

*AASHTOWare BrDR 7.5.0*

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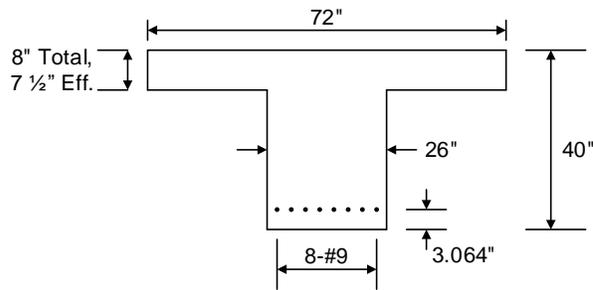
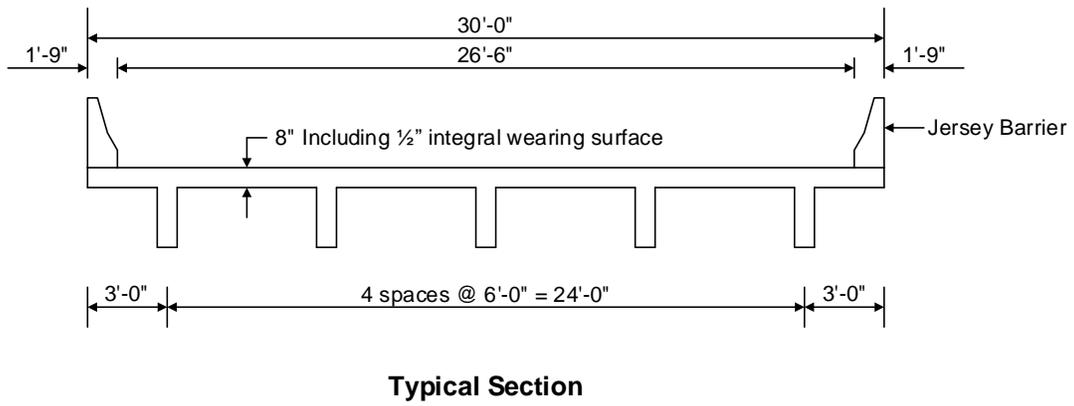
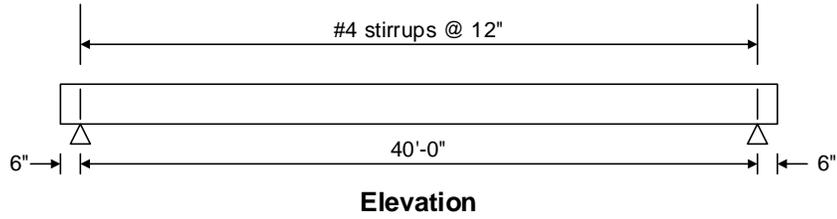
*Reinforced Concrete Structure Tutorial*

*RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine*

# RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

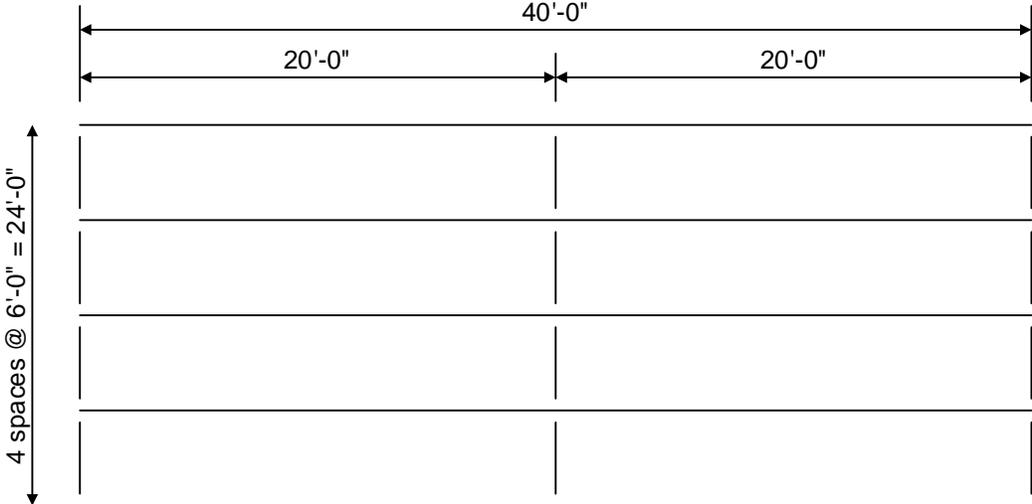
## Introduction – Elevation and Section

### RC6 – Reinforced Concrete Tee Beam Using BrDR AASHTO LRFD Engine



RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

Framing Plan and Material Properties



**Framing Plan**

Diaphragm weight = 1.2 kips/.each

**Material Properties**

Slab Concrete: Class A (US)  $f'_c = 4.0$  ksi, modular ratio  $n = 8$

Slab Reinforcing Steel: AASHTO M31, Grade 60 with  $F_y = 60$  ksi

# RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

## BrDR Training

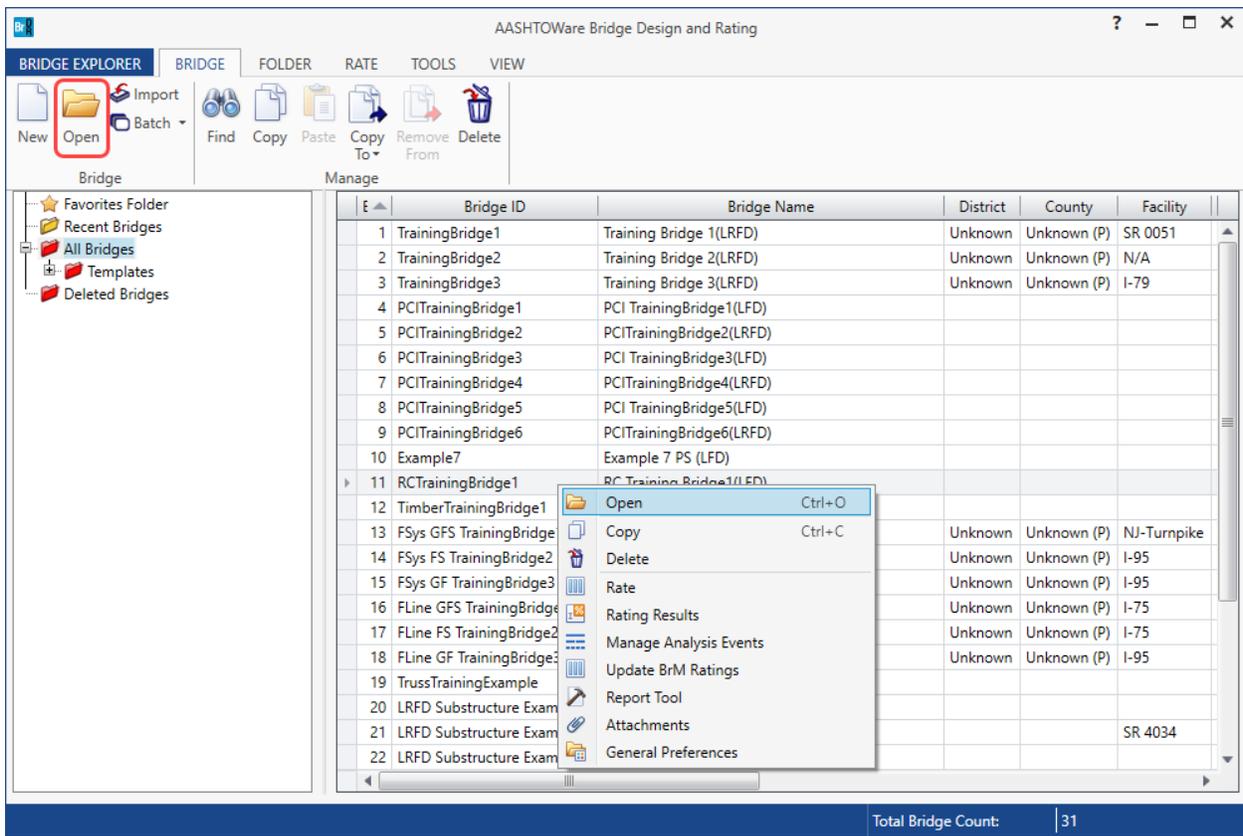
### RC6 - Reinforced Concrete Tee Beam Using BrDR LRFD Engine

#### Topics Covered

- Reinforced concrete schedule based tee input as girder system.
- Export of schedule based reinforced concrete beams to the BrDR LRFD analysis engine
- BrDR LRFD specification checking

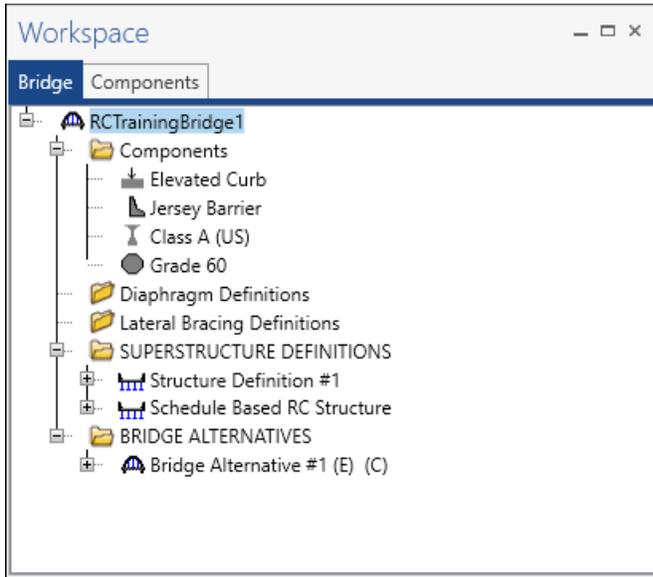
Reinforced concrete schedule based tee input as girder system.

Open the **Bridge Workspace** for **BID 11, RCTrainingBridge1** from the **BRIDGE EXPLORER** by selecting the bridge in the **BRIDGE EXPLORER** and clicking the **Open** button from the **Bridge** group of the ribbon (or by right clicking the bridge and selecting **Open** from the drop-down menu) as shown below.



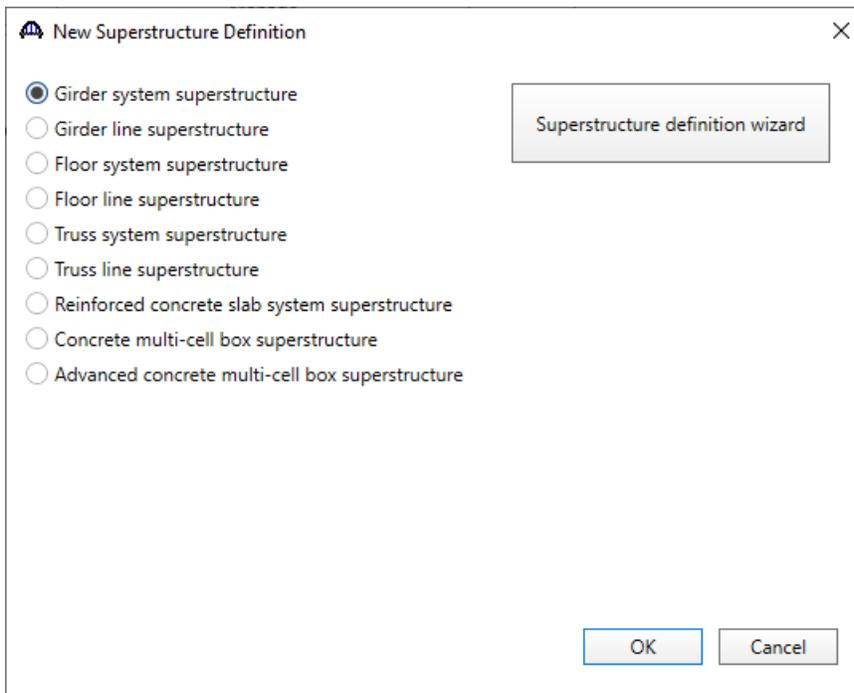
## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

The **Bridge Workspace** is shown below.



### SUPERSTRUCTURE DEFINITION

Double click on **SUPERSTRUCTURE DEFINITIONS** (or click on **SUPERSTRUCTURE DEFINITIONS** and select **New** from the **Manage** group of the **WORKSPACE** ribbon or right mouse click on **SUPERSTRUCTURE DEFINITIONS** and select **New** from the popup menu) to create a new structure definition.



## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

Select the **Girder system superstructure** and click **OK** to open the **Girder System Superstructure Definition** window. Enter the data as shown below.

**Girder System Superstructure Definition**

Definition Analysis Specs Engine

Name: RC6 Tee Beam

Description:

Default units: US Customary

Number of spans: 1

Number of girders: 5

Enter span lengths along the reference line:

Span	Length (ft)
1	40.00

Modeling

Multi-girder system  MCB

With frame structure simplified definition

Deck type: Concrete Deck

For PS/PT only

Average humidity: %

Member alt. types

Steel

P/S

R/C

Timber

P/T

Horizontal curvature along reference line

Horizontal curvature

Distance from PC to first support line: ft

Superstructure alignment

Curved

Tangent, curved, tangent

Tangent, curved

Curved, tangent

Start tangent length: ft

Radius: ft

Direction: Left

End tangent length: ft

Distance from last support line to PT: ft

Design speed: mph

Superelevation: %

OK Apply Cancel

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

## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

### Load Case Description

Expand the tree for **RC6 Tee Beam** superstructure and double click on the **Load Case Description** node in the **Bridge Workspace** tree to open the **Load Case Description** window and define the dead load cases. Use the **Add Default Load Case Descriptions** button to create the following load cases. The completed **Load Case Description** window is shown below.

Load case name	Description	Stage	Type	Time* (days)
DC1	DC acting on non-composite section	Non-composite (Stage 1)	D,DC	
DC2	DC acting on long-term composite section	Composite (long term) (Stage 2)	D,DC	
DW	DW acting on long-term composite section	Composite (long term) (Stage 2)	D,DW	
SIP Forms	Weight due to stay-in-place forms	Non-composite (Stage 1)	D,DC	

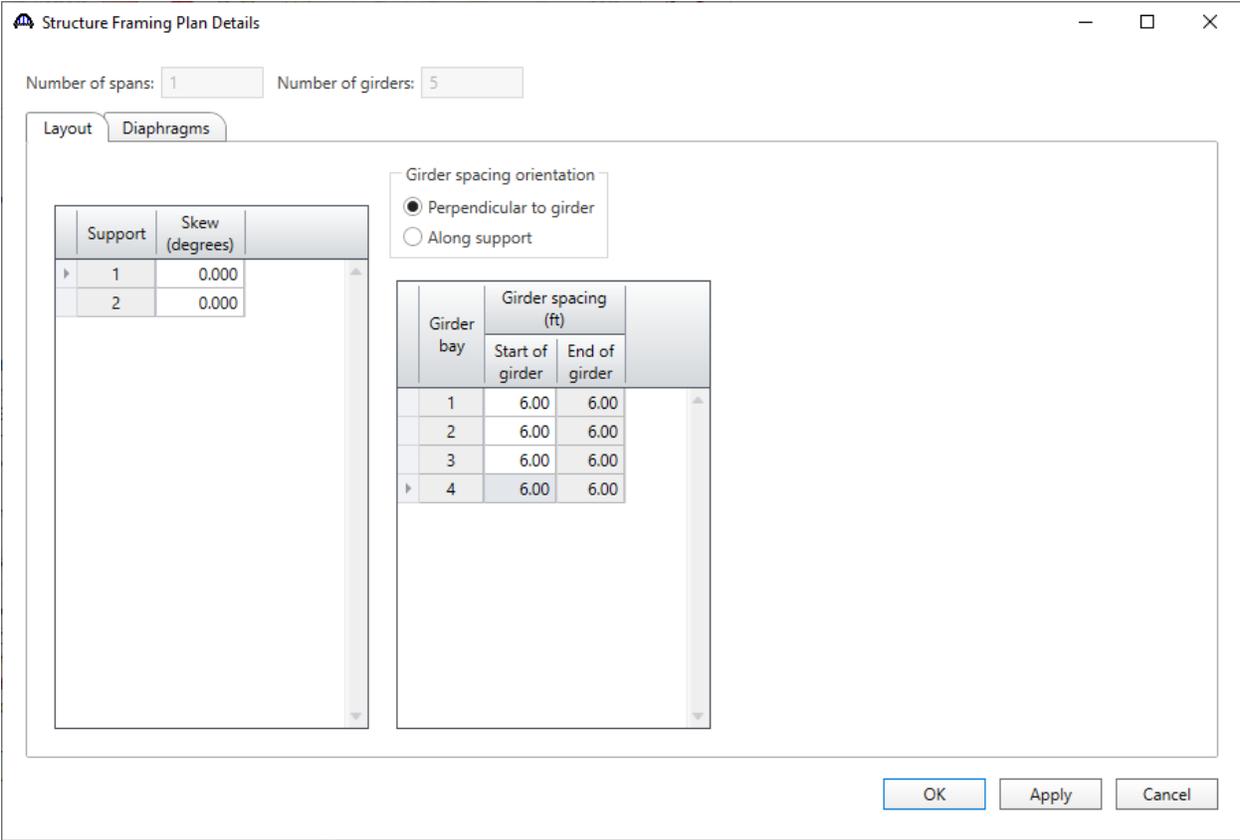
\*Prestressed members only

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

RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

Structure Framing Plan Detail - Layout

Double-click on **Framing Plan Detail** in the **Bridge Workspace** tree to describe the framing plan in the **Structure Framing Plan Details** window. Enter the data as shown below.

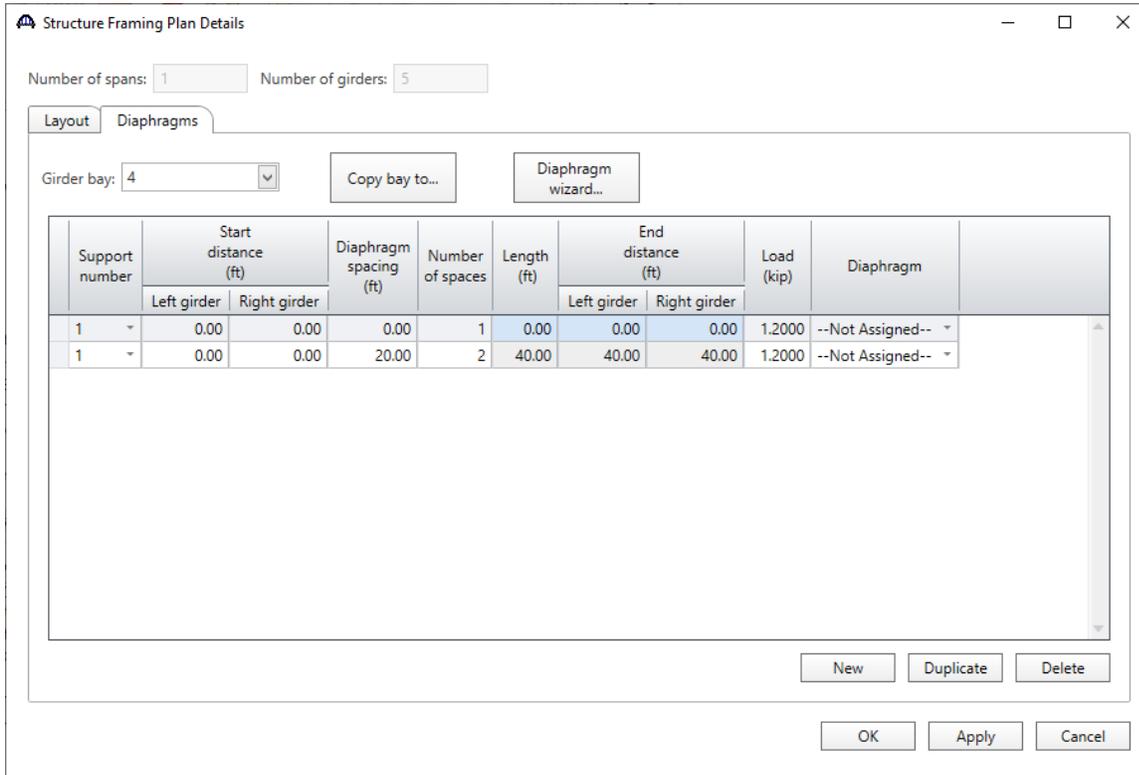


Click **OK** to apply the data and close the window.

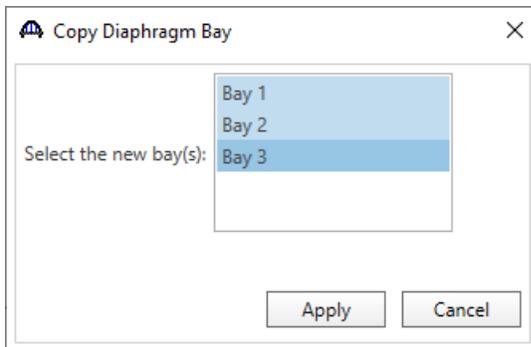
# RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

## Structure Framing Plan Detail - Diaphragms

Switch to the **Diaphragms** tab to enter diaphragm spacing. Enter the diaphragm locations shown below for **Girder bay 1**. Click on the **Copy bay to...** button to copy the diaphragm locations to bays 2 to 4.



Click on the **Copy bay to...** button. The **Copy Diaphragm Bay** window opens as shown below.



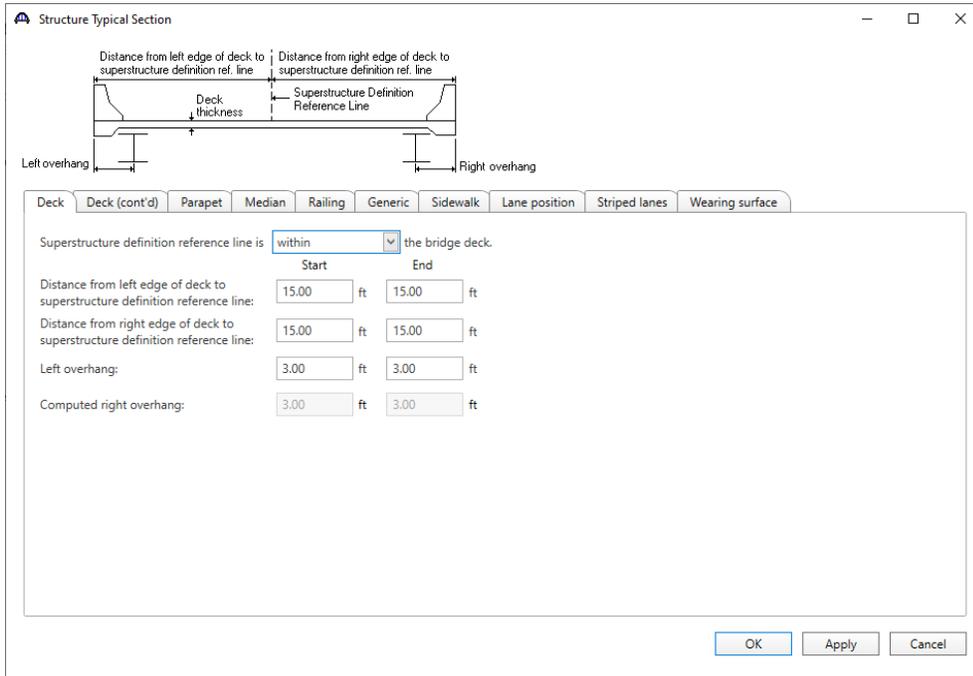
Select **Bay 2**, **Bay 3** and **Bay 4** and click **Apply** to copy the diaphragm locations to bays 2 to 4.

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

# RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

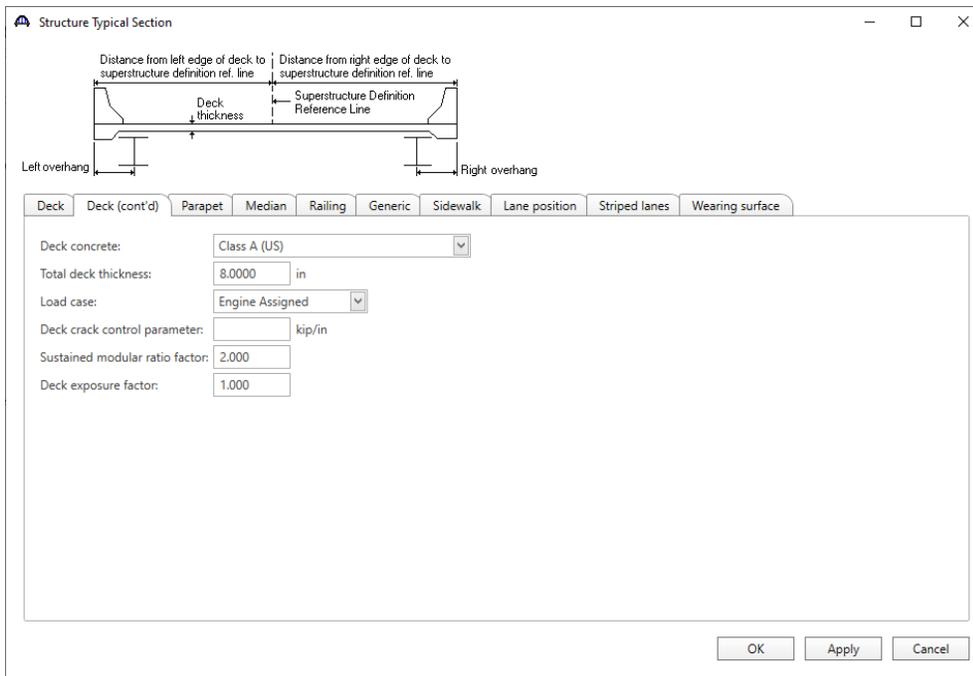
## Structure Typical Section - Deck

Next define the structure typical section by double-clicking on **Structure Typical Section** in the **Bridge Workspace** tree. Input the data describing the typical section as shown below.



## Structure Typical Section – Deck (cont'd)

The **Deck (cont'd)** tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described previously. Enter data as shown below.



## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

### Structure Typical Section - Parapets

The two parapets are described using the **Parapet** tab. Click **New** to add a row to the table. The name of the parapet defaults to the only barrier described for the bridge. Change the **Load Case** to **DC2**. Reinforced concrete structures only have 1 stage but for this example, select **DC2** since the dead load of the parapets needs to be uniformly distributed to all girders and BrDR only allows that type of load distribution in stage 2.

Select **Back** in the **Measure to** field (we are locating the parapet on the deck by referencing the back of the parapet to the left edge of the deck). Enter **0.0** for the **Distance at start** and **Distance at end**. Change the **Front face orientation** to **Right**. The completed tab is shown below.

The screenshot shows the 'Structure Typical Section' window with the 'Parapet' tab selected. A diagram of a parapet cross-section is shown with 'Back' and 'Front' labels. Below the diagram is a table with the following data:

Name	Load case	Measure to	Edge of deck dist. measured from	Distance at start (ft)	Distance at end (ft)	Front face orientation
Jersey Barrier	DC2	Back	Left Edge	0.00	0.00	Right
Jersey Barrier	DC2	Back	Right Edge	0.00	0.00	Left

Buttons for 'New', 'Duplicate', 'Delete', 'OK', 'Apply', and 'Cancel' are visible at the bottom of the window.

## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

### Structure Typical Section - Lane positions

Select the **Lane position** tab. Enter the values shown below or click the **Compute...** button to automatically compute the lane positions. A window showing the results of the computation opens.

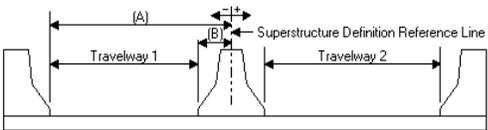
Compute Lane Positions

Travelway number	Distance from left edge of travelway to superstructure definition reference line at start (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at start (B) (ft)	Distance from left edge of travelway to superstructure definition reference line at end (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at end (B) (ft)
1	-13.25	13.25	-13.25	13.25

Apply Cancel

Click **Apply** to apply the computed values. The **Lane Position** tab is populated as shown below.

Structure Typical Section



Deck Deck (cont'd) Parapet Median Railing Generic Sidewalk Lane position Striped lanes Wearing surface

Travelway number	Distance from left edge of travelway to superstructure definition reference line at start (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at start (B) (ft)	Distance from left edge of travelway to superstructure definition reference line at end (A) (ft)	Distance from right edge of travelway to superstructure definition reference line at end (B) (ft)
1	-13.25	13.25	-13.25	13.25

LRFD fatigue  
 Lanes available to trucks:   
 Override Truck fraction:  Compute New Duplicate Delete

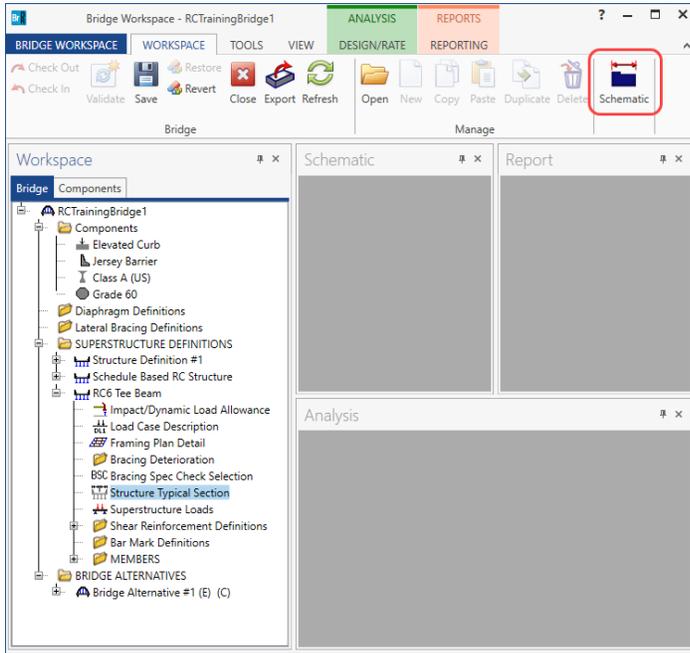
OK Apply Cancel

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

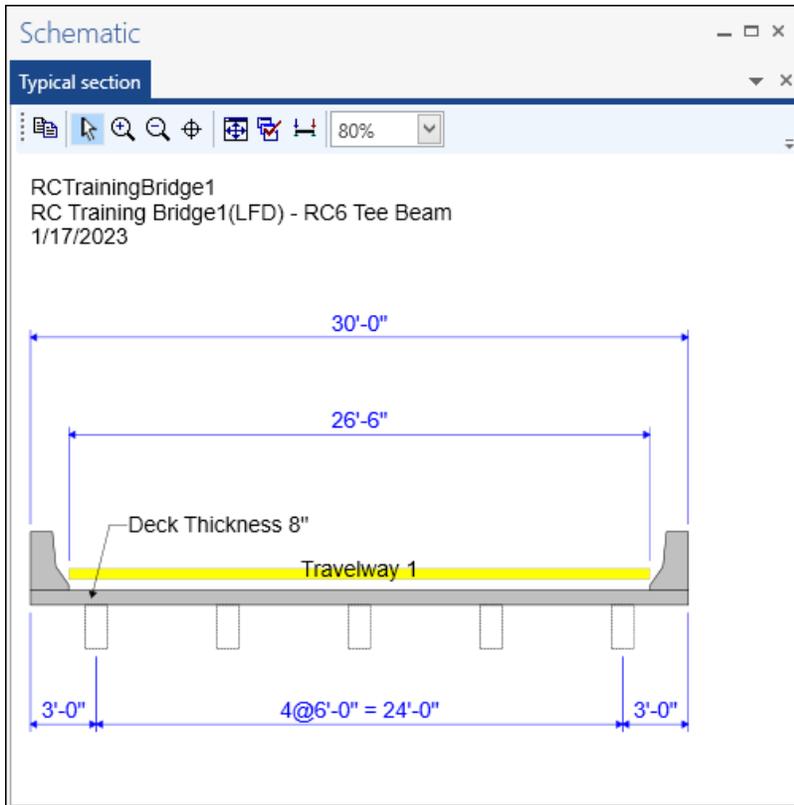
# RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

## Schematic – Structure Typical Section

A schematic view of the structure typical section is available while the **Structure Typical Section** node is selected on the Bridge Workspace tree.



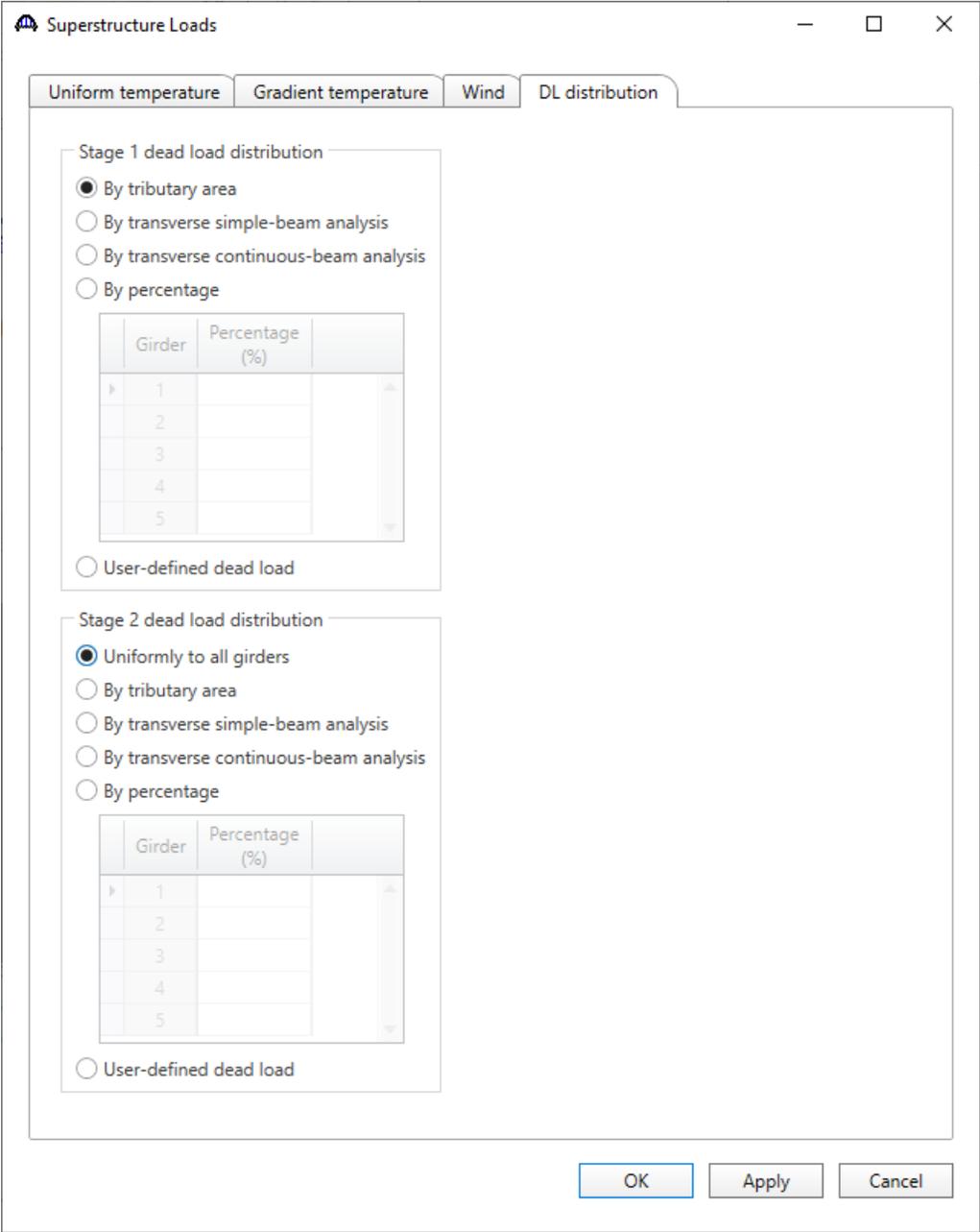
The schematic of the **Structure Typical Section** is shown below.



# RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

## Superstructure Loads – DL Distribution

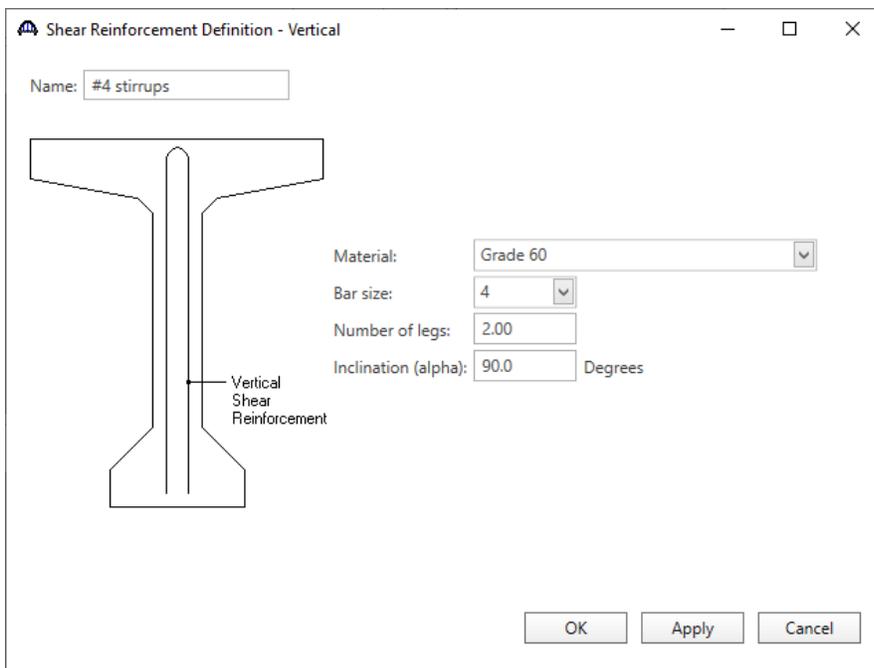
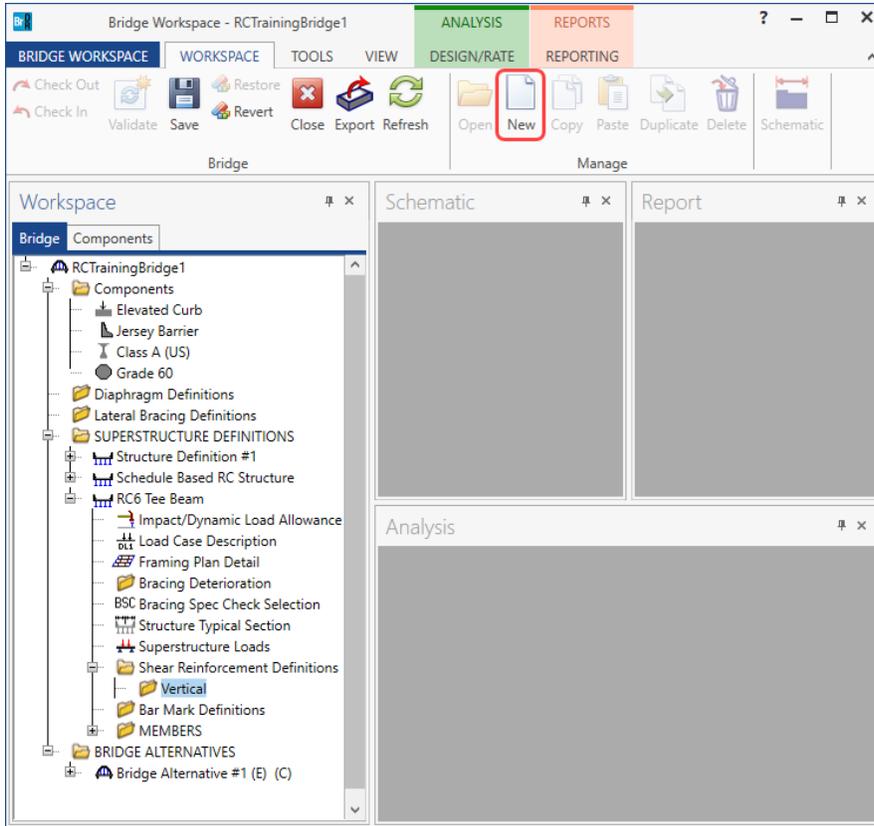
Double-click on the **Superstructure Loads** node in the Bridge Workspace tree to open the **Superstructure Loads** window. Navigate to the **DL Distribution** tab of this window. The **DL Distribution** tab of the **Superstructure Loads** window is shown below. BrDR only provides the **Uniformly to all girders** distribution option for stage 2 dead loads. Even though reinforced concrete only has 1 stage, we previously assigned our parapets to stage 2 on the Structure Typical Section window to take advantage of the **Uniformly to all girders** option. The export to the BrDR LRFD analysis engine will uniformly distribute the parapets to all girders and assign that load to the stage 1 model.



# RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

## Shear Reinforcement

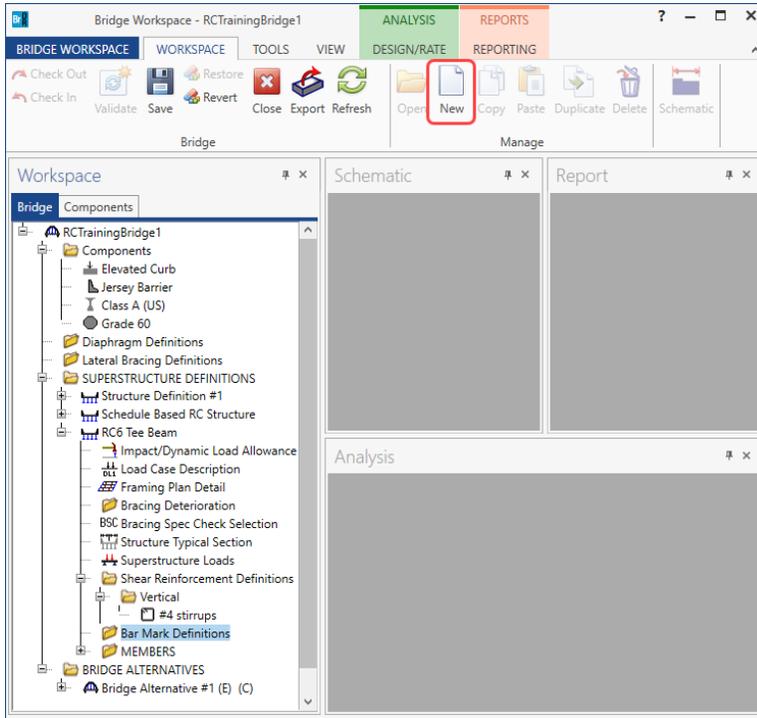
Define shear reinforcement to be used by the girders. Expand the **Shear Reinforcement Definitions** node on the Bridge Workspace tree, select **Vertical** and click on **New** from the **Manage** group of the Workspace ribbon (or double click on **Vertical**). Define the stirrup as shown below. Click **OK** to apply the data and close the window.



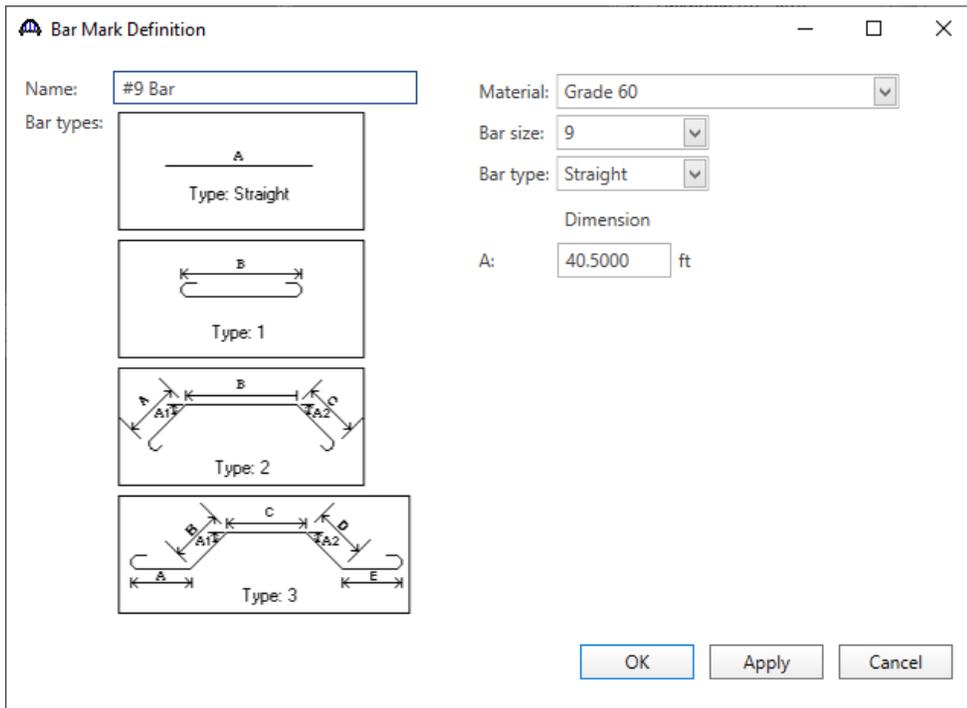
## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

### Bar Mark Definitions

Select **Bar Mark Definitions** from the Bridge Workspace tree and click the **New** button from the **Manage** group of the Workspace ribbon (or double click on **Bar Mark Definitions**) to open the **Bar Mark Definition** window.



Create the following Bar Mark Definition to be used for the longitudinal reinforcement in the beam.



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

## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

### Describing member G2

The **Member** window for member **G2** shows the data that was generated when the structure definition was created. No changes are required at this time. After Member Alternatives are defined it will appear in the list of member alternatives.

Member name: G2 Link with: -- None --

Description:

Existing	Current	Member alternative name	Description
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Number of spans: 1

Span no.	Span length (ft)
1	40.00

OK Apply Cancel

### Supports

Expand the **G2** member on the **Bridge Workspace** tree and double click on **Supports** to open the **Supports** window. Support constraints were generated when the structure definition was created and are shown below. No changes are required.

Advanced support conditions

General Elastic 3D General 3D Elastic

Support number	Support type	Translation constraints			Rotation constraints		
		X	Y	Z			
1	Pinned	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>			
2	Roller	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>			

OK Apply Cancel

## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

### Defining a Member Alternative

Double click on **MEMBER ALTERNATIVES** in the Bridge Workspace tree for member **G2** to create a new alternative. The **New Member Alternative** window shown below will open. Select **Reinforced concrete** for the **Material type** and **Reinforced Concrete Tee** for the **Girder type**.

The 'New Member Alternative' dialog box contains two list boxes. The 'Material type' list includes: Post tensioned concrete, Prestressed (pretensioned) concrete, Reinforced concrete (selected), Steel, and Timber. The 'Girder type' list includes: Advanced Concrete RC, Reinforced Concrete I, and Reinforced Concrete Tee (selected). At the bottom are 'OK' and 'Cancel' buttons.

Enter the following data in the Member Alternative window.

The 'Member Alternative Description' dialog box has the 'Member alternative' field set to 'Tee Beam Alt'. The 'Description' tab is selected. The 'Description' field is empty. The 'Material type' is 'Reinforced Concrete', 'Girder type' is 'Reinforced Concrete Tee', 'Modeling type' is 'Multi Girder System', and 'Default units' is 'US Customary'. Under 'Girder property input method', 'Schedule based' is selected. 'End bearing locations' are 'Left: 6.0000 in' and 'Right: 6.0000 in'. 'Self load' settings: 'Load case' is 'Engine Assigned', 'Additional self load' is '0 kip/ft' and '0%'. 'Default rating method' is 'LFR'. 'Crack control parameter (Z)' is 'Bottom of beam: 0 kip/in'. 'Exposure factor' is 'Bottom of beam: 1.000'. 'OK', 'Apply', and 'Cancel' buttons are at the bottom.

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

## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

For a schedule based reinforced concrete member, it is important to enter a value for the End Bearing Locations on this window. This data describes the distance from the physical end of the beam to the centerline of the end bearings. It is important to enter this value here so that when the bar mark definitions are assigned to the reinforcement profile, the bars can start to the left of the first support line and to the right of the last support line.

If the bars start to the left of the first support line and to the right of the last support line, BrDR will consider the bars to be partially developed at the centerline of the bearing. Then the analysis engine will be able to compute the **d** distance from the extreme compression fiber to the centroid of the tension reinforcement. This **d** value is required to compute the shear capacity of the section. If the rebar starts at the centerline of the bearing, it will be considered as zero percent developed at this point so a **d** distance cannot be computed, and the shear capacity of the beam will be zero.

### Girder Profile - Section

The girder profile can now be defined. Expand the **Tee Beam Alt** member alternative on the Bridge Workspace tree, double click on the **Girder Profile** node to open the **Girder Profile** window and enter the following section properties.

The screenshot shows the "Girder Profile" window with the "Section" tab selected. The "Type" is set to "Reinforced Concrete Tee". The "Allow flange width to vary" checkbox is unchecked. The diagram shows a tee beam with a tributary width of 72.0000 in, a flange thickness of 8.0000 in, and a web width of 26.0000 in. The effective width (LRFD) is 72.0000 in, and the structural thickness is 7.5000 in. The material is set to "Class A (US)".

Property	Value
Type	Reinforced Concrete Tee
Allow flange width to vary	<input type="checkbox"/>
Tributary width	72.0000 in
Flange thickness	8.0000 in
Web width	26.0000 in
Effective width (LRFD)	72.0000 in
Struct. thick	7.5000 in
Material (Top flange)	Class A (US)
Material (Other parts)	Class A (US)

The LRFD effective flange width is computed as follows.

### AASHTO LRFD Article 4.6.2.6.1

For interior beams, effective flange width taken as least of:

- average spacing of adjacent beams =  $6'(12''/? ) = 72''$

# RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

## Girder Profile - Web

Enter the following data for the web.

The screenshot shows the 'Girder Profile' dialog box with the 'Web depth' tab selected. The 'Type' is 'Reinforced Concrete Tee'. The table below contains the following data:

Begin depth (in)	Depth vary	End depth (in)	Support number	Start distance (ft)	Length (ft)	End distance (ft)
40.0000	None	40.0000	1	0.000	40.000	40.000

Buttons at the bottom: New, Duplicate, Delete, OK, Apply, Cancel.

## Girder Profile – Reinforcement

Enter the following data for the reinforcement.

The screenshot shows the 'Girder Profile' dialog box with the 'Reinforcement' tab selected. The 'Type' is 'Reinforced Concrete Tee'. The table below contains the following data:

Set	Bar mark	Invert	Measured from	Distance (in)	Std number	LRF number	Bar spacing (in)	Side cover (in)	Support number	Direction	Start distance (ft)	Straight length (ft)	End distance (ft)	Start fully developed	End fully developed
1	#9 Bar	<input type="checkbox"/>	Bottom of Girder	3.0640	8.00	8.00			1	Left	0.250	40.500	40.250	<input type="checkbox"/>	<input type="checkbox"/>

Buttons at the bottom: New, Duplicate, Delete, OK, Apply, Cancel.

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

RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

Shear Reinforcement Ranges

Double-click on the **Shear Reinforcement Ranges** on the Bridge Workspace tree to open the **Shear Reinforcement Ranges** window and enter the data as shown below.

The diagram shows a horizontal beam with a pin support on the left and a roller support on the right. Vertical lines represent stirrups. The first stirrup is at the left support, and subsequent stirrups are spaced evenly along the beam. Labels 'Start Distance' and 'Spacing' are shown with arrows indicating the distance from the support to the first stirrup and the distance between consecutive stirrups, respectively.

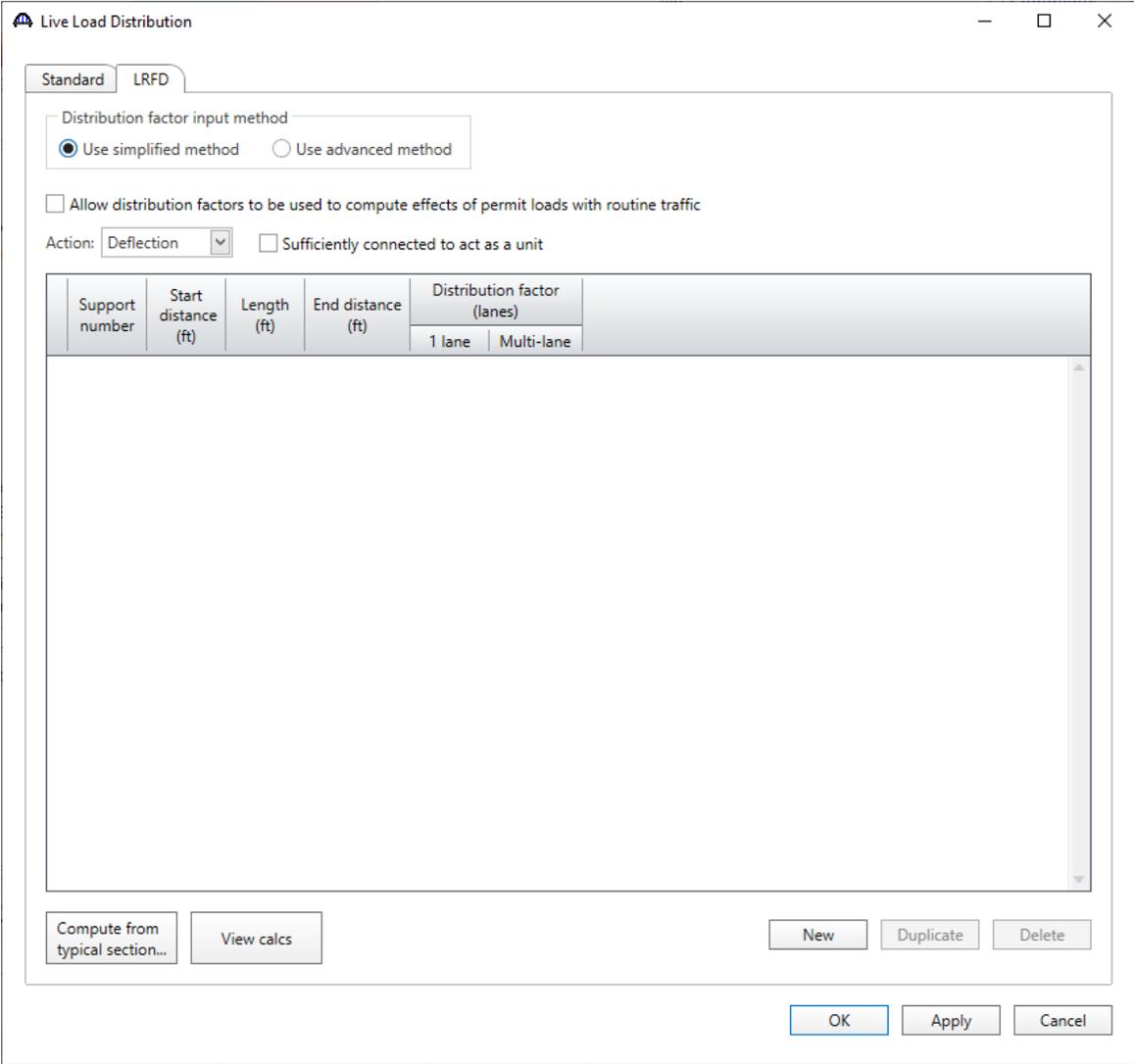
Name	Support number	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
#4 stirrups	1	0.00	1	0.0000	0.00	0.00
#4 stirrups	1	0.00	40	12.0000	40.00	40.00

Buttons: Stirrup wizard..., New, Duplicate, Delete, OK, Apply, Cancel

RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

Live Load Distribution Factors

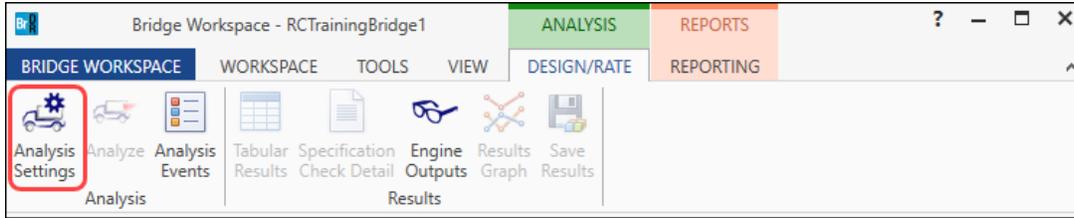
The BrDR LRFD analysis engine will compute the live load distribution factors. No values need to be entered if the user wants the BrDR engine to compute them.



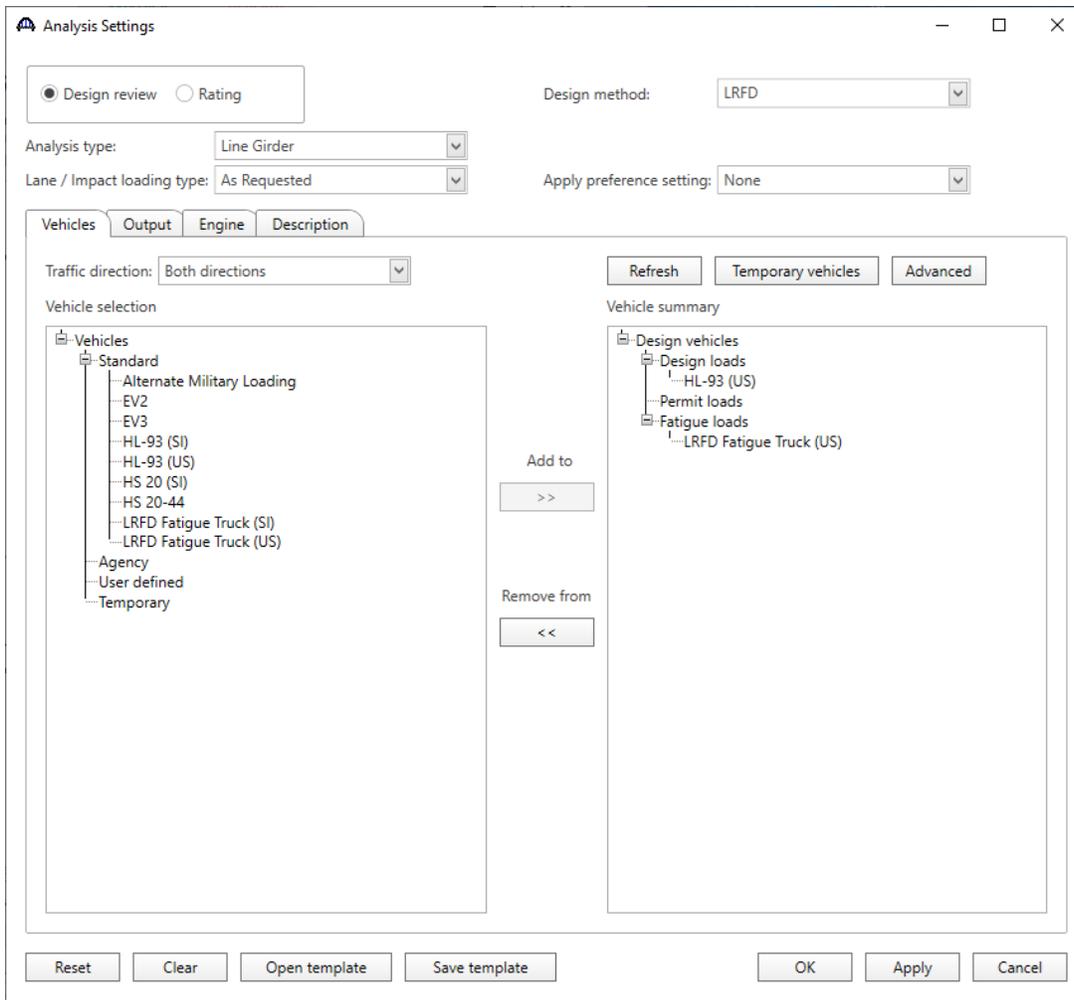
# RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

## LRFD Design Review

To perform an LRFD design review, click the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon which opens the **Analysis Settings** window.

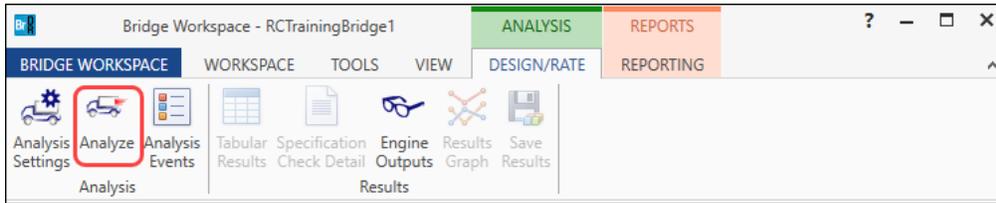


Click the **Open Template** button and select **HL-93 Design Review** to be used in the rating and click **OK**. The **Analysis Settings** window will appear as shown below.



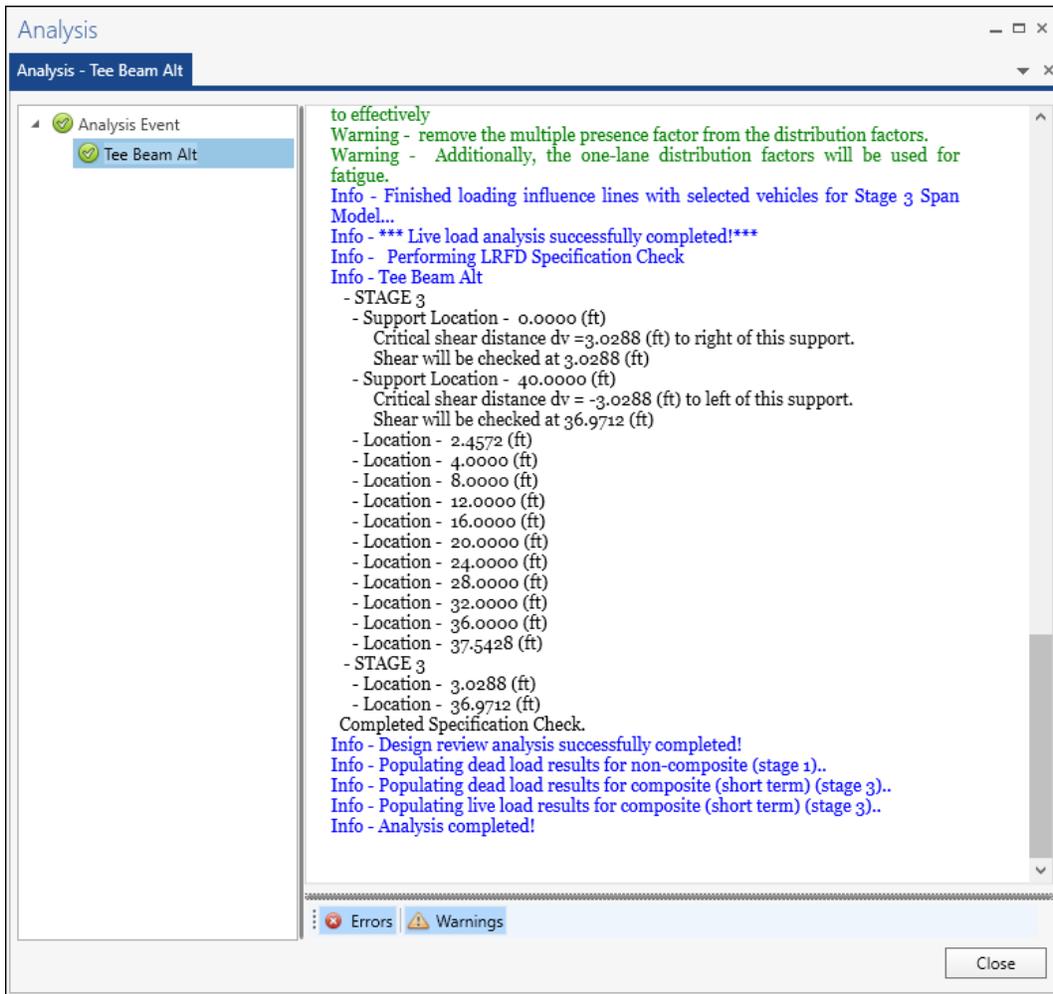
## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

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



The Analysis log should always be reviewed when performing an analysis with the BrDR LRFD Engine.

Informational messages are displayed in blue, warning messages are displayed in green and error messages are displayed in red font.



The following steps are performed in a design review using the BrDR LRFD analysis engine.

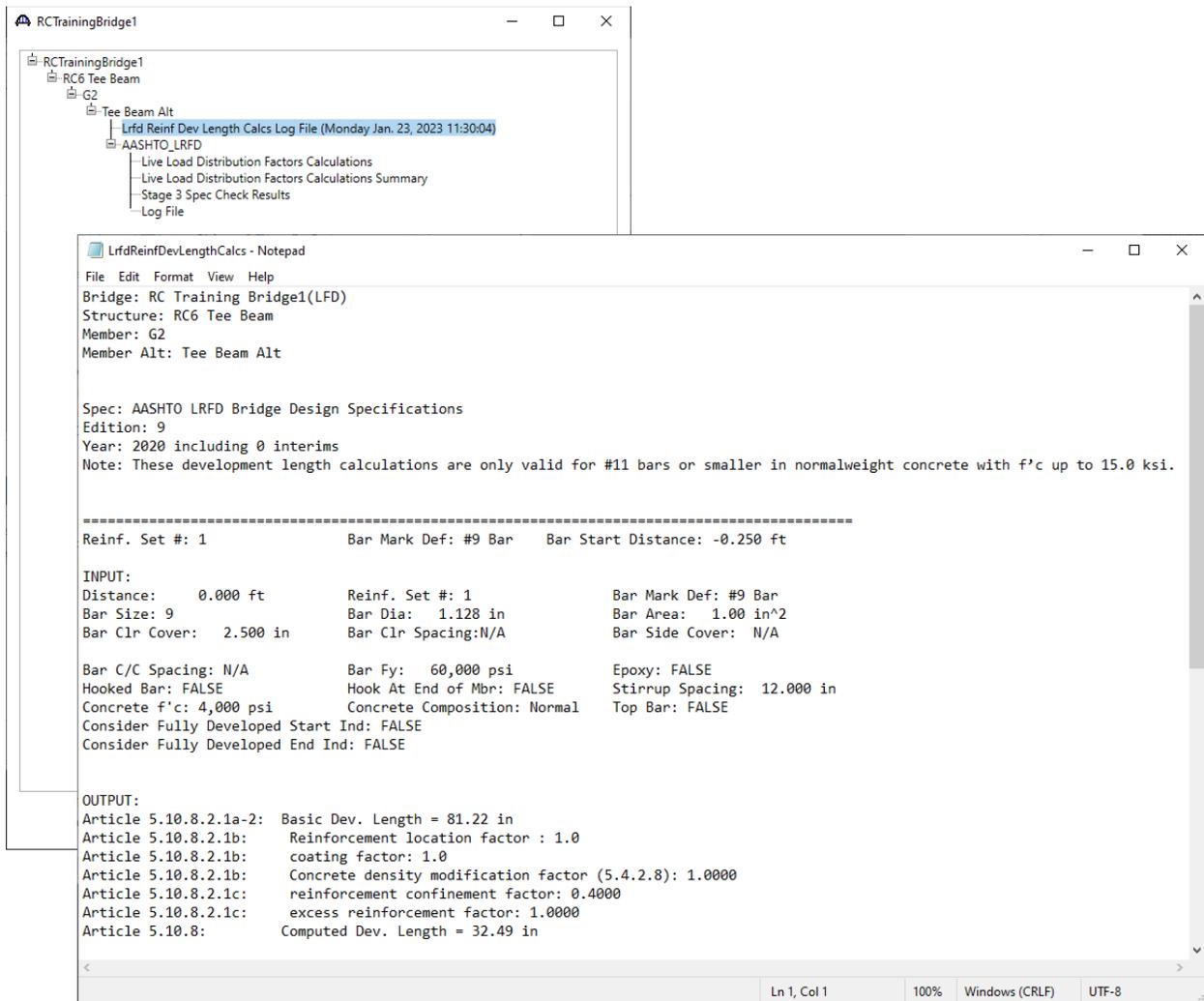
1. Finite element models are generated for the dead load and live load analyses. A Stage 1 FE model is generated for the dead loads on the reinforced concrete beam. A Stage 3 FE model is generated for the live load analysis. Reinforced concrete beams only have 1 stage so the Stage 1 and Stage 3 models contain the same cross section properties.

## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

The model generated by the export to the BrDR LRFD analysis engine will contain node points at locations where the cross section properties change, span tenth points, support locations, and user defined points of interest.

2. The Stage 1 FE model is analyzed for the dead load. The Stage 3 FE model is loaded with unit loads at each node to generate influence lines for the beam. The influence loads are then loaded with the selected vehicles to find the maximum live load effects.
3. Load combinations are generated for the loadings and specification checks are performed at each of the nodes in the finite element model as well as the locations where schedule based reinforcement is developed.

The report containing the calculations of the rebar development locations is shown below.



The screenshot displays a software interface with two windows. The top window, titled 'RCTrainingBridge1', shows a file tree structure. The selected file is 'LrfdReinDev Length Calcs Log File (Monday Jan. 23, 2023 11:30:04)'. The bottom window, titled 'LrfdReinDevLengthCalcs - Notepad', displays the contents of the log file. The report includes the following information:

```
Bridge: RC Training Bridge1(LFD)
Structure: RC6 Tee Beam
Member: G2
Member Alt: Tee Beam Alt

Spec: AASHTO LRFD Bridge Design Specifications
Edition: 9
Year: 2020 including 0 interims
Note: These development length calculations are only valid for #11 bars or smaller in normalweight concrete with f'c up to 15.0 ksi.

-----
Reinf. Set #: 1          Bar Mark Def: #9 Bar   Bar Start Distance: -0.250 ft

INPUT:
Distance: 0.000 ft      Reinf. Set #: 1        Bar Mark Def: #9 Bar
Bar Size: 9             Bar Dia: 1.128 in     Bar Area: 1.00 in^2
Bar Clr Cover: 2.500 in Bar Clr Spacing:N/A    Bar Side Cover: N/A

Bar C/C Spacing: N/A    Bar Fy: 60,000 psi     Epoxy: FALSE
Hooked Bar: FALSE      Hook At End of Mbr: FALSE Stirrup Spacing: 12.000 in
Concrete f'c: 4,000 psi Concrete Composition: Normal Top Bar: FALSE
Consider Fully Developed Start Ind: FALSE
Consider Fully Developed End Ind: FALSE

OUTPUT:
Article 5.10.8.2.1a-2: Basic Dev. Length = 81.22 in
Article 5.10.8.2.1b: Reinforcement location factor : 1.0
Article 5.10.8.2.1b: coating factor: 1.0
Article 5.10.8.2.1b: Concrete density modification factor (5.4.2.8): 1.0000
Article 5.10.8.2.1c: reinforcement confinement factor: 0.4000
Article 5.10.8.2.1c: excess reinforcement factor: 1.0000
Article 5.10.8: Computed Dev. Length = 32.49 in
```

## RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

A summary and a detailed report of the computed live load distribution factors are available.

The screenshot shows a software interface with a project tree on the left and a Notepad window displaying the LRFD Dist Factor Summary report.

**Project Tree:**

- RCTrainingBridge1
  - RC6 Tee Beam
    - G2
      - Tee Beam Alt
        - Lrfd Reinf Dev Length Calcs Log File
        - AASHTO\_LRFD
          - Live Load Distributions
          - Live Load Distribution Factors Calculations Summary (Monday Jan. 23, 2023 11:30:06)
          - Stage 3 Spec Check Results
          - Log File

**LRFD Dist Factor Summary - Notepad:**

```

File Edit Format View Help
*****
** Note that this file contains the distribution factors      **
** computed by the BrD wizard based on the bridge description **
** in BrD on the date and time below.  These computed values **
** may not match those shown in BrD if the user has changed  **
** the BrD bridge description after these distribution        **
** factors were computed.                                    **
*****

Bridge: RC Training Bridge1(LFD)
Bridge ID: RCTrainingBridge1      NBI Structure ID: RCTrainBridge1
Bid: 11

Superstructure Def: RC6 Tee Beam
Member: G2
Member Alternative: Tee Beam Alt

Date: 1/23/2023      Time: 11:30:06 AM

AASHTO LRFD Bridge Design Specifications, Edition 9, Interim 0

      Moment Distribution Factor Schedule

      Start      End      Single Lane      Multi Lane
      Distance   Distance   DF               DF
      (ft)       (ft)       (Lanes)         (Lanes)
-----
      0.00       40.00     0.491(A)        0.630(A)

      Shear Distribution Factor Schedule

      Start      End      Single Lane      Multi Lane
      Distance   Distance   DF               DF
      (ft)       (ft)       (Lanes)         (Lanes)
-----
      0.00       40.00     0.600(A)        0.671(A)
    
```

Ln 1, Col 1 | 100% | Windows (CRLF) | UTF-8

# RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

## BrDR LRFD specification checking

A summary report of the specification check results is also available. This summary report lists the design ratios for each spec article at each spec check location point. The design ratio is the ratio of capacity to demand. A design ratio less than one indicates the demand is greater than the capacity and the spec article fails. A design ratio equal to 99.0 indicates the section is subject to zero demand.

The screenshot shows a software window titled 'RCTrainingBridge1'. The left pane displays a project tree with the following structure:

- RCTrainingBridge1
  - RC6 Tee Beam
    - G2
      - Tee Beam Alt
        - Lrfd Reinf Dev Length Calcs Log File
        - AASHTO\_LRFD
          - Live Load Distribution Factors Calculations
          - Live Load Distribution Factors Calculations Summary
          - Stage 3 Spec Check Results (Monday Jan. 23, 2023 11:30:09)
          - Log File

The main window displays the following information:

Bridge ID : RCTrainingBridge1      NBI Structure ID : RCTrainBridge1  
 Bridge : RC Training Bridge1(LFD)      Bridge Alt :  
 Superstructure Def : RC6 Tee Beam  
 Member : G2      Member Alt : Tee Beam Alt  
 Analysis Preference Setting :

AASHTO LRFD Specification, Edition 9, Interim 0

### Specification Check Summary

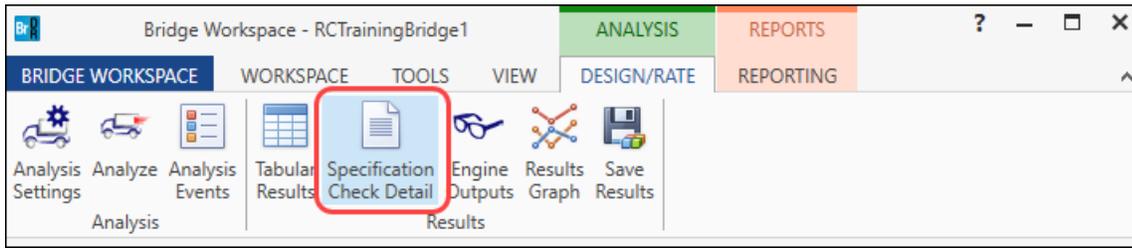
Article	Status
Flexure (5.6.3.2, 5.6.3.3)	Pass
Crack Control (5.6.7)	Pass
Shear (5.7.3.3, 5.7.2.5, 5.7.2.6, 5.7.3.5)	Fail
Fatigue (5.5.3.2)	Pass
Deflection (2.5.2.6.2)	Pass

### Girder Positive Flexure Analysis

Location (ft)	LS	Load Comb	Mr (kip-ft)	Mu (kip-ft)	Design Ratio Mr/Mu	Code
0.000	STR-I	1	120.91	0.00	99.000	Pass
2.457	STR-I	1	1276.49	298.36	4.278	Pass
2.020	STR-I	1	1276.40	267.73	4.771	Pass

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



The screenshot shows the 'Specification Checks for Tee Beam Alt - 17 of 223' window. The 'Specification filter' is set to 'Stage 3' and 'Tee Beam Alt'. The 'Report' format is 'Bullet list'. The table below shows the results of the specification checks.

Specification reference	Limit State	Flex. Sense	Pass/Fail
✓ 2.5.2.6.2 Criteria for Deflection		N/A	Passed
✓ 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.
✓ 5.5.3.2 Reinforcing Bars and Welded Wire Reinforcement		N/A	Passed
5.5.4.2 Strength Limit State - Resistance Factors		N/A	General Comp.
5.6.2.2 Rectangular Stress Distribution		N/A	General Comp.
✓ 5.6.3.2 Flexural Resistance (Reinforced Concrete)		N/A	Passed
✓ 5.6.3.3 Minimum Reinforcement		N/A	Passed
Control of Cracking by Distribution of Reinforcement		N/A	Passed
Transverse Reinforcement		N/A	Passed
Spacing of Transverse Reinforcement		N/A	Passed
✓ 5.7.3.3 Nominal Shear Resistance		N/A	Passed
for Determining Shear Resistance		N/A	General Comp.
Reinforcement		N/A	Failed
of_Inertia Section Property Calculations		N/A	General Comp.

Two specific checks are highlighted with red boxes and callouts:

- Span 1 - 36.97 ft.** (Callout: **dv distance from support**)
- Span 1 - 37.54 ft.** (Callout: **Rebar developed at this point**)

The BrDR RC LRFD engine performs spec checks at span tenth points, cross section property change points, and support locations. In addition, the program will perform spec checks at distance  $dv$  from the support and at locations where schedule based reinforcement starts/stops and is fully developed. The program will perform spec checks at user defined points of interest as well but note that a BrDR point of interest need not be created to have spec checks performed at the preceding locations.

Open the spec check detail window for the flexural resistance at midspan. The following is noted for this window, other spec articles are similar:

1. For each spec check location, both the left and right sides of the point are evaluated. The Deflection article is an exception to this since deflection must be the same between the left and right sides of a point.

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- The design ratio is printed out for the article. The design ratio is the ratio of capacity to demand. A design ratio less than one indicates the demand is greater than the capacity and the spec article fails. A design ratio equal to 99.0 indicates the section is subject to zero demand.
- The Strength-I, Service-I and Fatigue limit states are the only limit states investigated. For each limit state, the max and min force effect is checked. Thus, each limit state shows two rows of data.
- The LL load combination is shown in this column. If the location is not at a node in the FE model (e.g., the node is at a point where the rebar is fully developed), this column will list two load combinations separated by a comma. The first load combination is the combination considered at the left end and the second load combination is the combination considered at the right end of the FE element that contains this location. The resulting load displayed is a linear interpolation between the two displayed load cases.

Spec Check Detail for 5.6.3.2 Flexural Resistance (Reinforced Concrete)

```

5 Concrete Structures
5.6 Design for Flexural and Axial Effects - B Regions
5.6.3 Flexural Members
5.6.3.2 Flexural Resistance
(AASHTO LRFD Bridge Design Specifications, Ninth Edition)

RC T-Beam - At Location = 20.0000 (ft) - Left 1
-----
Cross Section Properties
-----
Total height = 39.50(in)      Web Width Top = 26.00(in)
Flange Width = 72.00(in)     Web Width Bot = 26.00(in)
Flange Thick = 7.50(in)
No fillet specified.
Area = 1372.00(in^2)

Flexural Reinforcement
-----
As      Dist. From
(in^2)  Bottom
8.00    3.06

f'c = 4.00 ksi

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.

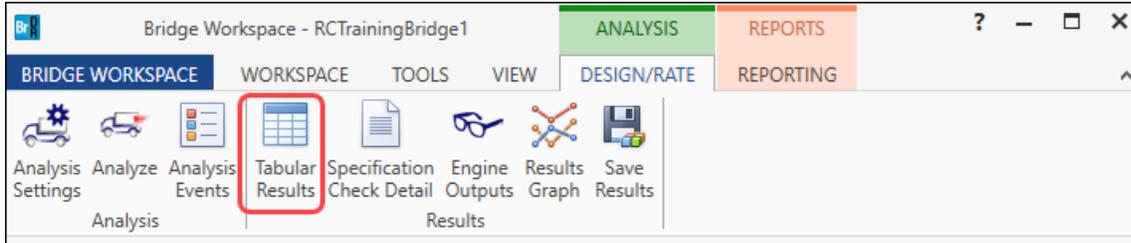
3      4      2
Limit State  Load      Mu      Phi      Mn      -- Override --      Mr=      Mr/Mu
Combination  kip-ft    kip-ft  kip-ft  Phi      Mn      kip-ft  kip-ft
STR-I        1          1218.90 0.900   1418.32 ---      ---      1276.49 1.05
STR-I        1          311.17 0.900   1418.32 ---      ---      1276.49 4.10
STR-I        2          1233.57 0.900   1418.32 ---      ---      1276.49 1.03
STR-I        2          311.17 0.900   1418.32 ---      ---      1276.49 4.10
SER-I        1          795.30 0.900   1418.32 ---      ---      1276.49 1.61
SER-I        1          345.75 0.900   1418.32 ---      ---      1276.49 3.69
SER-I        2          803.68 0.900   1418.32 ---      ---      1276.49 1.59
SER-I        2          345.75 0.900   1418.32 ---      ---      1276.49 3.69
FAT-I        3          283.40 0.900   1418.32 ---      ---      1276.49 4.50
FAT-I        3          0.00   0.900   1418.32 ---      ---      1276.49 99.00
FAT-II       3          129.55 0.900   1418.32 ---      ---      1276.49 9.85
    
```

OK

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## Tabular Results

Tabular dead load and live load analysis results are available in the Analysis Results window. They can be reviewed by clicking the **Tabular Results** button on the **Results** group of the **DESIGN/RATE** ribbon. The window shown below will open.



Analysis Results - Tee Beam Alt

Print

Report type: Dead Load Actions | Stage: Non-composite (Stage 1) | Dead Load Case: Load Case 1 - Self Load(Stage 1:D,DC)

Span	Location (ft)	% Span	Side	Moment (kip-ft)	Shear (kip)	Axial (kip)	Load Case 1 - Self Load(Stage 1:D,DC)	Load Case 2 - Exterior Diaphragm Loads(Stage 1:D,DC)	Load Case 3 - Parapet Loads(DC2:Stage 1:D,DC)
1	0.00	0.0	Right	0.00	29.33	0.00	29.33	0.0000	0.0000
1	4.00	10.0	Both	105.60	23.47	0.00		0.0000	-0.0362
1	8.00	20.0	Both	187.73	17.60	0.00		0.0000	-0.0684
1	12.00	30.0	Both	246.40	11.73	0.00		0.0000	-0.0937
1	16.00	40.0	Both	281.60	5.87	0.00		0.0000	-0.1097
1	20.00	50.0	Left	293.33	0.00	0.00		0.0000	-0.1152
1	20.00	50.0	Right	293.33	0.00	0.00		0.0000	-0.1152
1	24.00	60.0	Both	281.60	-5.87	0.00		0.0000	-0.1097
1	28.00	70.0	Both	246.40	-11.73	0.00		0.0000	-0.0937
1	32.00	80.0	Both	187.73	-17.60	0.00		0.0000	-0.0684
1	36.00	90.0	Both	105.60	-23.47	0.00		0.0000	-0.0362
1	40.00	100.0	Left	0.00	-29.33	0.00	29.33	0.0000	0.0000

AASHTO LRFD Engine Version 7.5.0.3001  
Analysis preference setting: None

Close

# RC8 – Reinforced Concrete Tee Beam Using BrDR LRFD Engine

Analysis Results - Tee Beam Alt

Print

Report type: Live Load Actions Stage Composite (short term) (Stage 3) Live Load HL-93 (US) Live Load Type Axle Load

Span	Location (ft)	% Span	Positive Moment (kip-ft)	Negative Moment (kip-ft)	Positive Shear (kip)	Negative Shear (kip)	Positive Axial (kip)	Negative Axial (kip)	Live Load Type	Reaction (kip)	Positive X Deflection (in)	Negative X Deflection (in)	Positive Y Deflection (in)	Negative Y Deflection (in)	% Impact Pos Reaction	% Impact Neg Reaction
1	0.00	0.0	0.00	0.00	49.23	0.00	0.00	0.00	Tandem + Lane	0.00	0.0000	0.0000	0.0000	0.0000	33.000	0.000
1	4.00	10.0	160.96	0.00	42.81	-2.85	0.00	0.00			0.0000	0.0000	0.0000	-0.0278		
1	8.00	20.0	273.63	0.00	36.39	-5.71	0.00	0.00			0.0000	0.0000	0.0000	-0.0530		
1	12.00	30.0	338.02	0.00	29.97	-8.56	0.00	0.00			0.0000	0.0000	0.0000	-0.0727		
1	16.00	40.0	372.89	0.00	24.26	-12.84	0.00	0.00			0.0000	0.0000	0.0000	-0.0849		
1	20.00	50.0	368.87	0.00	18.55	-18.55	0.00	0.00			0.0000	0.0000	0.0000	-0.0888		
1	24.00	60.0	372.89	0.00	12.84	-24.26	0.00	0.00			0.0000	0.0000	0.0000	-0.0849		
1	28.00	70.0	338.02	0.00	8.56	-29.97	0.00	0.00			0.0000	0.0000	0.0000	-0.0727		
1	32.00	80.0	273.63	0.00	5.71	-36.39	0.00	0.00			0.0000	0.0000	0.0000	-0.0530		
1	36.00	90.0	160.96	0.00	2.85	-42.81	0.00	0.00			0.0000	0.0000	0.0000	-0.0278		
1	40.00	100.0	0.00	0.00	0.00	-49.23	0.00	0.00	49.23	0.00	0.0000	0.0000	0.0000	0.0000	33.000	0.000

AASHTO LRFD Engine Version 7.5.0.3001  
Analysis preference setting: None

Close

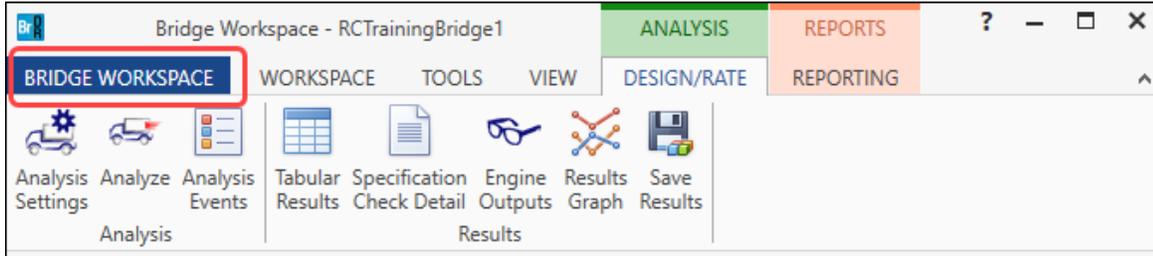
Note these values include dynamic load allowance, distribution factors and any live load scale factor entered in the **Analysis Settings** window.

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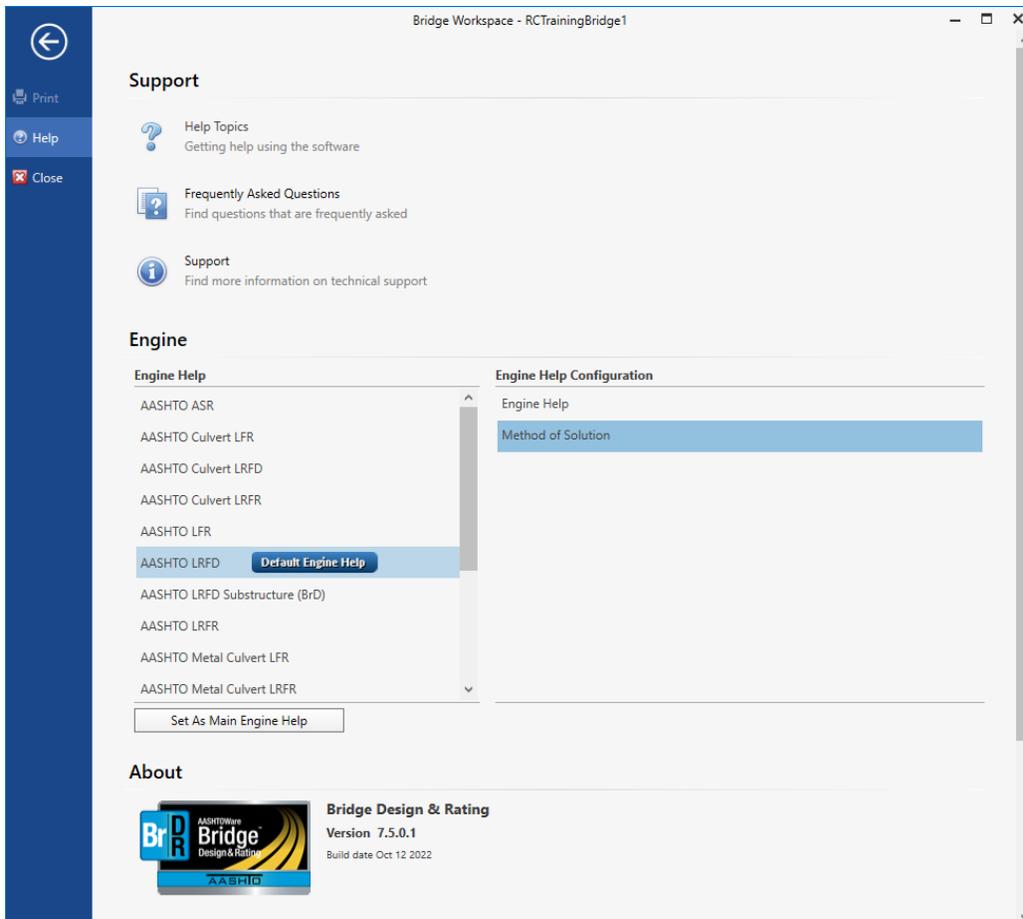
## Method of Solution

The Method of Solution manual can be accessed from the Help menu in BrDR.

Click on the **Bridge Workspace** ribbon to access the **Support** menu.



In the **Engine Help** column select **AASHTO LRFD** to access the **Engine Help** and **Method of Solution** for the selected engine. Double-click on **Method of Solution** from the **Engine Help Configuration** column to open the method of solution for the selected engine



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