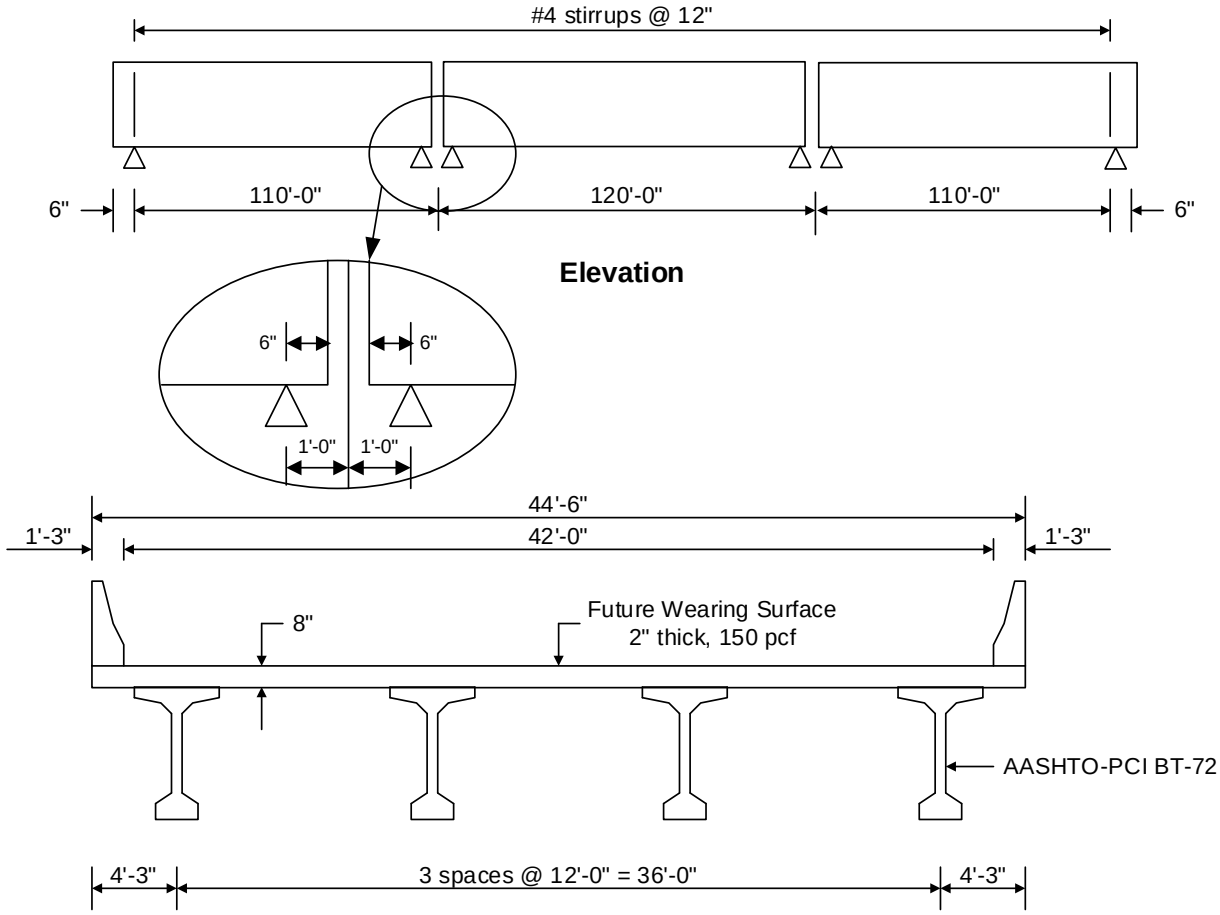
AASHTOWare BrDR 7.5.0

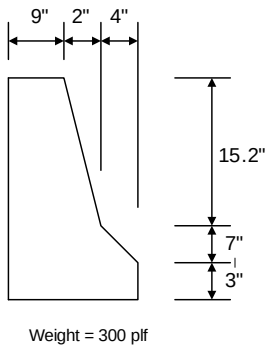
Prestressed Concrete Structure Tutorial

PS12 – Three Span Prestressed I Beam Stirrup Design Example

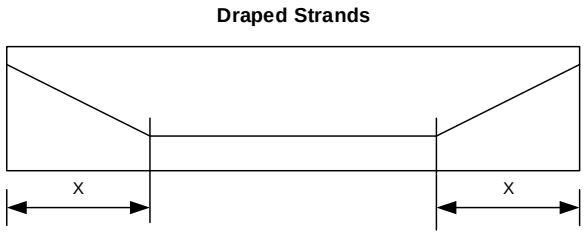
PS12 - Three Span Prestressed I Beam Stirrup Design Example



Typical Section

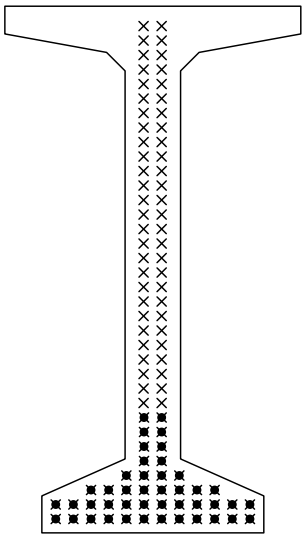


Parapet Detail

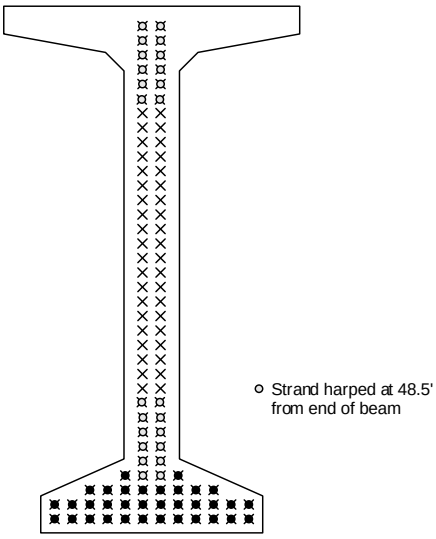


X = 32.00 ft (End Spans)
X = 35.50 ft (Mid Span)

Strand Pattern for all Spans



Strand Pattern at Mid-Span



Strand Pattern at End of Beam

Material Properties

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

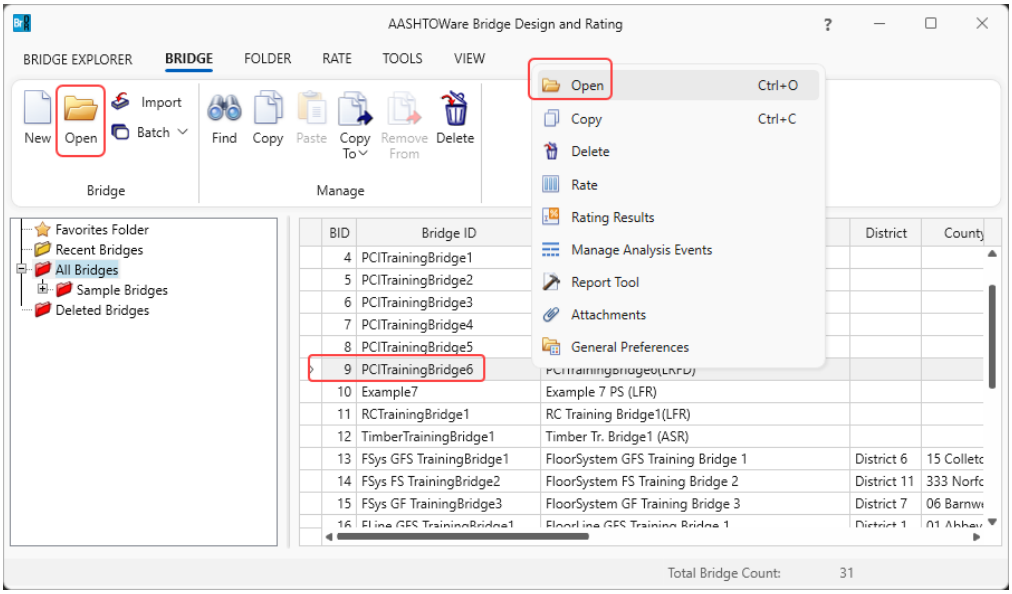
Deck Concrete: f'c = 4.0 ksi

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

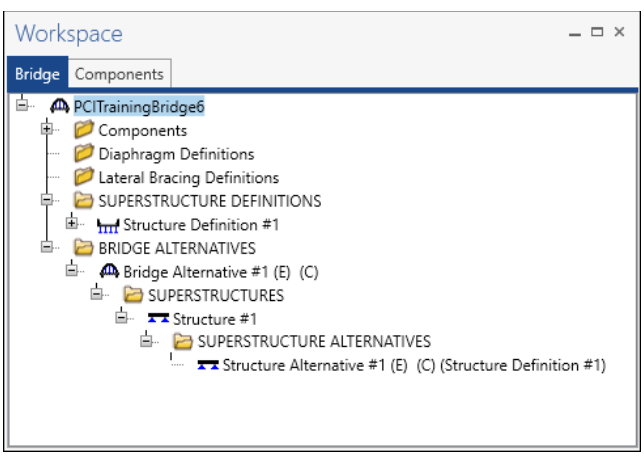
BrDR Training

PS12 - Three Span Prestressed I Beam Stirrup Design Example

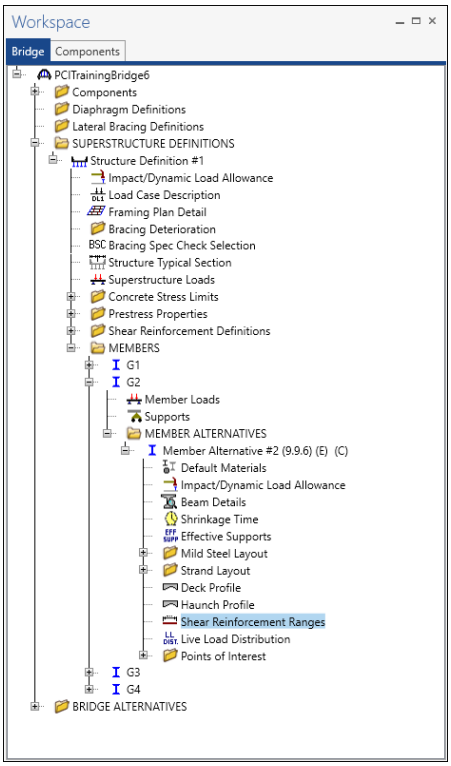
From the **Bridge Explorer** open the bridge **PCITrainingBridge6 (BID 9)** by double clicking on **BID 9** (or by selecting **BID 9** and clicking on the **Open** button from the **BRIDGE** ribbon or right click and select **Open**) as shown below.



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

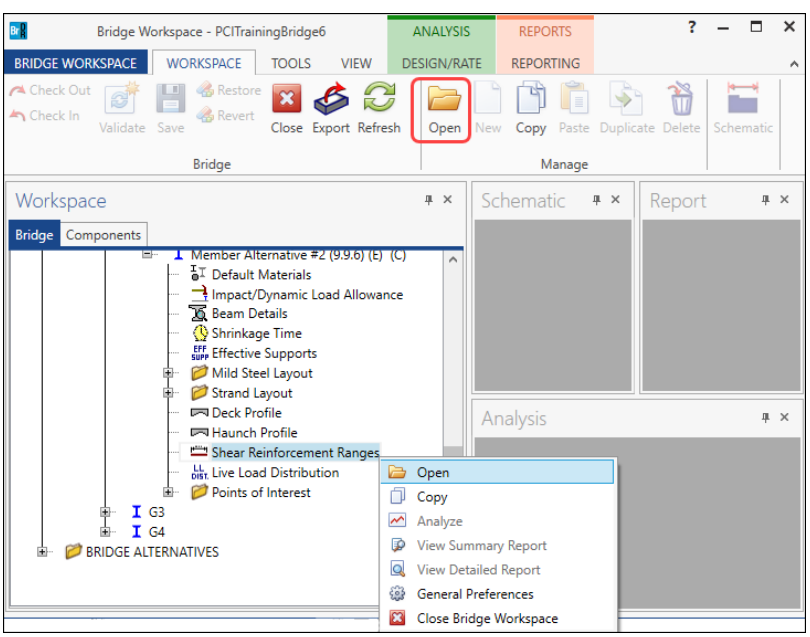


Expand the **SUPERSTRUCTURE DEFINITIONS** tree, and then expand the **Structure Definition #1**. Expand **MEMBERS**, **G2**, **MEMBER ALTERNATIVES** and finally expand **Member Alternative #2 (9.9.6) (E)(C)**.

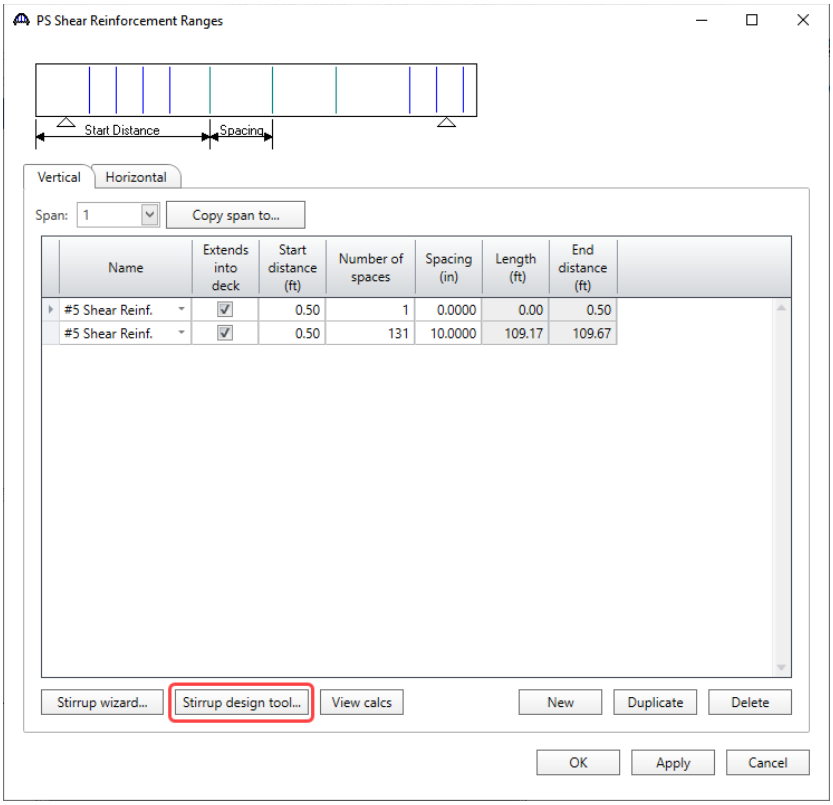


PS Shear Reinforcement Ranges

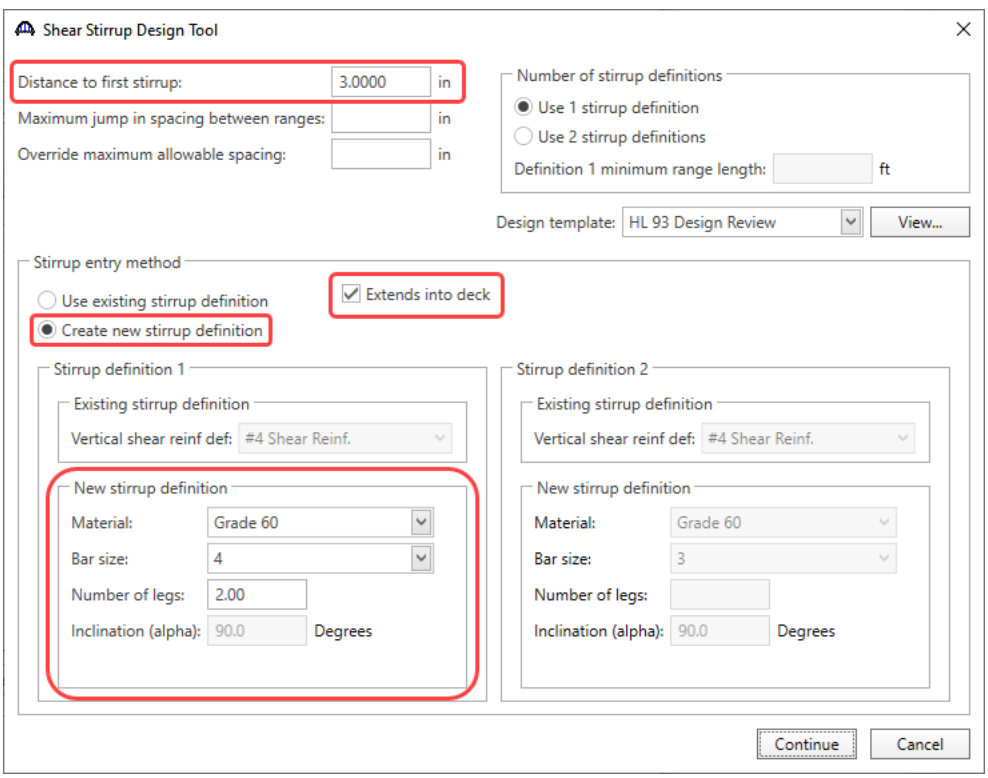
Select the **Shear Reinforcement Ranges** node in the **Bridge Workspace** tree and click the **Open** button from the **Manage** group of the **WORKSPACE** ribbon (or right click on the **Shear Reinforcement Ranges** node and select **Open** from the drop-down menu).



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.



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 5.8.2.7 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.

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.

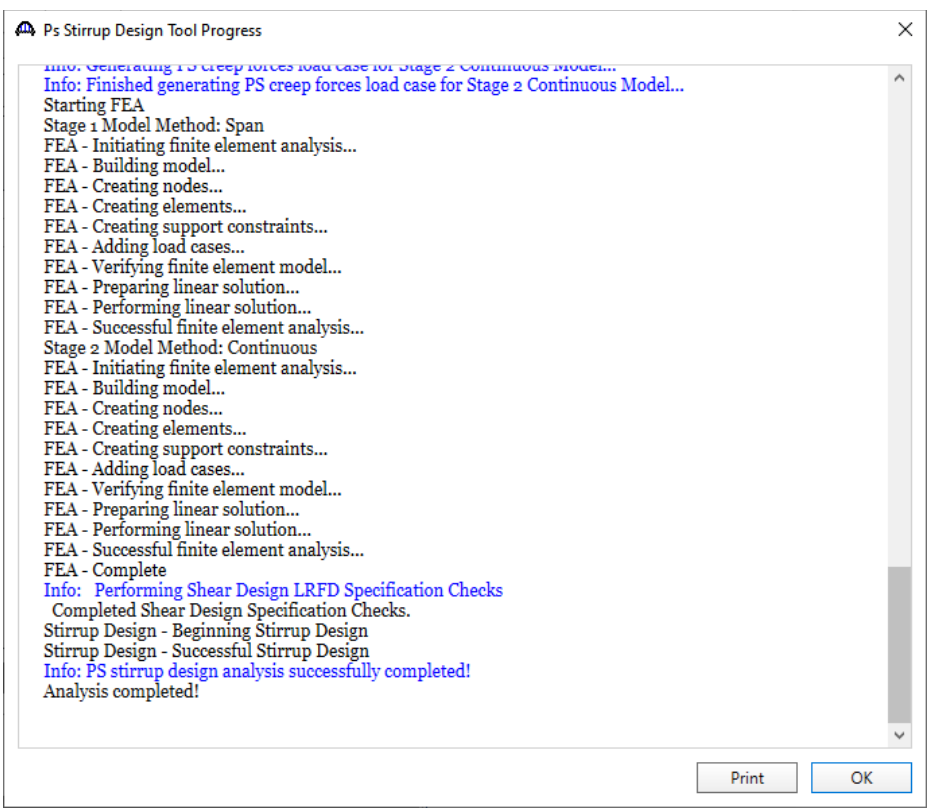
Stirrup Definition (1 or 2)

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.

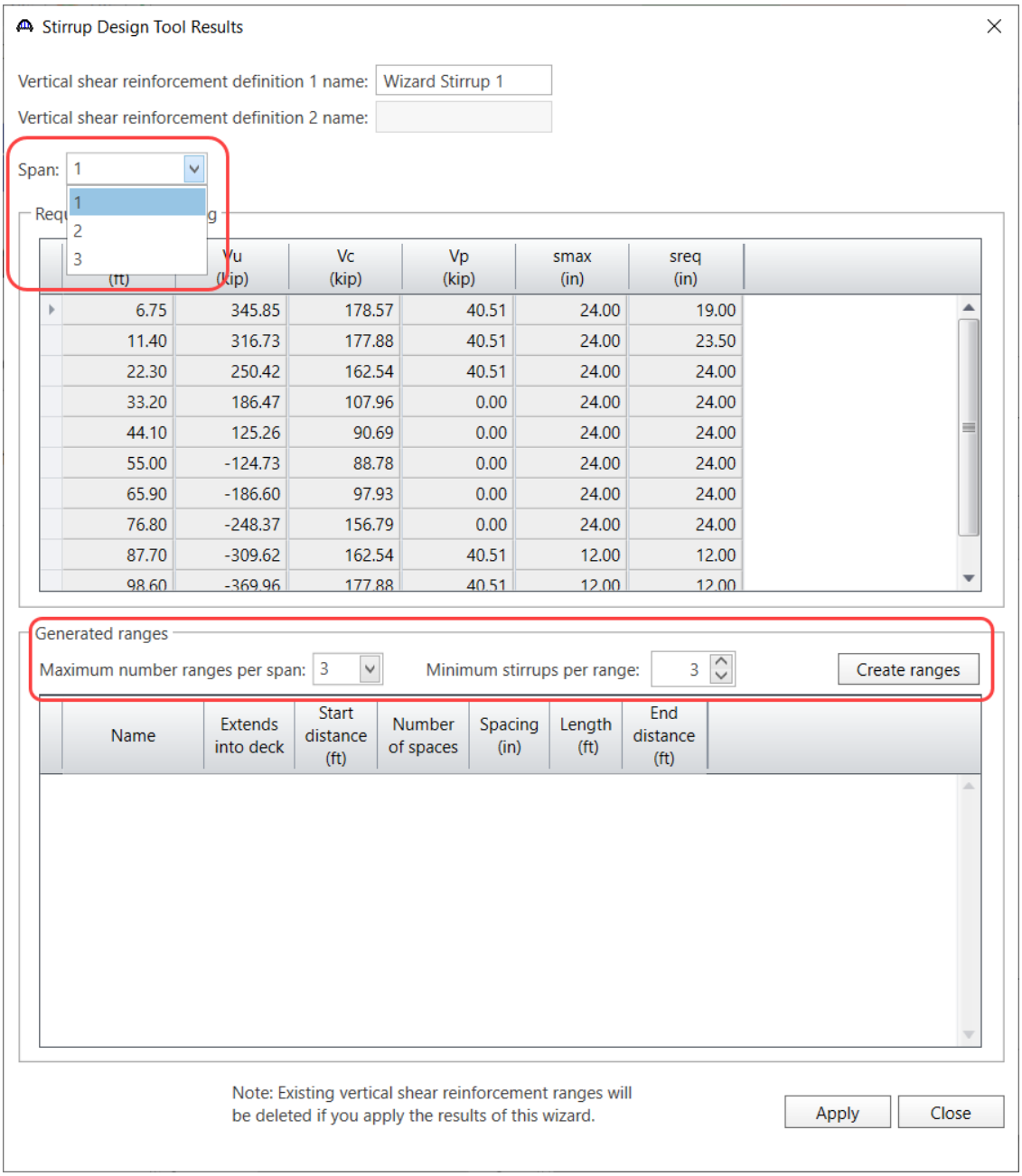
New Stirrup Definition

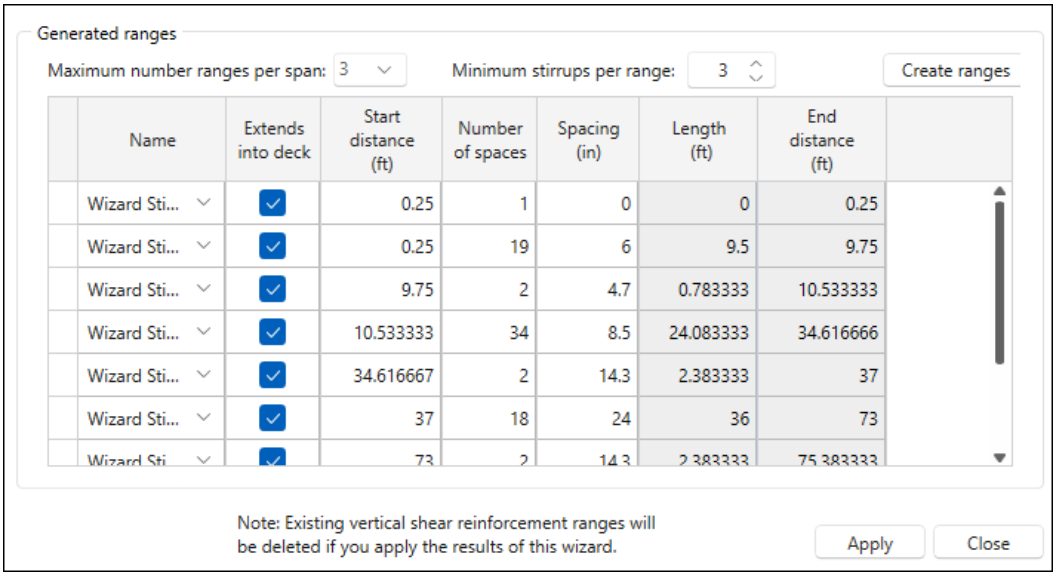
When using the design tool to create a stirrup definition, this section will be available. The user will enter the material and a bar size from the two drop-down lists. The number of legs is then entered. The inclination is always 90 degrees. In this example, **Grade 60** will be used as the **Material**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



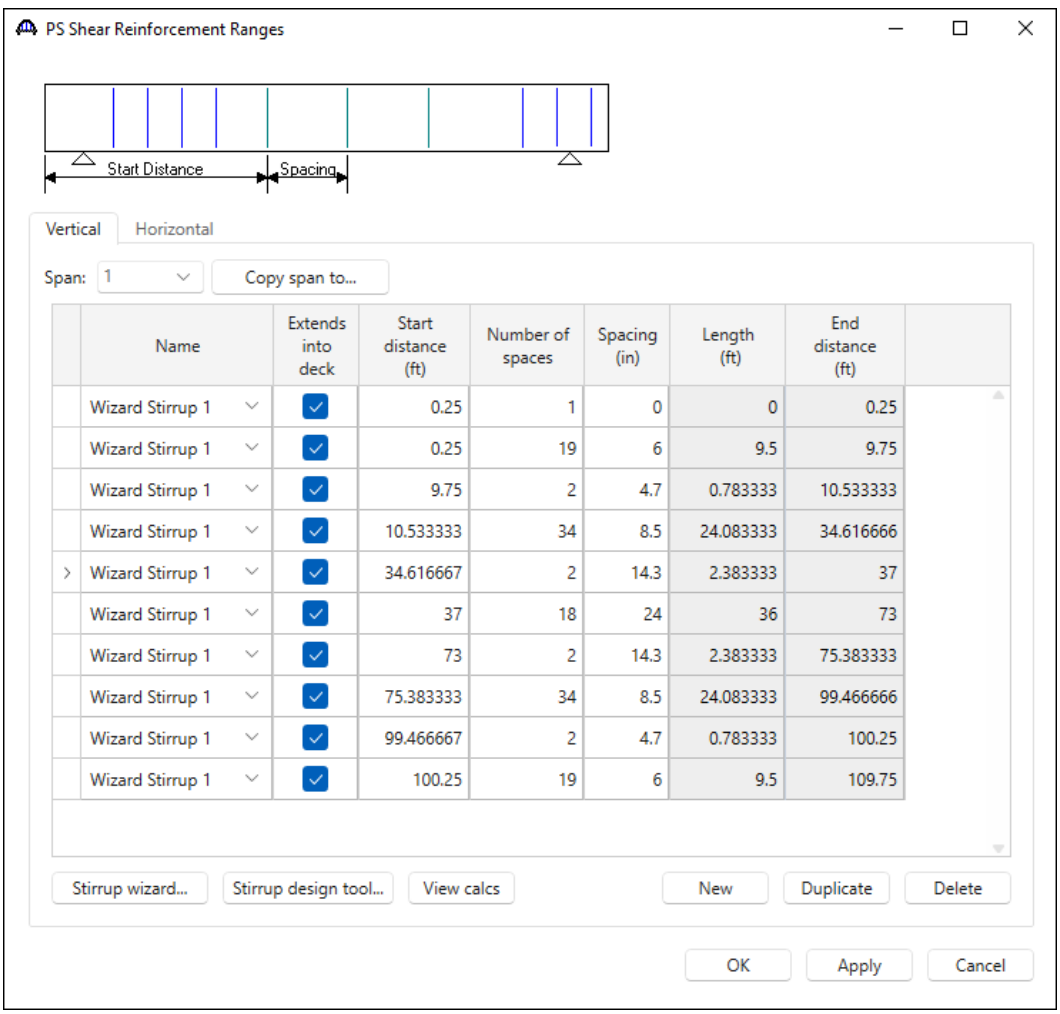
The **Stirrup Design Tool Results** window will appear as shown below. This window has a table showing the **Required stirrup spacing** at each analysis location throughout the beam for each span. The user can select the **Span** from the drop-down list and see the results for each span. Using the results from the analysis the user can construct the desired stirrup layout scheme by selecting the **maximum number of ranges** and the number of **minimum stirrups per range**. In this example, default value of **3** ranges and at least **3** stirrups per range will be used. For each span, enter the data as shown below and click on the **Create ranges** button and then click **Apply**. Once completed, close the window by clicking on the **Close** button.





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

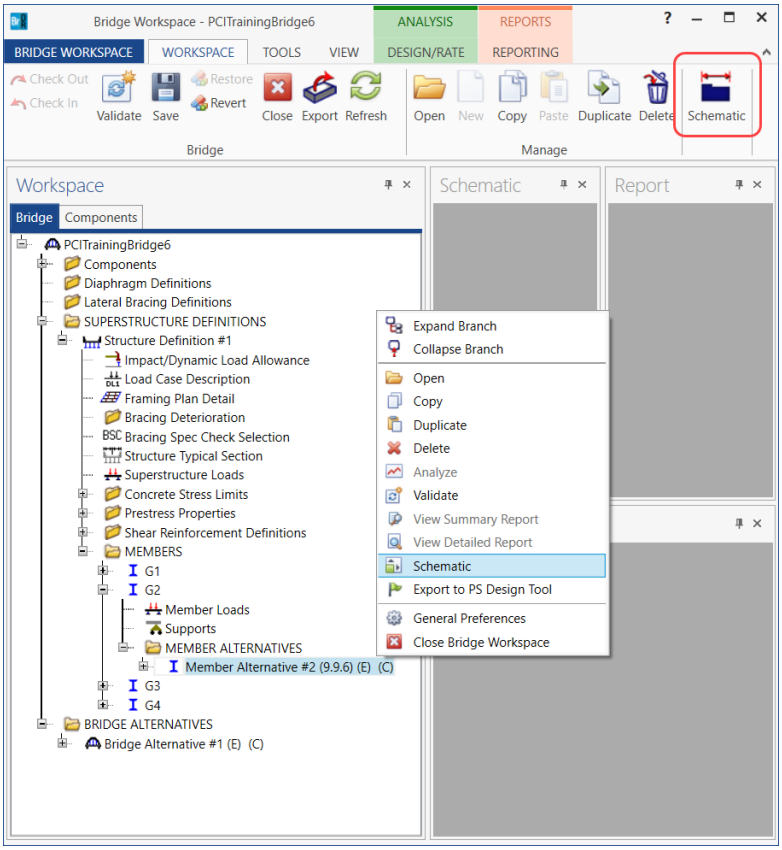
The results are displayed in the **PS Shear Reinforcement Ranges** window as shown below.

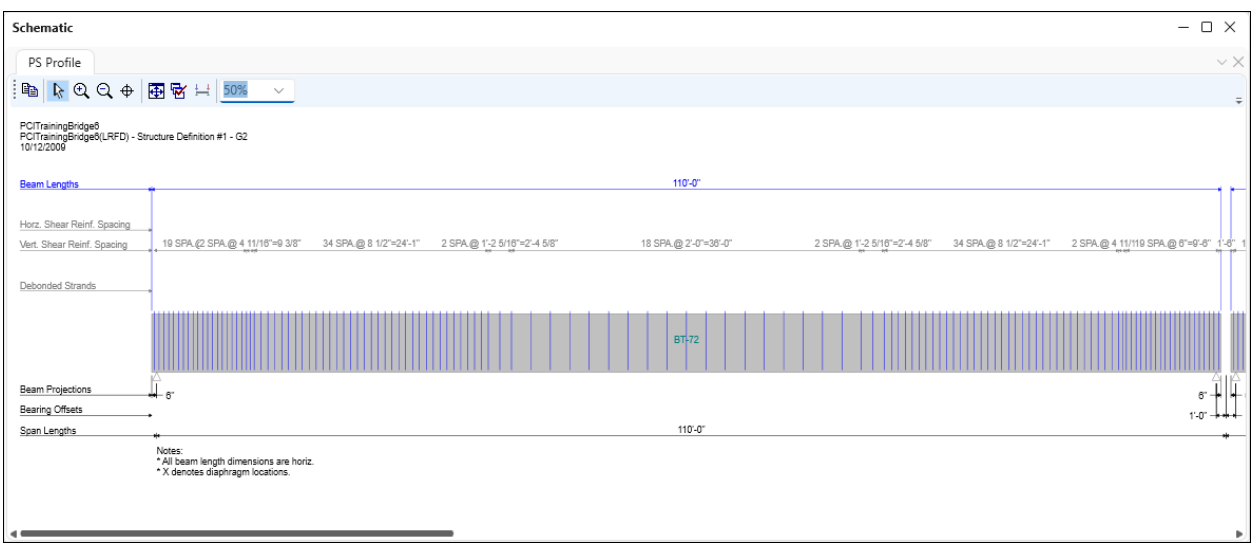


Name	Extends into deck	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
Wizard Stirrup 1	✓	0.25	1	0	0	0.25
Wizard Stirrup 1	✓	0.25	19	6	9.5	9.75
Wizard Stirrup 1	✓	9.75	2	4.7	0.783333	10.533333
Wizard Stirrup 1	✓	10.533333	34	8.5	24.083333	34.616666
Wizard Stirrup 1	✓	34.616667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

Schematic – Structure Typical Section

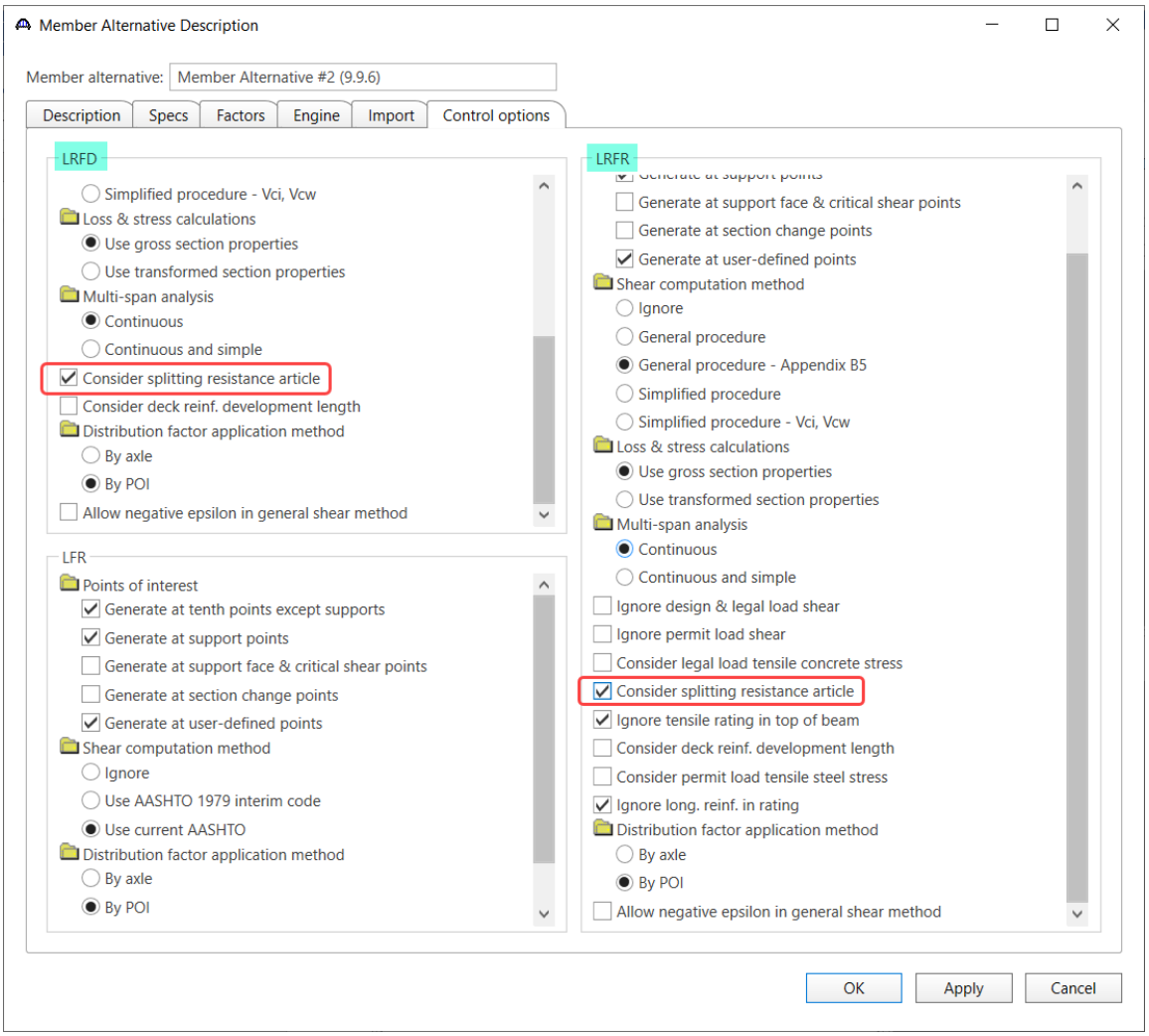
A schematic view of the member alternative can be viewed by selecting the member alternative **Member Alternative #2 (9.9.6)** node in **the Bridge Workspace** tree and clicking on the **Schematic** button from the **WORKSPACE** ribbon (or by right clicking on the **Member Alternative #2 (9.9.6)** node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





Prestressed Concrete Control Options for BrDR - Consider splitting resistance

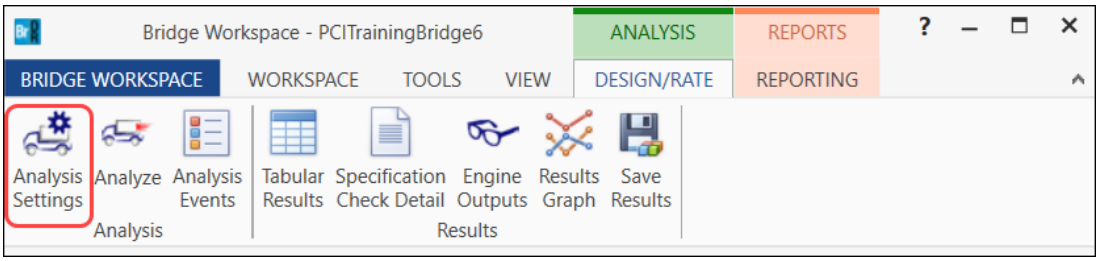
Double click on the member alternative **Member Alternative #2 (9.9.6)** in the **Bridge Workspace** tree to open the **Member Alternative Description** window and navigate to the **Control options** tab as shown below.



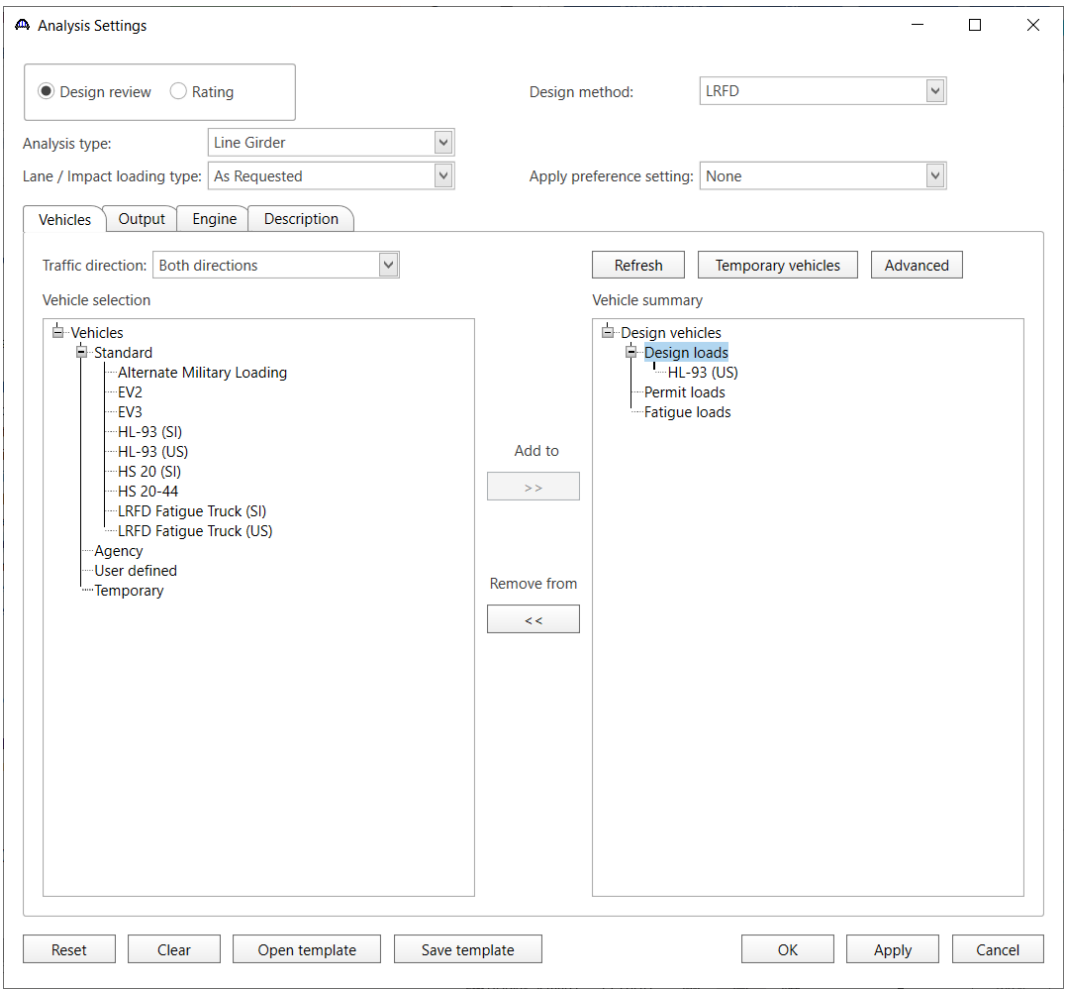
The user may select this option to consider the splitting resistance of the pretensioned anchorage zone as per **LRFD 5.9.4.4.1.** For this example, turn on the splitting resistance article in the control options for LRFD and run the LRFD analysis as shown below. In the spec check, open the **LRFD 5.9.4.4.1**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

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.

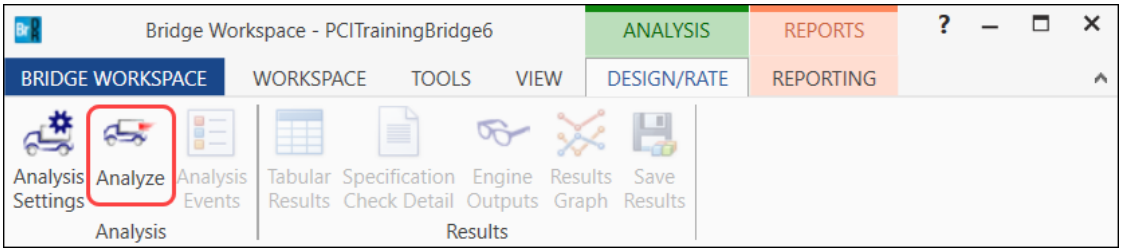


Select the **Design Review** button, **LRFD** as the Design method and **HL-93 (US)** vehicle in **Design Loads** as shown below.



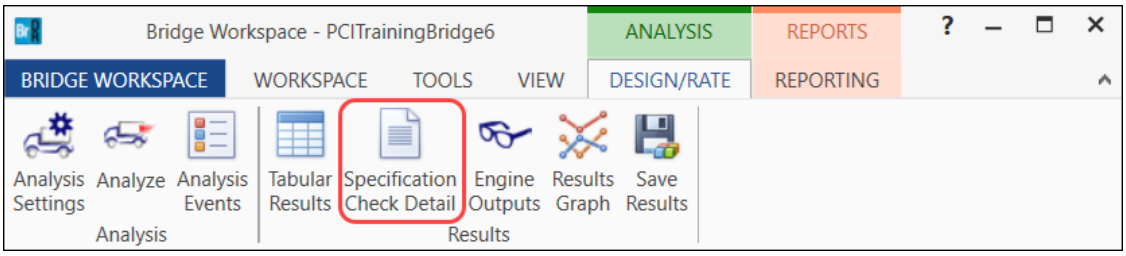
Click **OK** to save the settings and close the window.

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

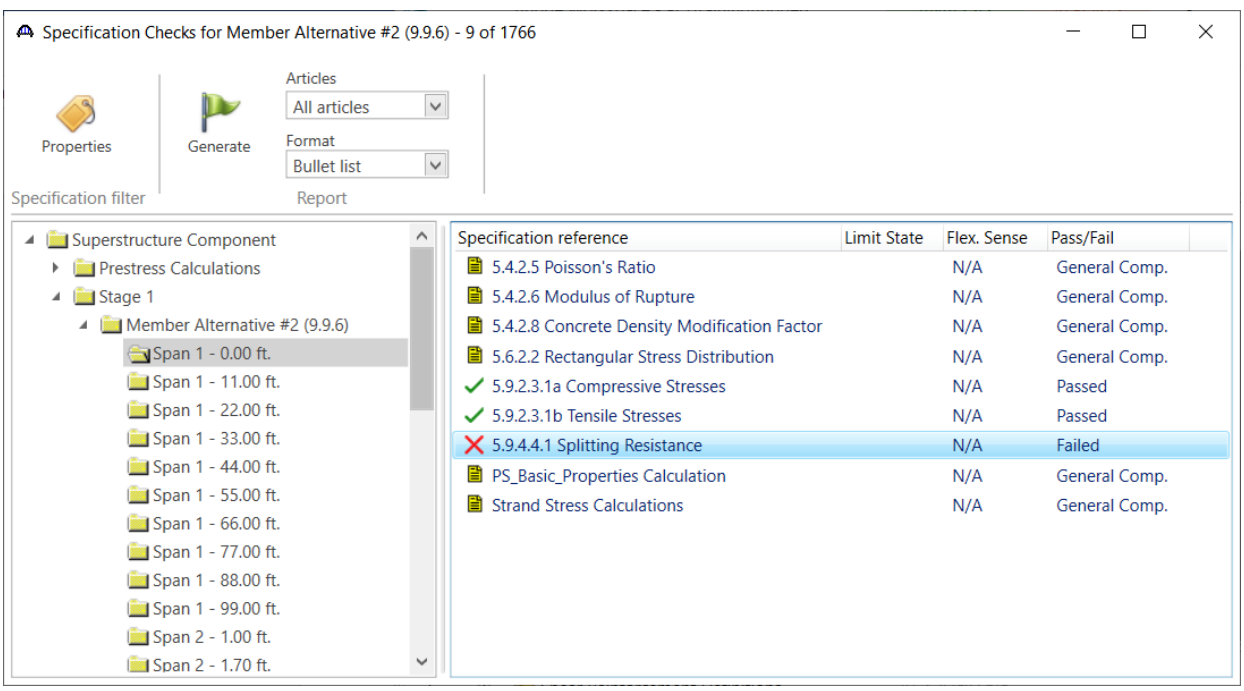


Specification Check Details

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.



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,      As =      1.2000 (in^2)
Area of prestressing strands,  Aps =      6.7320 (in^2)
Jacking stress,                fj  =    202.5000 (ksi)
Initial losses,            ES Loss =     18.7478 (ksi)
Stress in strands at transfer, fpt =    183.7522 (ksi)
h                                  =     72.0000 (in)


SUMMARY:

Maximum stress allowed in reinforcing,     fs =     20.0000 (ksi)
Total resistance available,     Pru = fs * As =     24.0000 (kip)
Force in strands at transfer, Fpt = fpt * Aps =   1237.0200 (kip)
Minimum resistance required,   Pr = .04 * Fpt =     49.4808 (kip)
Design ratio,                                DR =      0.485
Status                                         = FAIL




-----------------------------------------------------------------------------------------------------
```

OK

As 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.

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

$A_s \geq 2.73\ in^2$

h/4 = 72 in / 4 = 18 in

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

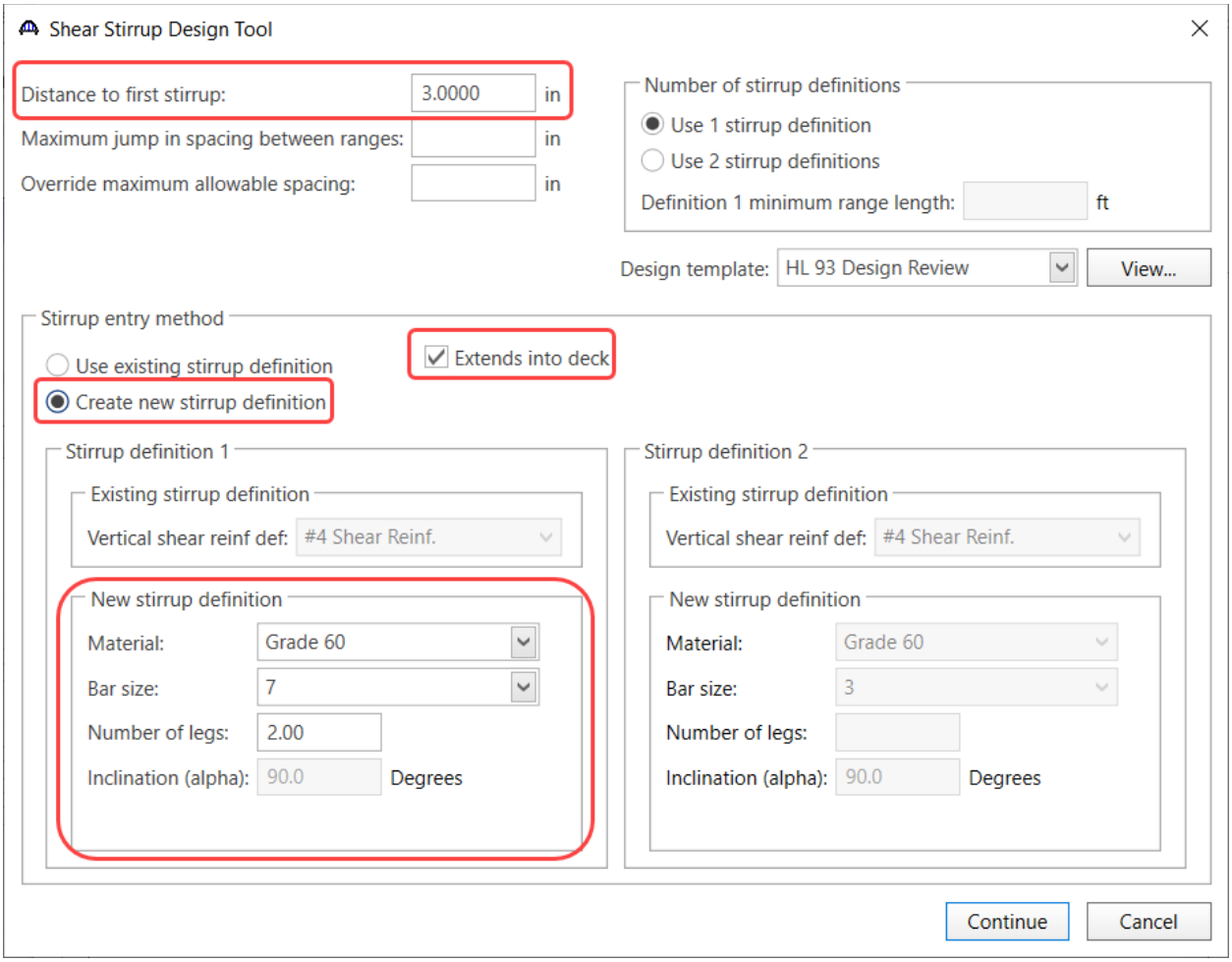
$A_s = 3 * 0.20\ in^2 * 2\ legs = 1.2\ in^2$

As of each bar = 2.73 in² / 3 = 0.91 in² for 6 in spacing or use 3 #7 bars or As = 3.6 in².

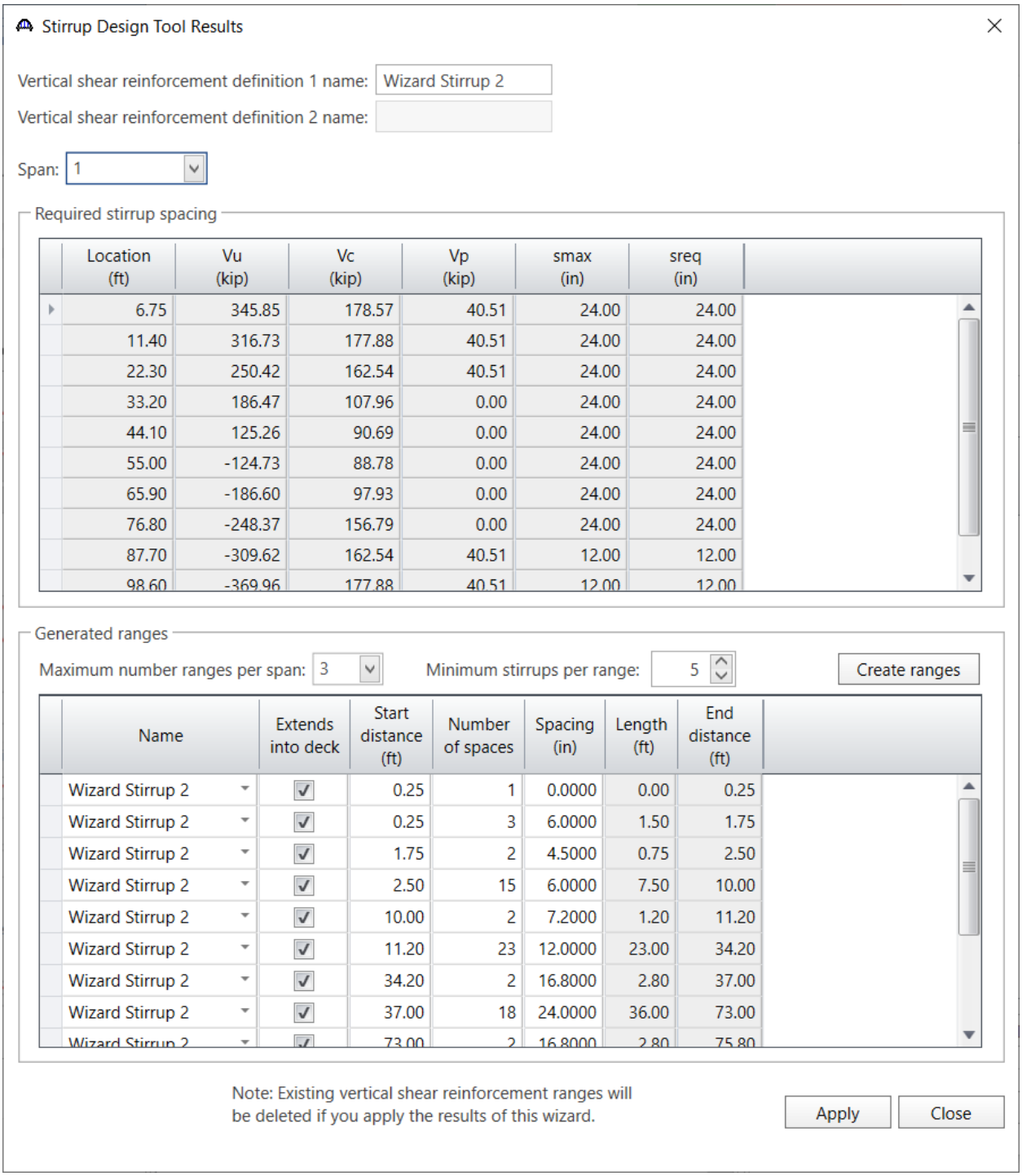
As of each bar = 2.73 in² / 5 = 0.55 in² for 4 in spacing or use 5 #5 bars or As = 3.1 in².

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.

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



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



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

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

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,       As =       3.6000 (in^2)
Area of prestressing strands,  Aps =       6.7320 (in^2)
Jacking stress,                fj  =     202.5000 (ki)
Initial losses,            ES Loss =      18.7478 (ksi)
Stress in strands at transfer, fpt =     183.7522 (ksi)
h                                  =      72.0000 (in)


SUMMARY:

Maximum stress allowed in reinforcing,      fs =      20.0000 (ksi)
Total resistance available,      Pru = fs * As =      72.0000 (kip)
Force in strands at transfer, Fpt = fpt * Aps =    1237.0200 (kip)
Minimum resistance required,   Pr = .04 * Fpt =      49.4808 (kip)
Design ratio,                                DR =       1.455
Status                                        = PASS
```

OK

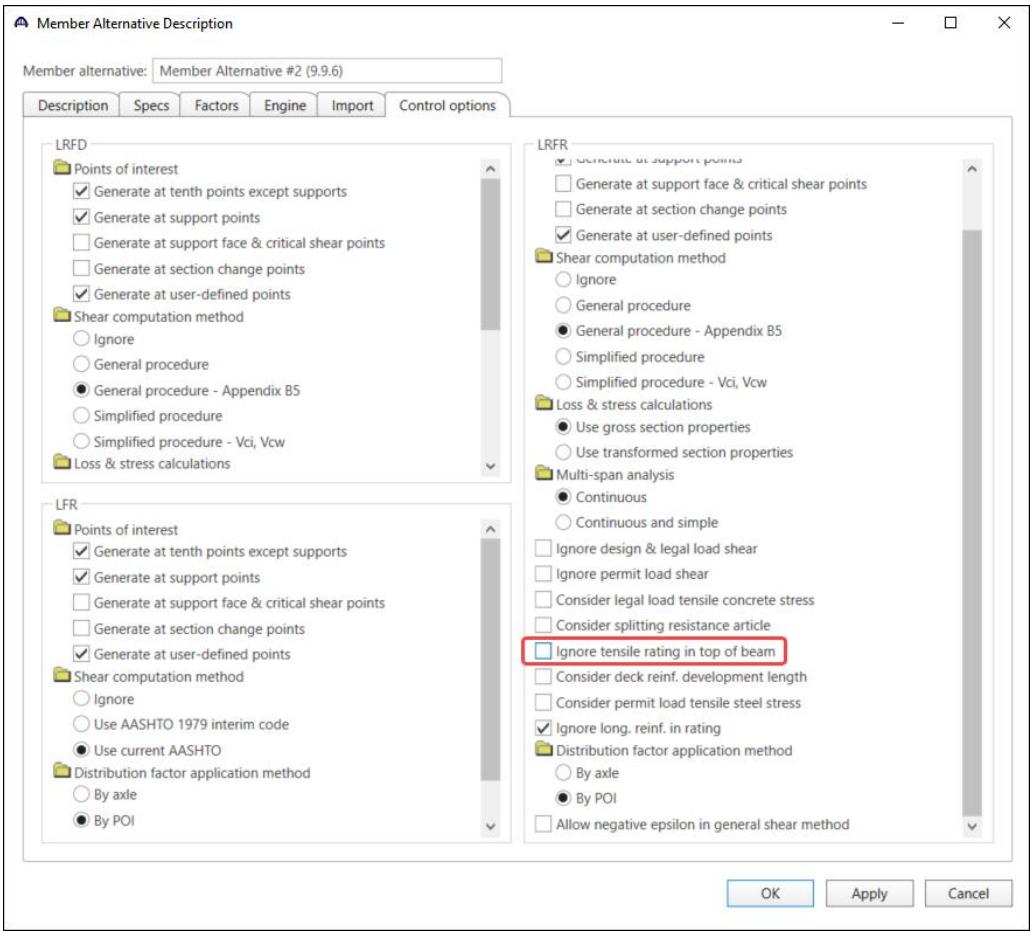
Tensile rating in the top of the beam

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

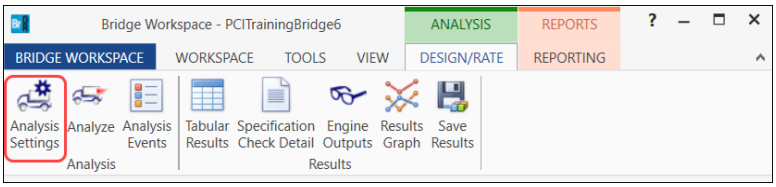
Double click on the member alternative **Member Alternative #2 (9.9.6)** in the **Bridge Workspace** tree to open the **Member Alternative Description** window and navigate to the **Control options** tab as shown below. Uncheck the **Ignore tensile rating in top of beam** checkbox under **LRFR**.



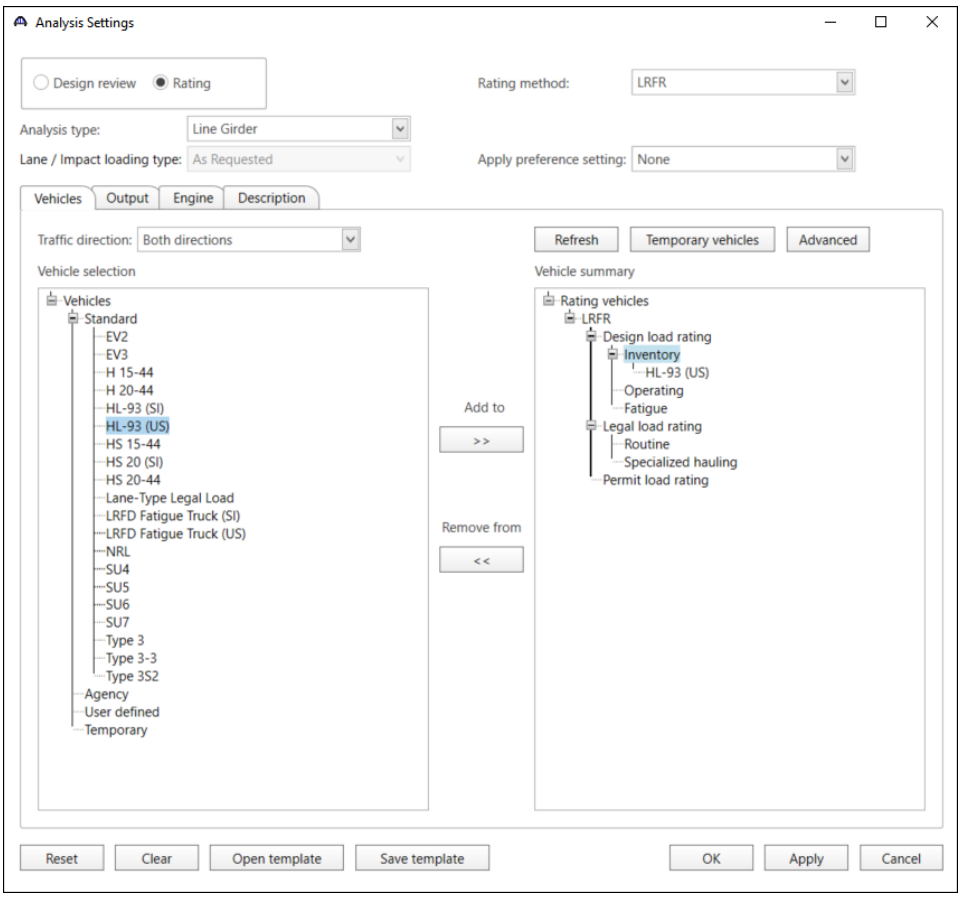
Click **OK** to apply the data and close the window.

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.

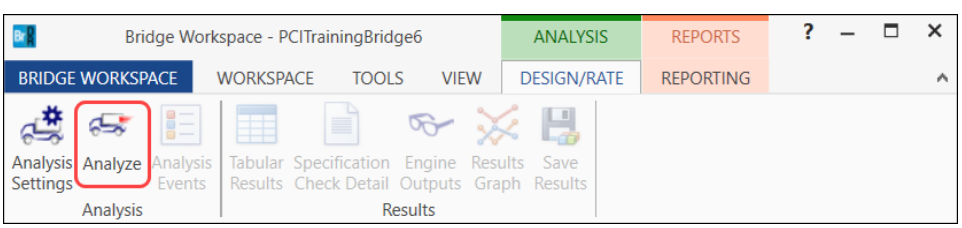


Select **LRFR** as the **Rating method** and **HL-93 (US)** vehicle in **Inventory** as shown below.



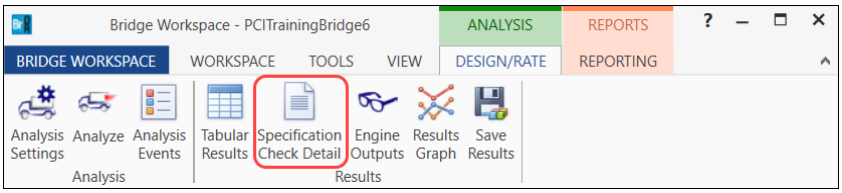
Click **OK** to save the analysis settings and close the window.

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

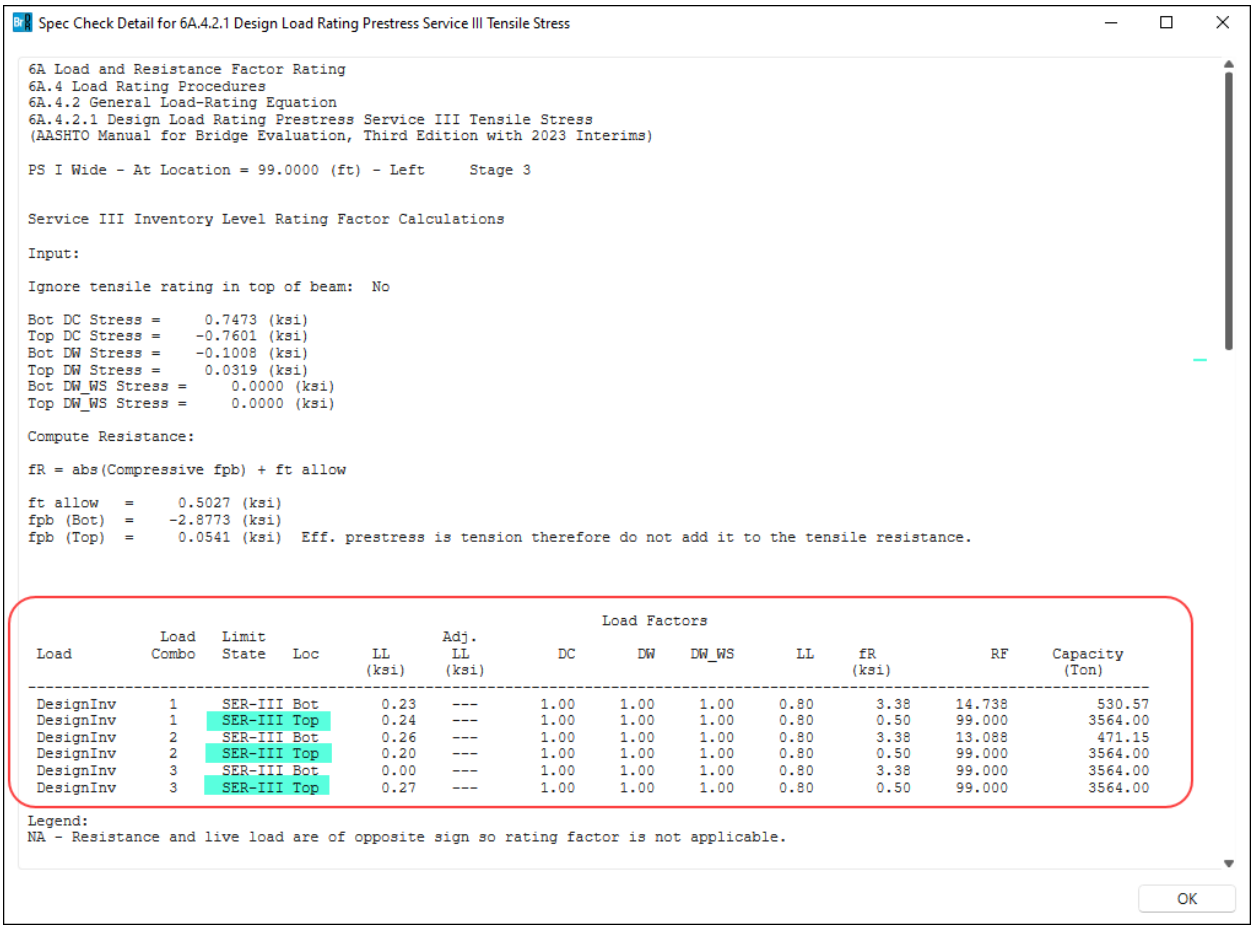


Specification Check Details

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.




```
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.
```

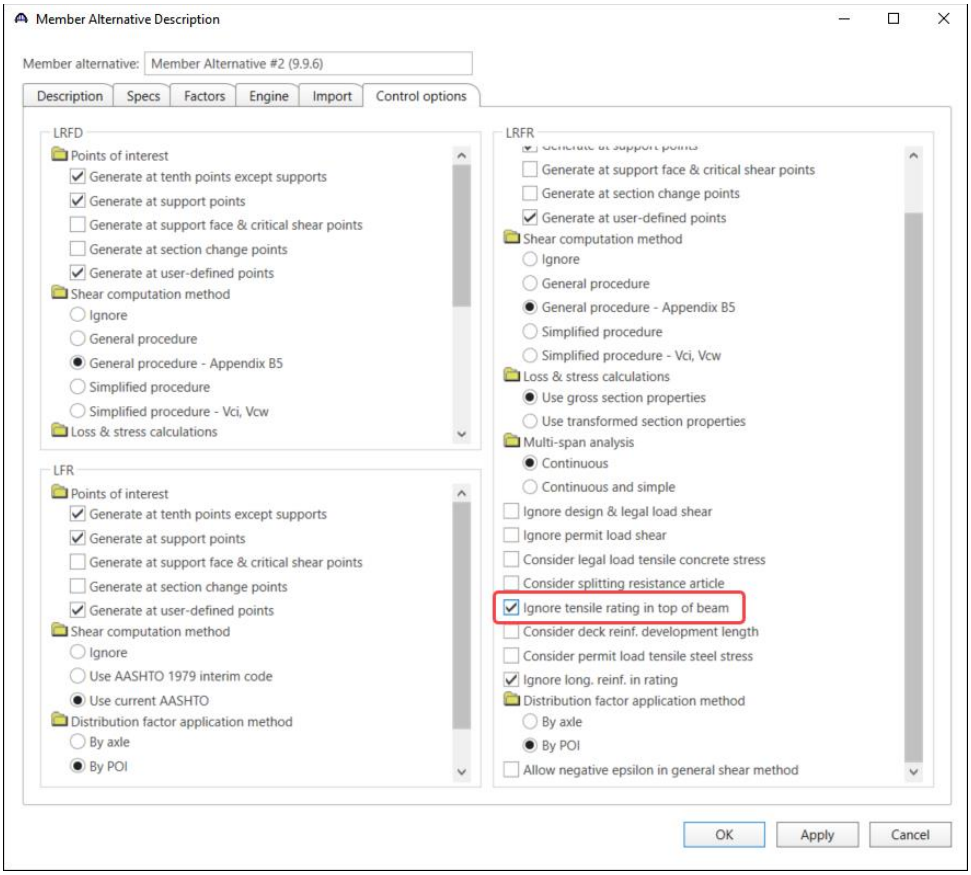
Load	Load Combo	Limit State	Loc	LL (ksi)	Adj. LL (ksi)	Load Factors DC	DW	DW_WS	LL	fR (ksi)	RF	Capacity (Ton)
DesignInv	1	SER-III Bot		0.23	---	1.00	1.00	1.00	0.80	3.38	14.738	530.57
DesignInv	1	SER-III Top		0.24	---	1.00	1.00	1.00	0.80	0.50	99.000	3564.00
DesignInv	2	SER-III Bot		0.26	---	1.00	1.00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

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.

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	LL (ksi)	Adj. LL (ksi)	Load Factors DC	DW	DW_WS	LL	fR (ksi)	RF	Capacity (Ton)
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

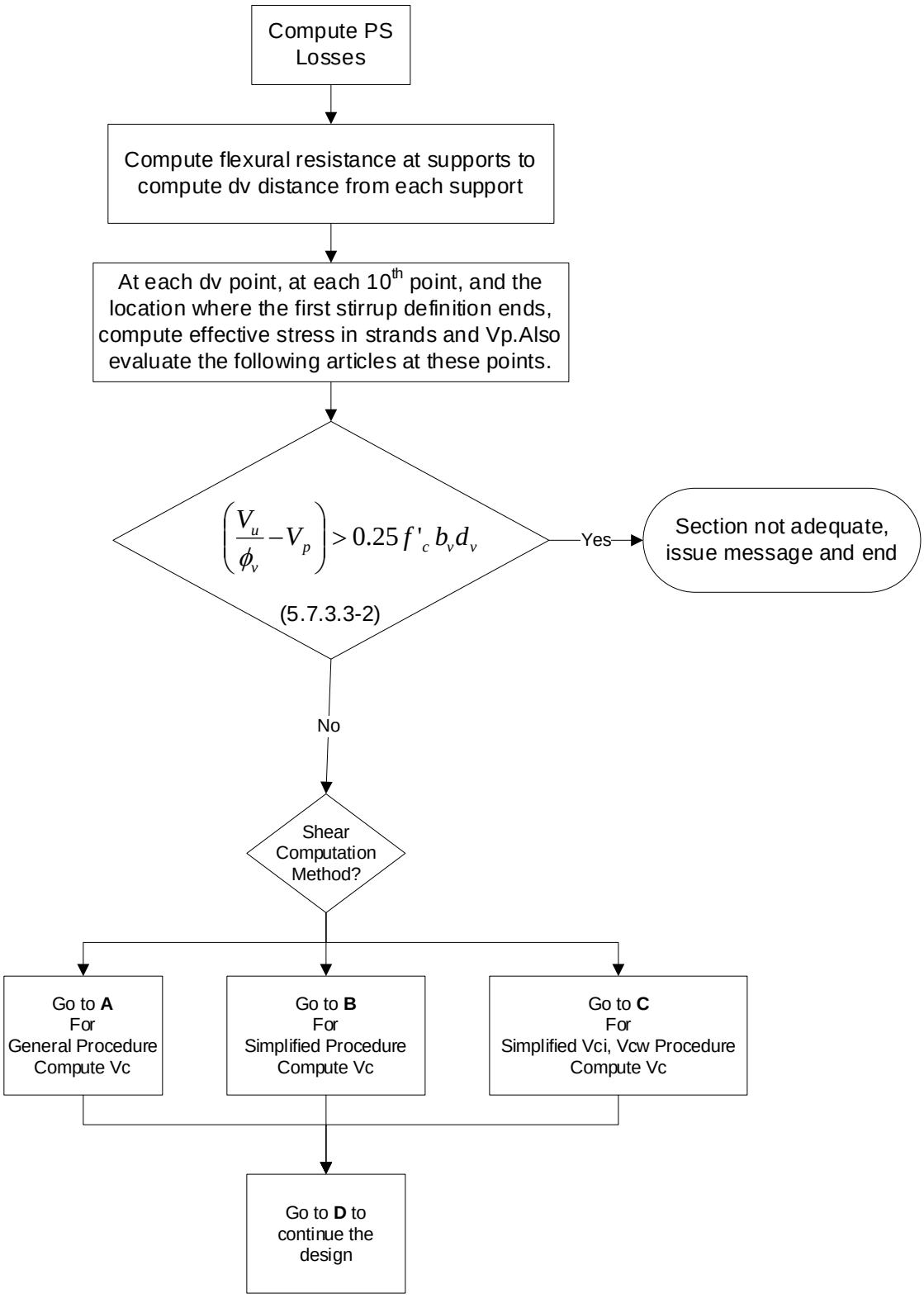
```
Legend:
NA - Resistance and live load are of opposite sign so rating factor is not applicable.


Load Combination Legend:

 Code      Vehicle
------------------------
```

OK

Flowcharts for PS Stirrup Design Tool



A. General Procedure to Compute Vc

$$s_{xe} = s_x \frac{1.38}{a_g + 0.63}$$

(5.7.3.4.2-7)

12.0in <= s_{xe} <= 80.0in

Determine β and θ
Article 5.7.3.4

$$\varepsilon_s = \frac{\frac{|M_u|}{d_v} + 0.5N_u + |V_u - V_p| - A_{ps} f_{po}}{E_s A_s + E_p A_{ps}}$$

(5.7.3.4.2-4)

Where $M_u >= (V_u - V_p)d_v$

The "Yes" is enforced by the smax equation on page 11. The Design Tool will always use the "Yes" path.

$$A_v = 0.0316\,\lambda\sqrt{f'_c}\frac{b_v s}{f_y}$$

(5.7.2.5-1)

Yes

$$\beta = \frac{4.8}{(1 + 750\varepsilon_s)}$$

(5.7.3.4.2-1)

No

$$\beta = \frac{4.8}{(1 + 750\varepsilon_s)}\frac{51}{(39 + s_{xe})}$$

(5.7.3.4.2-2)

$$\theta = 29 + 3500\varepsilon_s$$

(5.7.3.4.2-3)

$$V_c = 0.0316\,\beta\lambda\sqrt{f'_c}\,b_v d_v$$

(5.7.3.3-3)

Compute Vc
Article 5.7.3.3

B. Simplified Procedure to Compute Vc

β=2.0
θ = 45.0°

Determine β and θ
Article 5.7.3.4

$$V_c = 0.0316\,\beta\lambda\sqrt{f'_c}\,b_v d_v$$

(5.7.3.3-3)

Compute Vc
Article 5.7.3.3

C. Simplified Vci, Vcw Procedure to Compute Vc

$$V_{ci} = 0.02\sqrt{f'_c}\,b_v d_v + V_d + \frac{V_i M_{cre}}{M_{max}} \geq 0.06\sqrt{f'_c}\,b_v d_v$$

(5.8.3.4.3-1)

$$M_{cre} = S_c\left(f_r + f_{cpe} - \frac{M_{dnc}}{S_{nc}}\right)$$

(5.8.3.4.3-2)

Article 5.8.3.4.3

$$V_{cw} = (0.06\sqrt{f'_c} + 0.30 f_{pc})\,b_v d_v + V_p$$

(5.8.3.4.3-3)

$V_c = \min(V_{ci}, V_{cw})$

Compute Vc
Article 5.8.3.3

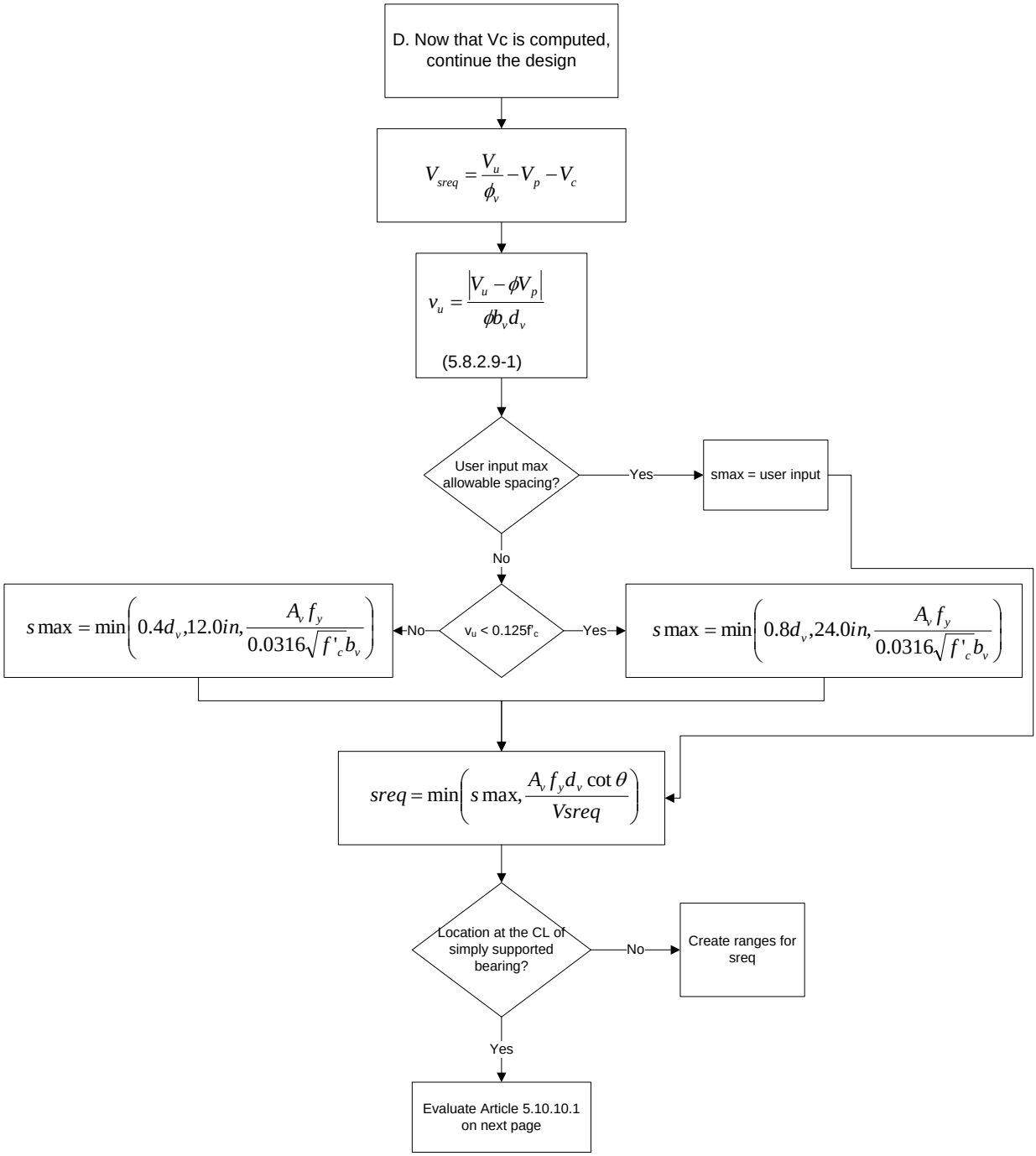
$V_{ci} <= V_{cw}$?

Yes → cot θ = 1.0

No →

$$\cot\theta = 1.0 + 3\left(\frac{fpc}{\sqrt{f'c}}\right) \leq 1.8$$

(5.8.3.4.3-4)


D. Now that Vc is computed, continue the design
$V_{sreq} = \frac{V_u}{\phi_v} - V_p - V_c$
$v_u = \frac{|V_u - \phi V_p|}{\phi b_v d_v}$
(5.8.2.9-1)
User input max allowable spacing?
Yes
smax = user input
No
$v_u < 0.125f'_c$
No
Yes
$s\max = \min\left(0.4d_v, 12.0in, \frac{A_v f_y}{0.0316\sqrt{f'_c} b_v}\right)$
$s\max = \min\left(0.8d_v, 24.0in, \frac{A_v f_y}{0.0316\sqrt{f'_c} b_v}\right)$
$sreq = \min\left(s\max, \frac{A_v f_y d_v \cot\theta}{Vsreq}\right)$
Location at the CL of simply supported bearing?
No
Create ranges for sreq
Yes
Evaluate Article 5.10.10.1 on next page

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

(Article 5.10.10.1)

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

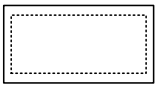
fs = service stress in the stirrup steel, limited to 20ksi

For I beams:

As 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:

As 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.



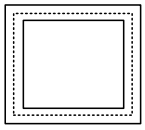
For box beams:

As 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.

Pr is evaluated twice:

once for the Aps in the bottom flange and the horizontal As

and once for the Aps above the bottom flange and the vertical As



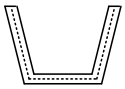
For U beams:

As 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.

Pr is evaluated twice:

once for the Aps in the bottom flange and the horizontal As

and once for the Aps above the bottom flange and the vertical As



For T beams:

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

fpbt = stress in prestress steel at transfer (= jacking stress without losses)

Aps = 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

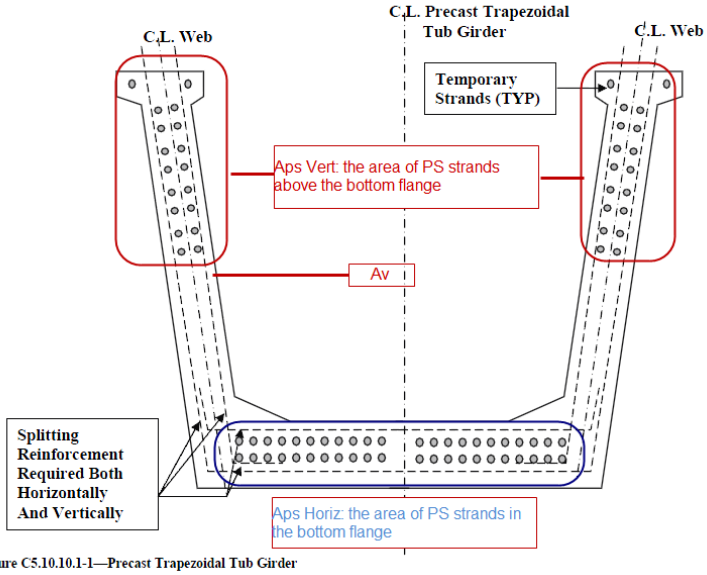
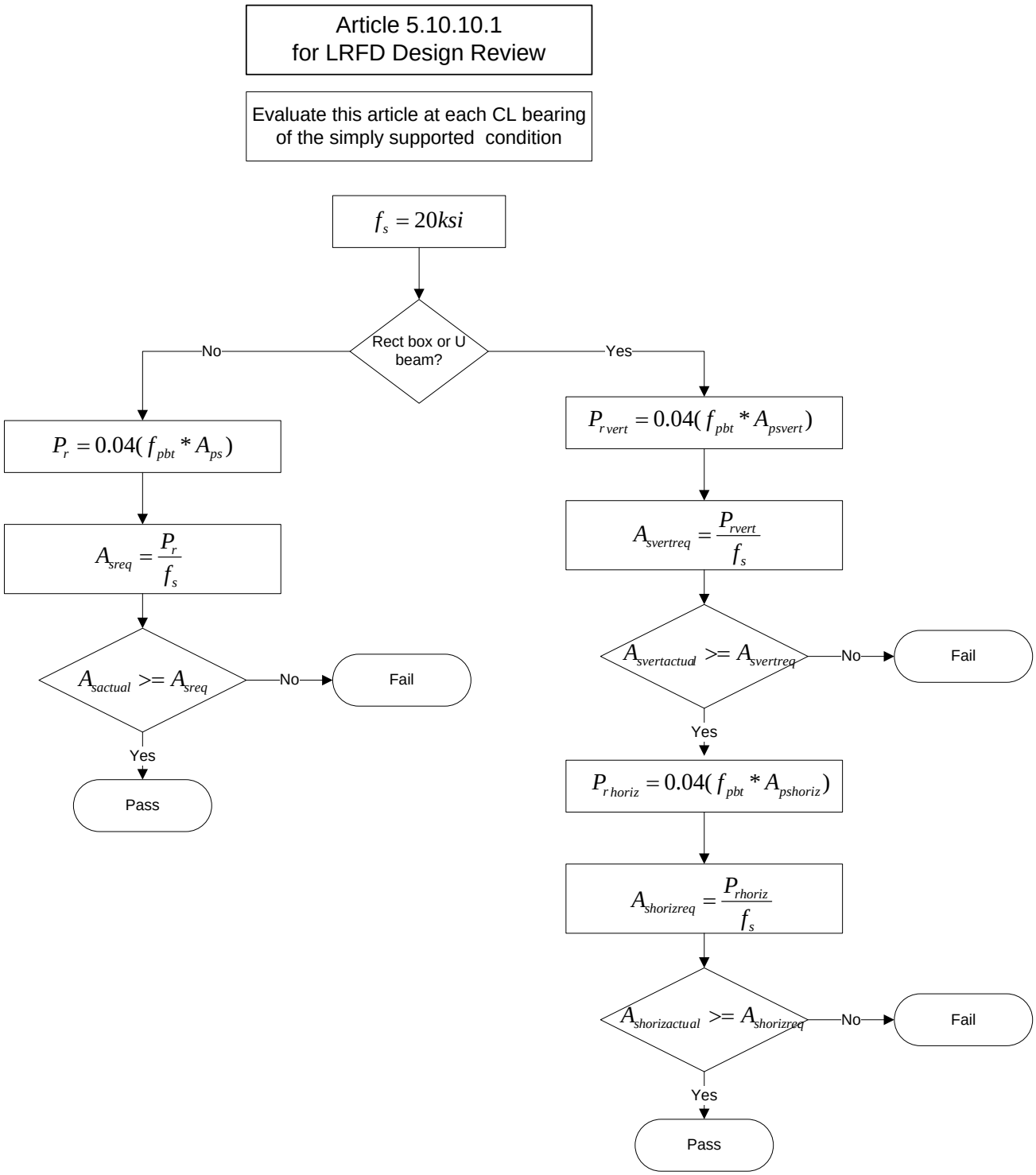


Figure C5.10.10.1-1—Precast Trapezoidal Tub Girder


Article 5.10.10.1
for LRFD Design Review
Evaluate this article at each CL bearing of the simply supported condition
$f_s = 20ksi$
Rect box or U beam?
No
Yes
$P_r = 0.04(f_{pbt} * A_{ps})$
$A_{sreq} = \frac{P_r}{f_s}$
$A_{sactual} >= A_{sreq}$
No
Fail
Yes
Pass
$P_{rvert} = 0.04(f_{pbt} * A_{psvert})$
$A_{svertreq} = \frac{P_{rvert}}{f_s}$
$A_{svertactual} >= A_{svertreq}$
No
Fail
Yes
$P_{rhoriz} = 0.04(f_{pbt} * A_{pshoriz})$
$A_{shorizreq} = \frac{P_{rhoriz}}{f_s}$
$A_{shorizactual} >= A_{shorizreq}$
No
Fail
Yes
Pass