35	0.90	227.86	---	---	2.902	104.47
DesignOp	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	23.559	848.12

Load Combination Legend:

Code Vehicle

OK

Figure 9 - 6A.4.2.1 General Load Rating Equation -Concrete Shear MBE 3rd edition, 2023 interim

Highlighted portion in image below shows the improvement of rating factor from 0.848 in 2022 interim to 0.911 in 2023 interim for Design inventory, load case 1, STR-1 limit state.

Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity. Otherwise the Resistance is computed as per the Specification.

Load	Load Combo	Limit State	Governing Action	LL (kip)	Adj. LL (kip)	Load Factors				Phi	Vn (kip)	-- Override --		RF	Capacity (Ton)
						DC	DW	DW-WS	LL			Phi	Vn (kip)		
DesignInv	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.75	0.90	127.44	---	---	0.848	30.51
DesignInv	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	19.917	717.02
DesignOp	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.35	0.90	167.47	---	---	1.612	58.03
DesignOp	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	25.819	929.47
DesignInv	2	STR-I	Max M	42.75	---	1.25	1.50	1.50	1.75	0.90	154.53	---	---	1.357	48.84
DesignInv	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	18.174	654.26
DesignOp	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.35	0.90	209.88	---	---	2.622	94.38
DesignOp	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	23.559	848.12

Load	Load Combo	Limit State	Governing Action	LL (kip)	Adj. LL (kip)	Load Factors				Phi	Vn (kip)	-- Override --		RF	Capacity (Ton)
						DC	DW	DW-WS	LL			Phi	Vn (kip)		
DesignInv	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.75	0.90	127.67	---	---	0.862	31.03
DesignInv	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.75	0.90	133.83	---	---	0.911	32.79
DesignInv	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.75	0.90	-236.35	---	---	19.917	717.02
DesignOp	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.35	0.90	167.80	---	---	1.639	59.01
DesignOp	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.35	0.90	176.78	---	---	1.731	62.33
DesignOp	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	25.819	929.47
DesignInv	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.75	0.90	154.88	---	---	1.384	49.84
DesignInv	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.75	0.90	164.51	---	---	1.477	53.16
DesignInv	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.75	0.90	-236.35	---	---	18.174	654.26
DesignOp	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.35	0.90	210.48	---	---	2.677	96.36
DesignOp	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.35	0.90	227.86	---	---	2.902	104.47
DesignOp	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	23.559	848.12

Figure 10 - 6A.4.2.1 General Load Rating Equation -Concrete Shear rating comparison

MBE 2023 Spec Interim Update - Shear Rating Iteration Example

Spec Check Detail for 6A.5.8 Evaluation for Shear

6A Load and Resistance Factor Rating	
6A.5 Concrete Structures	
6A.5.8 Evaluation for Shear	
(AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)	
PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3	
Longitudinal Reinforcement	

From LRFD 5.7.3.5-1	
LHS or Tr = Aps*fps + As*fy	
$RHS = \frac{ Mu }{dv*phif} + 0.5 \frac{Nu}{phic} + \frac{ Vu }{ phiv } - Vp - 0.5 * Vs \cot(\theta) \quad (LRFD 5.7.3.5-1)$	
$T(DL) = SignMDL * \frac{ MuDL }{dv*phif} + 0.5 * SignNDL * \frac{NuDL}{phic} + (SignVDLp * \frac{ VuDL }{ phiv } - Vp - 0.5 * Vs) * \cot(\theta), \text{ where } Vs = \min(Vs, Vu/phiv) \quad (\text{Based on LRFD 5.7.3.5-1 and MBE 6A.5.8})$	
$T(LL) = SignMLL * \frac{ MuLL }{dv*phif} + 0.5 * SignNLL * \frac{NuLL}{phic} + (SignVLL * \frac{ VuLL }{ phiv }) * \cot(\theta) \quad (\text{Based on LRFD 5.7.3.5-1 and MBE 6A.5.8})$	
Where:	
$Mu = MuDL + MuLL; Nu = NuDL + NuLL; VT = \frac{VuDL + VuLL}{phiv} - Vp; VuDLp = \frac{VuDL}{phiv} - Vp$	
$SignMDL = Sign \text{ of } \frac{MuDL}{Mu}; SignNDL = Sign \text{ of } \frac{NuDL}{Nu}; SignVDLp = Sign \text{ of } \frac{VuDLp}{VT}; SignMLL = Sign \text{ of } \frac{MuLL}{Mu}; SignNLL = Sign \text{ of } \frac{NuLL}{Nu}; SignVLL = Sign \text{ of } \frac{VuLL}{VT}$	
$RF = \frac{T(r) - T(DL)}{T(LL)}$	
Ignore design & legal shear : No	
Ignore permit shear : Yes	
Consider iterative shear rating : No	
Consider MCFT theta : No	
Shear computation method type : General	
Iteration required : No	
phif = 1.000 phic = 0.750 phiv = 0.900	

As(pos) = 0.000 (in^2) (used for Positive Mu) As(neg) = 0.000 (in^2) (used for Negative Mu) fy(pos) = 0.000 (ksi) (used for Positive Mu) fy(neg) = 0.000 (ksi) (used for Negative Mu) Aps(pos) = 4.254 (in^2) (used for Positive Mu) Aps(neg) = 0.306 (in^2) (used for Negative Mu) fps(pos) = 245.606 (ksi) (used for Positive Mu) fps(neg) = 141.252 (ksi) (used for Negative Mu) Bv(pos) = 10.000 (in) (used for Positive Mu) Bv(neg) = 10.000 (in) (used for Negative Mu) Dv(pos) = 33.765 (in) (used for Positive Mu) Dv(neg) = 28.080 (in) (used for Negative Mu)	

Figure 11 - 6A.5.8 Evaluation for Shear MBE 3rd edition, 2023 interim

Limit State	Load Comb	dv (in)	Ar*fy (kips)	Aps*fps (kips)	Tr (kips)	MuDL (kip-in)	NuDL (kips)	VuDL (kips)	Vp (kips)	Governing Action	MuLL (kip-in)	NuLL (kips)	VuLL (kips)	epsilon	beta	theta (Deg.)	Ar (in^2)	s (in)	Vs (kips)	TDL (kips)	TLL (kips)	LHS/RHS	RF	Capacity (Ton)
STB-1	1, DeadLow	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max M	21909.89	0.00	89.71	0.002471	1.68	37.65	0.40	12.00	87.53	332.60	778.10	0.95	0.925	33.29
STB-1	1, DeadLow	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min M	0.00	0.00	0.00	0.000000	4.80	29.00	0.40	12.00	121.83	372.88	0.00	2.82	99.000	3564.00
STB-1	1, DeadLow	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max V	20745.45	0.00	90.99	0.002199	1.11	36.70	0.40	12.00	90.41	330.45	750.05	0.97	0.962	36.64
STB-1	1, DeadLow	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min V	11460.36	0.00	-12.57	0.000000	4.80	29.00	0.40	12.00	121.83	385.47	314.23	1.50	2.122	76.38
STB-1	1, DeadOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max M	14890.91	0.00	69.21	0.001088	2.64	32.81	0.40	12.00	104.78	318.74	659.69	1.12	1.183	42.40
STB-1	1, DeadOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min M	0.00	0.00	0.00	0.000000	4.80	29.00	0.40	12.00	121.83	372.88	0.00	2.82	99.000	3564.00
STB-1	1, DeadOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max V	16003.63	0.00	70.19	0.000879	2.89	32.08	0.40	12.00	107.76	315.87	598.42	1.15	1.230	44.30
STB-1	1, DeadOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min V	8841.00	0.00	-9.69	0.000000	4.80	29.00	0.40	12.00	121.83	382.99	242.41	1.68	2.762	99.44
STB-1	2, DeadLow	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max M	18231.13	0.00	73.54	0.001444	2.30	34.06	0.40	12.00	99.91	323.08	660.40	1.07	1.104	39.73
STB-1	2, DeadLow	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min M	0.00	0.00	0.00	0.000000	4.80	29.00	0.40	12.00	121.83	372.88	0.00	2.82	99.000	3564.00
STB-1	2, DeadLow	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max V	17088.69	0.00	74.82	0.001172	2.83	33.10	0.40	12.00	103.98	319.82	632.72	1.10	1.157	41.67
STB-1	2, DeadLow	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min V	12359.88	0.00	-13.77	0.000000	4.80	29.00	0.40	12.00	121.83	386.68	344.37	1.44	1.932	69.97
STB-1	2, DeadOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max M	14057.84	0.00	56.73	0.000296	3.93	30.04	0.40	12.00	116.79	316.81	525.36	1.25	1.400	50.39
STB-1	2, DeadOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min M	0.00	0.00	0.00	0.000000	4.80	29.00	0.40	12.00	121.83	372.88	0.00	2.82	99.000	3564.00
STB-1	2, DeadOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max V	13119.36	0.00	57.72	0.000087	4.31	29.30	0.40	12.00	120.32	315.08	504.00	1.28	1.462	52.63
STB-1	2, DeadOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min V	9689.05	0.00	-10.62	0.000000	4.80	29.00	0.40	12.00	121.83	383.53	245.66	1.62	2.517	90.61

Figure 12 - 6A.5.8 Evaluation for Shear MBE 3rd edition, 2023 interim

Control option added to consider iterative shear rating

This section details the effects of considering an iterative process to compute the shear capacity used in the LRFR shear rating of concrete bridges. The shear strength for a load rating with Modified Compression Field Theory (MCFT) is an iterative process due to the underlying differences in strain's role in determining shear capacity in design versus load rating. In the iterative process, the factored shear capacity ($C = \Phi C * \Phi S * \phi V_n$) is compared to the applied V_u . If they are not equal, iterations will begin by updating V_u , M_u and N_u by proportionally increasing or decreasing the live load portion of these force effects until the C is equal to the applied V_u . This is applicable to all concrete structures, i.e., reinforced concrete, prestressed concrete, post tensioned concrete and reinforced concrete box culverts.

Member Alternative Description – Control options

Navigate to the member alternative Precast Box Alternative of member **G2**, double click on it (or click the **Open** button from the **WORKSPACE** ribbon) to open its **Member Alternative Description** window. Navigate to the **Control options** tab as shown below.

Check the box - **Consider iterative shear rating** as shown below.

Member Alternative Description

Member alternative: Precast Box Alternative

Description Specs Factors Engine Import Control options

LRFD

- Points of interest
 - ☒ Generate at tenth points except supports
 - ☒ Generate at support points
 - ☒ Generate at support face & critical shear points
 - ☒ Generate at section change points
 - ☒ Generate at user-defined points
- Shear computation method
 - ☐ Ignore
 - ☒ General procedure
 - ☐ General procedure - Appendix B5

LRFR

- ☒ Use gross section properties
- ☐ Use transformed section properties
- Multi-span analysis
 - ☒ Continuous
 - ☐ Continuous and simple
- ☐ Ignore design & legal load shear
- ☒ Ignore permit load shear
- ☐ Consider legal load tensile concrete stress
- ☐ Consider splitting resistance article
- ☒ Ignore tensile rating in top of beam
- ☐ Consider deck reinf. development length
- ☐ Consider permit load tensile steel stress
- ☐ Ignore long. reinf. in rating
- Distribution factor application method
 - ☐ By axle
 - ☒ By POI
- ☐ Allow negative epsilon in general shear method
- ☐ Allow moment redistribution
- ☒ Consider iterative shear rating
- ☐ Modify MCFT theta
- ☐ Modify MCFT size effect

OK Apply Cancel

Click **OK** to apply the data and close the window.

MBE 2023 Spec Interim Update - Shear Rating Iteration Example

Run an LRFR analysis using the analysis settings shown in the previous step.

Specification Check Detail

Once the analysis is complete, open the Specification Check Detail. The specification check articles for the analyzed member alternative for Stage 3 at Span 1 – 19.00 ft, is shown below. Highlighted are the articles where the iteration process is detailed.

Specification reference	Limit State	Flex. Sense	Pass/Fail
✓ 5.4.2.1 Compressive Strength		N/A	Passed
5.4.2.5 Poisson's Ratio		N/A	General Comp.
5.4.2.6 Modulus of Rupture		N/A	General Comp.
5.4.2.8 Concrete Density Modification Factor		N/A	General Comp.
NA 5.5.3.2 Reinforcing Bars and Welded Wire Reinforcement		N/A	Not Required
5.5.4.2 PS Strength Limit State - Resistance Factors		N/A	General Comp.
5.6.2.2 Rectangular Stress Distribution		N/A	General Comp.
✓ 5.6.3.2 PS Flexural Resistance (Prestressed Concrete)		N/A	Passed
✓ 5.6.3.3 Minimum Reinforcement		N/A	Passed
NA 5.7.4 Interface Shear Transfer		N/A	Not Required
NA 5.7.4.2 Minimum Area of Interface Shear Reinforcement		N/A	Not Required
✓ 5.9.2.3.2b Tensile Stresses		N/A	Passed
5.9.4.3.2 Bonded Strand		N/A	General Comp.
✓ 6A.4.2.1 Design Load Rating Prestress Service III Tensile Stress		N/A	Passed
✓ 6A.4.2.1 General Load Rating Equation - Concrete Flexure		N/A	Passed
✗ 6A.4.2.1 General Load Rating Equation - Concrete Shear		N/A	Failed
6A.4.2.1 Shear-5.6.3.3 Minimum Reinforcement		N/A	General Comp.
✓ 6A.4.2.1 Shear-5.7.2.5 Minimum Transverse Reinforcement		N/A	Passed
✓ 6A.4.2.1 Shear-5.7.2.6 Maximum Spacing of Transverse Reinforcement		N/A	Passed
6A.4.2.1 Shear-5.7.3.3 Nominal Shear Resistance		N/A	General Comp.
6A.4.2.1 Shear-5.7.3.4 Procedures for Determining Shear Resistance		N/A	General Comp.
✗ 6A.5.8 Evaluation for Shear		N/A	Failed
Computation of Vp		N/A	General Comp.
Cracked_Moment_of_Inertia Section Property Calculations		N/A	General Comp.
PS_Basic_Properties Calculation		N/A	General Comp.
PS_Gross_Composite_Section_Properties PS Gross Composite Section		N/A	General Comp.

Double click on the 6A.4.2.1 Shear-5.7.3.3 Nominal Shear Resistance article to view the iterations. Additional columns in the final iteration table (shown below) details the status of iteration, convergence, and any failure reason, if applicable, for each load case. If iterations for a given load case converge, then this table will show the result of the final iteration. The capacity from the final iteration is used in the rating equation. If the iteration process does not converge, then the corresponding row from the initial capacity table will be used.

Spec Check Detail for 6A.4.2.1 Shear-5.7.3.3 Nominal Shear Resistance

Limit State	Load Combo	Governing Action	Mu (kip-in)	MuDL (kip-in)	MuLL (kip-in)	Vu (kip)	VuDL (kip)	VuLL (kip)	Nu (kip)	bv (in)	dv (in)	s (in)	Av1 (in ²)	Beta	cot (Theta)	Epsilon	Vc (kip)	Vs1 (kip)	Vs2 (kip)	Vs2Max (kip)	Vp (kip)	Vrs1 (kip)	--- Override ---						
																							Vn1 (kip)	Vn2 (kip)	Phi	Vn (kip)	Vr (kip)		
STR-I	1, DesInv	Max M	33228.57	11318.68	21909.89	127.29	37.57	89.71	0.00	10.00	33.77	12.00	0.40	1.682	1.296	0.002471	40.13	87.53	0.00	71.73	0.00	0.00	---	127.67	422.06	---	114.90		
STR-I	1, DesInv	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-I	1, DesInv	Max V	32076.18	11318.68	20745.45	128.96	37.57	90.99	0.00	10.00	33.77	12.00	0.40	1.612	1.342	0.002199	43.22	90.61	0.00	71.73	0.00	0.00	---	130.93	422.06	---	120.45		
STR-I	1, DesInv	Min V	22779.24	11318.68	11460.96	25.01	37.57	-12.57	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-I	1, DesOp	Max M	28220.60	11318.68	16901.91	106.78	37.57	69.21	0.00	10.00	33.77	12.00	0.40	2.643	1.551	0.001088	63.05	104.75	0.00	71.73	0.00	0.00	---	167.80	422.06	---	151.02		
STR-I	1, DesOp	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-I	1, DesOp	Max V	27322.31	11318.68	16003.63	107.77	37.57	70.19	0.00	10.00	33.77	12.00	0.40	2.993	1.596	0.000879	69.03	107.76	0.00	71.73	0.00	0.00	---	176.78	422.06	---	159.11		
STR-I	1, DesOp	Min V	20159.68	11318.68	8841.00	27.88	37.57	-9.69	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-I	2, DesInv	Max M	29541.51	11318.68	12223.13	111.12	37.57	73.54	0.00	10.00	33.77	12.00	0.40	2.304	1.479	0.001444	54.97	99.91	0.00	71.73	0.00	0.00	---	154.85	422.06	---	139.39		
STR-I	2, DesInv	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-I	2, DesInv	Max V	25377.37	11318.68	17058.69	112.39	37.57	74.82	0.00	10.00	33.77	12.00	0.40	2.554	1.534	0.001172	60.94	103.58	0.00	71.73	0.00	0.00	---	164.51	422.06	---	145.06		
STR-I	2, DesInv	Min V	23979.56	11318.68	12559.88	23.60	37.57	-13.77	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-I	2, DesOp	Max M	25376.52	11318.68	14057.84	94.31	37.57	56.73	0.00	10.00	33.77	12.00	0.40	3.927	1.729	0.000296	93.69	116.79	0.00	71.73	0.00	0.00	---	210.48	422.06	---	199.43		
STR-I	2, DesOp	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-I	2, DesOp	Max V	24475.24	11318.68	13159.56	85.29	37.57	57.12	0.00	10.00	33.77	12.00	0.40	4.507	1.782	0.000087	107.53	120.32	0.00	71.73	0.00	0.00	---	227.86	422.06	---	205.07		
STR-I	2, DesOp	Min V	21007.73	11318.68	9689.05	26.95	37.57	-10.62	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-III	1, DesInv	Max M	18928.30	8812.35	10015.95	70.27	29.26	41.01	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-III	1, DesInv	Min M	8812.35	8812.35	0.00	29.26	29.26	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-III	1, DesInv	Max V	18295.99	8812.35	9483.63	70.86	29.26	41.59	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-III	1, DesInv	Min V	14051.47	8812.35	5239.11	23.52	29.26	-5.74	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-III	2, DesInv	Max M	17142.93	8812.35	8330.57	62.88	29.26	33.62	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-III	2, DesInv	Min M	8812.35	8812.35	0.00	29.26	29.26	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-III	2, DesInv	Max V	14610.61	8812.35	7759.26	63.46	29.26	34.20	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
STR-III	2, DesInv	Min V	14554.01	8812.35	5741.66	22.97	29.26	-6.30	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71		
NOTES: In the table below, live load is increased or decreased to achieve, if possible, the final shear capacity when C = VuDL + VuLL = Vu where shear rating capacity C = phiC + phiS + phi + Vn with condition, system, and resistance factors phiC = 1.000 phiS = 1.000 phi = 0.900 and phiC + phiS >= 0.85																													
(6A.4.2.1-2)																													
Limit State	Load Combo	Governing Action	Mu (kip-in)	MuDL (kip-in)	MuLL (kip-in)	Vu (kip)	VuDL (kip)	VuLL (kip)	Nu (kip)	bv (in)	dv (in)	s (in)	Av1 (in ²)	Beta	cot (Theta)	Epsilon	Vc (kip)	Vs1 (kip)	Vs2 (kip)	Vs2Max (kip)	Vp (kip)	Vrs1 (kip)	--- Override ---						
																							Vn1 (kip)	Vn2 (kip)	Phi	C (kip)	Iterated? Converged?	Failure Reason	
STR-I	1, DesInv	Max M	31965.50	11318.68	20646.82	122.11	37.57	84.54	0.00	10.00	33.77	12.00	0.40	1.852	1.355	0.002122	44.18	91.50	0.00	71.73	0.00	0.00	---	135.68	422.06	---	122.12	Yes	Yes
STR-I	1, DesInv	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71	Yes	Zero live load
STR-I	1, DesInv	Max V	31298.33	11318.68	19979.65	128.20	37.57	87.63	0.00	10.00	33.77	12.00	0.40	1.928	1.379	0.001986	46.00	93.12	0.00	71.73	0.00	0.00	---	139.12	422.06	---	125.21	Yes	---
STR-I	1, DesInv	Min V	109188.20	11318.68	97869.52	-69.74	37.57	-107.31	0.00	10.00	33.77	12.00	0.40	0.873	0.839	0.006000	20.82	56.66	0.00	71.73	0.00	0.00	---	77.49	422.06	---	69.74	Yes	---
STR-I	1, DesOp	Max M	31965.49	11318.68	20646.81	122.11	37.57	84.54	0.00	10.00	33.77	12.00	0.40	1.852	1.355	0.002122	44.18	91.50	0.00	71.73	0.00	0.00	---	135.68	422.06	---	122.12	Yes	Zero live load
STR-I	1, DesOp	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71	Yes	---
STR-I	1, DesOp	Max V	31298.30	11318.68	19979.62	128.20	37.57	87.63	0.00	10.00	33.77	12.00	0.40	1.928	1.379	0.001986	46.00	93.12	0.00	71.73	0.00	0.00	---	139.12	422.06	---	125.21	Yes	---
STR-I	1, DesOp	Min V	109188.16	11318.68	97869.48	-69.74	37.57	-107.31	0.00	10.00	33.77	12.00	0.40	0.873	0.839	0.006000	20.82	56.66	0.00	71.73	0.00	0.00	---	77.49	422.06	---	69.74	Yes	Zero live load
STR-I	2, DesInv	Max M	32107.99	11318.68	20789.31	121.47	37.57	83.90	0.00	10.00	33.77	12.00	0.40	1.836	1.350	0.002152	43.81	91.16	0.00	71.73	0.00	0.00	---	134.97	422.06	---	121.47	Yes	---
STR-I	2, DesInv	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71	Yes	---
STR-I	2, DesInv	Max V	31298.32	11318.68	19979.64	128.20	37.57	87.63	0.00	10.00	33.77	12.00	0.40	1.928	1.379	0.001986	46.00	93.12	0.00	71.73	0.00	0.00	---	139.12	422.06	---	125.21	Yes	---
STR-I	2, DesOp	Max M	32108.06	11318.68	20789.38	121.47	37.57	83.90	0.00	10.00	33.77	12.00	0.40	1.836	1.350	0.002152	43.81	91.16	0.00	71.73	0.00	0.00	---	134.97	422.06	---	121.47	Yes	Zero live load
STR-I	2, DesOp	Min M	11318.68	11318.68	0.00	37.57	37.57	0.00	0.00	10.00	33.77	12.00	0.40	4.800	1.804	0.000000	114.52	121.83	0.00	71.73	0.00	0.00	---	236.35	422.06	---	212.71	Yes	---
STR-I	2, DesOp	Max V	31298.29	11318.68	19979.60	128.20	37.57	87.63	0.00	10.00	33.77	12.00	0.40	1.928	1.379	0.001986	46.00	93.12	0.00	71.73	0.00	0.00	---	139.12	422.06	---	125.21	Yes	---
STR-I	2, DesOp	Min V	109188.17	11318.68	97869.49	-69.74	37.57	-107.31	0.00	10.00	33.77	12.00	0.40	0.873	0.839	0.006000	20.82	56.66	0.00	71.73	0.00	0.00	---	77.49	422.06	---	69.74	Yes	---
STR-III	1, DesInv	Max M	18918.30	8812.35	97869.48	-69.74	29.26																						

Here is a comparison of rating factors at this location with and without iterations.

Spec Check Detail for 6A.4.2.1 General Load Rating Equation - Concrete Shear

6A Load and Resistance Factor Rating
6A.4 Load Rating Procedures
6A.4.2 General Load-Rating Equation
6A.4.2.1 Concrete Shear General
(AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)

PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3

Shear Rating Factor Calculations

Input:

Condition Factor = 1.0000
System Factor = 1.0000

DC Shear (Max) = 25.2718 (kip)
DC Shear (Min) = 25.2718 (kip)
DW Shear (Max) = 3.9900 (kip)
DW Shear (Min) = 3.9900 (kip)
DW-WS Shear (Max) = 0.0000 (kip)
DW-WS Shear (Min) = 0.0000 (kip)

Ignore design & legal shear: False
Ignore permit shear: True

Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
Otherwise the Resistance is computed as per the Specification.

Load	Load Combo	Limit State	Governing Action	LL (kip)	Adj. LL (kip)	Load Factors					Phi	-- Override --		RF	Capacity (Ton)
						DC	DW	DW-WS	LL	Vn (kip)		Phi	Vn (kip)		
DesignInv	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.75	0.90	127.67	---	---	0.862	31.03
DesignInv	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.75	0.90	133.83	---	---	0.911	32.79
DesignInv	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.75	0.90	-236.35	---	---	19.917	717.02
DesignOp	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.35	0.90	167.80	---	---	1.639	59.01
DesignOp	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.35	0.90	176.78	---	---	1.731	62.33
DesignOp	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	25.819	929.47
DesignInv	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.75	0.90	154.88	---	---	1.384	49.84
DesignInv	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.75	0.90	164.51	---	---	1.477	53.16
DesignInv	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.75	0.90	-236.35	---	---	18.174	654.26
DesignOp	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.35	0.90	210.48	---	---	2.677	96.36
DesignOp	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.35	0.90	227.86	---	---	2.902	104.47
DesignOp	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	23.559	848.12

Load Combination Legend:

Code Vehicle

OK

Figure 14 - 6A.4.2.1 General Load Rating Equation - Concrete Shear without iterations

Spec Check Detail for 6A.4.2.1 General Load Rating Equation - Concrete Shear

6A Load and Resistance Factor Rating
6A.4 Load Rating Procedures
6A.4.2 General Load-Rating Equation
6A.4.2.1 Concrete Shear General
(AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)

PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3

Shear Rating Factor Calculations

Input:

Condition Factor = 1.0000
System Factor = 1.0000

DC Shear (Max) = 25.2718 (kip)
DC Shear (Min) = 25.2718 (kip)
DW Shear (Max) = 3.9900 (kip)
DW Shear (Min) = 3.9900 (kip)
DW-WS Shear (Max) = 0.0000 (kip)
DW-WS Shear (Min) = 0.0000 (kip)

Ignore design & legal shear: False
Ignore permit shear: True

Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
Otherwise the Resistance is computed as per the Specification.

Load	Load Combo	Limit State	Governing Action	LL (kip)	Adj. LL (kip)	Load Factors					Phi	-- Override --		RF	Capacity (Ton)
						DC	DW	DW-WS	LL	Vn (kip)		Phi	Vn (kip)		
DesignInv	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.75	0.90	135.68	---	---	0.942	33.92
DesignInv	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.75	0.90	139.12	---	---	0.963	34.67
DesignInv	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.75	0.90	-77.49	---	---	8.540	307.43
DesignOp	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.35	0.90	135.68	---	---	1.222	43.98
DesignOp	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.35	0.90	139.12	---	---	1.248	44.94
DesignOp	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.35	0.90	-77.49	---	---	11.070	398.52
DesignInv	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.75	0.90	134.97	---	---	1.141	41.07
DesignInv	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.75	0.90	139.12	---	---	1.171	42.16
DesignInv	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.75	0.90	-77.49	---	---	7.792	280.32
DesignOp	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.35	0.90	134.97	---	---	1.479	53.24
DesignOp	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.35	0.90	139.12	---	---	1.518	54.66
DesignOp	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.35	0.90	-77.49	---	---	10.101	363.64

Load Combination Legend:

Code Vehicle

OK

Figure 15 - 6A.4.2.1 General Load Rating Equation - Concrete Shear with iterations

MBE 2023 Spec Interim Update - Shear Rating Iteration Example

Image below highlights some examples of improvements in rating factors with the iteration process.

Load	Load Combo	Limit State	Governing Action	LL (kip)	Adj. LL (kip)	Load Factors				Phi	Vn (kip)	-- Override --		RF	Capacity (Ton)
						DC	DW	DW-WS	LL			Phi	Vn (kip)		
DesignInv	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.75	0.90	135.68	---	---	0.942	33.92
DesignInv	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.75	0.90	139.12	---	---	0.963	34.67
DesignInv	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.75	0.90	-77.49	---	---	8.540	307.43
DesignOp	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.35	0.90	135.68	---	---	1.222	43.98
DesignOp	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.35	0.90	139.12	---	---	1.248	44.94
DesignOp	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.35	0.90	-77.49	---	---	11.070	396.52
DesignInv	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.75	0.90	134.97	---	---	1.141	41.07
DesignInv	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.75	0.90	139.12	---	---	1.171	42.16
DesignInv	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.75	0.90	-77.49	---	---	7.792	280.52
DesignOp	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.35	0.90	134.97	---	---	1.479	53.24
DesignOp	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.35	0.90	139.12	---	---	1.518	54.66
DesignOp	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.35	0.90	-77.49	---	---	10.101	363.64

Load Combination Legend:

Code Vehicle

OK

Load	Load Combo	Limit State	Governing Action	LL (kip)	Adj. LL (kip)	Load Factors				Phi	Vn (kip)	-- Override --		RF	Capacity (Ton)
						DC	DW	DW-WS	LL			Phi	Vn (kip)		
DesignInv	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.75	0.90	127.67	---	---	0.862	31.03
DesignInv	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.75	0.90	133.83	---	---	0.911	32.79
DesignInv	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.75	0.90	-236.35	---	---	19.917	717.02
DesignOp	1	STR-I	Max M	51.26	---	1.25	1.50	1.50	1.35	0.90	167.80	---	---	1.639	59.01
DesignOp	1	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	1	STR-I	Max V	51.99	---	1.25	1.50	1.50	1.35	0.90	176.78	---	---	1.731	62.33
DesignOp	1	STR-I	Min V	-7.18	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	25.819	929.47
DesignInv	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.75	0.90	154.88	---	---	1.384	49.84
DesignInv	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.75	0.90	236.35	---	---	99.000	3564.00
DesignInv	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.75	0.90	164.51	---	---	1.477	53.16
DesignInv	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.75	0.90	-236.35	---	---	18.174	654.26
DesignOp	2	STR-I	Max M	42.02	---	1.25	1.50	1.50	1.35	0.90	210.48	---	---	2.677	96.36
DesignOp	2	STR-I	Min M	0.00	---	1.25	1.50	1.50	1.35	0.90	236.35	---	---	99.000	3564.00
DesignOp	2	STR-I	Max V	42.75	---	1.25	1.50	1.50	1.35	0.90	227.86	---	---	2.902	104.47
DesignOp	2	STR-I	Min V	-7.87	---	1.25	1.50	1.50	1.35	0.90	-236.35	---	---	23.559	848.12

Load Combination Legend:

Code Vehicle

OK

Figure 16 - 6A.4.2.1 General Load Rating Equation - Concrete Shear rating comparison

Longitudinal reinforcement evaluation for shear rating is based on the equilibrium of tensile capacity and demand of the longitudinal reinforcement (LRFD eq. 5.7.3.5-1) determined by iterating the live load component of V_u , M_u and N_u .

Spec Check Detail for 6A.5.8 Evaluation for Shear	
6A Load and Resistance Factor Rating	
6A.1 Concrete Structures	
6A.5.8 Evaluation for Shear	
(ASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)	
PS Box Rect Void - At Location - 19.0000 (ft) - Left Stage 3	
Longitudinal Reinforcement	

From LRFD 5.7.3.5-1	
LMS or Tr = $A_{gs}f_{ps} + A_s f_y$	
$RMS = \frac{M_u}{\phi M_n} + 0.5 \frac{V_u}{\phi V_n} + \frac{ V_u }{\phi V_n} \left(-0.5 + V_n \right) \cot(\theta) \quad (\text{LRFD 5.7.3.5-1})$	
$T(DL) = \text{Sign}M_{DL} \cdot \frac{ M_{DL} }{\phi M_n} + 0.5 \cdot \text{Sign}M_{DL} \cdot \frac{ V_{DL} }{\phi V_n} \left(-0.5 + V_n \right) \cot(\theta), \text{ where } V_n = \min(V_n, V_u/\phi V_n) \quad (\text{Based on LRFD 5.7.3.5-1 and MBE 6A.5.8})$	
$T(LL) = \text{Sign}M_{LL} \cdot \frac{ M_{LL} }{\phi M_n} + 0.5 \cdot \text{Sign}M_{LL} \cdot \frac{ V_{LL} }{\phi V_n} \cot(\theta) \quad (\text{Based on LRFD 5.7.3.5-1 and MBE 6A.5.8})$	
Where:	
$M_u = M_{uDL} + M_{uLL}; M_n = M_{nDL} + M_{nLL}; V_n = \frac{V_{uDL} + V_{uLL}}{\phi V_n} - V_p; V_{nDL} = \frac{V_{uDL}}{\phi V_n} - V_p$	
$\text{Sign}M_{DL} = \text{Sign of } \frac{M_{DL}}{M_n}; \text{Sign}M_{LL} = \text{Sign of } \frac{M_{LL}}{M_n}; \text{Sign}V_{nDL} = \text{Sign of } \frac{V_{nDL}}{V_n}; \text{Sign}M_{LL} = \text{Sign of } \frac{M_{LL}}{M_n}; \text{Sign}M_{LL} = \text{Sign of } \frac{M_{LL}}{M_n}; \text{Sign}M_{LL} = \text{Sign of } \frac{M_{LL}}{M_n}; \text{Sign}M_{LL} = \text{Sign of } \frac{M_{LL}}{M_n}$	
$T(r) = T(DL)$	
$RF = \frac{T(r) - T(DL)}{T(LL)}$	
Ignore design & legal shear : No Ignore permit shear : Yes Consider iterative shear rating : Yes Consider RCFT theta : No Shear computation method type : General Iteration required : Yes	
$\phi M_n = 1.000$ $\phi V_n = 0.750$ $\phi V_p = 0.900$	

Figure 17 - 6A.5.8 Evaluation for shear – Part 1

MBE 2023 Spec Interim Update - Shear Rating Iteration Example

Spec Check Detail for 6A.5.8 Evaluation for Shear

As (pos) = 0.000 (in²) (used for Positive Mu)
 As (neg) = 0.000 (in²) (used for Negative Mu)
 fy (pos) = 0.000 (ksi) (used for Positive Mu)
 fy (neg) = 0.000 (ksi) (used for Negative Mu)
 Aps (pos) = 4.284 (in²) (used for Positive Mu)
 Aps (neg) = 0.306 (in²) (used for Negative Mu)
 fps (pos) = 245.606 (ksi) (used for Positive Mu)
 fps (neg) = 141.252 (ksi) (used for Negative Mu)
 Bv (pos) = 10.000 (in) (used for Positive Mu)
 Bv (neg) = 10.000 (in) (used for Negative Mu)
 Dv (pos) = 33.765 (in) (used for Positive Mu)
 Dv (neg) = 28.080 (in) (used for Negative Mu)
 Mcr (pos) = 28801.178 (kips-in) (used for Positive Mu)
 Mcr (neg) = -4929.748 (kips-in) (used for Negative Mu)
 fy (shear) = 60.000 (ksi)

Limit State	Load Comb	dv (in)	As*fy (kips)	Aps*fps (kips)	Tr (kips)	MuDL (kip-in)	NuDL (kips)	VuDL (kips)	Vp (kips)	Governing Action	MuLL (kip-in)	NuLL (kips)	VuLL (kips)
STR-I	1, DesInv	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max M	21909.89	0.00	89.71
STR-I	1, DesInv	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min M	0.00	0.00	0.00
STR-I	1, DesInv	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max V	20745.45	0.00	90.99
STR-I	1, DesInv	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min V	11460.56	0.00	-12.57
STR-I	1, DesOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max M	16901.91	0.00	69.21
STR-I	1, DesOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min M	0.00	0.00	0.00
STR-I	1, DesOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max V	16003.63	0.00	70.19
STR-I	1, DesOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min V	8941.00	0.00	-9.69
STR-I	2, DesInv	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max M	18223.13	0.00	73.54
STR-I	2, DesInv	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min M	0.00	0.00	0.00
STR-I	2, DesInv	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max V	17058.69	0.00	74.82
STR-I	2, DesInv	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min V	12559.88	0.00	-13.77
STR-I	2, DesOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max M	14057.84	0.00	56.73
STR-I	2, DesOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min M	0.00	0.00	0.00
STR-I	2, DesOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Max V	13159.56	0.00	57.72
STR-I	2, DesOp	33.77	0.00	1052.17	1052.17	11318.68	0.00	37.57	0.00	Min V	9689.05	0.00	-10.62

Load Combination Legend:

Code	Vehicle
1	HL-93 (US) - Truck + Lane
2	HL-93 (US) - Tandem + Lane

Figure 18 - 6A.5.8 Evaluation for shear – Part 2

Shown below is a comparison of rating factors between non-iteration and iteration from LRFD equation 5.7.3.5-1

Non-Iterated										Iterated										Capacity (Ton)
epsilon	beta	theta (Deg.)	Av (in ²)	s (in)	Vs (kips)	TDL (kips)	TLL (kips)	LHS/RHS	RF	epsilon	beta	theta (Deg.)	Av (in ²)	s (in)	Vs (kips)	TDL (kips)	TLL (kips)	LHS/RHS	RF	
0.002471	1.68	37.65	0.40	12.00	87.53	332.60	778.10	0.95	0.925	--	--	--	--	--	--	--	--	--	--	33.29
0.000000	4.80	29.00	0.40	12.00	121.83	372.88	0.00	2.82	99.000	--	--	--	--	--	--	--	--	--	--	3564.00
0.002199	1.81	36.70	0.40	12.00	90.41	330.45	750.05	0.97	0.962	--	--	--	--	--	--	--	--	--	--	34.64
0.000000	4.80	29.00	0.40	12.00	121.83	385.47	314.23	1.50	2.122	0.002006	1.92	36.02	0.40	12.00	92.87	373.53	320.22	1.00	2.119	76.38
0.001088	2.64	32.81	0.40	12.00	104.75	319.74	619.95	1.12	1.183	0.001986	1.93	35.95	0.40	12.00	93.11	328.59	606.60	1.00	1.193	42.60
0.000000	4.80	29.00	0.40	12.00	121.83	372.88	0.00	2.82	99.000	--	--	--	--	--	--	--	--	--	--	3564.00
0.000879	2.89	32.08	0.40	12.00	107.76	315.87	598.42	1.15	1.230	0.001963	1.94	35.87	0.40	12.00	93.39	328.38	581.83	1.00	1.244	44.30
0.000000	4.80	29.00	0.40	12.00	121.83	382.59	242.41	1.68	2.762	0.002006	1.92	36.02	0.40	12.00	92.88	371.34	247.02	1.00	2.756	99.44
0.001444	2.30	34.06	0.40	12.00	99.91	323.08	660.60	1.07	1.104	0.001992	1.92	35.97	0.40	12.00	93.05	328.64	652.29	1.00	1.109	39.73
0.000000	4.80	29.00	0.40	12.00	121.83	372.88	0.00	2.82	99.000	--	--	--	--	--	--	--	--	--	--	3564.00
0.001172	2.55	33.10	0.40	12.00	103.98	319.82	632.72	1.10	1.157	0.001964	1.94	35.87	0.40	12.00	93.38	328.38	620.18	1.00	1.167	41.67
0.000000	4.80	29.00	0.40	12.00	121.83	386.68	344.37	1.44	1.932	0.002006	1.92	36.02	0.40	12.00	92.87	374.45	350.93	1.00	1.931	69.57
0.000286	3.93	30.04	0.40	12.00	116.79	316.81	525.36	1.25	1.400	0.001985	1.93	35.95	0.40	12.00	93.12	328.58	503.27	1.00	1.438	50.39
0.000000	4.80	29.00	0.40	12.00	121.83	372.88	0.00	2.82	99.000	--	--	--	--	--	--	--	--	--	--	3564.00
0.000087	4.51	29.30	0.40	12.00	120.32	315.28	504.00	1.28	1.462	0.001966	1.94	35.88	0.40	12.00	93.36	328.40	478.40	1.00	1.513	52.63
0.000000	4.80	29.00	0.40	12.00	121.83	383.53	265.66	1.62	2.517	0.002006	1.92	36.02	0.40	12.00	92.88	372.05	270.72	1.00	2.512	90.61

Figure 19 - 6A.5.8 Evaluation for shear – Part 3

Control option added to consider modifying MCFT theta

This section discusses the control option “Modify MCFT theta” added for all concrete structures, i.e., reinforced concrete, prestressed concrete, post tensioned concrete and reinforced concrete box culverts.

Member Alternative Description – Control options

Navigate to the member alternative **Precast Box Alternative** of member **G2**, double click on it (or click the **Open** button from the **WORKSPACE** ribbon) to open its **Member Alternative Description** window. Navigate to the **Control options** tab as shown below. Check the box - **Modify MCFT theta** as shown below.

The screenshot shows the 'Member Alternative Description' window with the 'Control options' tab selected. The window is titled 'Member Alternative Description' and has a dropdown menu for 'Member alternative:' set to 'Precast Box Alternative'. The 'Control options' tab is active, showing two main sections: 'LRFD' and 'LFR'. Each section has a list of 'Points of interest' and a 'Shear computation method'. The 'LRFD' section has a 'Shear computation method' of 'General procedure'. The 'LFR' section has a 'Shear computation method' of 'Use current AASHTO'. The 'LRFD' section has a 'Multi-span analysis' section with 'Continuous' selected. The 'LFR' section has a 'Distribution factor application method' section with 'By POI' selected. The 'Modify MCFT theta' checkbox is checked and highlighted with a red box. Other checkboxes like 'Ignore design & legal load shear', 'Ignore long. reinf. in rating', and 'Modify MCFT size effect' are also highlighted with red boxes. The 'OK', 'Apply', and 'Cancel' buttons are at the bottom right.


Section	Option	Value
LRFD	Points of interest	Generate at tenth points except supports (checked)
	Points of interest	Generate at support points (checked)
	Points of interest	Generate at support face & critical shear points (checked)
	Points of interest	Generate at section change points (checked)
	Points of interest	Generate at user-defined points (checked)
	Shear computation method	General procedure (selected)
	Multi-span analysis	Continuous (selected)
	Ignore design & legal load shear	Unchecked
	Ignore permit load shear	Checked
	LFR	Points of interest
Points of interest		Generate at support points (checked)
Points of interest		Generate at support face & critical shear points (checked)
Points of interest		Generate at section change points (checked)
Points of interest		Generate at user-defined points (checked)
Shear computation method		Use current AASHTO (selected)
Distribution factor application method		By POI (selected)
Ignore long. reinf. in rating		Unchecked
Modify MCFT theta		Checked
Modify MCFT size effect		Unchecked

Click **OK** to apply the data and close the window.

Run an LRFR analysis using the analysis settings shown in the previous step.

Specification Check Detail

Once the analysis is complete, open the 6A.4.2.1 Shear-5.7.3.4 Procedures for Determining Shear Resistance article for the analyzed member alternative for Stage 3 at Span 1 – 19.00 ft. This article highlights the status of the “Modify MCFT Theta” control option. With this control option checked, in areas of low strain where the section remains uncracked i.e., if the factored moment at this section is less than the cracking moment ($M_u < M_{cr}$), the strain ϵ_s may be assumed to be zero regardless of the values of moment (M_u) and shear (V_u), therefore, “Theta” can be taken as 29° .

 Spec Check Detail for 6A.4.2.1 Shear-5.6.3.3 Minimum Reinforcement

6A.4.2.1 Shear - 5 Concrete Structures
6A.4.2.1 Shear - 5.6 Design for Flexural and Axial Effects - B Regions
6A.4.2.1 Shear - 5.6.3 Flexural Members
6A.4.2.1 Shear - 5.6.3.3 Minimum Reinforcement
(AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)

PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3

Cross Section Properties for Prestress box beam with Rectangular void

Name: BIII-48Girder f'c = 5.00(ksi)Girder f'ci = 4.00(ksi)

Beam Height = 39.00(in)Side Wall Thickness = 5.00(in)
Top Slab Width = 47.25(in)
Top Slab Thick = 5.50(in)
Bottom Slab Width = 48.00(in)
Bottom Slab Thick = 5.50(in)
Shear Key Top = 6.00(in)
Shear Key Height = 6.00(in)
Shear Key Depth = 0.75(in)
B1 = 3.00(in)
B2 = 3.00(in)
B3 = 3.00(in)
B4 = 3.00(in)

Slab f'c = 0.00(ksi)
Effective Slab Width = 0.00(in)Haunch Width = 0.00(in)
Effective Slab Thickness = 0.00(in)Haunch Thickness = 0.00(in)

Input:
fr beam = 0.54ksi
ScTop = -8569.07in^3Mdnc = 8812.35kip-in
ScBot = 8734.21in^3SncBot = 8734.21in^3
Gamma1 = 1.60
Gamma2 = 1.10
Gamma3 = 1.00 (Prestressed Concrete)
Gamma3 = 0.67 (Reinforced Concrete)

Mcr = Gamma3 * [(gamma1*fr + Gamma2*fcpe)*Sc - Mdnc * (Sc/Snc - 1)] (5.6.3.3-1)
Note: If the capacity has been overridden, the Resistance is computed as override phi*override capacity.
Otherwise the Resistance is computed as per the Specification.

Limit State	Load Comb	fcpe ksi	fr ksi	Gamma3	Governing Action	Mu kip-in	Vu kip	Sc in^3	Mcr kip-in
STR-I	1, DesInv	2.22	0.54	1.00	Max M	33228.57	127.29	8734.21	28801.18
STR-I	1, DesInv	2.22	0.54	1.00	Min M	11318.68	37.57	8734.21	28801.18
STR-I	1, DesInv	2.22	0.54	1.00	Max V	32064.13	128.56	8734.21	28801.18
STR-I	1, DesInv	2.22	0.54	1.00	Min V	22779.24	25.01	8734.21	28801.18
STR-I	1, DesOp	2.22	0.54	1.00	Max M	28220.60	106.78	8734.21	28801.18
STR-I	1, DesOp	2.22	0.54	1.00	Min M	11318.68	37.57	8734.21	28801.18
STR-I	1, DesOp	2.22	0.54	1.00	Max V	27322.31	107.77	8734.21	28801.18
STR-I	1, DesOp	2.22	0.54	1.00	Min V	20159.68	27.88	8734.21	28801.18
STR-I	2, DesInv	2.22	0.54	1.00	Max M	29541.81	111.12	8734.21	28801.18
STR-I	2, DesInv	2.22	0.54	1.00	Min M	11318.68	37.57	8734.21	28801.18
STR-I	2, DesInv	2.22	0.54	1.00	Max V	28377.37	112.39	8734.21	28801.18
STR-I	2, DesInv	2.22	0.54	1.00	Min V	23878.56	23.80	8734.21	28801.18
STR-I	2, DesOp	2.22	0.54	1.00	Max M	25376.52	94.31	8734.21	28801.18
STR-I	2, DesOp	2.22	0.54	1.00	Min M	11318.68	37.57	8734.21	28801.18
STR-I	2, DesOp	2.22	0.54	1.00	Max V	24478.24	95.29	8734.21	28801.18
STR-I	2, DesOp	2.22	0.54	1.00	Min V	21007.73	26.95	8734.21	28801.18
SER-III	1, DesInv	2.22	0.54	1.00	Max M	18828.30	70.27	8734.21	28801.18
SER-III	1, DesInv	2.22	0.54	1.00	Min M	8812.35	29.26	8734.21	28801.18
SER-III	1, DesInv	2.22	0.54	1.00	Max V	18295.99	70.86	8734.21	28801.18
SER-III	1, DesInv	2.22	0.54	1.00	Min V	14051.47	23.52	8734.21	28801.18
SER-III	2, DesInv	2.22	0.54	1.00	Max M	17142.93	62.88	8734.21	28801.18
SER-III	2, DesInv	2.22	0.54	1.00	Min M	8812.35	29.26	8734.21	28801.18
SER-III	2, DesInv	2.22	0.54	1.00	Max V	16610.61	63.46	8734.21	28801.18
SER-III	2, DesInv	2.22	0.54	1.00	Min V	14554.01	22.97	8734.21	28801.18

Figure 20 6A.4.2.1 Shear 5.6.3.3 Minimum Reinforcement

Spec Check Detail for 6A.4.2.1 Shear-5.7.3.4 Procedures for Determining Shear Resistance

6A.4.2.1 Shear - 5 Concrete Structures
 6A.4.2.1 Shear - 5.7 Shear and Torsion
 6A.4.2.1 Shear - 5.7.3 Sectional Design Model
 6A.4.2.1 Shear - 5.7.3.4 Procedures for Determining Shear Resistance
 (AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)

PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3

Calculation of Beta/Theta

Es = 0.000 (kips/in^2)
 phi = 0.900
 f'c = 5.000 (kips/in^2)
 fpc = 0.937 (kips/in^2)
 fy = 60.000 (kips/in^2)
 Agg diam = 1.000 (in)
 Vp = 0.000 (kips)
 Ep = 28500.000 (kips/in^2)
 As(pos) = 0.000 (in^2) (used for Positive Mu)
 As(neg) = 0.000 (in^2) (used for Negative Mu)
 Aps(pos) = 4.284 (in^2) (used for Positive Mu)
 Aps(neg) = 0.306 (in^2) (used for Negative Mu)
 fpo = 189.000 (kips/in^2)
 Ec = 4592.232 (kips/in^2)

Beta Calc (used in table below) :
 (1) - Beta = $4.8 / (1 + 750 \text{ EpsilonS})$
 (2) - Beta = $(4.8 / (1 + 750 \text{ EpsilonS})) * (51 / (39 + \text{sxe}))$
 where:
 $\text{sxe} = \text{sx} * (1.38 / (\text{ag} + 0.63))$

Mu_calc = Max(Mu, |Vu - Vp| * dv)

Modify MCFT Theta: Yes

Modify MCFT Size Effect: No
 fpc / f'c = 0.19

Limit State	Load Comb	Epsilon	Theta	Beta	Governing Action	Mu (kip-in)
STR-I	1, DesInv	0.002471	37.65	1.68	Max M	33228.57
STR-I	1, DesInv	0.000000	29.00	4.80	Min M	11318.68
STR-I	1, DesInv	0.002199	36.70	1.81	Max V	32064.13
STR-I	1, DesInv	0.000000	29.00	4.80	Min V	22779.24
STR-I	1, DesOp	0.000000	29.00	4.80	Max M	28220.60
STR-I	1, DesOp	0.000000	29.00	4.80	Min M	11318.68
STR-I	1, DesOp	0.000000	29.00	4.80	Max V	27322.31
STR-I	1, DesOp	0.000000	29.00	4.80	Min V	20159.68
STR-I	2, DesInv	0.001444	34.06	2.30	Max M	29541.81
STR-I	2, DesInv	0.000000	29.00	4.80	Min M	11318.68
STR-I	2, DesInv	0.000000	29.00	4.80	Max V	28377.37
STR-I	2, DesInv	0.000000	29.00	4.80	Min V	23878.56
STR-I	2, DesOp	0.000000	29.00	4.80	Max M	25376.52
STR-I	2, DesOp	0.000000	29.00	4.80	Min M	11318.68
STR-I	2, DesOp	0.000000	29.00	4.80	Max V	24478.24
STR-I	2, DesOp	0.000000	29.00	4.80	Min V	21007.73
SER-III	1, DesInv	0.000000	29.00	4.80	Max M	18828.30
SER-III	1, DesInv	0.000000	29.00	4.80	Min M	8812.35
SER-III	1, DesInv	0.000000	29.00	4.80	Max V	18295.99
SER-III	1, DesInv	0.000000	29.00	4.80	Min V	14051.47
SER-III	2, DesInv	0.000000	29.00	4.80	Max M	17142.93
SER-III	2, DesInv	0.000000	29.00	4.80	Min M	8812.35
SER-III	2, DesInv	0.000000	29.00	4.80	Max V	16610.61
SER-III	2, DesInv	0.000000	29.00	4.80	Min V	14554.01

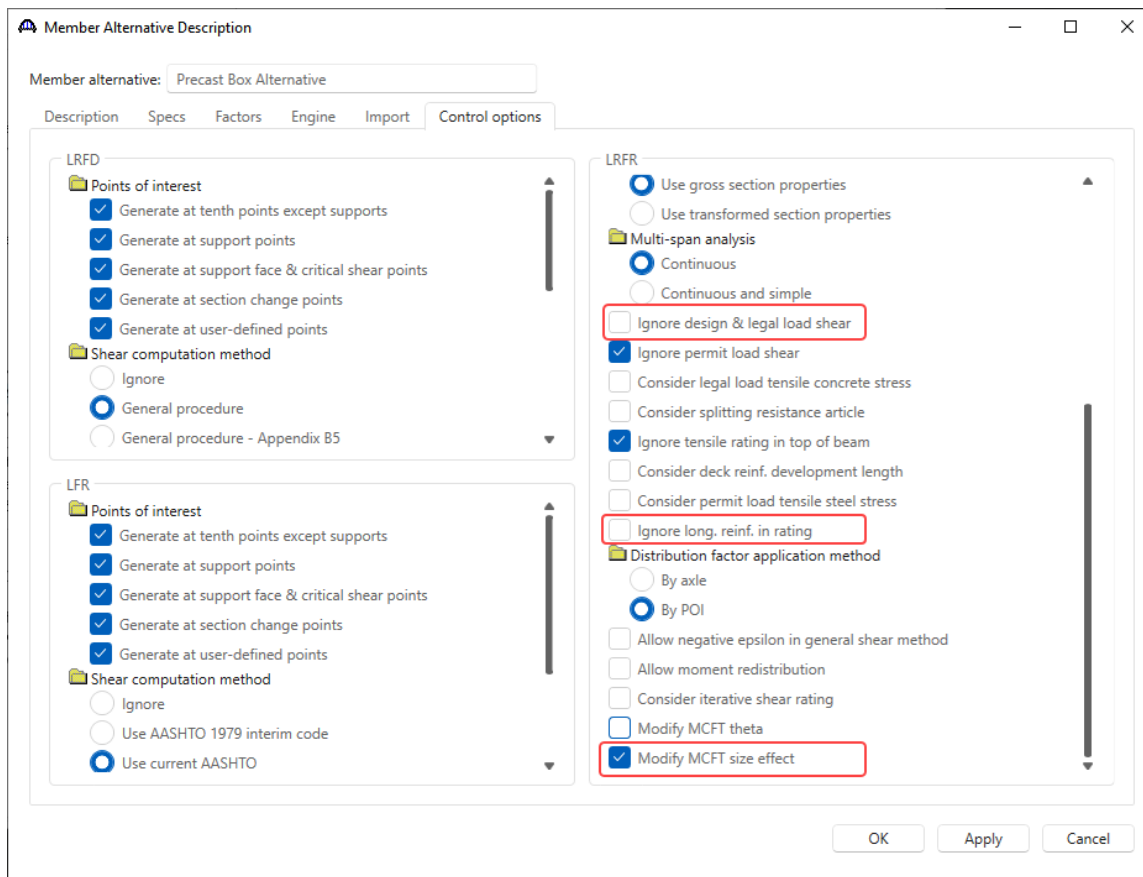
Figure 21 6A.4.2.1 Shear 5.7.3.4 Procedures for Determining Shear Resistance

Control option added to consider modifying MCFT size effect

This section discusses the control option “Modify MCFT size effect” added for prestressed concrete and post-tensioned concrete structures only. This does not apply to reinforced concrete structures and culverts.

Member Alternative Description – Control options

Navigate to the member alternative **Precast Box Alternative** of member **G2**, double click on it (or click the **Open** button from the **WORKSPACE** ribbon) to open its **Member Alternative Description** window. Navigate to the **Control options** tab as shown below. Check the box - **Modify MCFT size effect** as shown below.



Click **OK** to apply the data and close the window.

Run an LRFR analysis using the analysis settings shown in the previous step.

Spec Check Detail for 6A.4.2.1 Shear-5.7.3.4 Procedures for Determining Shear Resistance														
6A.4.2.1 Shear - 5 Concrete Structures 6A.4.2.1 Shear - 5.7 Shear and Torsion 6A.4.2.1 Shear - 5.7.3 Sectional Design Model 6A.4.2.1 Shear - 5.7.3.4 Procedures for Determining Shear Resistance (AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)														
PS Box Rect Void - At Location = 19.0000 (ft) - Left Stage 3														
Calculation of Beta/Theta														
Es = 0.000 (kips/in^2) phi = 0.900 f'c = 5.000 (kips/in^2) fpc = 0.937 (kips/in^2) fy = 60.000 (kips/in^2) Agg diam = 1.000 (in) Vp = 0.000 (kips) Ep = 28500.000 (kips/in^2) As(pos) = 0.000 (in^2) (used for Positive Mu) As(neg) = 0.000 (in^2) (used for Negative Mu) Aps(pos) = 4.284 (in^2) (used for Positive Mu) Aps(neg) = 0.306 (in^2) (used for Negative Mu) fpx = 189.000 (kips/in^2) Ec = 4592.232 (kips/in^2)														
Beta Calc (used in table below) :														
(1) - Beta = 4.8 / (1 + 750 EpsilonS)														
(2) - Beta = (4.8 / (1 + 750 EpsilonS)) * (S1 / (39 + sxe))														
where:														
sxe = sx * (1.38 / (ag + 0.63))														
Mu_calc = Max(Mu, Vu - Vp * dv)														
Modify MCFT Theta: No														
Modify MCFT Size Effect: Yes fpc / f'c = 0.19														
Limit State	Load Comb	Epsilon	Theta	Beta	Governing Action	Mu (kip-in)	Mu Calc (kip-in)	Vu (kips)	Nu (kips)	bv (in)	dv (in)	Sx (in)	Sxe (in)	Beta Calc
STR-I	1, DesInv	0.002471	37.65	1.68	Max M	33228.57	33228.57	127.29	0.00	10.00	33.77	33.77	--	(1)
STR-I	1, DesOp	0.000000	29.00	4.80	Min M	11318.68	11318.68	37.57	0.00	10.00	33.77	33.77	--	(1)
STR-I	1, DesInv	0.002199	36.70	1.81	Max V	32064.13	32064.13	128.56	0.00	10.00	33.77	33.77	--	(1)
STR-I	1, DesOp	0.000000	29.00	4.80	Min V	22779.24	22779.24	25.01	0.00	10.00	33.77	33.77	--	(1)
STR-I	1, DesOp	0.001088	32.81	2.64	Max M	28220.60	28220.60	106.78	0.00	10.00	33.77	33.77	--	(1)
STR-I	1, DesOp	0.000000	29.00	4.80	Min M	11318.68	11318.68	37.57	0.00	10.00	33.77	33.77	--	(1)
STR-I	1, DesOp	0.000879	32.08	2.89	Max V	27322.31	27322.31	107.77	0.00	10.00	33.77	33.77	--	(1)
STR-I	1, DesOp	0.000000	29.00	4.80	Min V	20159.68	20159.68	27.88	0.00	10.00	33.77	33.77	--	(1)
STR-I	2, DesInv	0.001444	34.06	2.30	Max M	29541.81	29541.81	111.12	0.00	10.00	33.77	33.77	--	(1)
STR-I	2, DesInv	0.000000	29.00	4.80	Min M	11318.68	11318.68	37.57	0.00	10.00	33.77	33.77	--	(1)
STR-I	2, DesInv	0.001172	33.10	2.55	Max V	28377.37	28377.37	112.39	0.00	10.00	33.77	33.77	--	(1)
STR-I	2, DesInv	0.000000	29.00	4.80	Min V	2387								

Figure 22 6A.4.2.1 Shear-5.7.3.4 Procedures for Determining Shear Resistance

MBE 2023 specification interim update for reinforced concrete box culverts

The specification update for culvert will impact culvert wall (6A.4.2.1-5.7.3.3 Nominal shear resistance) and culvert slab specification checking (6A.4.2.1-5.7.3.3 Nominal shear resistance and 6A.4.2.1-5.12.7.3 Nominal shear resistance).

Import the culvert bridge provided with the CVT1 tutorial. Expand the **Bridge Workspace** tree and navigate to the **CULVERT ALTERNATIVES** node. Double click on **Culvert Alt 1** to open the culvert alternative. Navigate to the **Control options** tab of the **Culvert Alternative Description** window to access the **LRFR** control options.

Consider iterative shear rating and **Consider MCFT theta** control options are added for iterative shear rating.



These options are applicable when **General procedure** - Shear computation method is used. Select these options to perform iterative shear rating and consider modifying the MCFT theta value and view results as discussed in previous sections of this tutorial.

The following articles detail the iterative process of shear rating.

Specification Checks for Culvert Seg 1 - 9 of 857

Articles: All articles
Format: Bullet list
Report

Specification filter

Culvert Component

- Ext. Wall 1
- 0.00 ft.
- 0.75 ft.
- 1.20 ft.
- 2.40 ft.
- 3.60 ft.
- 4.80 ft.
- 6.00 ft.
- 7.20 ft.
- 8.40 ft.
- 9.60 ft.
- 10.80 ft.
- 11.27 ft.
- 12.00 ft.

Specification reference	Limit State	Flex. Sense	Pass/Fail
5.4.2.8 Concrete Density Modification Factor		N/A	General Comp.
✓ 5.6.4.5.BoxCulvert Biaxial Flexure		N/A	Passed
5.6.7.Crack.BoxCulvert Control of Cracking by Distribution of Reinforcement		N/A	General Comp.
6A.4.2.1 Shear-5.6.3.3.BoxCulvert Minimum Reinforcement		N/A	General Comp.
6A.4.2.1 Shear-5.7.3.3 Box Culvert Nominal Shear Resistance		N/A	General Comp.
6A.4.2.1 Shear-5.7.3.4.BoxCulvert Procedures for Determining Shear Resistance		N/A	General Comp.
✓ 6A.4.2.1.BoxCulvert.Concrete Shear General Load Rating Equation - Concrete Shear		N/A	Passed
✓ APPC.6.1 P-M Interaction Diagram		N/A	Passed
Cracked_Moment_Of_Inertia_BoxCulvert Section Property Calculations		N/A	General Comp.

Figure 23 - Specification check article for Exterior wall 1

Specification Checks for Culvert Seg 1 - 11 of 857

Articles: All articles
Format: Bullet list
Report

Specification filter

Culvert Component

- Ext. Wall 1
- Int. Wall 1
- Ext. Wall 2
- Top Slab 1
- 0.00 ft.
- 0.75 ft.
- 1.20 ft.
- 2.40 ft.
- 3.60 ft.
- 4.80 ft.
- 6.00 ft.
- 7.20 ft.
- 8.40 ft.
- 9.60 ft.
- 10.80 ft.
- 11.24 ft.
- 12.00 ft.

Specification reference	Limit State	Flex. Sense	Pass/Fail
5.4.2.8 Concrete Density Modification Factor		N/A	General Comp.
5.5.4.2.BoxCulvert Strength Limit State - Resistance Factors		N/A	General Comp.
✓ 5.6.3.2.BoxCulvert Flexural Resistance (Reinforced Concrete)		N/A	Passed
✓ 5.6.3.3.BoxCulvert Minimum Reinforcement		N/A	Passed
5.6.7.Crack.BoxCulvert Control of Cracking by Distribution of Reinforcement		N/A	General Comp.
6A.4.2.1 Shear-5.12.7.3.BoxCulvert Design for Shear in Slabs of Box Culverts		N/A	General Comp.
6A.4.2.1 Shear-5.6.3.3.BoxCulvert Minimum Reinforcement		N/A	General Comp.
6A.4.2.1 Shear-5.7.3.4.BoxCulvert Procedures for Determining Shear Resistance		N/A	General Comp.
✓ 6A.4.2.1.BoxCulvert.Concrete Flexure General Load Rating Equation - Concrete Flexure		N/A	Passed
✓ 6A.4.2.1.BoxCulvert.Concrete Shear General Load Rating Equation - Concrete Shear		N/A	Passed
Cracked_Moment_Of_Inertia_BoxCulvert Section Property Calculations		N/A	General Comp.

Figure 24 - Specification check articles for Top slab 1