

AASHTOWare BrDR 7.5.0

Truss Tutorial

T7 – Truss LRFD Net Area Deduction In LRFR Truss Rating Example

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BrDR Tutorial

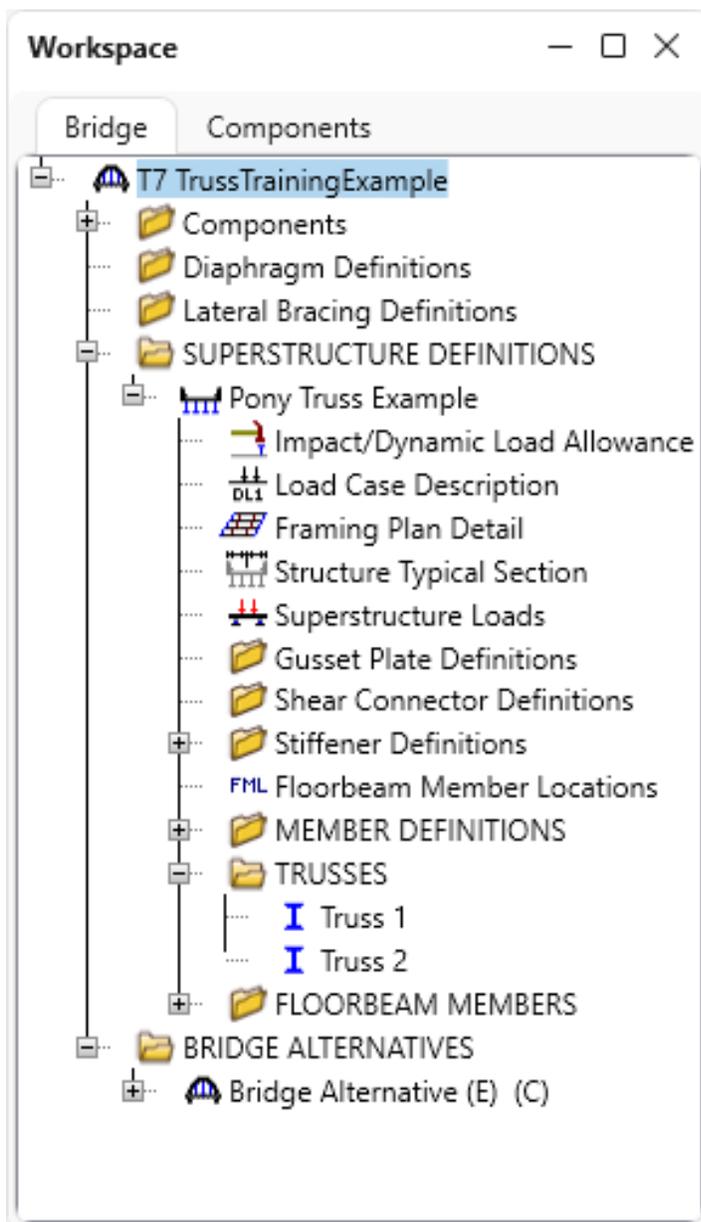
This example discusses the truss Net deduction area use in LRFD 6.8.2 to compute the tensile capacity added to input the Net deduction area to be considered for a Load and Resistance Factor Rating (LRFR) rating of trusses.

Topics Covered

- Truss command line input for LRFD Truss Net area deduction
- LRFR analysis

From the **Bridge Explorer** import the bridge given with this tutorial.

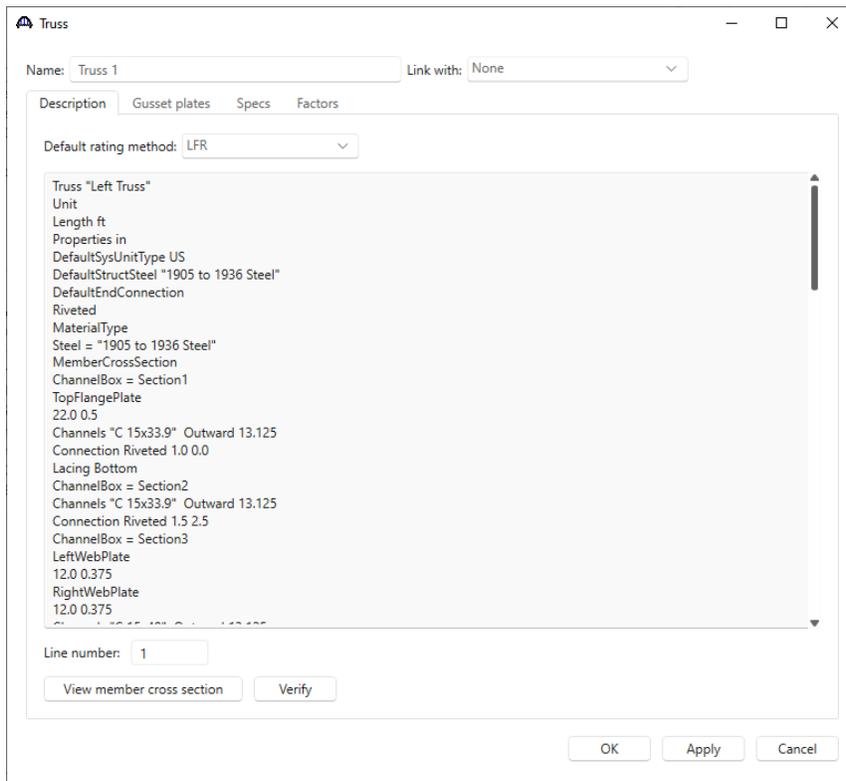
The partially expanded **Bridge Workspace** tree is shown below.



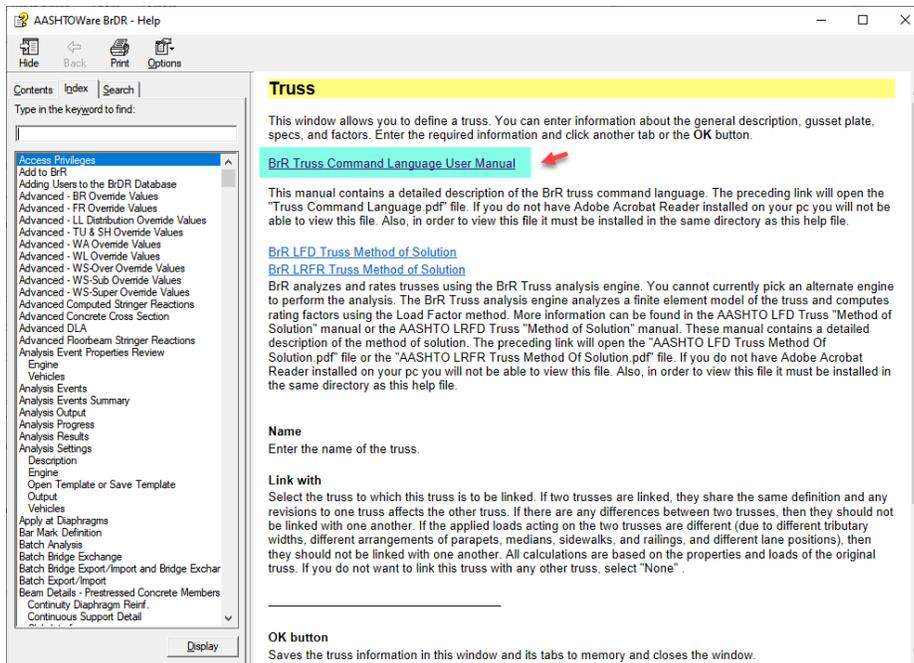
T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

Truss command line input for LRFD Truss Net area deduction

Navigate to the **TRUSSES** node and double click on **Truss 1** to open the **Truss** window as shown below.

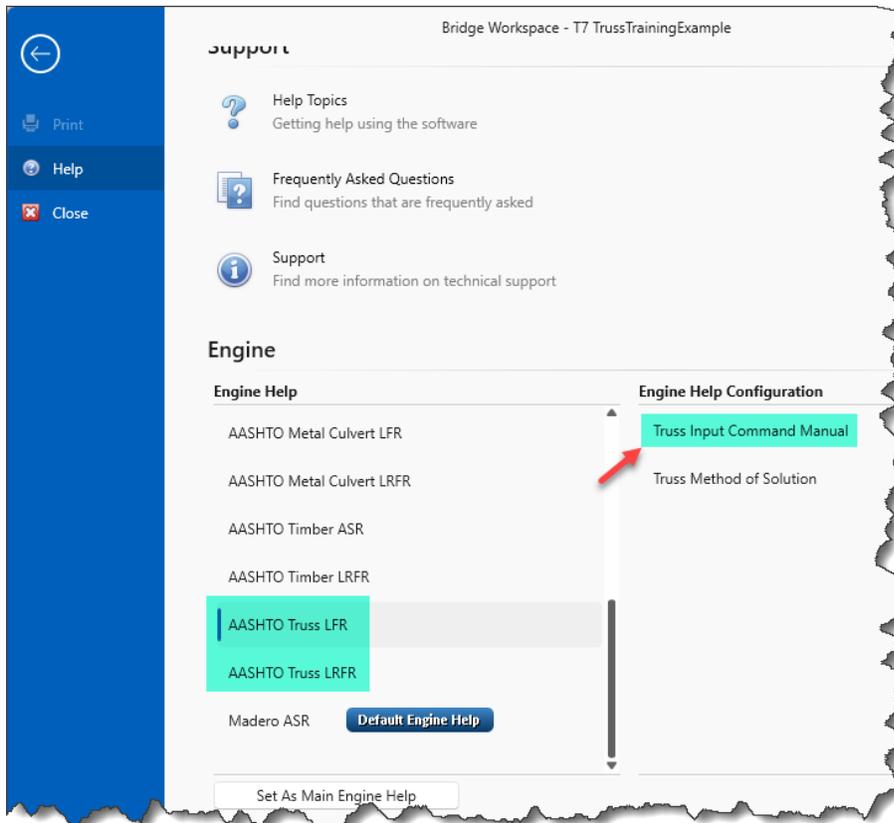


A description of the command language and its syntax is available by opening the **AASHTOWare BrDR Help** for the **Truss** window (F1) and accessing the file – **Truss Input Command Language** as shown below.



T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

It is also available from the **Bridge Workspace** as shown below.



This document describes all the input command used in defining a truss. Section 6.9 of the Truss Input Command Language manual provides the option to describe the cross section of the truss members. This option is available for all cross section types (rolled, built-up, channel box, angle box and non-detailed). Member cross section command has a set of sub commands specific to each cross section. Rolled, built-up, channel box and angle box section types provide an option to enter connection details as one of its sub commands. The detailed description of this sub command for a channel box section is shown below.

<u>Subcommand</u>	Connection <member_connection_type> <LFD_effective_area_deduction><LRFD_net_area_deduction‡>
<u>Description</u>	<member_connection_type> = Riveted Bolted Welded <LFD_effective_area_deduction> = Enter LFD effective area deduction. <LRFD_net_area_deduction> = Enter LRFD net area deduction. Note: <ol style="list-style-type: none"> 1. Sub-command name and data entries are in the same line. 2. Sub-command is optional. 3. ‡ Indicates the data entry is optional.

Figure 1 - Connection Subcommand (from Truss Input Command Language)

T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

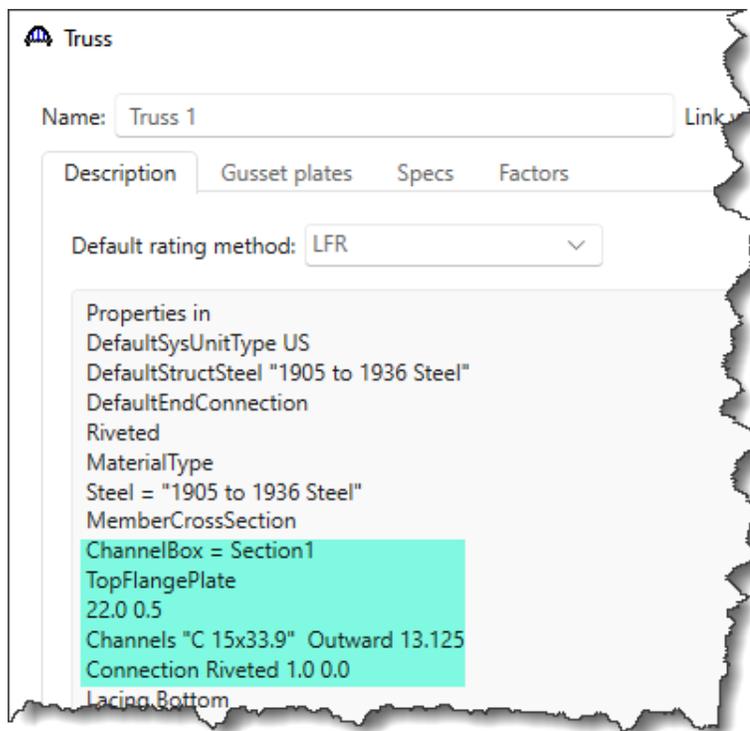
The Connection sub command is an optional command. As shown in the Figure above, this sub command consists of two mandatory entries and one optional data entry. When the Connection sub command is used, the member connection type and LFD Effective area deduction are required to be entered. However, the LRFD Net area deduction is an optional data entry. As the name suggests, the LFD Effective area deduction is used while running an LFR analysis and similarly, the LRFD Net area deduction is used for an LRFR analysis. Some points to keep in mind with these area reduction entries are as follows:

- LRFD Net area deduction being an optional entry, when not entered the LFD Effective area deduction will be used during an LRFR analysis.
- When LRFD Net area deduction is entered, even if the entered value is 0.0, this value will be used during an LRFR analysis.

To illustrate the connection details, the following cross section definitions have been modified as shown below.

1. Section 1

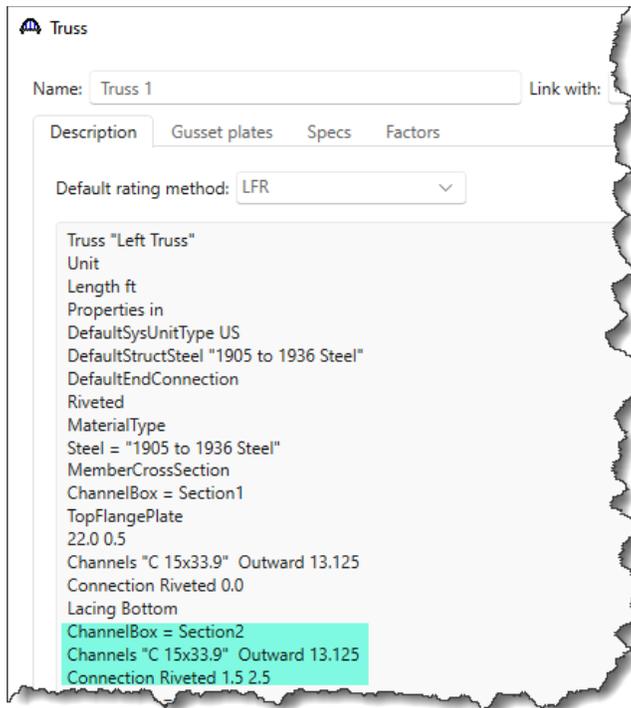
The LFD Effective area deduction is set to 1.0 and LRFD Net area deduction is set to 0.0 (see image below).



T7-Truss LRFD Net Area Deduction In LRF Truss Rating Example

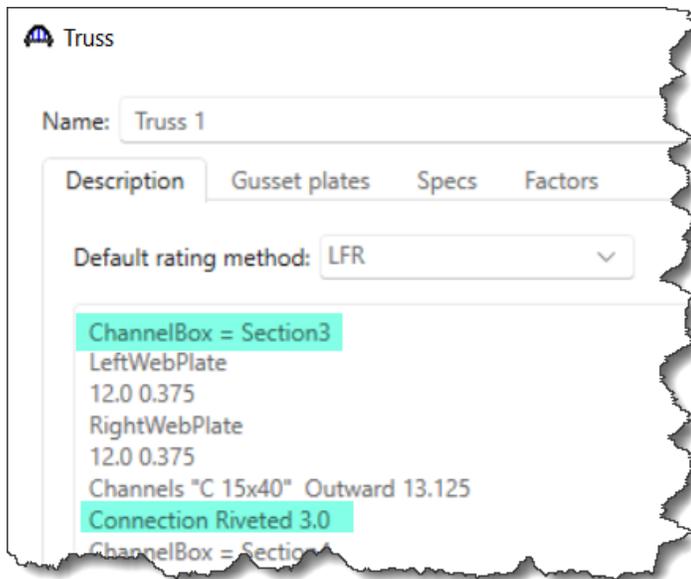
2. Section 2

The LFD Effective area deduction is set to 1.5 and LRFD Net area deduction is set to 2.5 (see image below).



3. Section 3

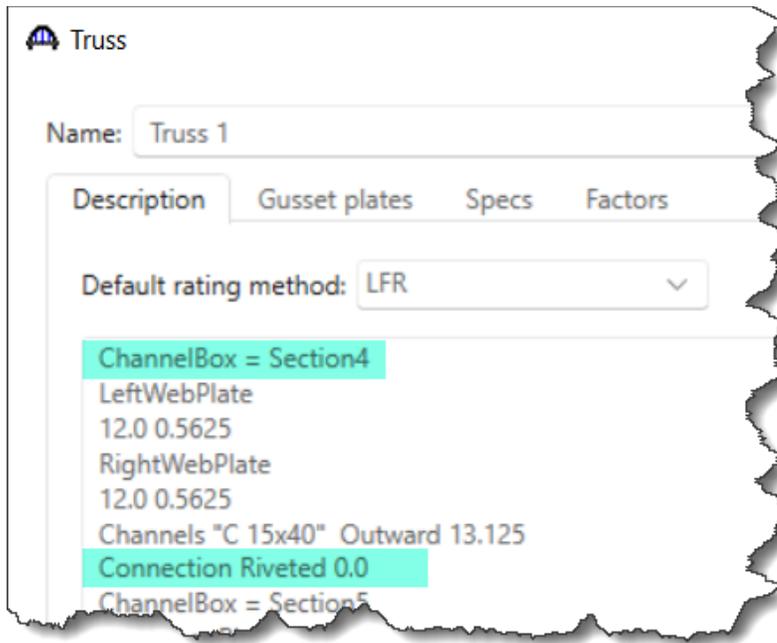
The LFD Effective area deduction is set to 3.0 and LRFD Net area deduction is not defined (see image below).



T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

4. Section 4

The LFD Effective area deduction is set to 0.0 and LRFD Net area deduction is not defined (see image below).



These cross section definitions are assigned to each member of this truss in the "Member" command as shown below.

T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

Truss

Name: Truss 1

Description Gusset plates Specs Factors

Default rating method: LFR

Member

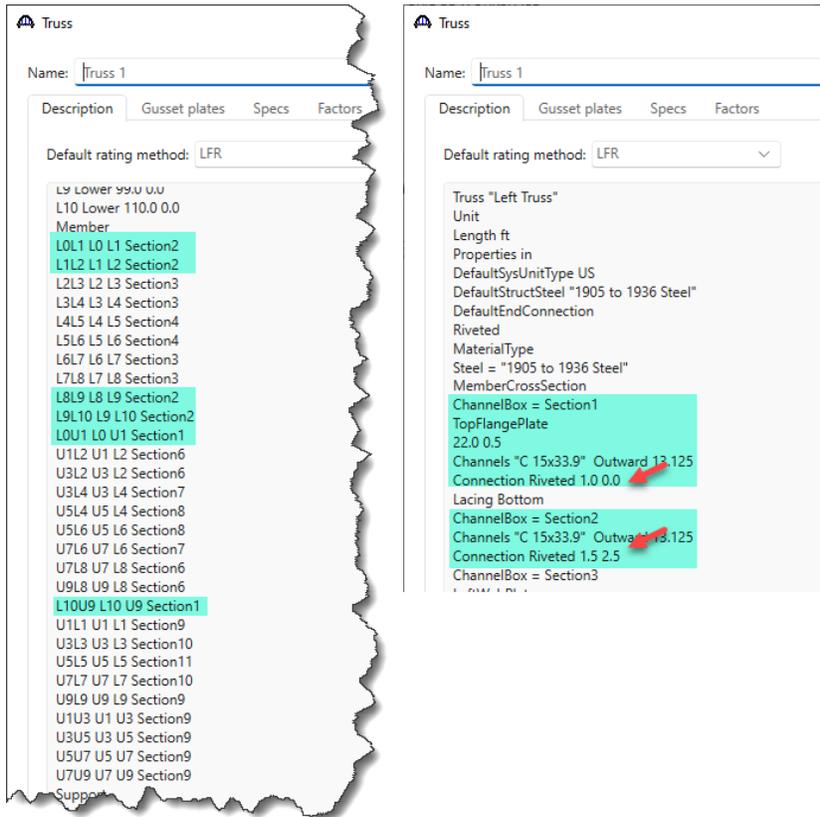
- L0L1 L0 L1 Section2
- L1L2 L1 L2 Section2
- L2L3 L2 L3 Section3
- L3L4 L3 L4 Section3
- L4L5 L4 L5 Section4
- L5L6 L5 L6 Section4
- L6L7 L6 L7 Section3
- L7L8 L7 L8 Section3
- L8L9 L8 L9 Section2
- L9L10 L9 L10 Section2
- L0U1 L0 U1 Section1
- U1L2 U1 L2 Section6
- U3L2 U3 L2 Section6
- U3L4 U3 L4 Section7
- U5L4 U5 L4 Section8
- U5L6 U5 L6 Section8
- U7L6 U7 L6 Section7
- U7L8 U7 L8 Section6
- U9L8 U9 L8 Section6
- L10U9 L10 U9 Section1
- U1L1 U1 L1 Section9
- U3L3 U3 L3 Section10
- U5L5 U5 L5 Section11
- U7L7 U7 L7 Section10
- U9L9 U9 L9 Section9
- U1U3 U1 U3 Section9
- U3U5 U3 U5 Section9
- U5U7 U5 U7 Section9
- U7U9 U7 U9 Section9

Support

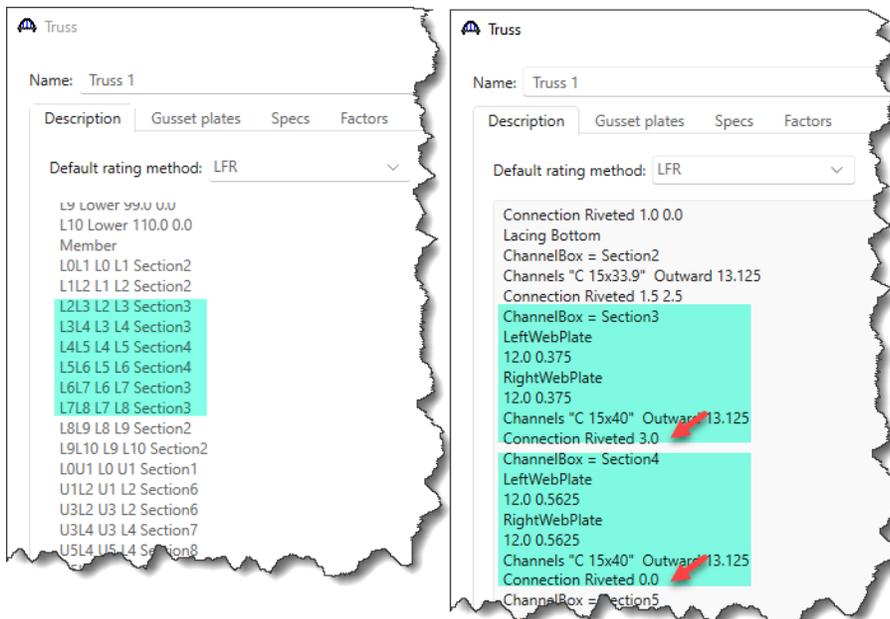
Member: 13

T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

In this example, the LRFD Net area deduction has been defined for Section1 and Section2. Members using these cross section definitions are shown below.



Members L2L3, L3L4, L6L7 and L7L8 use Section3 and members L4L5 and L5L6 use Section4. These sections have connection details defined as Riveted with the LFD Effective area deduction entered and LRFD Net area deduction not entered. (see image below).



T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

LRFR Analysis

Perform an LRFR rating on **Truss 1** using the analysis settings shown below.

The screenshot shows the 'Analysis Settings' dialog box with the following configuration:

- Design review** (radio button) is unselected, and **Rating** (radio button) is selected.
- Rating method:** LRFR (dropdown menu)
- Analysis type:** Line Girder (dropdown menu)
- Lane / Impact loading type:** As Requested (dropdown menu)
- Apply preference setting:** None (dropdown menu)

The **Vehicles** tab is active, showing a tree view of vehicle selection and a summary of rating vehicles.

Traffic direction: Both directions (dropdown menu)

Vehicle selection:

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

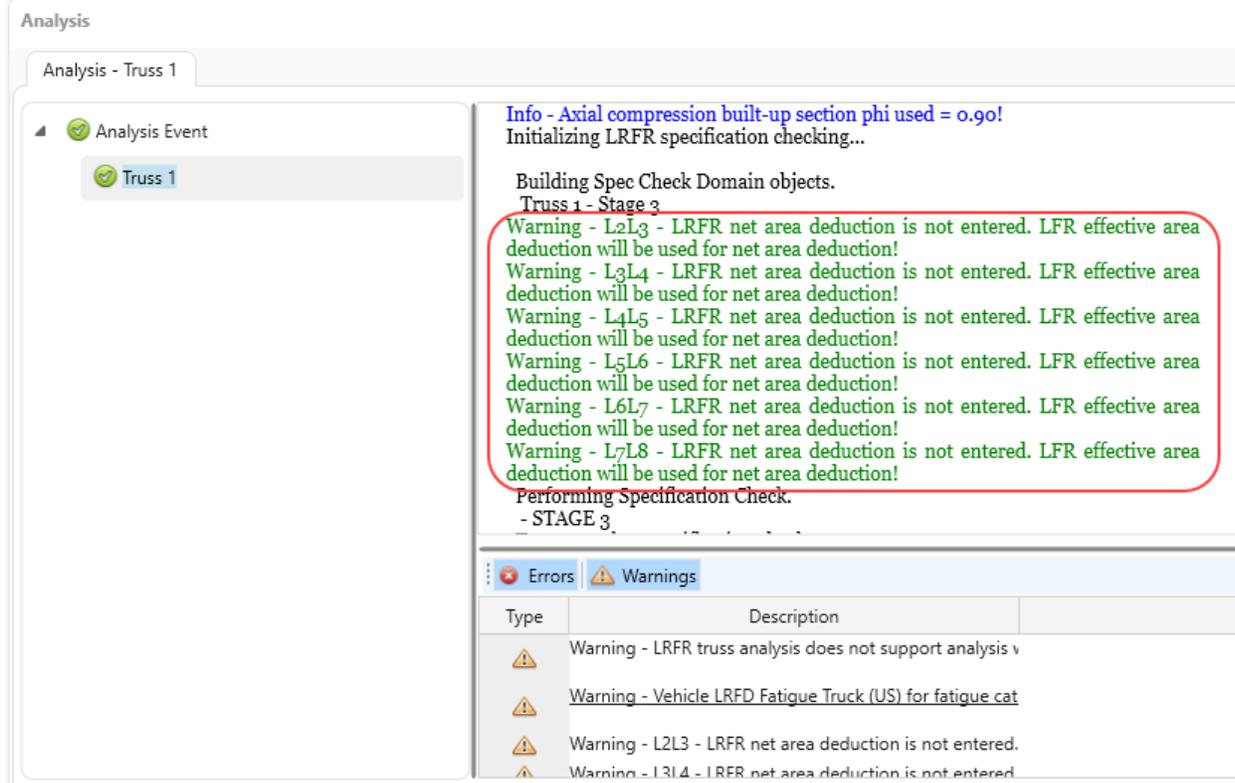
Vehicle summary:

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

Buttons at the bottom: Reset, Clear, Open template, Save template, OK, Apply, Cancel.

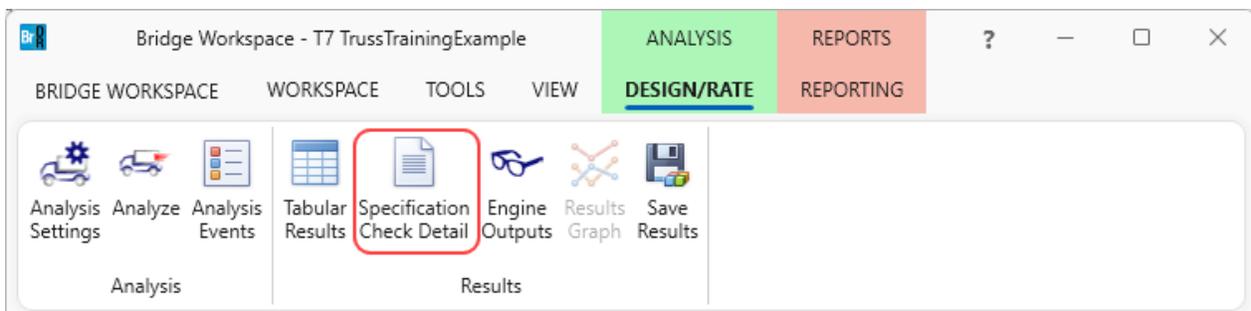
T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

During the analysis, the Analysis window displays the ongoing analysis events, error messages (if any) and warning messages (if any). It is to be noted that during an LRFR analysis, for members whose cross section with connection details defined, LRFD Net area deduction not entered, and only the LFD Effective area deduction entered, a warning message is shown (see image below) to let users know that the LFD Effective area will be used instead.



Specification Check Detail

When the Rating analysis is completed, specification check detail can be reviewed by selecting the **Truss 1** member in the **Bridge Workspace** tree and clicking the **Specification Check Detail** button from the **Results** group of the ribbon.



T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

In the Specification check detail window, click on member L0L1 and from the list of specification articles for this member, double click on article 6.8.2 Tensile Resistance. The Net area deduction used for this member is 2.5 in^2 i.e., the LRFD Net area deduction entered for Section2.

Spec Check Detail for 6.8.2 Tensile Resistance

6 Steel Structures
 6.8 Tension Members
 6.8.2 Tensile Resistance
 (AASHTO LRFD Bridge Design Specifications, Ninth Edition)

Steel Channel Box - Truss Member L0L1 (Section:Section2) - Start Stage 3

BOX MEMBER	b (in)	t (in)	Fy (ksi)	Fu (ksi)
Left Channel Flange 1	3.400	0.650	30.0	60.0
Left Channel Flange 2	3.400	0.650	30.0	60.0
Left Channel Web	12.140	0.400	30.0	60.0
Right Channel Flange 1	3.400	0.650	30.0	60.0
Right Channel Flange 2	3.400	0.650	30.0	60.0
Right Channel Web	12.140	0.400	30.0	60.0

Punched Holes : No
 Phiy = 0.95
 Phiu = 0.80
 Rp = 1.00
 Fu = 60.00 (ksi)
 Fy = 30.00 (ksi)
 Ag = 19.92 (in²)
Net area deduction = 2.50 (in²)
 Net Area, An = Ag - Net area deduction = 17.42 (in²)
 Connected Element = Channel Webs
 A_connected = 10.96 (in²)
 U_table = 0.7000 (Table 6.8.2.2-1 Case 7)
 U_min = 0.5502
 U = max(U_table, U_min) = 0.7000

$\bar{P}_{ny} = \phi_y P_{ny} = \phi_y F_y A_g$ (6.8.2.1-1)
 $\bar{P}_{nu} = \phi_u P_{nu} = \phi_u F_u A_n R_p U$ (6.8.2.1-2)
 \bar{R}_r (6.13.4-1)

Phiy*Pny = 567.72 (kip)
 Phiu*Pnu = 585.31 (kip)

Pr = 567.72 (kip)

Load Combination Legend:

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

T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

Similarly, for member LOU1 using Section1, the Net area deduction value is 0.0 in² as this is the entered LRFD Net area deduction value (see image below).

Spec Check Detail for 6.8.2 Tensile Resistance

6 Steel Structures
 6.8 Tension Members
 6.8.2 Tensile Resistance
 (AASHTO LRFD Bridge Design Specifications, Ninth Edition)

Steel Channel Box - Truss Member LOU1 (Section:Section1) - Start Stage 3

BOX MEMBER				
Element	b (in)	t (in)	Fy (ksi)	Fu (ksi)
Left Channel Flange 1	3.400	0.650	30.0	60.0
Left Channel Flange 2	3.400	0.650	30.0	60.0
Left Channel Web	12.140	0.400	30.0	60.0
Right Channel Flange 1	3.400	0.650	30.0	60.0
Right Channel Flange 2	3.400	0.650	30.0	60.0
Right Channel Web	12.140	0.400	30.0	60.0
Top Flange Pl	22.000	0.500	30.0	60.0

Punched Holes : No
 Phi_y = 0.95
 Phi_u = 0.80
 R_p = 1.00
 F_u = 60.00 (ksi)
 F_y = 30.00 (ksi)
 A_g = 30.92 (in²)
Net area deduction = 0.00 (in²)
 Net Area, A_n = A_g - Net area deduction = 30.92 (in²)
 Connected Element = Channel Webs
 A_{connected} = 10.96 (in²)
 U_{table} = 0.7000 (Table 6.8.2.2-1 Case 7)
 U_{min} = 0.3545
 U = max(U_{table}, U_{min}) = 0.7000

$$Pr = \min \left[\begin{array}{l} \frac{Phi_y * P_{ny}}{Phi_u * P_{nu}} = \frac{Phi_y * F_y * A_g}{Phi_u * F_u * A_n * R_p * U} \quad (6.8.2.1-1) \\ \frac{P_{ny}}{P_{nu}} \quad (6.13.4-1) \end{array} \right]$$

Phi_y*P_{ny} = 881.22 (kip)
 Phi_u*P_{nu} = 1038.91 (kip)
 Pr = 881.22 (kip)

Load Combination Legend:

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

T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

Shown below are examples of members using Section3 and Section4, where the LRFD Net area deduction was not entered, resulting in applying the LFD Effective area deduction.

Section3 – LFD Net area deduction = 3.0, Section4 – LFD Effective area deduction = 0.0.

Spec Check Detail for 6.8.2 Tensile Resistance

6 Steel Structures
6.8 Tension Members
6.8.2 Tensile Resistance
(AASHTO LRFD Bridge Design Specifications, Ninth Edition)

Steel Channel Box - Truss Member L2L3 (Section:Section3) - Start Stage 3

BOX MEMBER	b (in)	t (in)	Fy (ksi)	Fu (ksi)
Left Channel Flange 1	3.520	0.650	30.0	60.0
Left Channel Flange 2	3.520	0.650	30.0	60.0
Left Channel Web	12.140	0.520	30.0	60.0
Right Channel Flange 1	3.520	0.650	30.0	60.0
Right Channel Flange 2	3.520	0.650	30.0	60.0
Right Channel Web	12.140	0.520	30.0	60.0
Left Web Fl	12.000	0.375	30.0	60.0
Right Web Fl	12.000	0.375	30.0	60.0

Punched Holes : No
 Phiy = 0.95
 Phiu = 0.80
 Rp = 1.00
 Fu = 60.00 (ksi)
 Fy = 30.00 (ksi)
 Ag = 32.60 (in^2)
Net area deduction = 3.00 (in^2)
 Net Area, An = Ag - Net area deduction = 29.60 (in^2)
 Connected Element = Channel Webs
 A_connected = 23.25 (in^2)
 U_table = 0.7000 (Table 6.8.2.2-1 Case 7)
 U_min = 0.7131
 U = max(U_table, U_min) = 0.7131

Pr = min(Phiy*Fny = Phiy*Fy*Ag, (6.8.2.1-1)
 Phiu*Fnu = Phiu*Fu*An*Rp*U, (6.8.2.1-2)
 Rr, (6.13.4-1)

Phiy*Fny = 929.10 (kip)
 Phiu*Fnu = 1013.21 (kip)
 Pr = 929.10 (kip)

Spec Check Detail for 6.8.2 Tensile Resistance

6 Steel Structures
6.8 Tension Members
6.8.2 Tensile Resistance
(AASHTO LRFD Bridge Design Specifications, Ninth Edition)

Steel Channel Box - Truss Member L4L5 (Section:Section4) - Start Stage 3

BOX MEMBER	b (in)	t (in)	Fy (ksi)	Fu (ksi)
Left Channel Flange 1	3.520	0.650	30.0	60.0
Left Channel Flange 2	3.520	0.650	30.0	60.0
Left Channel Web	12.140	0.520	30.0	60.0
Right Channel Flange 1	3.520	0.650	30.0	60.0
Right Channel Flange 2	3.520	0.650	30.0	60.0
Right Channel Web	12.140	0.520	30.0	60.0
Left Web Fl	12.000	0.563	30.0	60.0
Right Web Fl	12.000	0.563	30.0	60.0

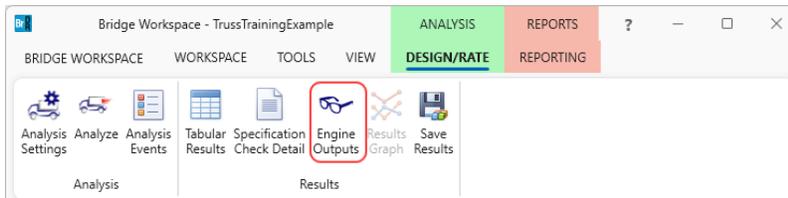
Punched Holes : No
 Phiy = 0.95
 Phiu = 0.80
 Rp = 1.00
 Fu = 60.00 (ksi)
 Fy = 30.00 (ksi)
 Ag = 37.10 (in^2)
Net area deduction = 0.00 (in^2)
 Net Area, An = Ag - Net area deduction = 37.10 (in^2)
 Connected Element = Channel Webs
 A_connected = 27.75 (in^2)
 U_table = 0.7000 (Table 6.8.2.2-1 Case 7)
 U_min = 0.7479
 U = max(U_table, U_min) = 0.7479

Pr = min(Phiy*Fny = Phiy*Fy*Ag, (6.8.2.1-1)
 Phiu*Fnu = Phiu*Fu*An*Rp*U, (6.8.2.1-2)
 Rr, (6.13.4-1)

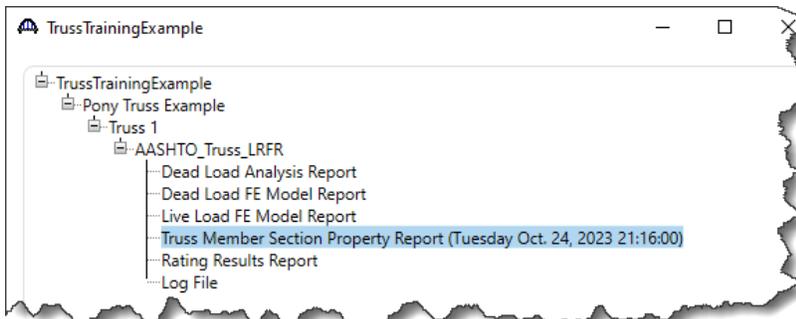
Phiy*Fny = 1057.35 (kip)
 Phiu*Fnu = 1331.90 (kip)
 Pr = 1057.35 (kip)

Engine Outputs

After the analysis, the output files can be viewed by clicking the **Engine Outputs** button from the **Results** group of the ribbon.



The **Truss Member Section Property Report** contains data related to the computed and user input truss member section properties. (see image below).



T7-Truss LRFD Net Area Deduction In LRFR Truss Rating Example

The summary table displays the gross area (compression and tension) and Net area (tension) for each member. The Net area displayed is calculated based on the area deduction values entered in the connection details for each member. Highlighted below are some examples of the computed Net area deduction value.

Truss Member Section Property Report

Truss Member Section Property Summary

Member	Gross Area Comp. (in ²)	Gross Area Tens. (in ²)	Net Area Tens. (in ²)	Izz (in ⁴)	Cy (in)	Rz (in)	Iyy (in ⁴)	Cz (in)	Ry (in)	Actual Length (ft)	Unbraced Length z (ft)	Unbraced Length y (ft)	Fy (ksi)	
L0L1	19.92	19.92	17.42	630.00	7.50	5.62	1092.24	6.56	7.40	11.00	11.00	11.00	30.00	Section2
L1L2	19.92	19.92	17.42	630.00	7.50	5.62	1092.24	6.56	7.40	11.00	11.00	11.00	30.00	LFD = 1.5 LRFD = 2.5
L2L3	32.60	32.60	29.60	806.00	7.50	4.97	1655.62	6.56	7.13	11.00	11.00	11.00	30.00	Section3
L3L4	32.60	32.60	29.60	806.00	7.50	4.97	1655.62	6.56	7.13	11.00	11.00	11.00	30.00	LFD = 3.0 LRFD = no entry
L4L5	37.10	37.10	37.10	860.00	7.50	4.81	1822.74	6.56	7.01	11.00	11.00	11.00	30.00	Section4
L5L6	37.10	37.10	37.10	860.00	7.50	4.81	1822.74	6.56	7.01	11.00	11.00	11.00	30.00	LFD = 0.0 LRFD = no entry
L6L7	32.60	32.60	29.60	806.00	7.50	4.97	1655.62	6.56	7.13	11.00	11.00	11.00	30.00	
L7L8	32.60	32.60	29.60	806.00	7.50	4.97	1655.62	6.56	7.13	11.00	11.00	11.00	30.00	
L8L9	19.92	19.92	17.42	630.00	7.50	5.62	1092.24	6.56	7.40	11.00	11.00	11.00	30.00	
L9L10	19.92	19.92	17.42	630.00	7.50	5.62	1092.24	6.56	7.40	11.00	11.00	11.00	30.00	
U1U3	19.10	19.10	19.10	533.00	6.06	5.28	174.00	0.00	3.02	22.20	22.20	22.20	30.00	
U3U5	19.10	19.10	19.10	533.00	6.06	5.28	174.00	0.00	3.02	22.02	22.02	22.02	30.00	
U5U7	19.10	19.10	19.10	533.00	6.06	5.28	174.00	0.00	3.02	22.02	22.02	22.02	30.00	
U7U9	19.10	19.10	19.10	533.00	6.06	5.28	174.00	0.00	3.02	22.20	22.20	22.20	30.00	
U1L1	19.10	19.10	19.10	533.00	6.06	5.28	174.00	0.00	3.02	11.00	11.00	11.00	30.00	
U3L3	20.58	20.58	20.58	539.00	6.00	5.12	180.70	0.00	2.96	14.00	14.00	14.00	30.00	
U5L5	22.35	22.35	22.35	560.20	6.00	5.01	187.50	0.00	2.90	15.00	15.00	15.00	30.00	
U7L7	20.58	20.58	20.58	539.00	6.00	5.12	180.70	0.00	2.96	14.00	14.00	14.00	30.00	
U9L9	19.10	19.10	19.10	533.00	6.06	5.28	174.00	0.00	3.02	11.00	11.00	11.00	30.00	
L0U1	30.92	30.92	30.92	1055.87	10.26	5.84	1535.91	6.56	7.05	15.56	15.56	15.56	30.00	Section1
U1L2	16.18	16.18	16.18	432.50	6.00	5.17	84.30	0.00	2.28	15.56	15.56	15.56	30.00	LFD = 1.0 LRFD = 0.0
U3L2	16.18	16.18	16.18	432.50	6.00	5.17	84.30	0.00	2.28	17.80	17.80	17.80	30.00	
U3L4	9.99	9.99	9.99	238.10	6.01	4.88	21.00	0.00	1.45	17.80	17.80	17.80	30.00	
U5L4	11.80	11.80	11.80	310.00	5.97	5.13	44.10	0.00	1.93	18.60	18.60	18.60	30.00	
U5L6	11.80	11.80	11.80	310.00	5.97	5.13	44.10	0.00	1.93	18.60	18.60	18.60	30.00	
U7L6	9.99	9.99	9.99	238.10	6.01	4.88	21.00	0.00	1.45	17.80	17.80	17.80	30.00	
U7L8	16.18	16.18	16.18	432.50	6.00	5.17	84.30	0.00	2.28	17.80	17.80	17.80	30.00	
U9L8	16.18	16.18	16.18	432.50	6.00	5.17	84.30	0.00	2.28	15.56	15.56	15.56	30.00	
L10U9	30.92	30.92	30.92	1055.87	10.26	5.84	1535.91	6.56	7.05	15.56	15.56	15.56	30.00	