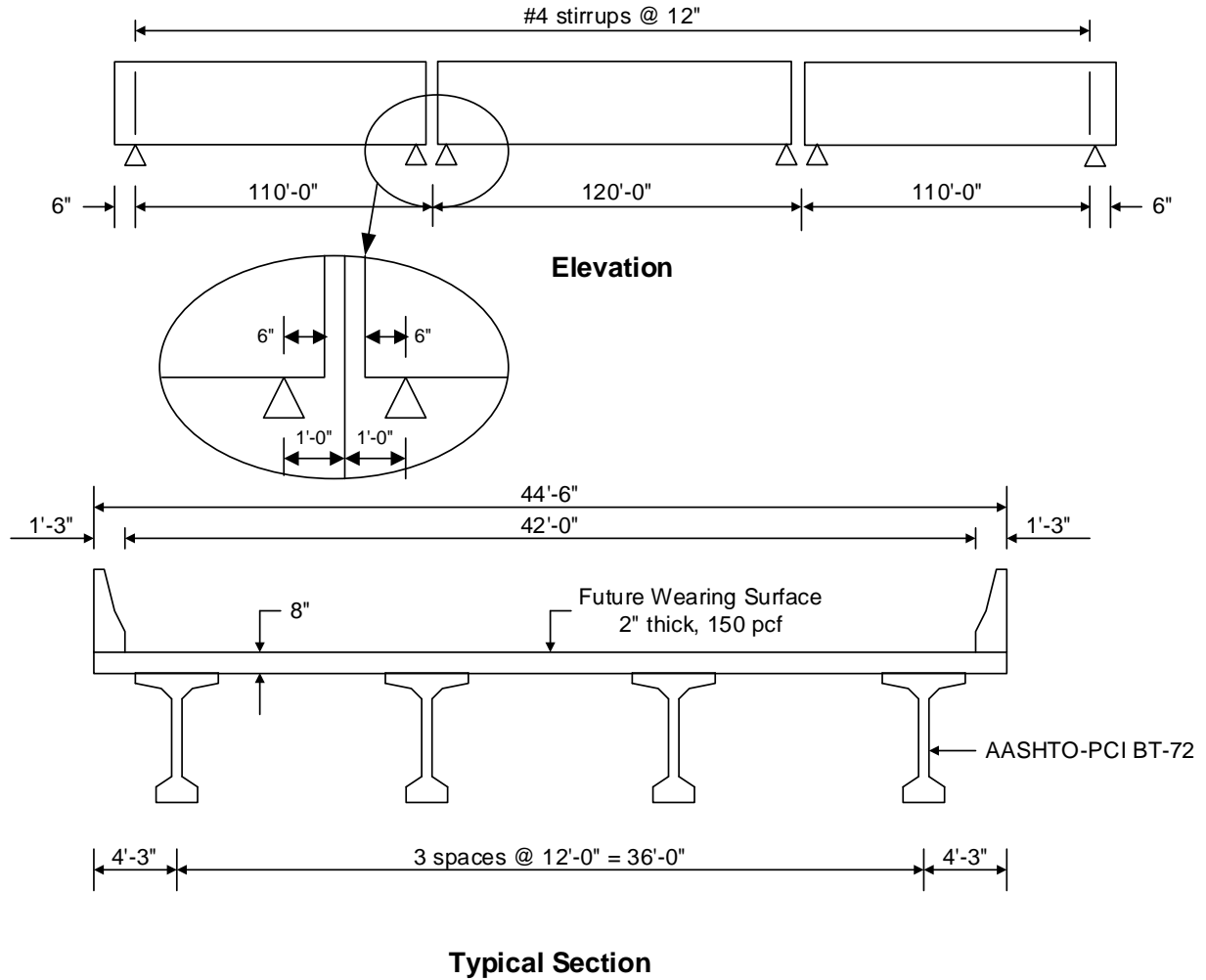


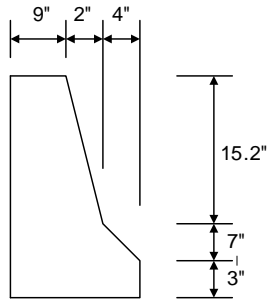
AASHTOWare BrDR 7.5.0

Prestressed Concrete Structure Tutorial
PS12 – Three Span Prestressed I Beam Stirrup Design Example

PS12 - Three Span Prestressed I Beam Stirrup Design Example

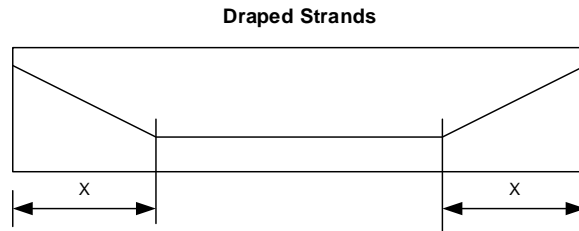


PS12 – Three Span Prestressed I Beam Stirrup Design Example



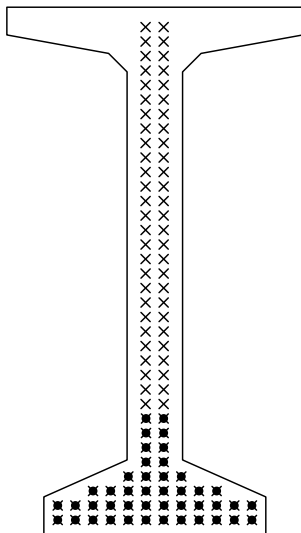
Weight = 300 plf

Parapet Detail

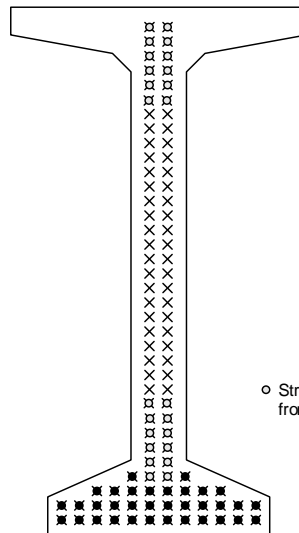


X = 32.00 ft (End Spans)
X = 35.50 ft (Mid Span)

Strand Pattern for all Spans



Strand Pattern at Mid-Span



Strand Pattern at End of Beam

o Strand harped at 48.5' from end of beam

Material Properties

Beam Concrete: $f'c = 7.0$ ksi, $f'ci = 5.5$ ksi

Deck Concrete: $f'c = 4.0$ ksi

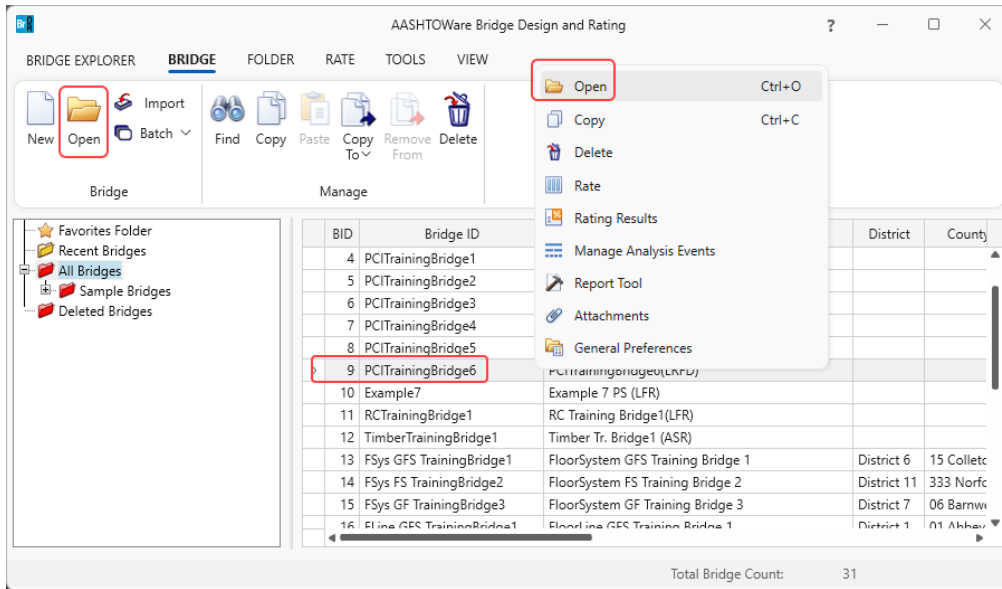
Prestressing Strand: 1/2" dia., 7 Wire strand, $F_u = 270$ ksi, Low Relaxation

PS12 – Three Span Prestressed I Beam Stirrup Design Example

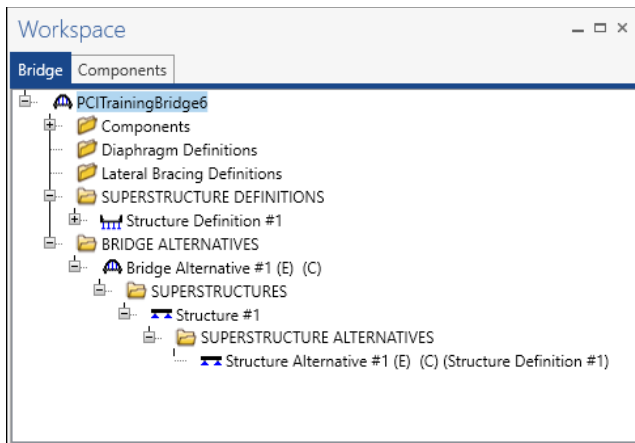
BrDR Training

PS12 - Three Span Prestressed I Beam Stirrup Design Example

From the **Bridge Explorer** open the bridge **PCITrainingBridge6 (BID 9)** by double clicking on **BID 9** (or by selecting **BID 9** and clicking on the **Open** button from the **BRIDGE** ribbon or right click and select **Open**) as shown below.

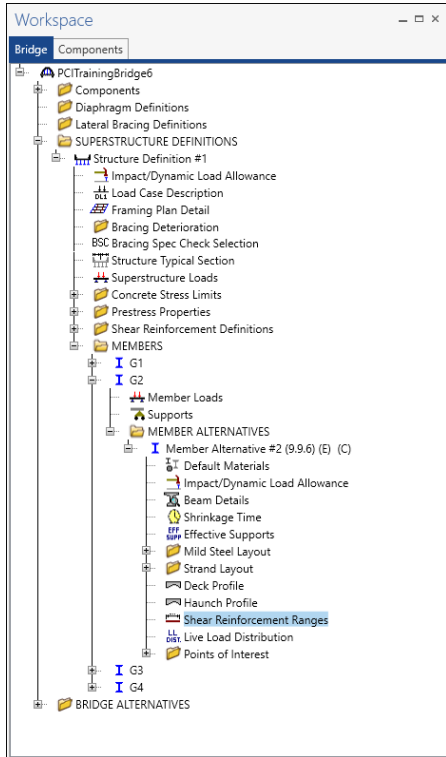


The partially expanded **Bridge Workspace** tree is shown below.



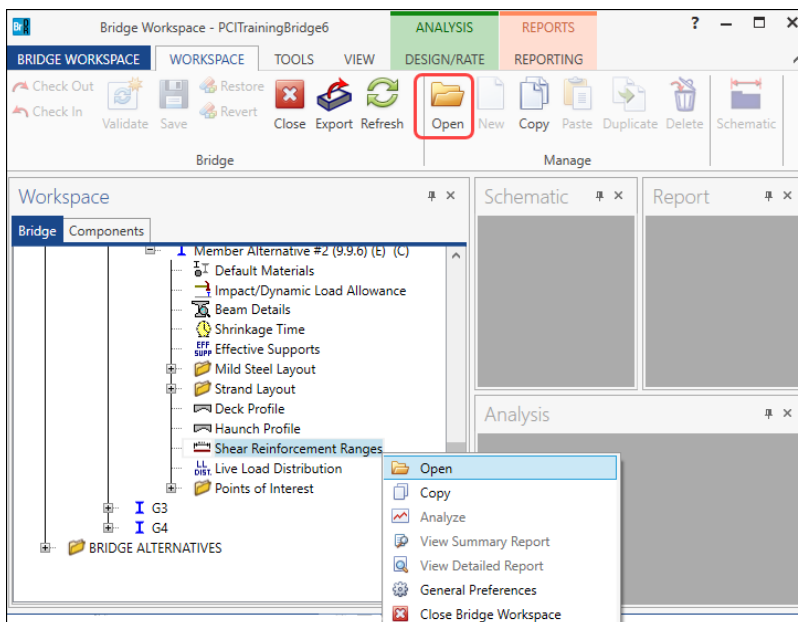
PS12 – Three Span Prestressed I Beam Stirrup Design Example

Expand the **SUPERSTRUCTURE DEFINITIONS** tree, and then expand the **Structure Definition #1**. Expand **MEMBERS, G2, MEMBER ALTERNATIVES** and finally expand **Member Alternative #2 (9.9.6) (E)(C)**.



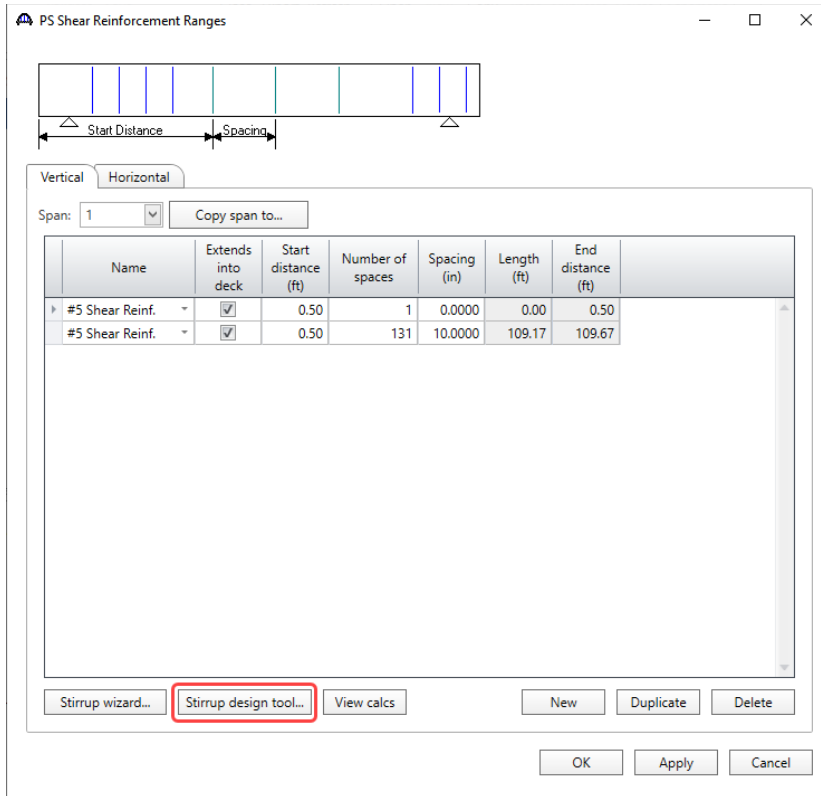
PS Shear Reinforcement Ranges

Select the **Shear Reinforcement Ranges** node in the **Bridge Workspace** tree and click the **Open** button from the **Manage** group of the **WORKSPACE** ribbon (or right click on the **Shear Reinforcement Ranges** node and select **Open** from the drop-down menu).

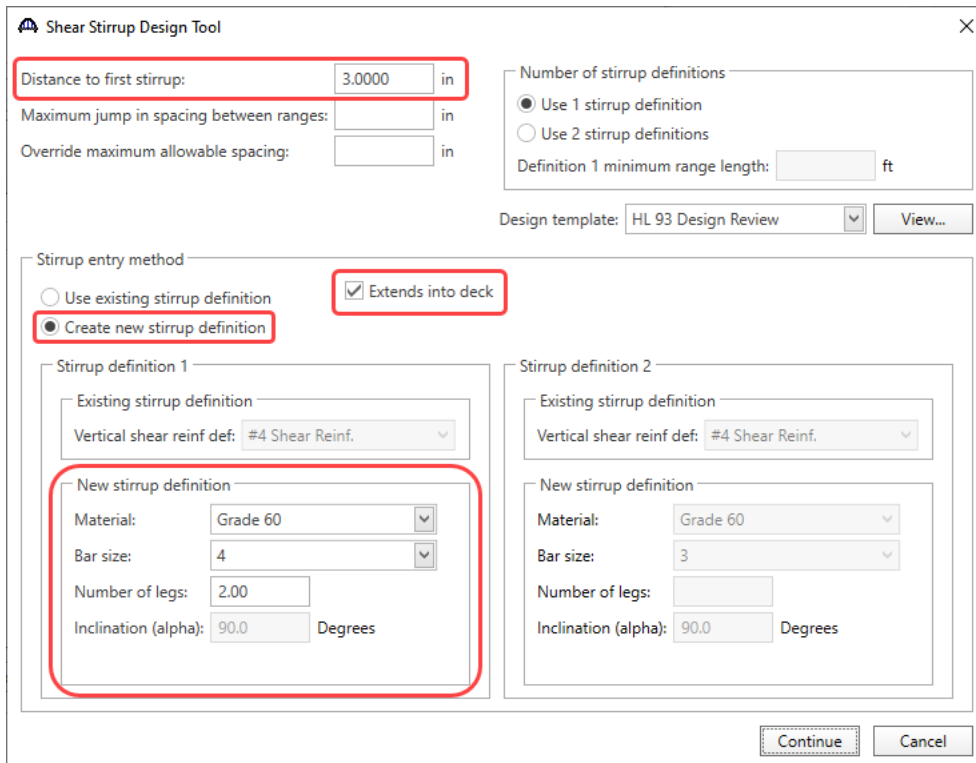


PS12 – Three Span Prestressed I Beam Stirrup Design Example

Click on the **Stirrup design tool** button to open the **Shear Stirrup Design Tool**.



Enter the data in the **Shear Stirrup Design Tool** window and click on the **Continue** button as shown below.



PS12 – Three Span Prestressed I Beam Stirrup Design Example

Using the design tool causes previously entered stirrup data to be deleted and replaced by newly computed stirrup data.

Distance to first stirrup

This is the distance to the first stirrup from the end of the beam. Typically, this will be 2 to 4 inches. Entering a number too high will provide a stirrup range that starts too far from the support. This will result in zero ratings and failed end shear resistance. Not entering a value will incorrectly put the first stirrup at the end face of the beam. Enter **3** inches for this example.

Maximum jump in spacing between ranges

This is the maximum jump in stirrup spacing that the module assumes from one range to the next. If this value is not entered, the default value used is **24"** (i.e., the maximum stirrup spacing).

The effect of leaving this field blank and using the default value of **24"** permits a change in spacing from range to range of any amount (since the maximum allowable spacing is **24"**). This will provide the most efficient stirrup ranges. Leave this value blank for this example.

Override maximum allowable spacing.

Enter a value for the desired maximum spacing of shear stirrups. If left blank, BrDR will use LRFD Article 5.7.2.6 to compute the maximum allowable spacing. For this example, this value will be left blank and allow the application to calculate the maximum shear steel spacing.

Number of Stirrup Definitions

The user may set the design tool to use one or two stirrup definitions. Some beams may benefit by having more robust steel sizes at the beam-ends where shear resistance is required and less robust steel sizes within the span where the shear resistance is less necessary. This example will use 1 stirrup definition.

Definition 1 minimum range length

This range is the minimum distance from end of beam over which the Stirrup Definition 1 is to be used. This is disabled when one stirrup definition is being used. The design of the bars is based on the stirrup area entered for each 1/10th point location (and critical distance). When those values are passed into the design module that calculate the final ranges, the shear areas for the design are based on the minimum range length and are then carried along as the ranges are being developed. The range length is a minimum and the final range length computed by the stirrup module will always be greater than or equal to this input. Since one stirrup definition is used, this need not be considered.

PS12 – Three Span Prestressed I Beam Stirrup Design Example

Stirrup Entry Method

Choose to either use existing stirrup definition(s) or create new stirrup definition(s). The user can define stirrups in the **Bridge Workspace** tree, or a new definition can be created using the design tool. For this example, use the design tool to create a new definition.

Extends into deck

Check this box if the reinforcing bars extend into the concrete deck. In this example, stirrups will be extended into the deck.

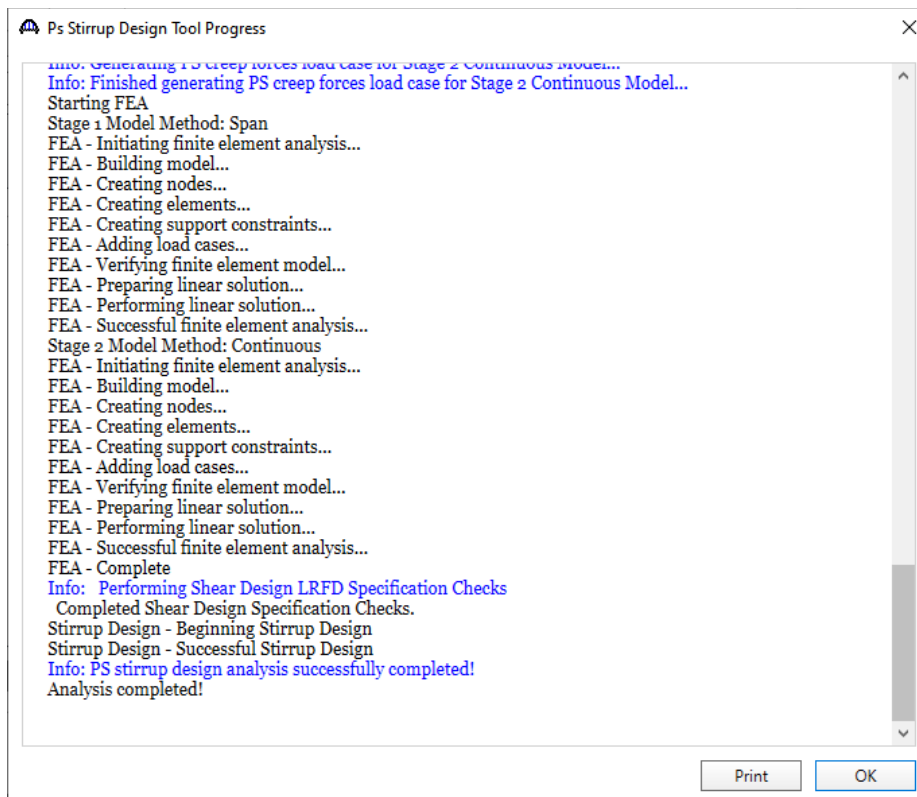
Stirrup Definition (1 or 2)

Under each of the **Existing stirrup definition** sections, select an existing **Vertical Shear Reinforcement Definition** from the drop down menu. This is available when the **Use existing stirrup definition** button is selected.

New Stirrup Definition

When using the design tool to create a stirrup definition, this section will be available. The user will enter the material and a bar size from the two drop-down lists. The number of legs is then entered. The inclination is always 90 degrees. In this example, **Grade 60** will be used as the **Material** and **#4 Bar size** that have **2 legs**.

Click **Continue** to compute the required stirrup spacing at each tenth point and the critical dv point. The **Ps Stirrup Design Tool Progress** window appears. Once the analysis is complete, click **OK**.



PS12 – Three Span Prestressed I Beam Stirrup Design Example

Generated ranges

Maximum number ranges per span: 3 Minimum stirrups per range: 3 Create ranges

Name	Extends into deck	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
Wizard Sti...	<input checked="" type="checkbox"/>	0.25	1	0	0	0.25
Wizard Sti...	<input checked="" type="checkbox"/>	0.25	19	6	9.5	9.75
Wizard Sti...	<input checked="" type="checkbox"/>	9.75	2	4.7	0.783333	10.533333
Wizard Sti...	<input checked="" type="checkbox"/>	10.533333	34	8.5	24.083333	34.616666
Wizard Sti...	<input checked="" type="checkbox"/>	34.616667	2	14.3	2.383333	37
Wizard Sti...	<input checked="" type="checkbox"/>	37	18	24	36	73
Wizard Sti...	<input checked="" type="checkbox"/>	73	2	14.3	2.383333	75.383333

Note: Existing vertical shear reinforcement ranges will be deleted if you apply the results of this wizard.

Apply Close

The results are displayed in the **PS Shear Reinforcement Ranges** window as shown below.

PS Shear Reinforcement Ranges

Vertical Horizontal

Span: 1 Copy span to...

Name	Extends into deck	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
Wizard Stirrup 1	<input checked="" type="checkbox"/>	0.25	1	0	0	0.25
Wizard Stirrup 1	<input checked="" type="checkbox"/>	0.25	19	6	9.5	9.75
Wizard Stirrup 1	<input checked="" type="checkbox"/>	9.75	2	4.7	0.783333	10.533333
Wizard Stirrup 1	<input checked="" type="checkbox"/>	10.533333	34	8.5	24.083333	34.616666
Wizard Stirrup 1	<input checked="" type="checkbox"/>	34.616667	2	14.3	2.383333	37
Wizard Stirrup 1	<input checked="" type="checkbox"/>	37	18	24	36	73
Wizard Stirrup 1	<input checked="" type="checkbox"/>	73	2	14.3	2.383333	75.383333
Wizard Stirrup 1	<input checked="" type="checkbox"/>	75.383333	34	8.5	24.083333	99.466666
Wizard Stirrup 1	<input checked="" type="checkbox"/>	99.466667	2	4.7	0.783333	100.25
Wizard Stirrup 1	<input checked="" type="checkbox"/>	100.25	19	6	9.5	109.75

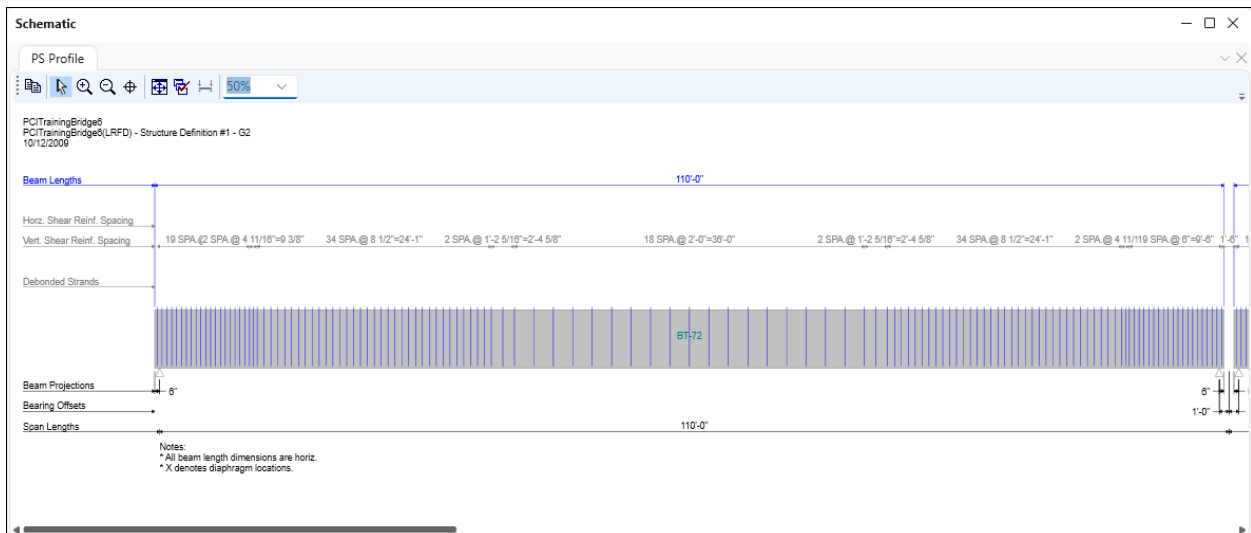
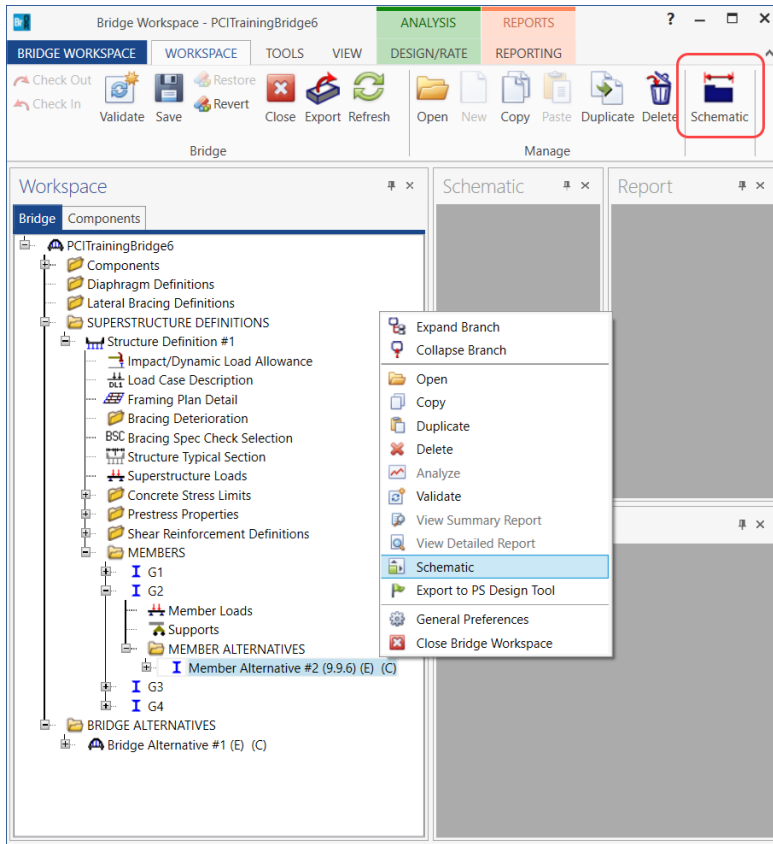
Stirrup wizard... Stirrup design tool... View calcs New Duplicate Delete

OK Apply Cancel

PS12 – Three Span Prestressed I Beam Stirrup Design Example

Schematic – Structure Typical Section

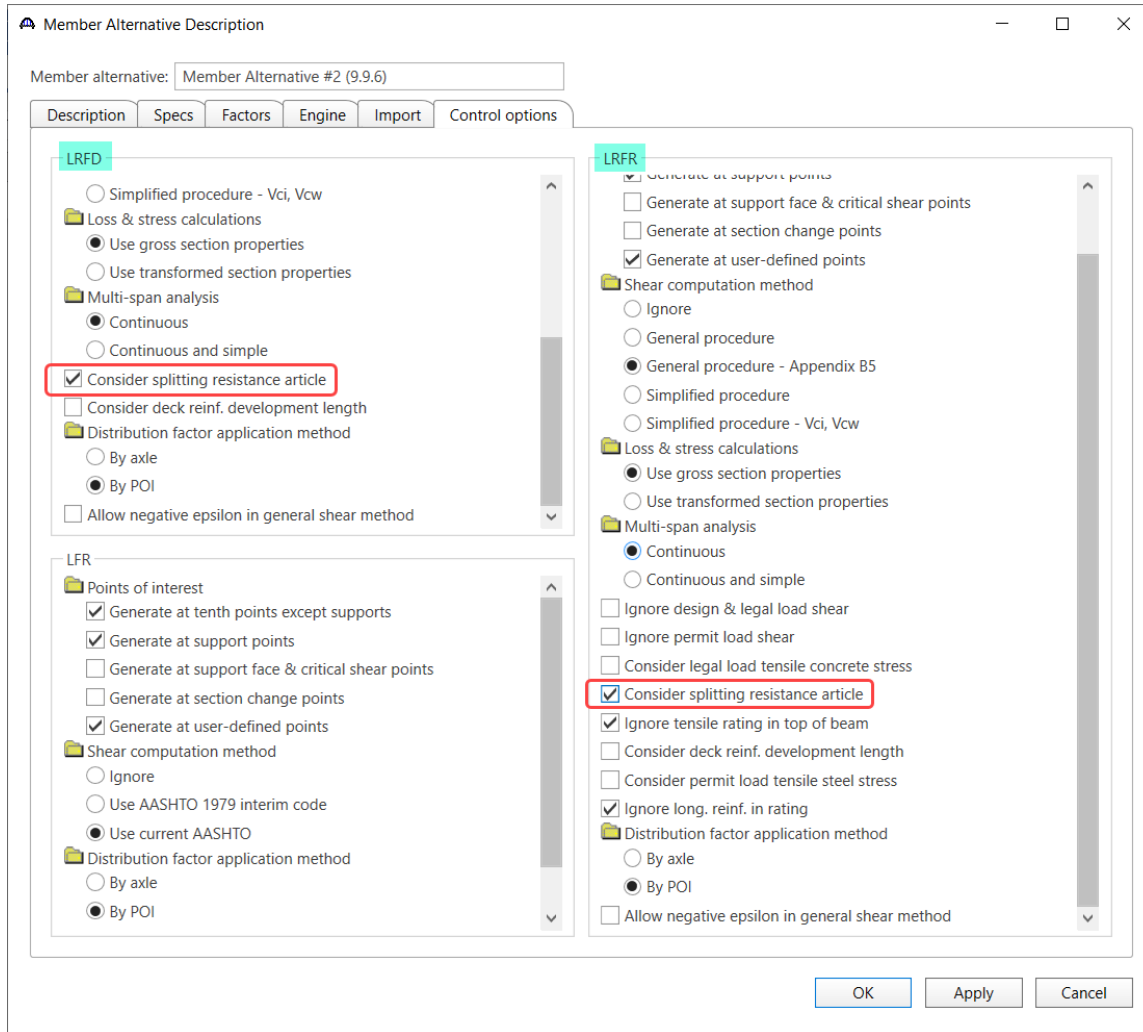
A schematic view of the member alternative can be viewed by selecting the member alternative **Member Alternative #2 (9.9.6)** node in the **Bridge Workspace** tree and clicking on the **Schematic** button from the **WORKSPACE** ribbon (or by right clicking on the **Member Alternative #2 (9.9.6)** node and selecting **Schematic** from the menu) as shown below.



PS12 – Three Span Prestressed I Beam Stirrup Design Example

Prestressed Concrete Control Options for BrDR - Consider splitting resistance

Double click on the member alternative **Member Alternative #2 (9.9.6)** in the **Bridge Workspace** tree to open the **Member Alternative Description** window and navigate to the **Control options** tab as shown below.

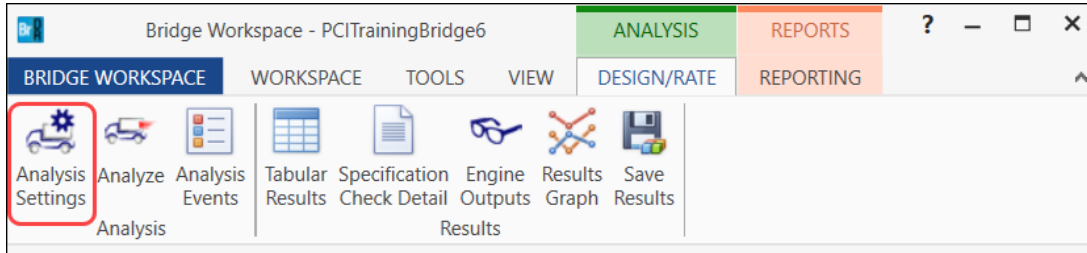


The user may select this option to consider the splitting resistance of the pretensioned anchorage zone as per **LRFD 5.9.4.4.1**. For this example, turn on the splitting resistance article in the control options for LRFD and run the LRFD analysis as shown below. In the spec check, open the **LRFD 5.9.4.4.1** article.

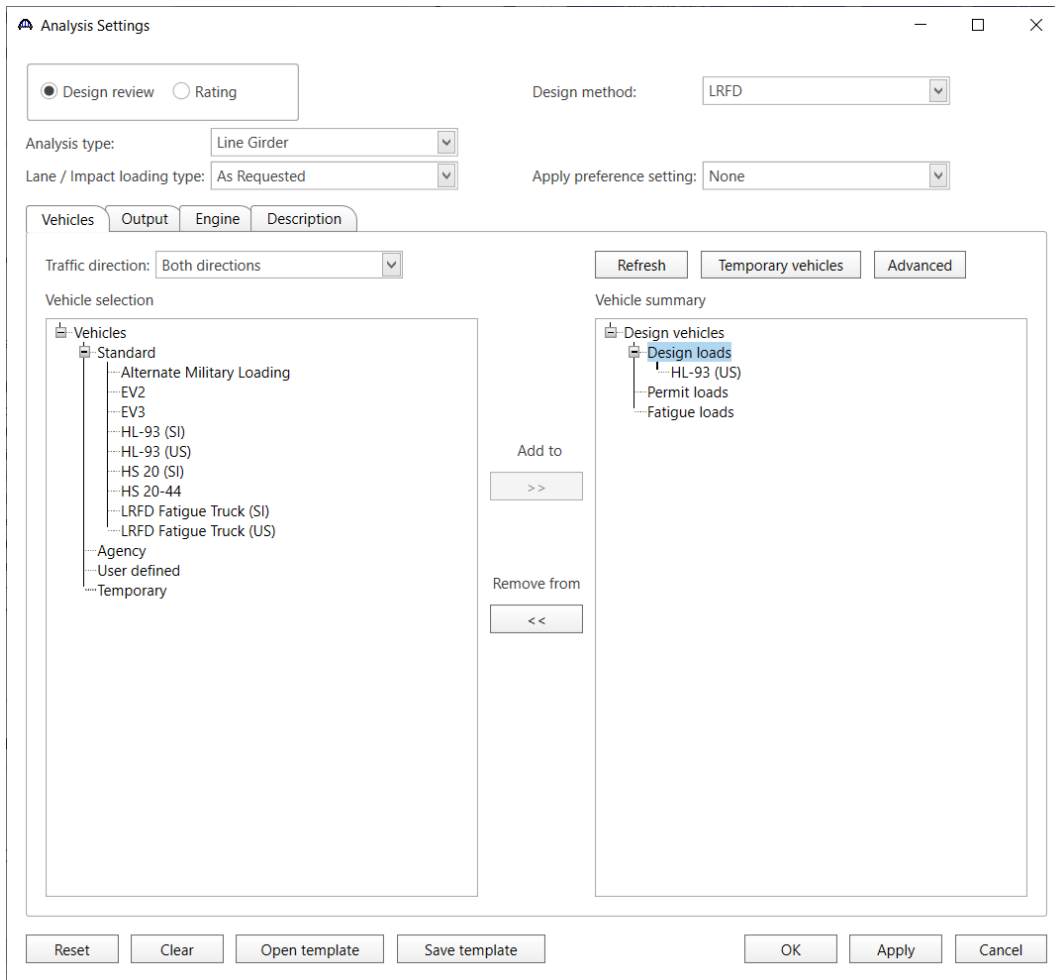
PS12 – Three Span Prestressed I Beam Stirrup Design Example

LRFD Design Review

To perform an **LRFD design review** on the member alternative **Member Alternative #2 (9.9.6)**, select the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon to open the window shown below.



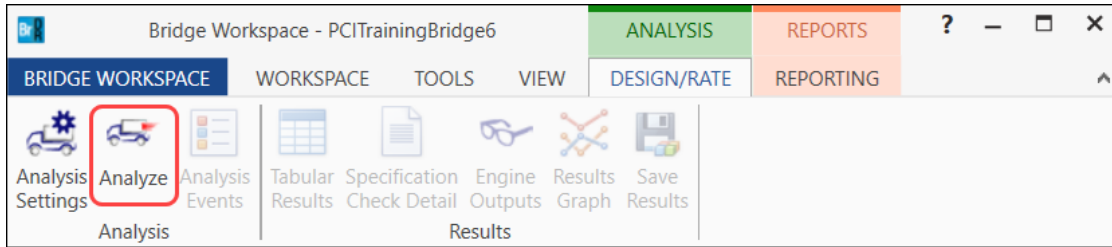
Select the **Design Review** button, **LRFD** as the Design method and **HL-93 (US)** vehicle in **Design Loads** as shown below.



Click **OK** to save the settings and close the window.

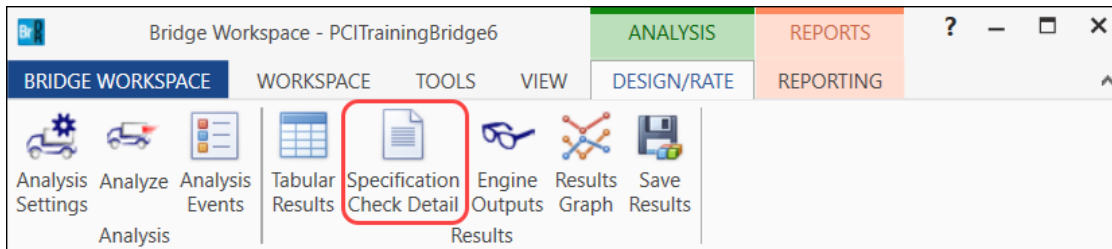
PS12 – Three Span Prestressed I Beam Stirrup Design Example

Next click the **Analyze** button on the **Analysis** group of the **DESIGN/RATE** ribbon to perform the rating.

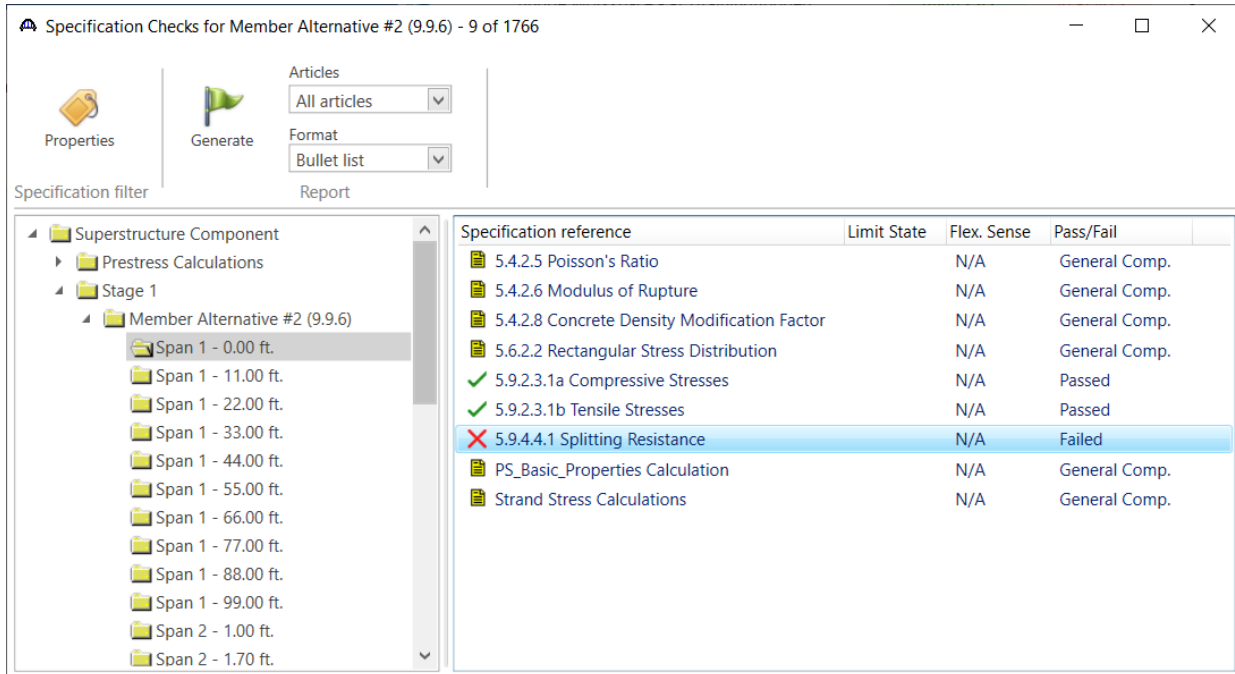


Specification Check Details

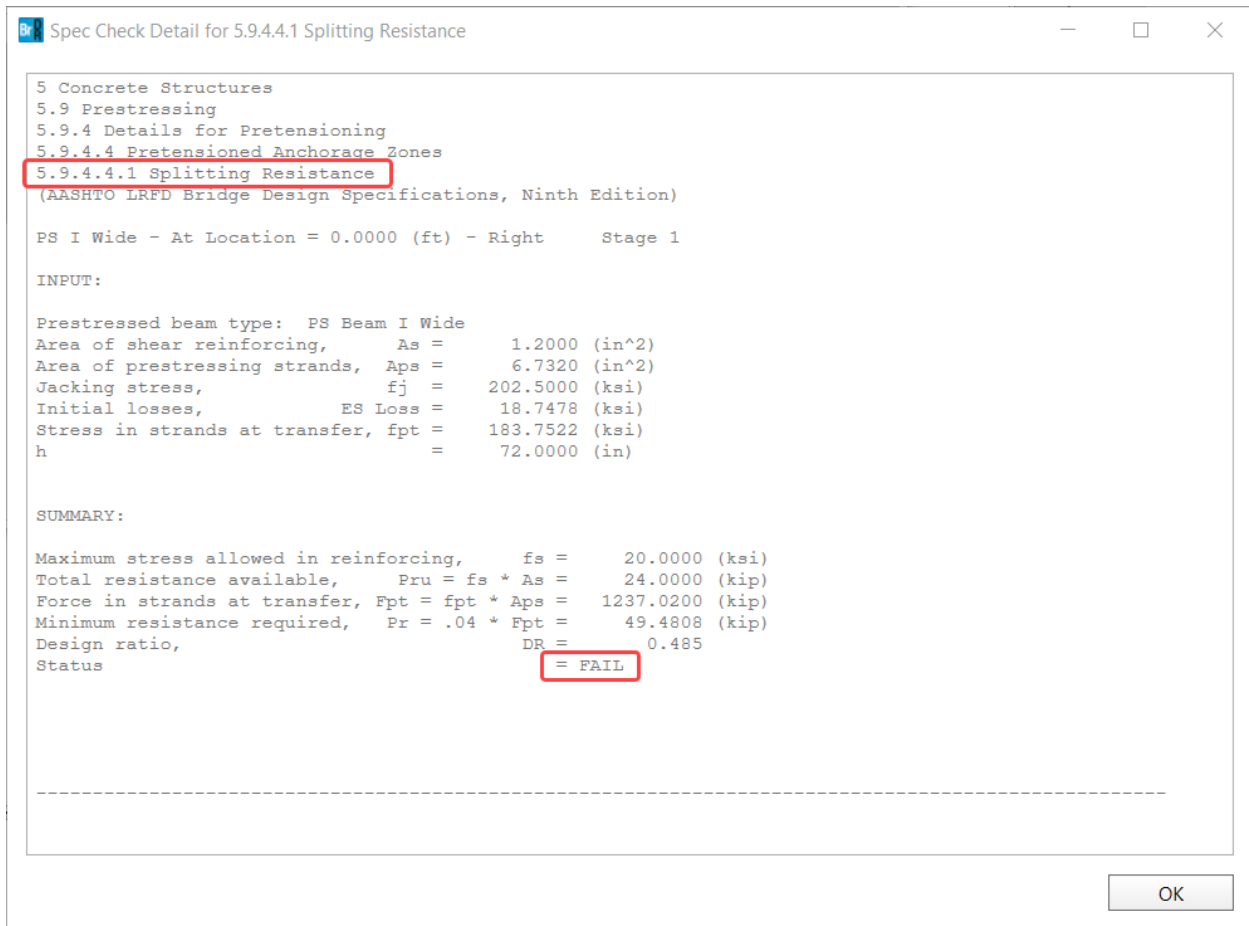
The specification checks can be viewed by selecting the **Specification Check Detail** button from the **Results** group of the **DESIGN/RATE** ribbon.



Expand the **Stage 1** node in the **Superstructure Component** tree and select **Span 1 – 0.00 ft.** Double-click on the article **5.9.4.4.1 Splitting Resistance** to open the article details.



PS12 – Three Span Prestressed I Beam Stirrup Design Example



A_s is the area of steel within the distance from $h/4$ from the end of beam. The area of steel in this zone needs to be increased.

$$P_{ru} = 54.53 \text{ kips} = f_s * A_s$$

$$A_s \geq 2.73 \text{ in}^2$$

$$h/4 = 72 \text{ in} / 4 = 18 \text{ in}$$

We have 3 #4 stirrups within the distance of $h/2$ at 6 in spacing.

$$A_s = 3 * 0.20 \text{ in}^2 * 2 \text{ legs} = 1.2 \text{ in}^2$$

As of each bar = $2.73 \text{ in}^2 / 3 = 0.91 \text{ in}^2$ for 6 in spacing or use 3 #7 bars or $A_s = 3.6 \text{ in}^2$.

As of each bar = $2.73 \text{ in}^2 / 5 = 0.55 \text{ in}^2$ for 4 in spacing or use 5 #5 bars or $A_s = 3.1 \text{ in}^2$.

The #5 bars at 4 inches over 16 inches from the first stirrup will be used. The stirrups will be pushed 1 inch closer to the end of the beam to ensure the stirrups fall within the $h/4$ distance.

PS12 – Three Span Prestressed I Beam Stirrup Design Example

Navigate back to the **Stirrup design tool** in **Shear Reinforcement Ranges** window and enter the following data.

The image shows a software dialog box titled "Shear Stirrup Design Tool". It contains several sections for configuring stirrup design parameters. Red boxes highlight the following fields:

- Distance to first stirrup:** 3.0000 in
- Stirrup entry method:** Create new stirrup definition
- Extends into deck:**
- Stirrup definition 1 - New stirrup definition:**
 - Material: Grade 60
 - Bar size: 7
 - Number of legs: 2.00
 - Inclination (alpha): 90.0 Degrees

Other visible fields include:

- Maximum jump in spacing between ranges: [] in
- Override maximum allowable spacing: [] in
- Number of stirrup definitions: Use 1 stirrup definition, Use 2 stirrup definitions
- Definition 1 minimum range length: [] ft
- Design template: HL 93 Design Review (dropdown), View... button
- Stirrup definition 1 - Existing stirrup definition: Vertical shear reinf def: #4 Shear Reinf. (dropdown)
- Stirrup definition 2 - Existing stirrup definition: Vertical shear reinf def: #4 Shear Reinf. (dropdown)
- Stirrup definition 2 - New stirrup definition: Material: Grade 60, Bar size: 3, Number of legs: [], Inclination (alpha): 90.0 Degrees
- Buttons: Continue, Cancel

PS12 – Three Span Prestressed I Beam Stirrup Design Example

Set the **Minimum number of stirrups per range to 5**. **Create ranges** and **Apply** the ranges to all 3 spans.

Stirrup Design Tool Results ✕

Vertical shear reinforcement definition 1 name:

Vertical shear reinforcement definition 2 name:

Span:

Required stirrup spacing

Location (ft)	Vu (kip)	Vc (kip)	Vp (kip)	smax (in)	sreq (in)
6.75	345.85	178.57	40.51	24.00	24.00
11.40	316.73	177.88	40.51	24.00	24.00
22.30	250.42	162.54	40.51	24.00	24.00
33.20	186.47	107.96	0.00	24.00	24.00
44.10	125.26	90.69	0.00	24.00	24.00
55.00	-124.73	88.78	0.00	24.00	24.00
65.90	-186.60	97.93	0.00	24.00	24.00
76.80	-248.37	156.79	0.00	24.00	24.00
87.70	-309.62	162.54	40.51	12.00	12.00
98.60	-369.96	177.88	40.51	12.00	12.00

Generated ranges

Maximum number ranges per span: Minimum stirrups per range:

Name	Extends into deck	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
Wizard Stirrup 2	<input checked="" type="checkbox"/>	0.25	1	0.0000	0.00	0.25
Wizard Stirrup 2	<input checked="" type="checkbox"/>	0.25	3	6.0000	1.50	1.75
Wizard Stirrup 2	<input checked="" type="checkbox"/>	1.75	2	4.5000	0.75	2.50
Wizard Stirrup 2	<input checked="" type="checkbox"/>	2.50	15	6.0000	7.50	10.00
Wizard Stirrup 2	<input checked="" type="checkbox"/>	10.00	2	7.2000	1.20	11.20
Wizard Stirrup 2	<input checked="" type="checkbox"/>	11.20	23	12.0000	23.00	34.20
Wizard Stirrup 2	<input checked="" type="checkbox"/>	34.20	2	16.8000	2.80	37.00
Wizard Stirrup 2	<input checked="" type="checkbox"/>	37.00	18	24.0000	36.00	73.00
Wizard Stirrup 2	<input checked="" type="checkbox"/>	73.00	2	16.8000	2.80	75.80

Note: Existing vertical shear reinforcement ranges will be deleted if you apply the results of this wizard.

PS12 – Three Span Prestressed I Beam Stirrup Design Example

Rerun the **AASHTO LRFD** analysis and check the specification article **LRFD 5.9.4.4.1** at **Span 1 – 0.0'** for **Stage 1**.

Spec Check Detail for 5.9.4.4.1 Splitting Resistance

5 Concrete Structures
5.9 Prestressing
5.9.4 Details for Pretensioning
5.9.4.4 Pretensioned Anchorage Zones
5.9.4.4.1 Splitting Resistance
(AASHTO LRFD Bridge Design Specifications, Ninth Edition)

PS I Wide - At Location = 0.0000 (ft) - Right Stage 1

INPUT:

Prestressed beam type: PS Beam I Wide

Area of shear reinforcing, A_s	=	3.6000 (in ²)
Area of prestressing strands, A_{ps}	=	6.7320 (in ²)
Jacking stress, f_j	=	202.5000 (ksi)
Initial losses, ES Loss	=	18.7478 (ksi)
Stress in strands at transfer, f_{pt}	=	183.7522 (ksi)
h	=	72.0000 (in)

SUMMARY:

Maximum stress allowed in reinforcing, f_s	=	20.0000 (ksi)
Total resistance available, $P_{ru} = f_s * A_s$	=	72.0000 (kip)
Force in strands at transfer, $F_{pt} = f_{pt} * A_{ps}$	=	1237.0200 (kip)
Minimum resistance required, $P_r = .04 * F_{pt}$	=	49.4808 (kip)
Design ratio, DR	=	1.455
Status	=	PASS

OK

PS12 – Three Span Prestressed I Beam Stirrup Design Example

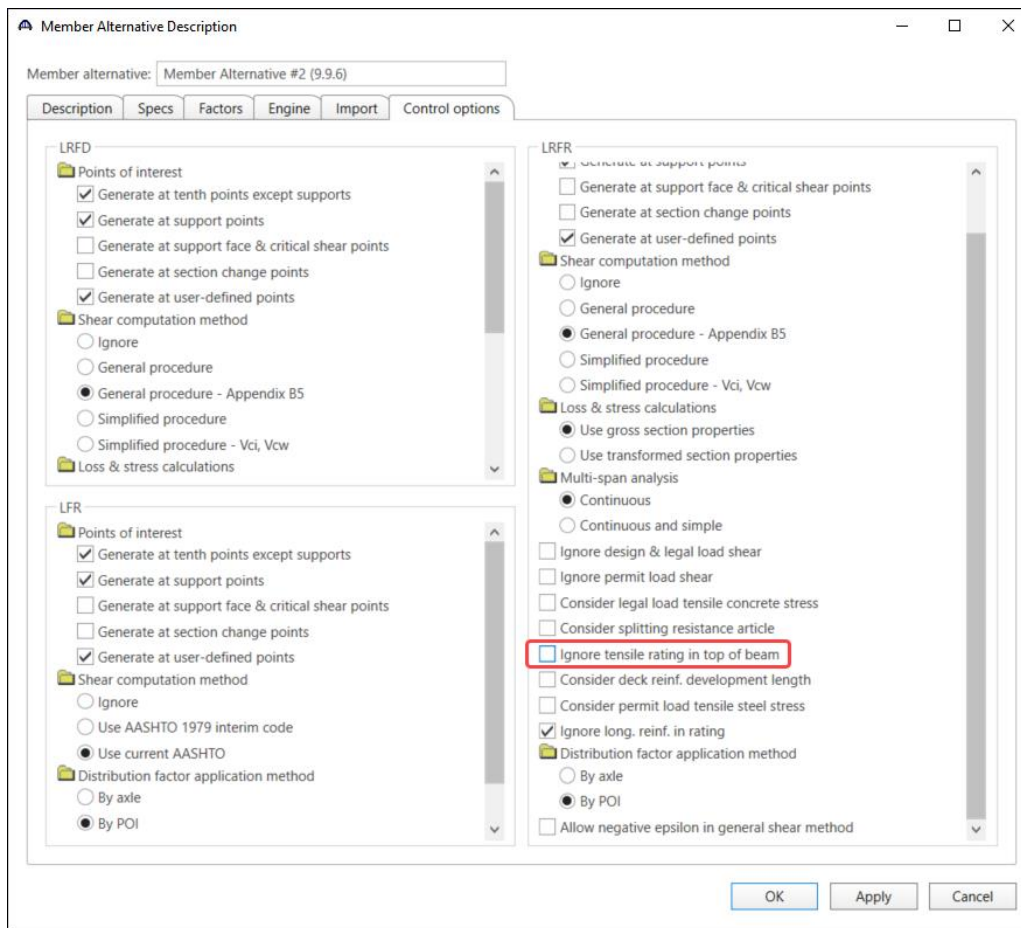
Tensile rating in the top of the beam

This section compares LRFR rating results when tensile rating in the top of the beam is considered vs ignored.

Consider tensile rating in the top of the beam.

Member Alternative Description – Control options

Double click on the member alternative **Member Alternative #2 (9.9.6)** in the **Bridge Workspace** tree to open the **Member Alternative Description** window and navigate to the **Control options** tab as shown below. Uncheck the **Ignore tensile rating in top of beam** checkbox under **LRFR**.

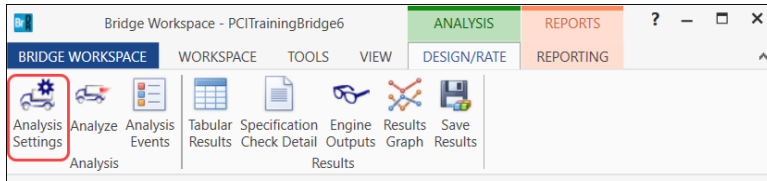


Click **OK** to apply the data and close the window.

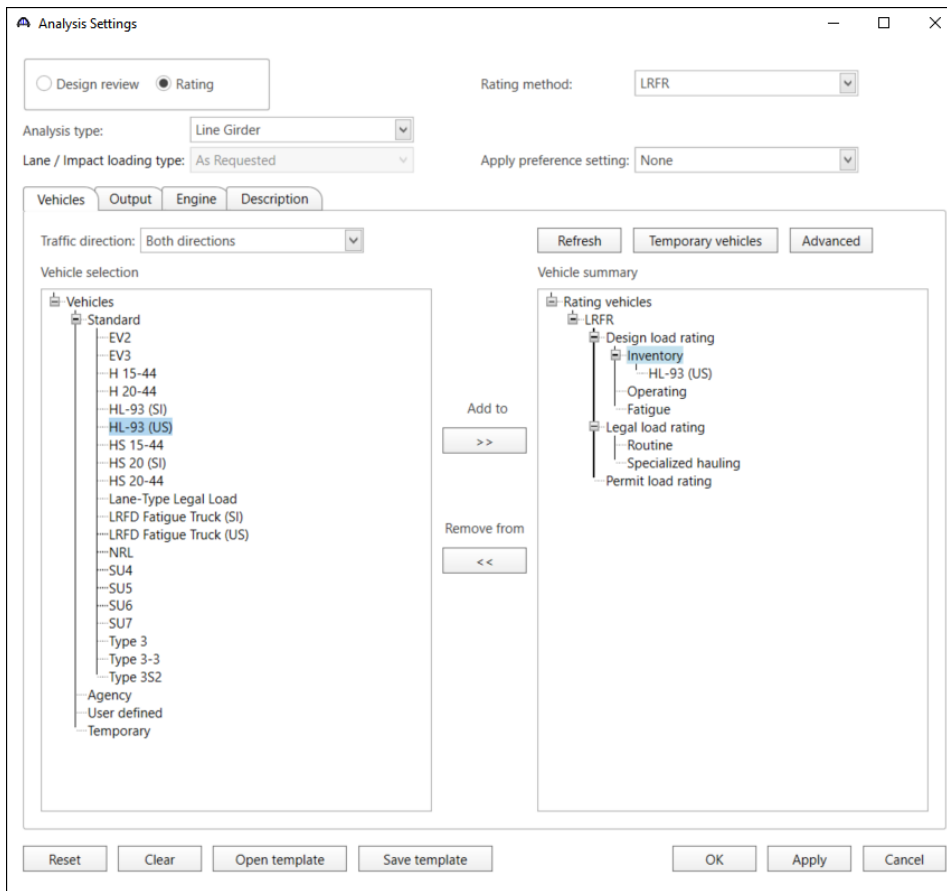
PS12 – Three Span Prestressed I Beam Stirrup Design Example

LRFR Analysis

To perform an **LRFR** rating, select the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon to open the window shown below.

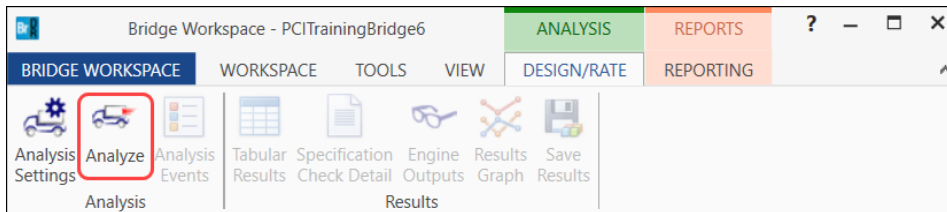


Select **LRFR** as the **Rating method** and **HL-93 (US)** vehicle in **Inventory** as shown below.



Click **OK** to save the analysis settings and close the window.

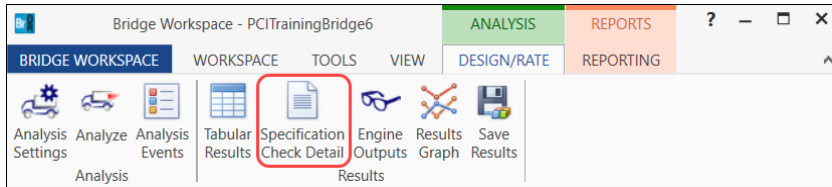
Next click the **Analyze** button on the **Analysis** group of the **DESIGN/RATE** ribbon to perform the rating.



PS12 – Three Span Prestressed I Beam Stirrup Design Example

Specification Check Details

Once the analysis is complete, the specification checks can be viewed by selecting the **Specification Check Detail** button from the **Results** group of the **DESIGN/RATE** ribbon.



Expand the **Stage 3** node in the **Superstructure Component** tree and select **Span 1 – 99.00 ft**. Double-click on the article **6A.4.2.1 Design Load Rating Prestress Service III Tensile Stress** to open the article details.

The dialog box displays the following information:

6A Load and Resistance Factor Rating
 6A.4 Load Rating Procedures
 6A.4.2 General Load-Rating Equation
 6A.4.2.1 Design Load Rating Prestress Service III Tensile Stress
 (AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)

PS I Wide - At Location = 99.0000 (ft) - Left Stage 3

Service III Inventory Level Rating Factor Calculations

Input:

Ignore tensile rating in top of beam: No

Bot DC Stress = 0.7473 (ksi)
 Top DC Stress = -0.7601 (ksi)
 Bot DW Stress = -0.1008 (ksi)
 Top DW Stress = 0.0319 (ksi)
 Bot DW_WS Stress = 0.0000 (ksi)
 Top DW_WS Stress = 0.0000 (ksi)

Compute Resistance:

fR = abs(Compressive fpb) + ft allow

ft allow = 0.5027 (ksi)
 fpb (Bot) = -2.8773 (ksi)
 fpb (Top) = 0.0541 (ksi) Eff. prestress is tension therefore do not add it to the tensile resistance.

Load	Load Combo	Limit State	Loc	LL (ksi)	Adj. LL (ksi)	Load Factors				fR (ksi)	RF	Capacity (Ton)
						DC	DW	DW_WS	LL			
DesignInv	1	SER-III Bot		0.23	---	1.00	1.00	1.00	0.80	3.38	14.738	530.57
DesignInv	1	SER-III Top		0.24	---	1.00	1.00	1.00	0.80	0.50	99.000	3564.00
DesignInv	2	SER-III Bot		0.26	---	1.00	1.00	1.00	0.80	3.38	13.088	471.15
DesignInv	2	SER-III Top		0.20	---	1.00	1.00	1.00	0.80	0.50	99.000	3564.00
DesignInv	3	SER-III Bot		0.00	---	1.00	1.00	1.00	0.80	3.38	99.000	3564.00
DesignInv	3	SER-III Top		0.27	---	1.00	1.00	1.00	0.80	0.50	99.000	3564.00

Legend:
 NA - Resistance and live load are of opposite sign so rating factor is not applicable.

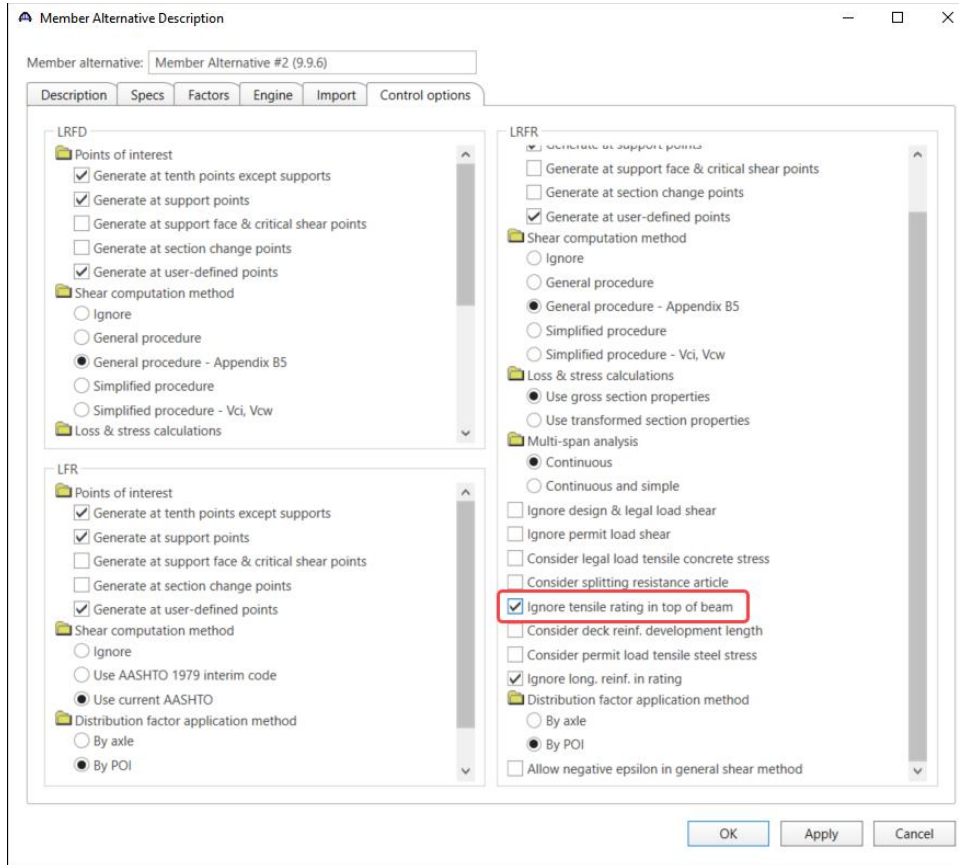
OK

PS12 – Three Span Prestressed I Beam Stirrup Design Example

Ignore tensile rating in the top of the beam.

Member Alternative Description – Control options

Double click on the member alternative **Member Alternative #2 (9.9.6)** in the **Bridge Workspace** tree to open the **Member Alternative Description** window and navigate to the **Control options** tab as shown below. Check the **Ignore tensile rating in top of beam** checkbox under **LRFR**.



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

PS12 – Three Span Prestressed I Beam Stirrup Design Example

LRFR Analysis

Re-run the **LRFR analysis** as described in the previous section and compare the same specification article **6A.4.2.1 Design Load Rating Prestress Service III Tensile Stress**. at the same location. (See image below.)

Spec Check Detail for 6A.4.2.1 Design Load Rating Prestress Service III Tensile Stress

6A Load and Resistance Factor Rating
 6A.4 Load Rating Procedures
 6A.4.2 General Load-Rating Equation
 6A.4.2.1 Design Load Rating Prestress Service III Tensile Stress
 (AASHTO Manual for Bridge Evaluation, Third Edition with 2023 Interims)

PS I Wide - At Location = 99.0000 (ft) - Left Stage 3

Service III Inventory Level Rating Factor Calculations

Input:

Ignore tensile rating in top of beam: Yes

Bot DC Stress = 0.7473 (ksi)
 Top DC Stress = -0.7601 (ksi)
 Bot DW Stress = -0.1008 (ksi)
 Top DW Stress = 0.0319 (ksi)
 Bot DW_WS Stress = 0.0000 (ksi)
 Top DW_WS Stress = 0.0000 (ksi)

Compute Resistance:

fR = abs(Compressive fpb) + ft allow

ft allow = 0.5027 (ksi)
 fpb (Bot) = -2.8773 (ksi)

Load	Load Combo	Limit State	Loc	Load Factors					LL	fR (ksi)	RF	Capacity (Ton)
				LL (ksi)	Adj. LL (ksi)	DC	DW	DW_WS				
DesignInv	1	SER-III Bot		0.23	---	1.00	1.00	1.00	0.80	3.38	14.738	530.57
DesignInv	2	SER-III Bot		0.26	---	1.00	1.00	1.00	0.80	3.38	13.088	471.15
DesignInv	3	SER-III Bot		0.00	---	1.00	1.00	1.00	0.80	3.38	99.000	3564.00

Legend:
 NA - Resistance and live load are of opposite sign so rating factor is not applicable.

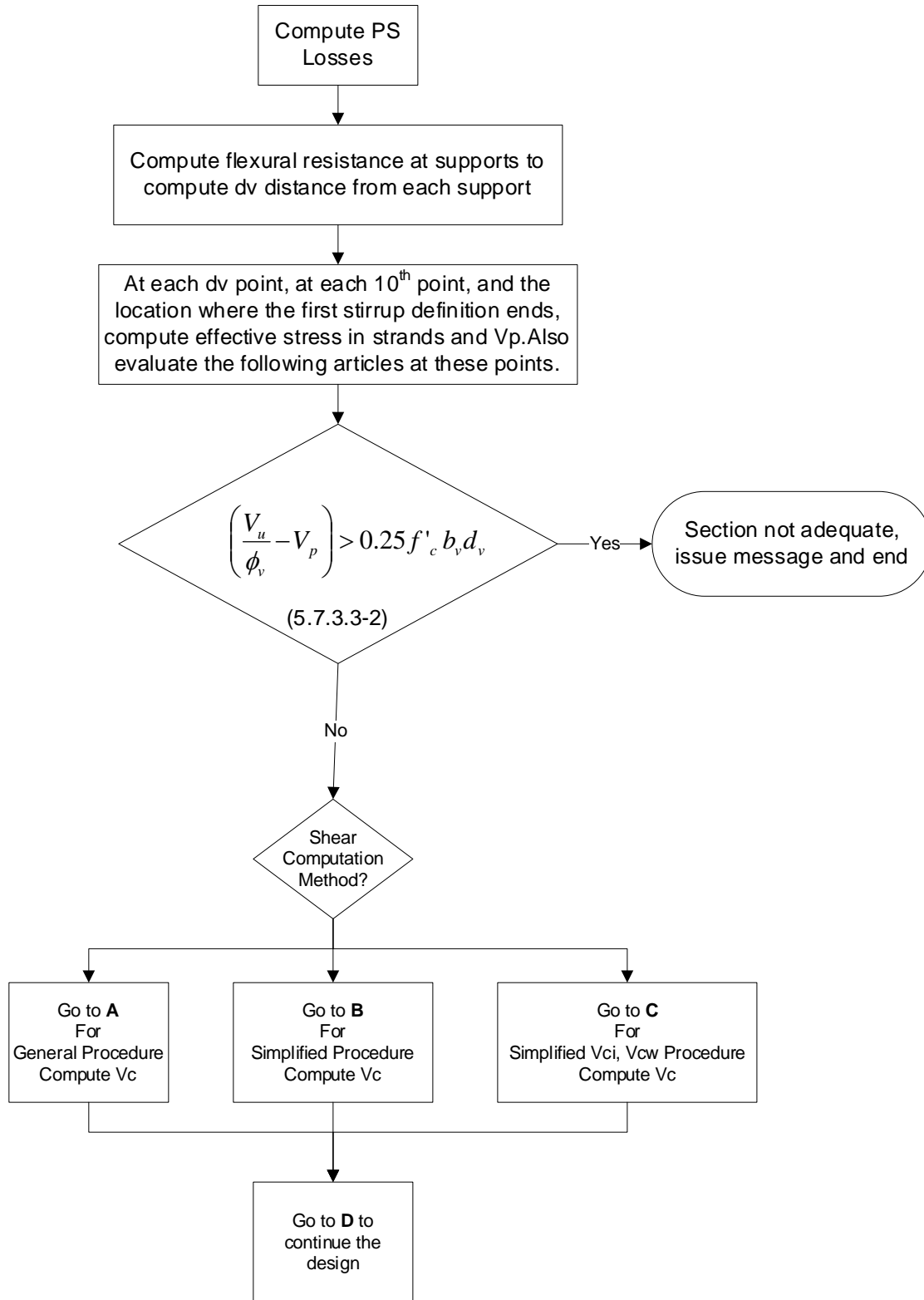
Load Combination Legend:

Code	Vehicle
-----	-----

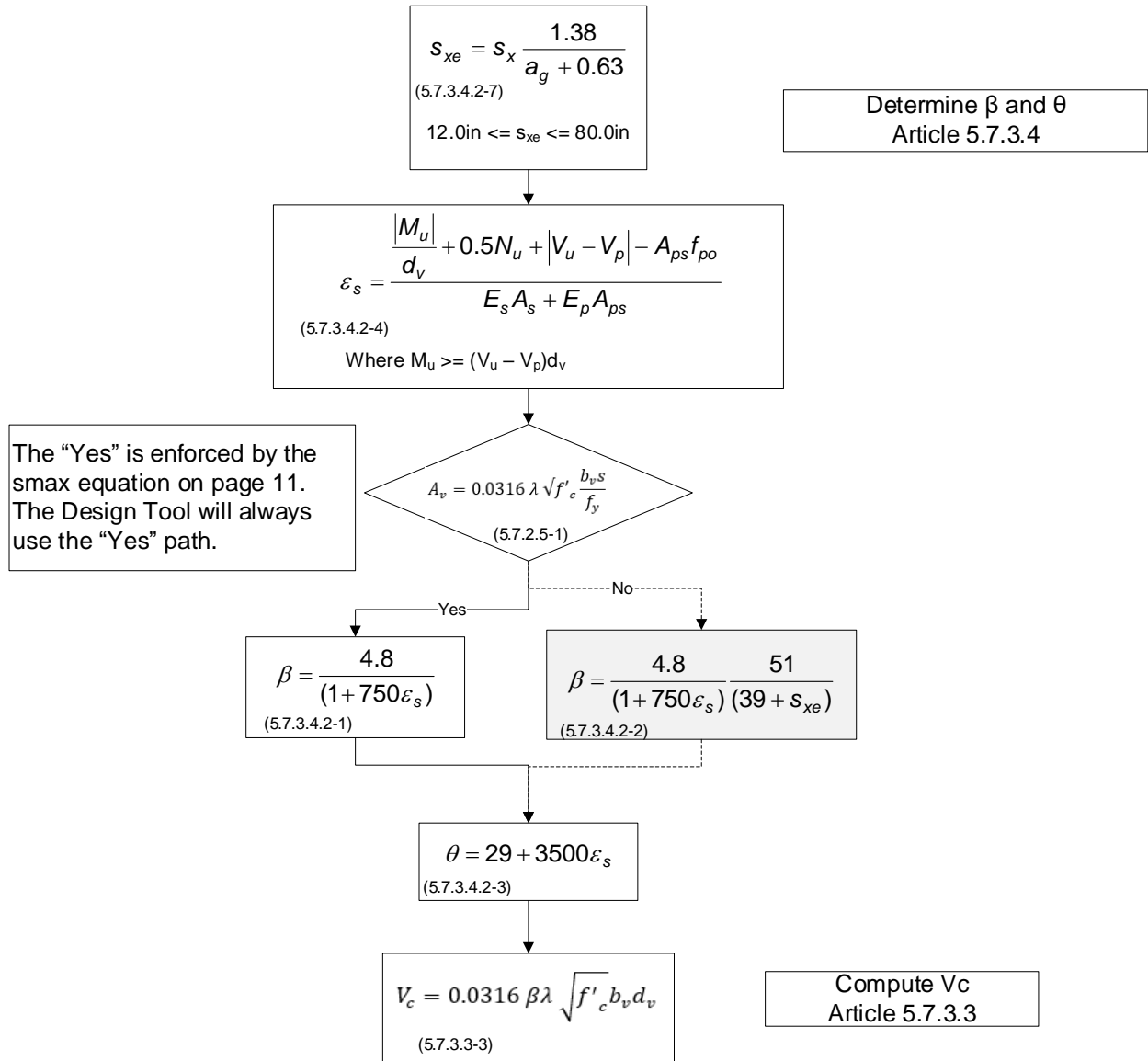
OK

PS12 – Three Span Prestressed I Beam Stirrup Design Example

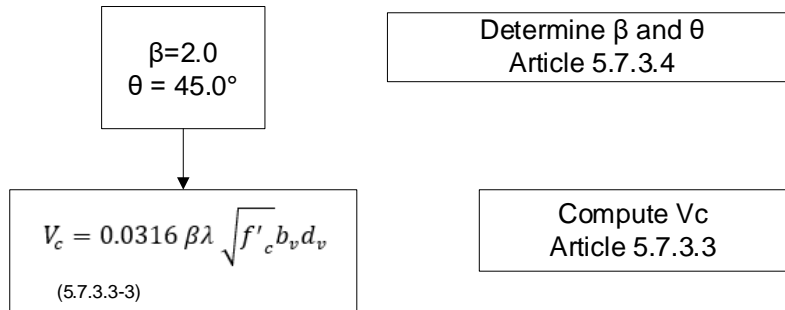
Flowcharts for PS Stirrup Design Tool



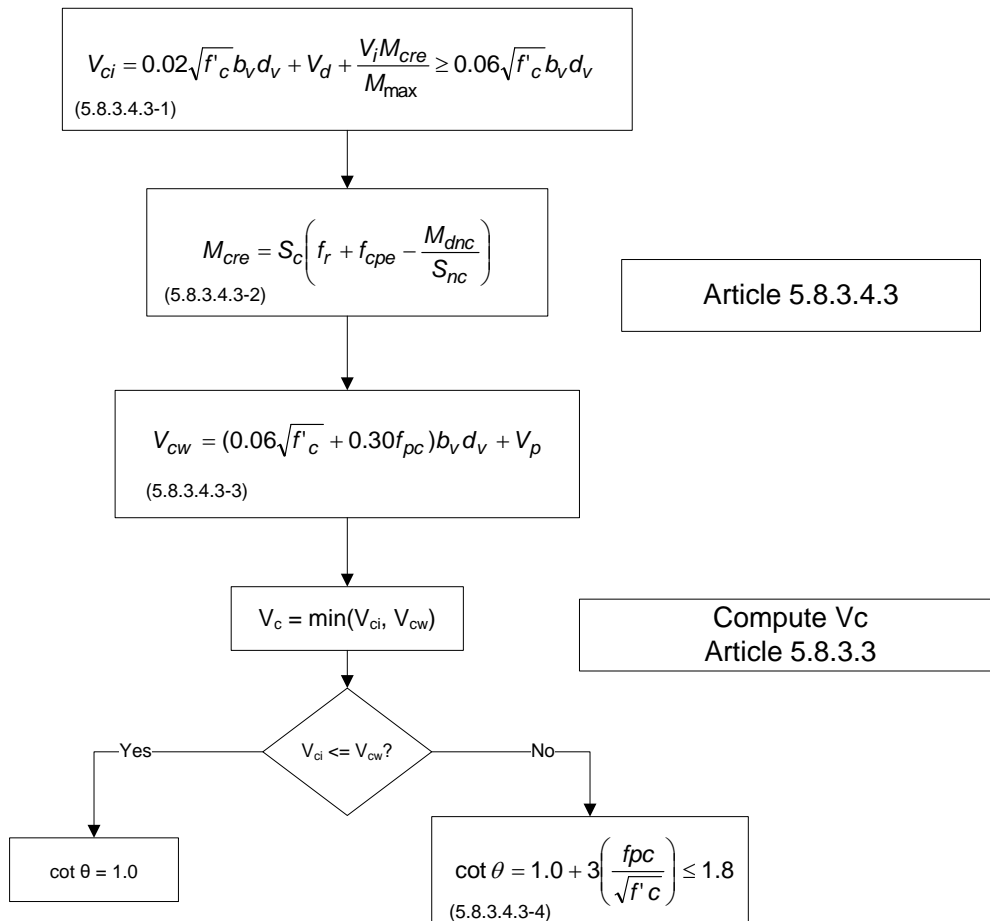
A. General Procedure to Compute Vc



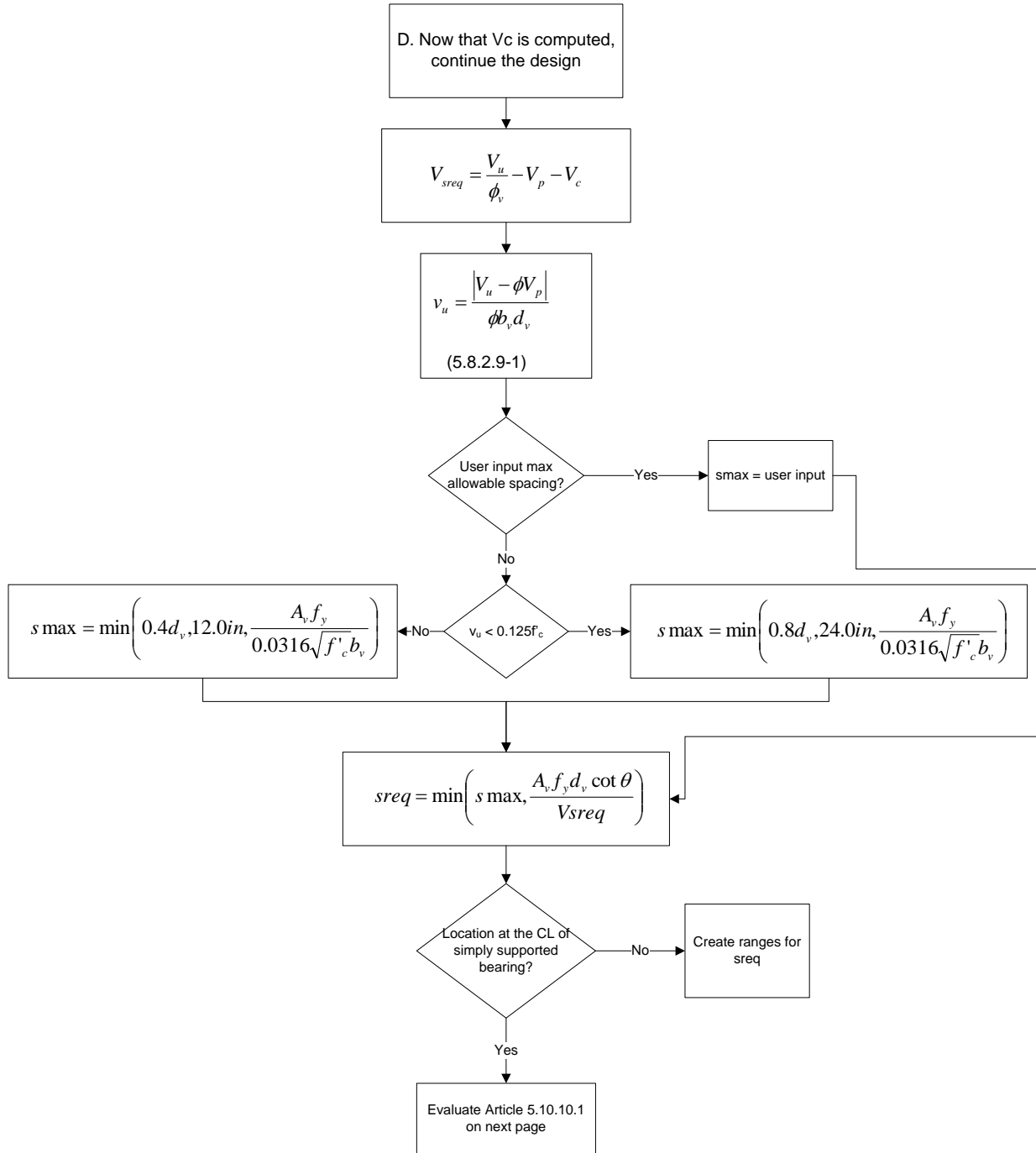
B. Simplified Procedure to Compute Vc



C. Simplified Vci, Vcw Procedure to Compute Vc



PS12 – Three Span Prestressed I Beam Stirrup Design Example



PS12 – Three Span Prestressed I Beam Stirrup Design Example

$$P_r = 0.04(f_{pbt} * A_{ps})$$

(Article 5.10.10.1)

$$sreq = \min\left(sreq \text{ from prev page, } \frac{(A_s) * (h / 4)}{P_r / f_s}\right)$$

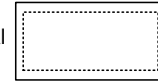
f_s = service stress in the stirrup steel, limited to 20ksi

For I beams:

A_s is the total area of vertical reinforcement within $h/4$ from the end of member where h = height of beam.

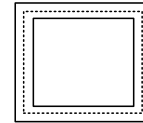
For box beams with no voids or circular voids:

A_s is the total area of horizontal reinforcement within $h/4$ from the end of member where h = overall width of beam. Opis will assume that each vertical leg of stirrup contributes 1 horizontal leg of reinforcement.



For box beams:

A_s is the area of vertical or horizontal reinforcement within $h/4$ from the end of member where h = min(overall height, overall width) of beam. Opis will assume that each vertical leg of stirrup contributes 1 horizontal leg of reinforcement.

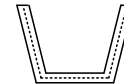


P_r is evaluated twice:

once for the A_{ps} in the bottom flange and the horizontal A_s and once for the A_{ps} above the bottom flange and the vertical A_s

For U beams:

A_s is the area of vertical or horizontal reinforcement within $h/4$ from the end of member where h = min(overall height, overall width) of beam. Opis will assume that 2 vertical legs of stirrup contributes 1 horizontal leg of reinforcement.



P_r is evaluated twice:

once for the A_{ps} in the bottom flange and the horizontal A_s and once for the A_{ps} above the bottom flange and the vertical A_s

For T beams:

A_s is the total area of vertical reinforcement within $h/4$ from the end of member where h = overall height of beam.

f_{pbt} = stress in prestress steel at transfer (= jacking stress without losses)

A_{ps} = area of prestressing steel, does not take into account the reduced area at the CL bearing due to transfer and development length

5-150

AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS

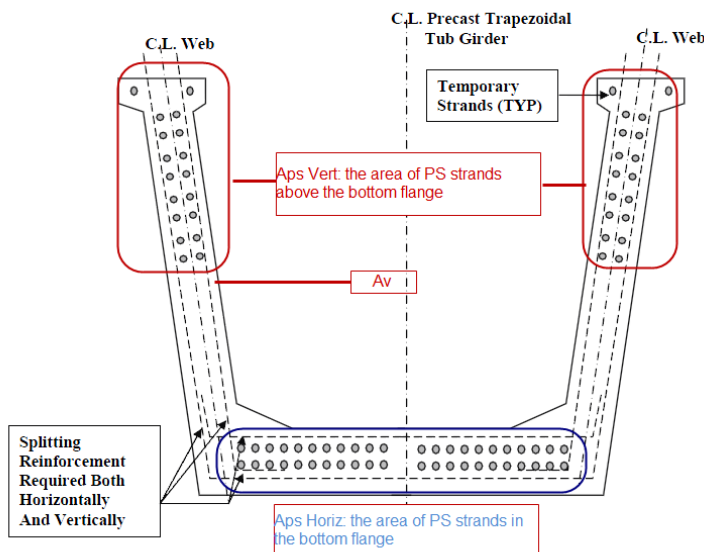


Figure C5.10.10.1-1—Precast Trapezoidal Tub Girder

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