

*AASHTOWare BrDR 7.5.0*

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*Truss Tutorial*

*T5 – Truss Enhancements*

## T5 – Truss Enhancements

### BrDR Tutorial

#### Topics Covered

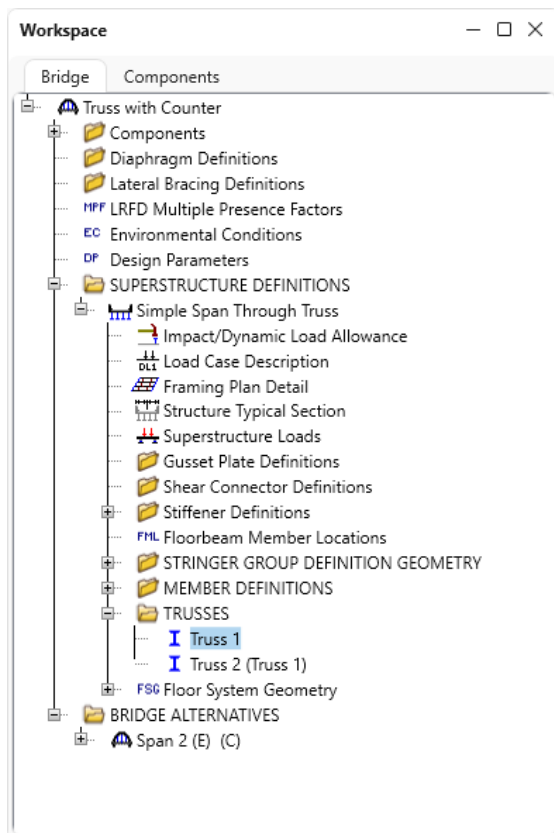
- Longitudinal Truss – Counters
- Longitudinal Truss - Member eccentricity
- Longitudinal Truss - Suspended span
- Longitudinal Truss - Deck-through configuration
- Floor truss – Element loads and Interaction Rating for Axial and Bending

#### Truss Manuals

The BrDR Truss Command Language User Manual and Truss Method of Solution can be accessed through the F1 Help for the Truss window. The **Truss Command Language User Manual** can be accessed from the **BrDR Help** menu as shown below.

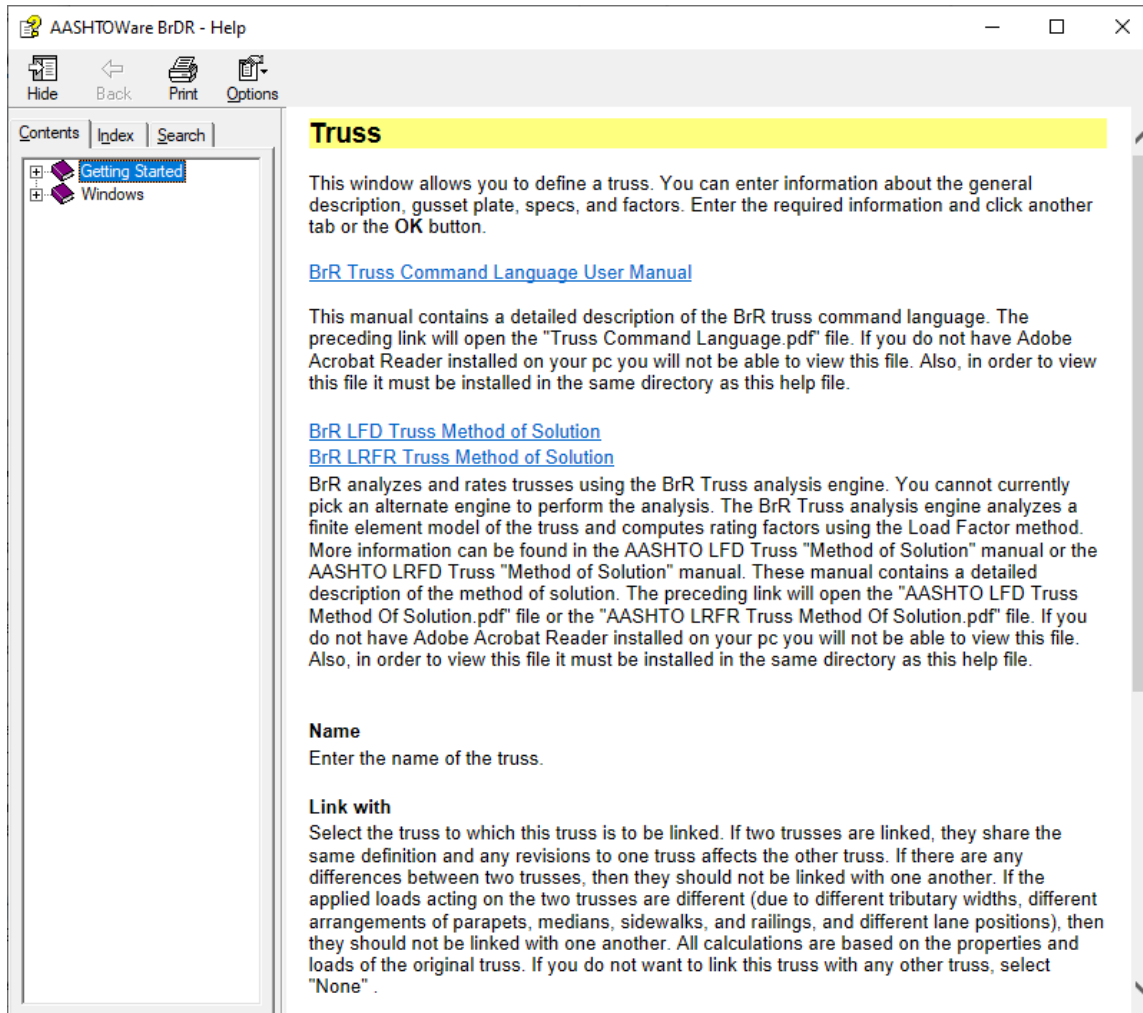
Open the truss example - *T5-Truss-Enhancements-with-Counter.xml* provided for this tutorial. Expand the **Bridge Workspace** tree for the **Simple Span Through Truss** superstructure definition, **TRUSSES**, and double click on **Truss 1** node to open the **Truss** window.

The partially expanded **Bridge Workspace** tree of the **Truss with Counter** is shown below.



## T5 – Truss Enhancements

Press the F1 key on this window to open the **BrDR Help** topic for Truss. This help topic has links to the **Truss Command Language User Manual** and **Truss Method of Solution**.



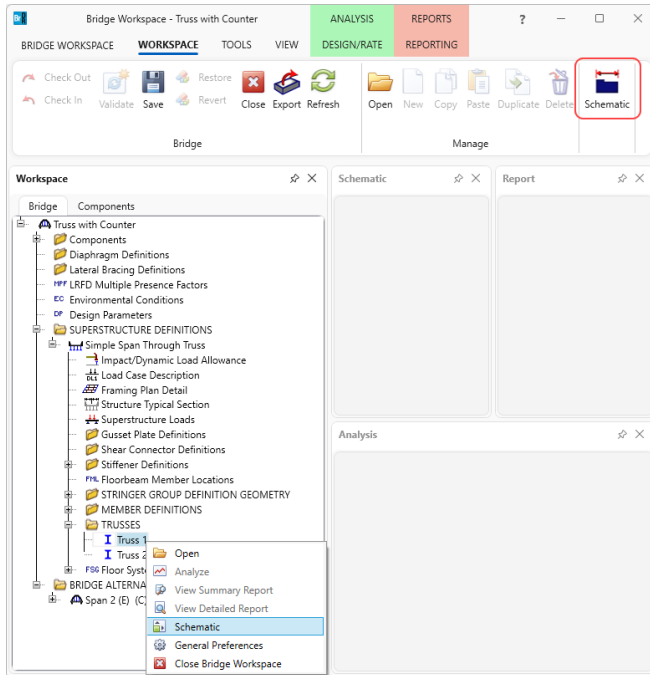
# T5 – Truss Enhancements

## Longitudinal Truss – Counters

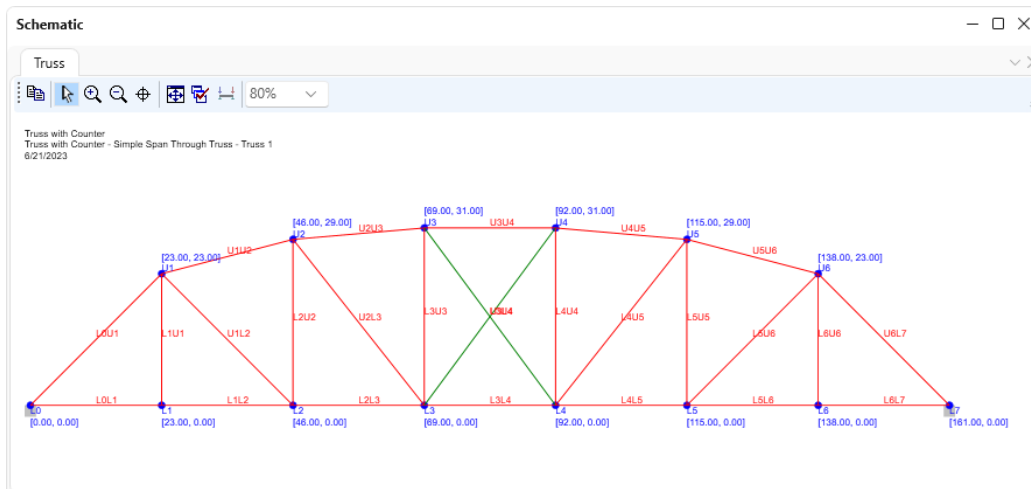
In this section of the example, the **Simple Span Through Truss** in the *T5-Truss-Enhancements-with-Counter.xml* bridge file. Counters for the diagonal members in the center panel will be specified and eccentricity for the upper and lower chord members in the center panel will be entered.

### Schematic - Truss

While **Truss 1** is selected in the **Bridge Workspace** tree, open the schematic for the truss by selecting the **Schematic** button on the **WORKSPACE** ribbon (or right click on **Truss 1** in the Bridge Workspace and select **Schematic** from the menu).



The truss schematic is shown below.



## T5 – Truss Enhancements

The counter is a tension-only member and is specified using the Member command. To specify that a member is a counter, enter the word **Counter** after the cross section name of that member. The word **Counter** is an optional entry in the Member command. All tension-only members in a truss should be specified as **Counter**.

### 6.12 Member Command

Use this command to describe the truss member connectivity, end connection type, cross section type, k values, unbraced lengths and whether or not a member is a counter.

	<u>Command</u>
<u>Command</u>	<p><b>Member</b>            (&lt;member_name&gt; &lt;panel_point_name&gt; &lt;panel_point_name&gt;&lt;cross_section_name&gt;            &lt;counter‡&gt;&lt;end_connection_type‡&gt;&lt;member_k_value‡&gt;&lt;z_unbraced_length‡&gt;            &lt;y_unbraced_length‡&gt;)*</p>
<u>Description</u>	<p>&lt;member_name&gt; = Enter your choice of name for member.            &lt;panel_point_name&gt; = Enter panel point name from records in command 11.            &lt;panel_point_name&gt; = Enter panel point name from records in command 11.            &lt;cross_section_name&gt; = Choose among the cross section declared in command 9.            &lt;counter&gt; = <b>Counter</b>            &lt;end_connection_type&gt; = <b>Pinned   Riveted   Bolted   Welded   UserDefined</b>            &lt;member_k_value&gt; = Enter k value.            &lt;z_unbraced_length&gt; = Enter z unbraced length value.            &lt;y_unbraced_length&gt; = Enter y unbraced length value.</p>

#### Truss

Double-click **Truss 1** in the **Bridge Workspace** tree to open the **Truss** window. Scroll down to the **Member** command and enter the word **Counter** for **U3L4** and **L3U4**. Click **OK** to apply the changes and close the window.

Counters introduce nonlinearity since the structural model changes as the live load moves across the truss. The analysis cannot use superposition of DL and LL or influence lines for computing LL effects. As a result, it is necessary to move the live load vehicle across the truss and generate a load case for each vehicle position. Each load case must include the factored dead load and the factored live load for a vehicle position.

The nonlinear analysis iterates for a solution for each load case by removing counters that are in compression and including counters that are in tension for the combined factored DL + LL load case. The results of the nonlinear analysis are scanned to determine the critical loading for each truss element. Another factored DL-only analysis is

## T5 – Truss Enhancements

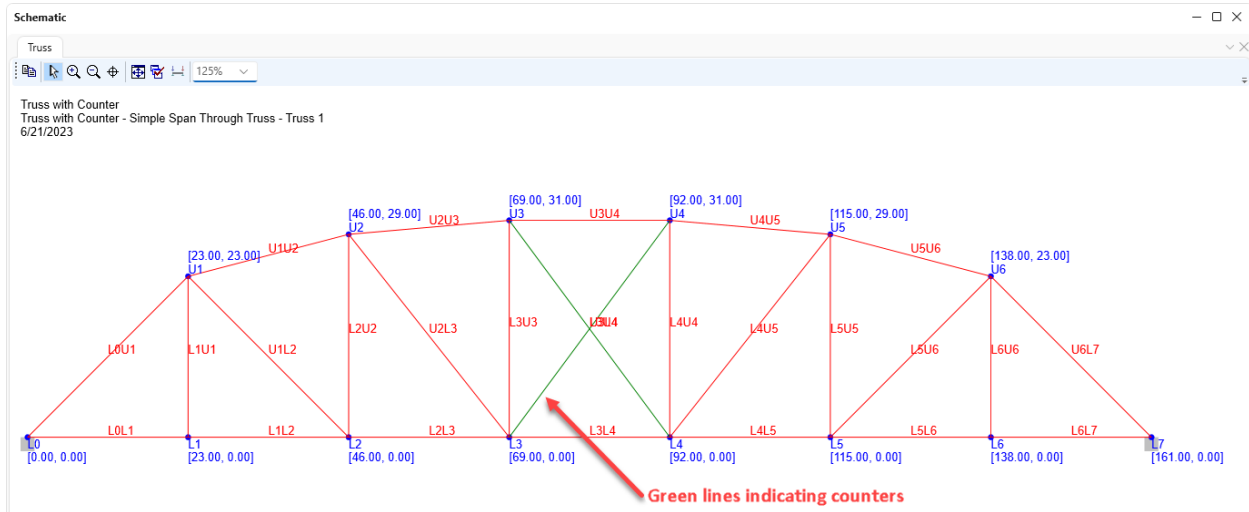
necessary for use in the rating equation. The factored LL for the rating equation is computed by subtracting the factored DL for each truss element from the critical loading for the element.

The screenshot shows the 'Truss' software window. At the top, there is a 'Name' field containing 'Truss 1' and a 'Link with' dropdown menu set to 'None'. Below this are four tabs: 'Description', 'Gusset plates', 'Specs', and 'Factors'. The 'Description' tab is active, showing a 'Default rating method' dropdown set to 'LFR'. A large list of members is displayed, with a red box highlighting the 'Member' header and the following two lines: 'U3L4 U3 L4 U3L4 Counter' and 'L3U4 L3 U4 U3L4 Counter'. Below the list is a 'Line number' field set to '1'. At the bottom of the list area are two buttons: 'View member cross section' and 'Verify'. At the very bottom of the window are three buttons: 'OK', 'Apply', and 'Cancel'.

Member
L0L1 L0 L1 L0L2
L1L2 L1 L2 L0L2
L2L3 L2 L3 L2L3
L3L4 L3 L4 L3L4
L4L5 L4 L5 L2L3
L5L6 L5 L6 L0L2
L6L7 L6 L7 L0L2
L0U1 L0 U1 L0U1
U1U2 U1 U2 U1U2
U2U3 U2 U3 U2U3
U3U4 U3 U4 U3U4
U4U5 U4 U5 U2U3
U5U6 U5 U6 U1U2
U6L7 U6 L7 L0U1
L1U1 L1 U1 L1U1
L2U2 L2 U2 L2U2
L3U3 L3 U3 L3U3
L4U4 L4 U4 L3U3
L5U5 L5 U5 L2U2
L6U6 L6 U6 L1U1
U1L2 U1 L2 U1L2
U2L3 U2 L3 U2L3
U3L4 U3 L4 U3L4 Counter
L3U4 L3 U4 U3L4 Counter
L4U5 L4 U5 U2L3
L5U6 L5 U6 U1L2

## T5 – Truss Enhancements

Follow the steps described previously to reopen the **Schematic** for **Truss 1**. The truss schematic is shown below. The counters in the center panel (U3L4 and L3U4) are colored in green and all other members are colored in red.



### Longitudinal Truss – Member Eccentricity

In-plane member eccentricity at a connection is entered using the MemberEccen command. The MemberEccen command is an optional command entered after the Member command. The following is an excerpt from the **Truss Input Command Language** manual.

#### 6.13 MemberEccen Command

Use this command to describe the eccentricity of truss members. The eccentricity of a truss member is in the truss main plane. No out-of-plane eccentricity will be considered.

	<u>Command</u>
<u>Command</u>	<b>MemberEccen</b> (<member_name> <eccentricity>)*
<u>Description</u>	<member_name> = Enter the name of an eccentric member. <eccentricity> = Enter the eccentricity. <b>Note:</b> 1. The unit of eccentricity is the same as that specified by <b>Properties</b> command.
<u>Example</u>	<b>MemberEccen</b> U3U4 0.5 L3L4 0.5

Double-click on **Truss 1** node in the **Bridge Workspace** tree to open the **Truss** window. Scroll down to after the **Member** command and before the **Support** command. Enter 0.5 in eccentricity for **U3U4** and **L3L4**. Click **OK** to apply the changes and close the window.

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The eccentricity is only applied to the rating by considering the axial force in the member to be acting at the user-specified eccentricity thus causing a moment  $M = P \times e$  about the axis perpendicular to the plane of the truss. The eccentricity is not considered in the structural analysis and secondary effects are not considered. Load ratings for eccentric members of a longitudinal truss are computed using the Secant Formula Method in the Load and Resistance Factor Rating method.

The screenshot shows the 'Truss' software window with the following details:

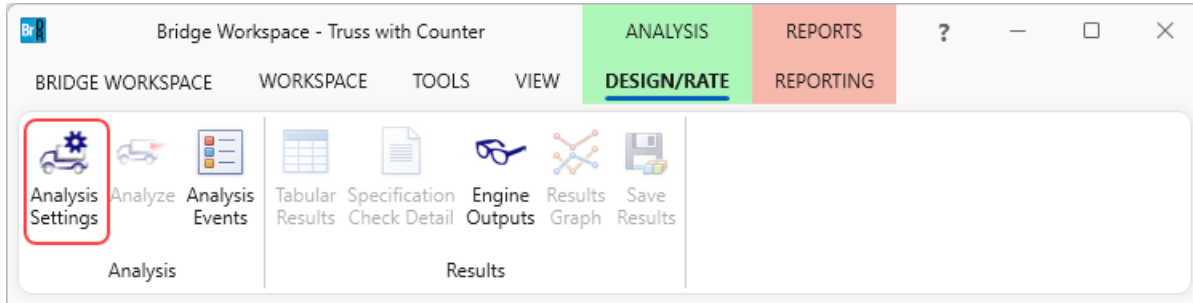
- Name: Truss 1
- Link with: None
- Default rating method: LFR
- Member list (MemberEccen):
  - U3U4 0.5
  - L3L4 0.5
- Supports: L0 Roller, L7 Pinned
- Line number: 1
- Buttons: View member cross section, Verify, OK, Apply, Cancel



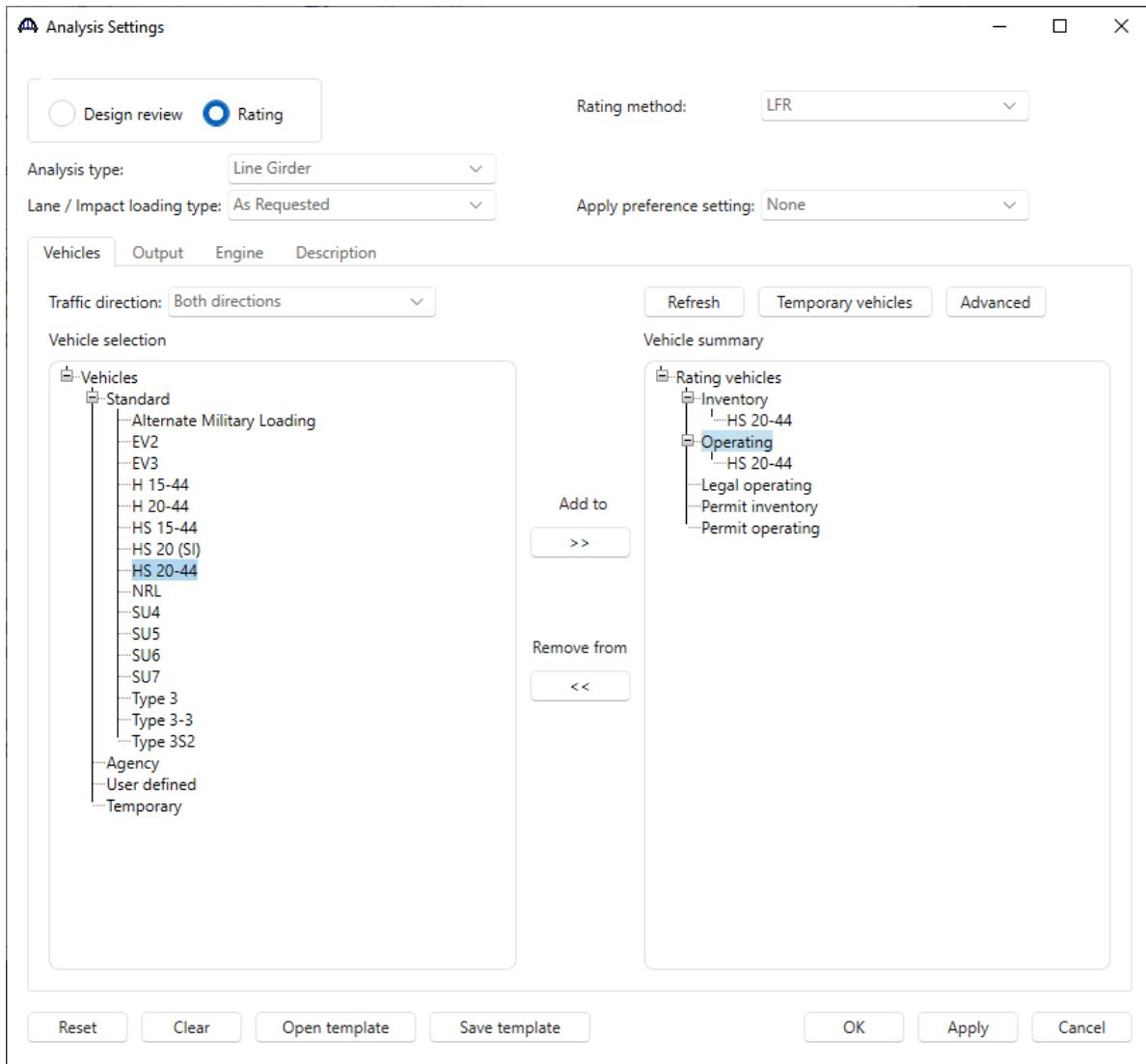
## T5 – Truss Enhancements

### LFR Analysis

To perform a rating on the **Truss 1**, select **Truss 1** in the **Bridge Workspace** tree and click the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon. The window shown below opens.



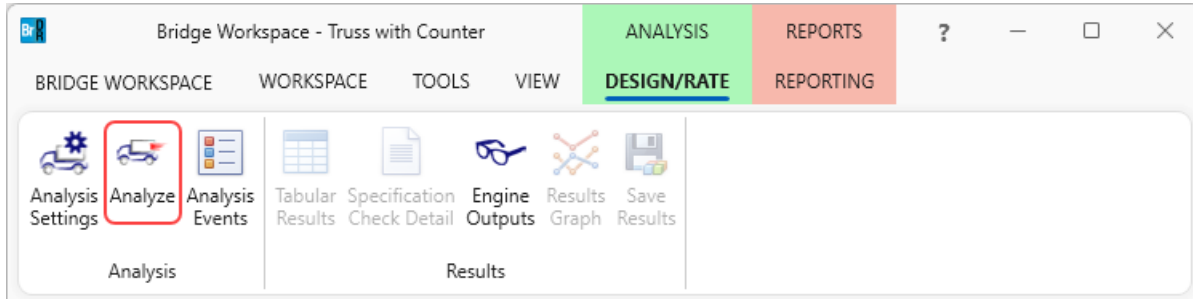
Select the vehicle **HS 20-44** under **Inventory** and **Operating** as shown below.



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

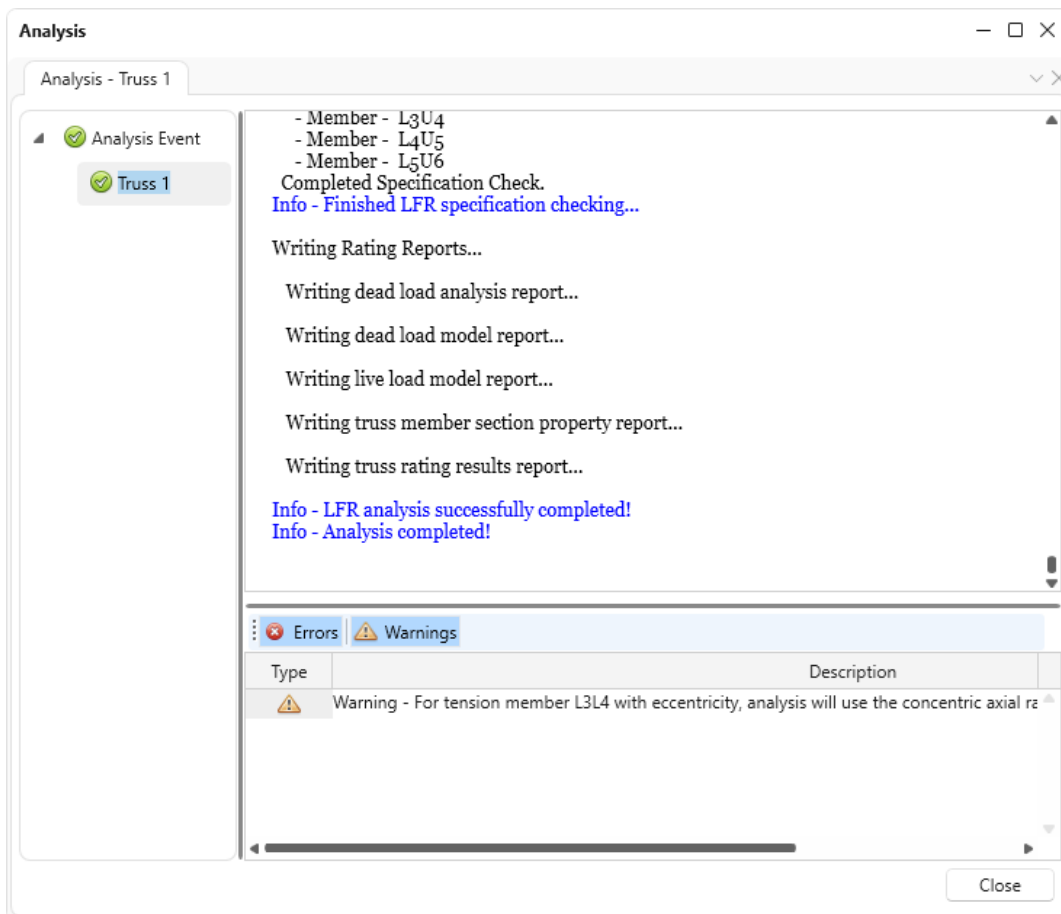
## T5 – Truss Enhancements

Select **Truss 1** in the **Bridge Workspace** tree and click the **Analyze** button from the **Analysis** group of the **DESIGN/RATE** ribbon to perform the rating.



### Analysis

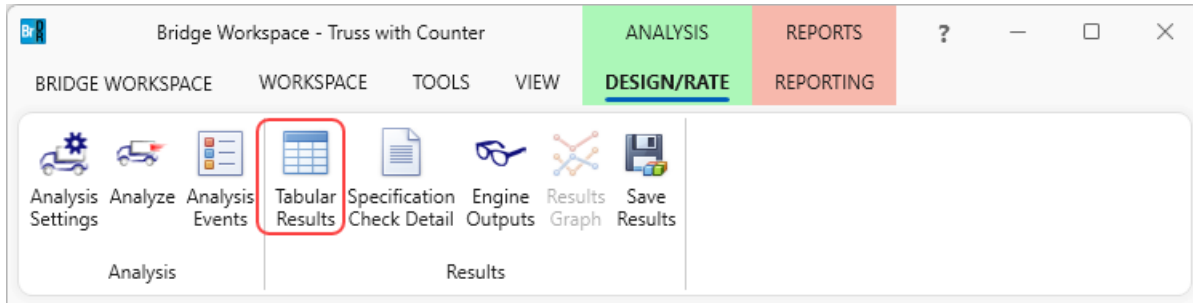
The **Analysis** window displays analysis progress messages during the analysis. Messages in **blue** are information messages. Warning messages are in **green** and error messages are in **red**. The **Analysis** window shown below indicates the analysis is successfully completed.



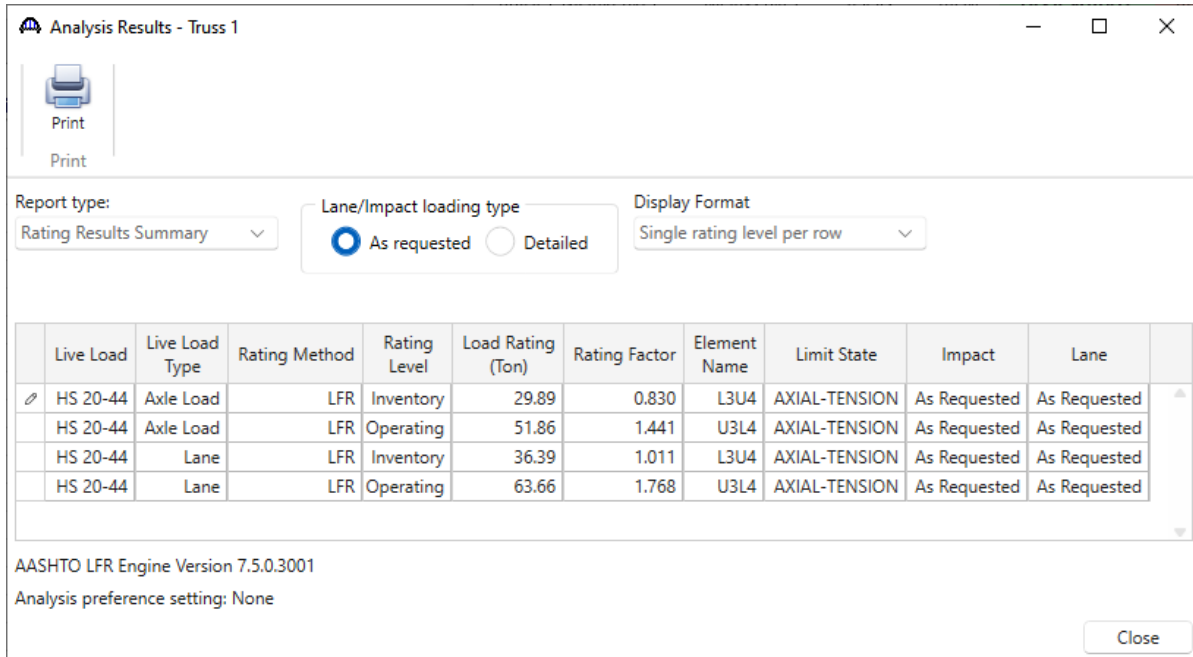
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### Tabular Results

When the rating is completed, results can be reviewed by selecting the **Truss 1** member in the **Bridge Workspace** tree and clicking the **Tabular Results** button on the **Results** group of the ribbon.



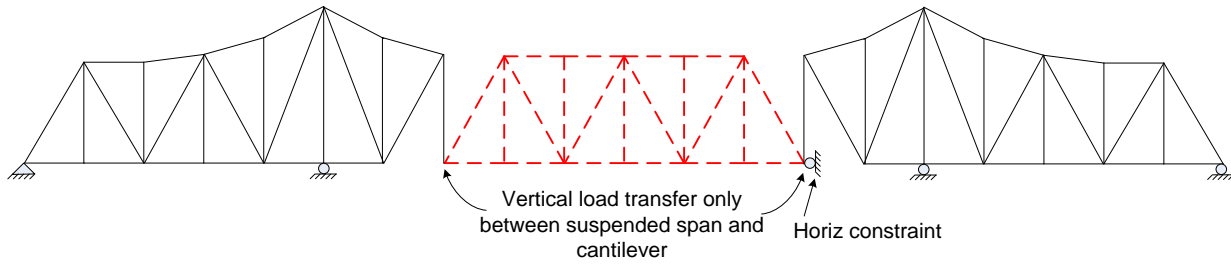
The window shown below will open.



# T5 – Truss Enhancements

## Longitudinal Truss - Suspended span

In this example, a truss bridge with a suspended span will be modeled. The following shows the model with two anchor and cantilever spans and a suspended span (dashed lines). The two top chord, and two bottom chord elements are removed from the model and a horizontal constraint is provided to eliminate instability in the model. No horizontal forces are transferred between the suspended span and the cantilevers.



### Description of example truss bridge (T5-Truss-Enhancements-Suspended-Truss-Bridge.xml bridge file)

1. Figure 1 shows the schematic of the example truss bridge. The span layout is 110 ft, 154 ft and 110 ft. The suspended span length is 88 ft.

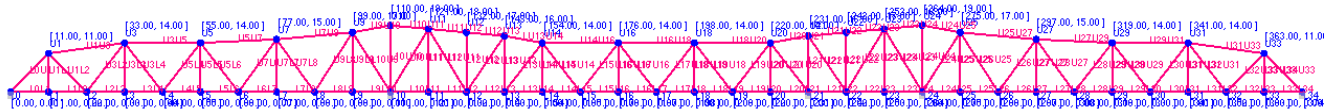


Figure 1

2. Figure 2 shows the schematic of the suspended span, which is from member L13U13 to L21U21.

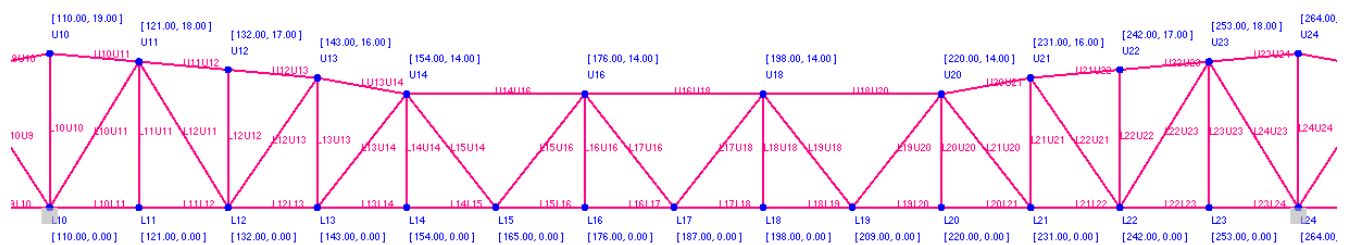


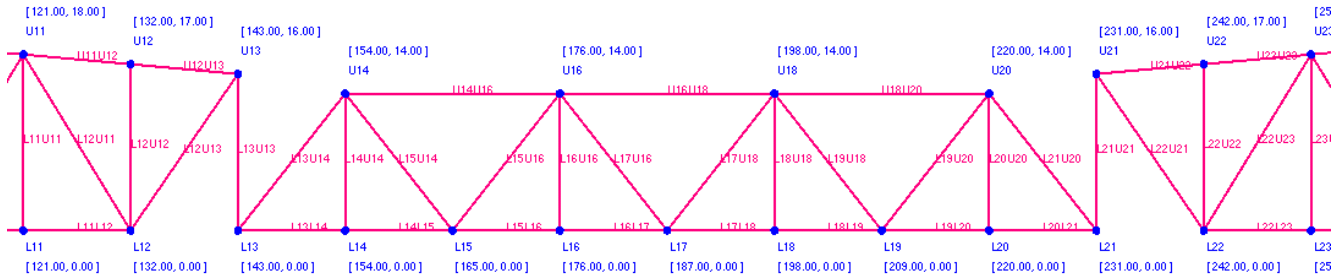
Figure 2

3. The suspended span is supported by the tension members L13U13 and L21U21. Chord members L12L13, U13U14, L21L22 and U20U21 are built as false member to release axial displacements for simulating hinges.

## T5 – Truss Enhancements

**Steps to model the suspended span** (Follow the steps with the *T5-Truss-Enhancements-Suspended-Truss-Bridge.xml* bridge file)

1. Remove the false members L12L13, U13U14, L21L22 and U20U21 from the model.



**Figure 3**

2. Use the Support Command to set left and right anchor spans as simple support spans.

Support

L0 Pinned

L10 Roller

L24 Roller

L34 Pinned

3. Use the UserDefined Support Command to add the horizontal restraint at L21 for providing horizontal stability to the suspended span. L13U13 and L21U21 will provide vertical support to the suspended span.

Support

L0 Pinned

L10 Roller

L24 Roller

L34 Pinned

L21 UserDefined True False False 1000000000000.0

4. Use the PanelPointLoad command to add the self-weight of the false members into the model. The vertical load -0.36 kips is half of the self-weight of the false member.

PanelPointLoad

U13 DC 0.0 -0.36

U14 DC 0.0 -0.36

L12 DC 0.0 -0.36

L13 DC 0.0 -0.36

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L21 DC 0.0 -0.36  
L22 DC 0.0 -0.36  
U20 DC 0.0 -0.36  
U21 DC 0.0 -0.36

The screenshot shows the 'Truss' software window with the following details:

- Name:** Truss 1
- Link with:** None
- Default rating method:** LFR
- Member Properties (highlighted in red):**
  - // False members
  - //L12L13 L12 L13 Section9
  - //U13U14 U13 U14 Section9
  - //L21L22 L21 L22 Section9
  - //U20U21 U20 U21 Section9
  - Support
  - L0 Pinned
  - L10 Roller
  - L24 Roller
  - L34 Pinned
  - L21 UserDefined True False False 1000000000000.0
  - PanelPointLoad
  - U13 DC 0.0 -0.36
  - U14 DC 0.0 -0.36
  - L12 DC 0.0 -0.36
  - L13 DC 0.0 -0.36
  - L21 DC 0.0 -0.36
  - L22 DC 0.0 -0.36
  - U20 DC 0.0 -0.36
  - U21 DC 0.0 -0.36
- LLDistribution:**
  - OneLane 0.76 0.5
  - MultiLane 1.08 1.0
- Line number:** 1
- Buttons:** View member cross section, Verify, OK, Apply, Cancel

## T5 – Truss Enhancements

### LFR Analysis and Rating Results

Perform an LFR analysis on **Truss 1** with **HS 20-44** vehicle in Inventory and Operating as shown in the previous section of this tutorial.

The **Rating Results Summary** of **Truss 1** is shown below.

Analysis Results - Truss 1

Print

Report type: Rating Results Summary

Lane/Impact loading type:  As requested  Detailed

Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Element Name	Limit State	Impact	Lane
HS 20-44	Axle Load	LFR	Inventory	32.75	0.910	U24U25	AXIAL-TENSION	As Requested	As Requested
HS 20-44	Axle Load	LFR	Operating	54.69	1.519	U24U25	AXIAL-TENSION	As Requested	As Requested
HS 20-44	Lane	LFR	Inventory	37.16	1.032	U24U25	AXIAL-TENSION	As Requested	As Requested
HS 20-44	Lane	LFR	Operating	62.06	1.724	U24U25	AXIAL-TENSION	As Requested	As Requested

AASHTO LFR Engine Version 7.5.0.3001  
Analysis preference setting: None

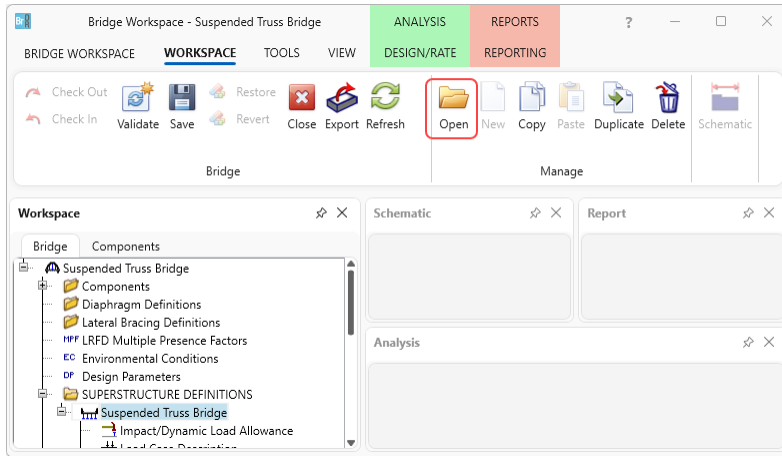
Close

## T5 – Truss Enhancements

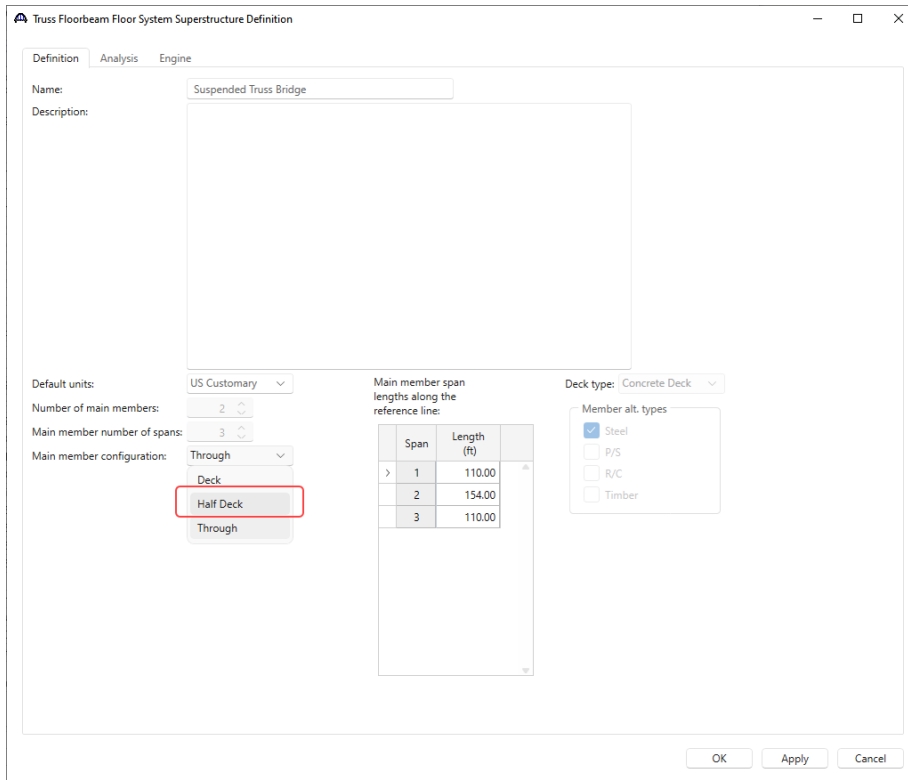
### Longitudinal Truss – Deck-through-configuration

This example will focus on windows for modeling a truss with a deck-through-configuration instead of the deck or through configuration.

Click on the **Suspended Truss Bridge** node in the **Bridge Workspace** tree and click on the **Open** button from the **Manage** group of the **WORKSPACE** ribbon (or double click on the **Suspended Truss Bridge** node in the **Bridge Workspace** tree) to open the **Truss Floorbeam Floor System Superstructure Definition** window as shown below.



In the **Truss Floorbeam Floor System Superstructure Definition** window, the **Half Deck** selection in **Main member configuration** is used to indicate the truss has a deck-through configuration.





When **Half Deck** is selected in **Main member configuration**, the HalfDeckLineLocations command is used to describe the panel points at the deck line locations. The following is an excerpt from the **Truss Input Command Language** manual.

### 6.15 HalfDeckLineLocations Command

Use this command to describe the panel points at the deck line locations for a deck-through truss configuration.

	<u>Command</u>
<u>Command</u>	<b>HalfDeckLineLocations</b> (<panel_point_name>)*
<u>Description</u>	<panel_point_name> = Enter panel point name from PanelPoint command which describes the deck line locations.
<u>Example</u>	<b>HalfDeckLineLocations</b> <b>M0</b> <b>M2</b> <b>M4</b> <b>M6</b> <b>M8</b> <b>M10</b>

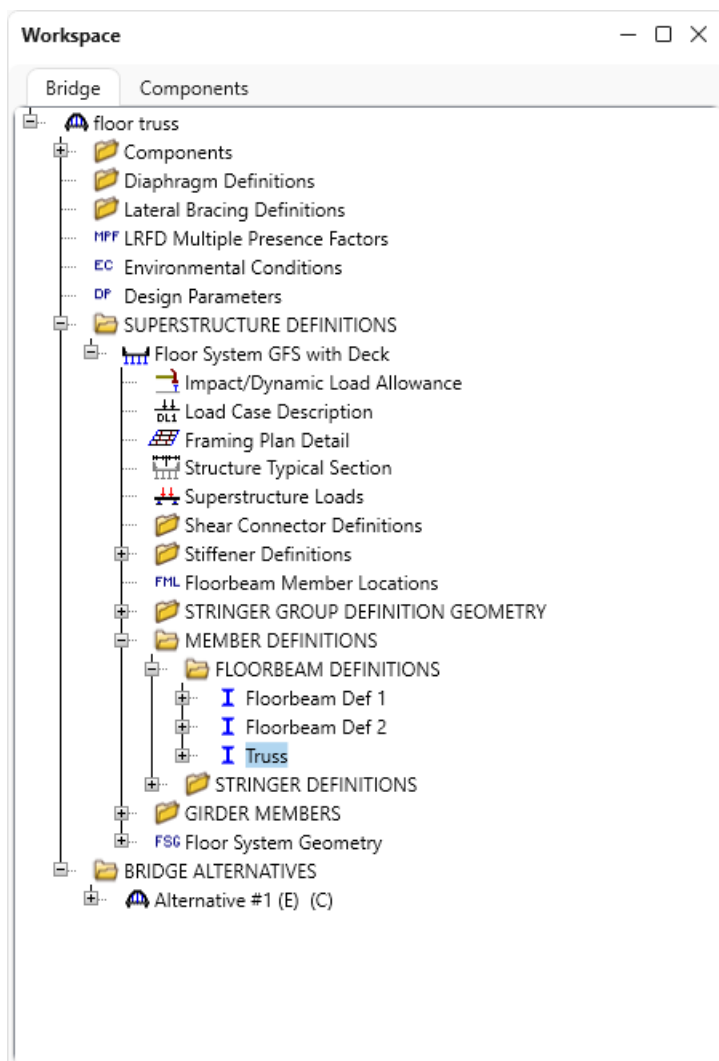
## T5 – Truss Enhancements

### Floor truss – Element loads and Interaction Rating for Axial and Bending

In this example, windows for modeling a floor truss using beam finite element instead of truss finite element will be explored. Import the *T5-Truss-Enhancements-with-Floorbeams.xml* bridge file.

Modeling the truss members using beam elements are required when the stringers are located between panel points or member loads are applied between panel points.

Expand the **SUPERSTRUCTURE DEFINITIONS** node **Floor System GFS with Deck**, **MEMBER DEFINITIONS**, **FLOORBEAM DEFINITIONS**. Double click on **Truss** to open the **Floorbeam Definition** window and navigate to the **Geometry** tab as shown below.



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This is the definition of the nodes for which the truss is defined.

Number of panels

Even number of panels

Odd number of panels

Symmetrical

Panel point	Type	X (ft)	Y (ft)
L0	Lower	0.00	0.00
L1	Lower	6.00	0.00
L2	Lower	12.00	0.00
L3	Lower	18.00	0.00
L4	Lower	24.00	0.00
L5	Lower	30.00	0.00
U0	Upper	0.00	6.00
U1	Upper	6.00	6.00
U2	Upper	12.00	6.00
U3	Upper	18.00	6.00
U4	Upper	24.00	6.00
U5	Upper	30.00	6.00

New Duplicate Delete

OK Apply Cancel

Expand the **Truss** node and then the **Truss Member Cross Sections** node. Double click on **rolled 6 x 20** to open the **Cross Sections** window. This is the steel section used for the floorbeam truss.

Dimensions Top cover plates Bottom cover plates

Name: rolled 6 x 20 Type: Rolled Steel Truss Cross Section

Shape: W 6x20

Material: FY 36ksi Steel

Top/bottom cover plates attachment: Bolted

## T5 – Truss Enhancements

Double click on the **Truss Member Properties** window. The **Model truss member as beam element** selection is used to indicate whether to use truss or beam elements in the finite element model.

Truss Member Properties
— □ ×

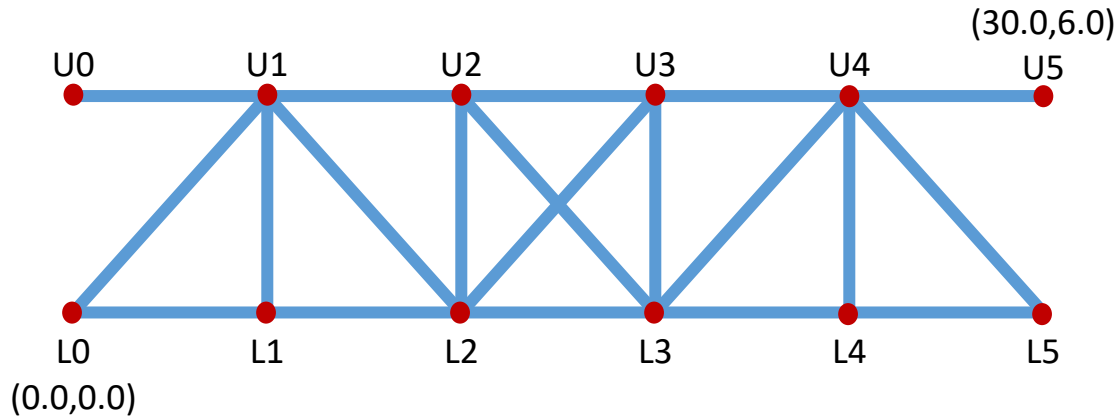
	Member name	Panel point from	Panel point to	Length (ft)	Z axis unbraced length (ft)	Y axis unbraced length (ft)	Cross section	End connection	K
>	L0L1	L0 ▾	L1 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	L1L2	L1 ▾	L2 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	L2L3	L2 ▾	L3 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	L3L4	L3 ▾	L4 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	L4L5	L4 ▾	L5 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	U0U1	U0 ▾	U1 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	U1U2	U1 ▾	U2 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	U2U3	U2 ▾	U3 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	U3U4	U3 ▾	U4 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	U4U5	U4 ▾	U5 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	L0U1	L0 ▾	U1 ▾	8.485281	8.485281	8.485281	rolled 6 x 20 ▾	Pinned ▾	0.875
	L1U1	L1 ▾	U1 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	U1L2	U1 ▾	L2 ▾	8.485281	8.485281	8.485281	rolled 6 x 20 ▾	Pinned ▾	0.875
	L2U2	L2 ▾	U2 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	L2U3	L2 ▾	U3 ▾	8.485281	8.485281	8.485281	rolled 6 x 20 ▾	Pinned ▾	0.875
	U2L3	U2 ▾	L3 ▾	8.485281	8.485281	8.485281	rolled 6 x 20 ▾	Pinned ▾	0.875
	L3U3	L3 ▾	U3 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	L3U4	L3 ▾	U4 ▾	8.485281	8.485281	8.485281	rolled 6 x 20 ▾	Pinned ▾	0.875
	L4U4	L4 ▾	U4 ▾	6	6	6	rolled 6 x 20 ▾	Pinned ▾	0.875
	U4L5	U4 ▾	L5 ▾	8.485281	8.485281	8.485281	rolled 6 x 20 ▾	Pinned ▾	0.875

New
Duplicate
Delete

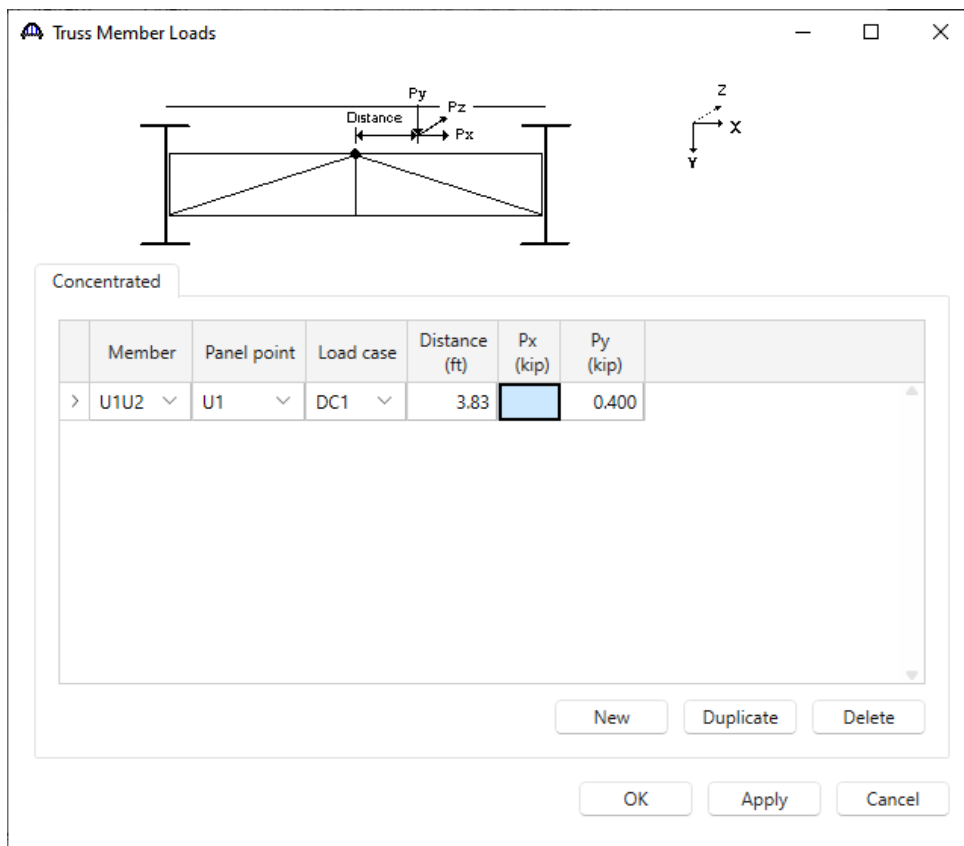
Model truss member as beam element

OK
Apply
Cancel

## T5 – Truss Enhancements



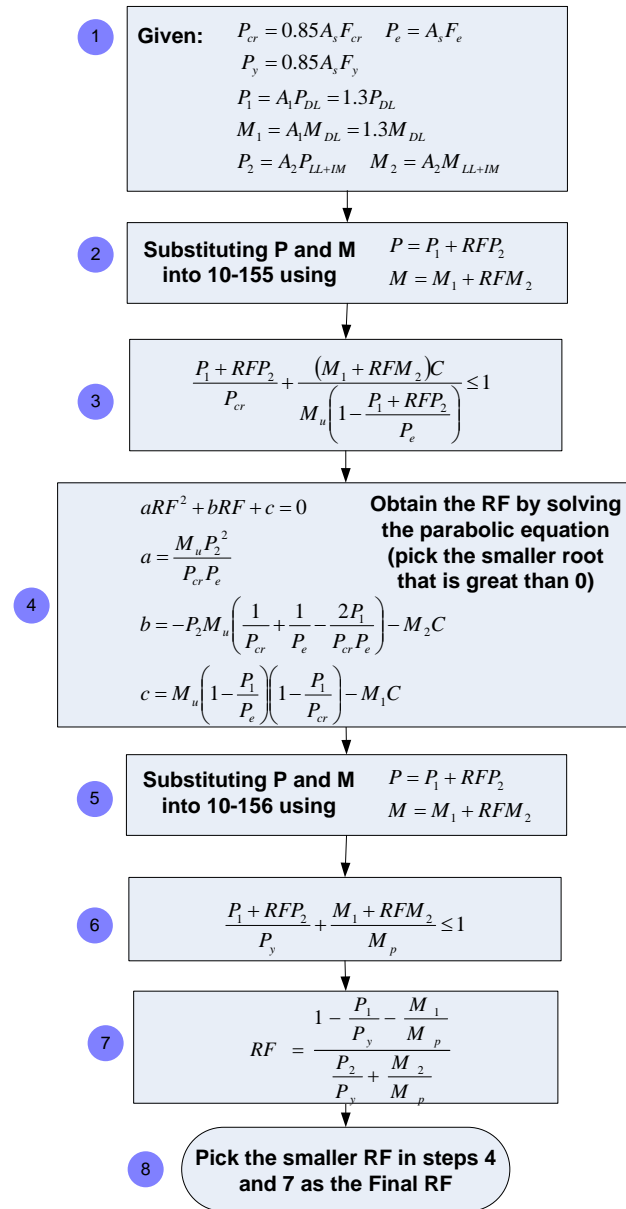
When **Model truss member as beam element** is selected, the **Truss Member Loads** window allows to enter member load to a distance from a panel point. For this example, this load will not be added.



When a floor truss is modeled using truss elements, live load analysis is performed by loading transverse load combinations on influence lines through stringer reactions. When it is modeled using beam elements, all transverse load combinations are analyzed as individual load cases, and the maximum and minimum forces are obtained by scanning the results of these individual load cases.

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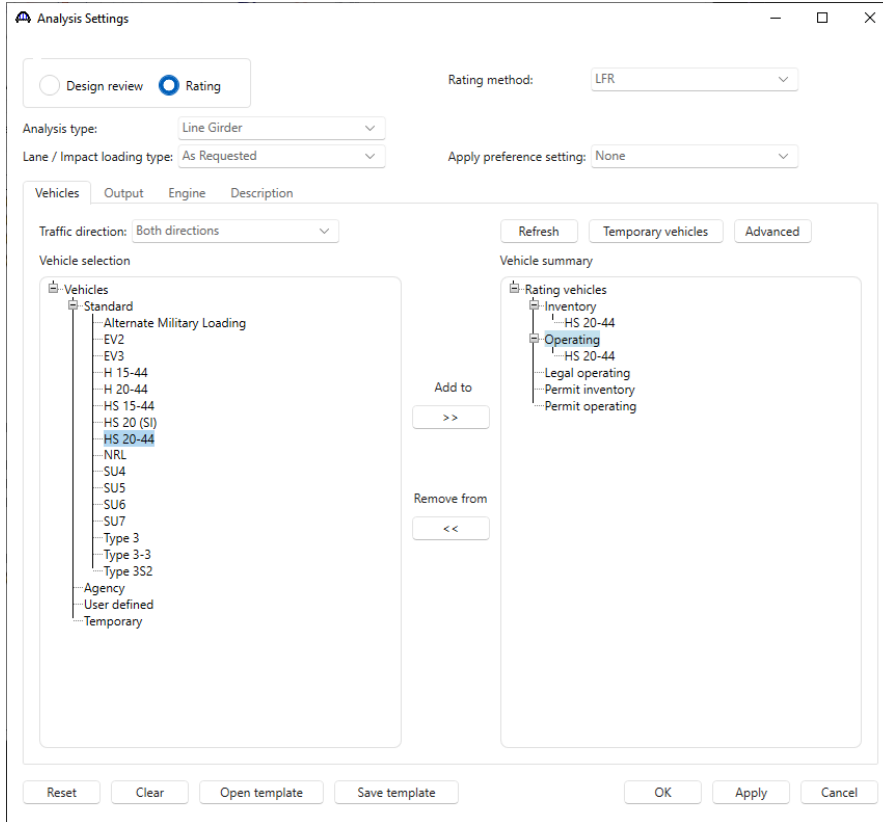
The Inventory and Operating rating factors are computed using the following flow chart. Please refer to the **Truss Method of Solution Manual** for the description of the notations.



## T5 – Truss Enhancements

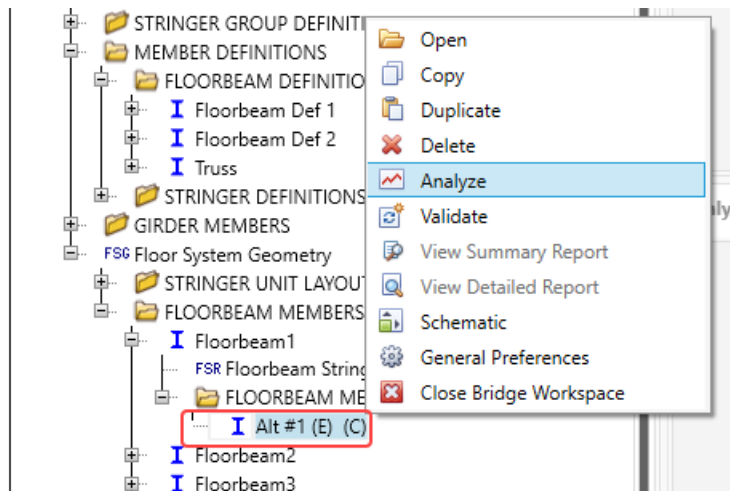
### Floor truss – Specification Check Details

BrDR includes the ability to view truss member specific specifications checks. Analyze the floor truss from before with LFR and the AASHTO HS 20-44 design truck in Inventory and Operating as shown below.



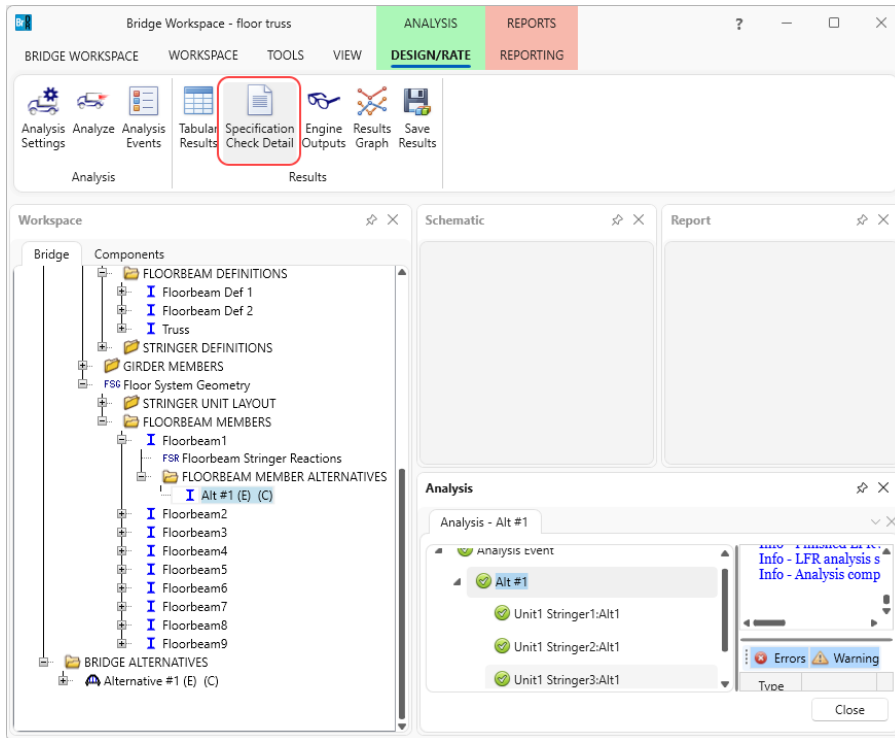
Click **OK** to apply the analysis settings and close the window.

Expand the **Floor System Geometry, FLOORBEAM MEMBERS, Floorbeam1, FLOORBEAM MEMBER ALTERNATIVES**. Right click on **Alt #1** and click **Analyze** to analyze the selected definition.

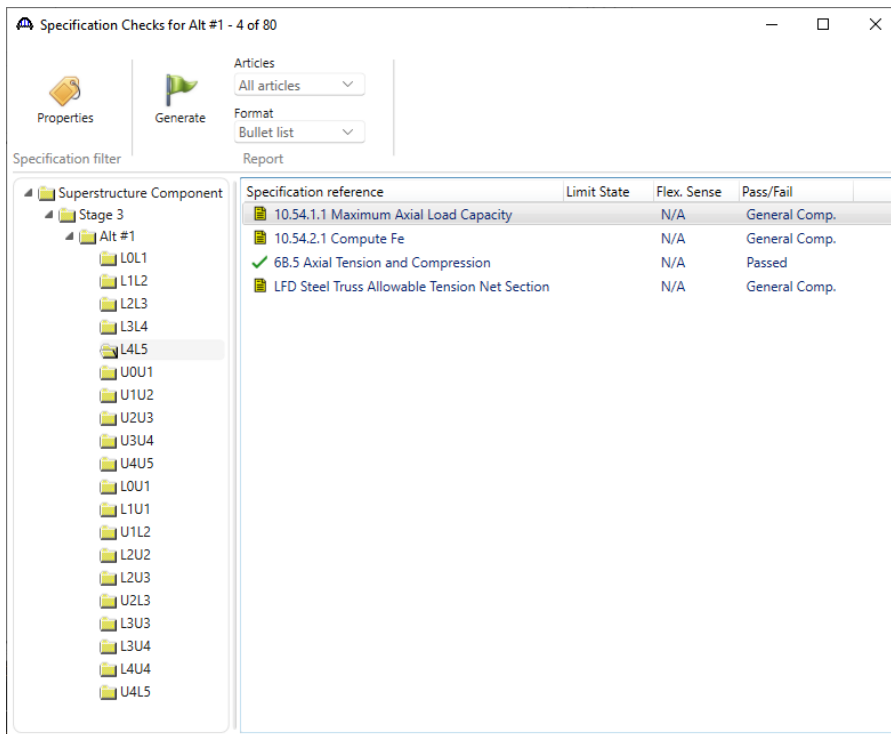


## T5 – Truss Enhancements

When the rating is finished spec check details can be reviewed by clicking the **Specification Check Detail** button on the **Results** group of the **DESIGN/RATE** ribbon.



The window shown below will open.





## T5 – Truss Enhancements

```

Spec Check Detail for 10.54.1.1 Maximum Axial Load Capacity
10 STRUCTURAL STEEL
10.54 COMPRESSION MEMBERS
10.54.1 Axial Loading
10.54.1.1 Maximum Capacity
(AASHTO Standard Specifications for Highway Bridges, Seventeenth Edition - 2002)

Steel Rolled Shape - Truss Member L4L5 (Section:rolled 6 x 20) - Center    Stage 3

Cross-section Properties:

Member Data:
-----
Web Depth = 5.4700 (in)
Web Thick = 0.2600 (in)
Web Fy    = 36.0000 (ksi)

Component          Width          Thick          Fy
          (in)          (in)          (ksi)
-----
Top Flange         6.0200         0.3650         36.0000
Bot Flange         6.0200         0.3650         36.0000

SUMMARY:

Pu = .85*As*Fcr                                (10-150)

where Pu = Maximum Axial Strength (kips)
      As = Cross-sectional area (in^2)
      Fcr = Maximum Buckling Stress (ksi)

K*Lc      (2*Pi^2*E)
IF ----- <= SQRT(-----) THEN          (10-152)
   r      ( Fy )

      [ Fy (K*Lc)^2 ]
Fcr = Fy*[1.0 - -----] (10-151)
      [ 4*Pi^2*E ( r ) ]

ELSE

      pi^2*E
Fcr = ----- (10-153)
      (K*Lc/r)^2

Y-AXIS RESULTS *****
Effective Length Factor, K = 0.8750
Length between supports, Lc = 72.0000 (in)
Radius of Gyration, r = 1.5052 (in)
    
```

OK

### Floor truss – Boundary Conditions

Before BrDR version 6.3, the supports at the four corners of a truss floorbeam was modeled as pinned supports. In the current version, the user can select the desired support conditions for the four corners.