Truss Tutorial

Truss Gusset Plate Example

TPG1-Truss Gusset Plate Example

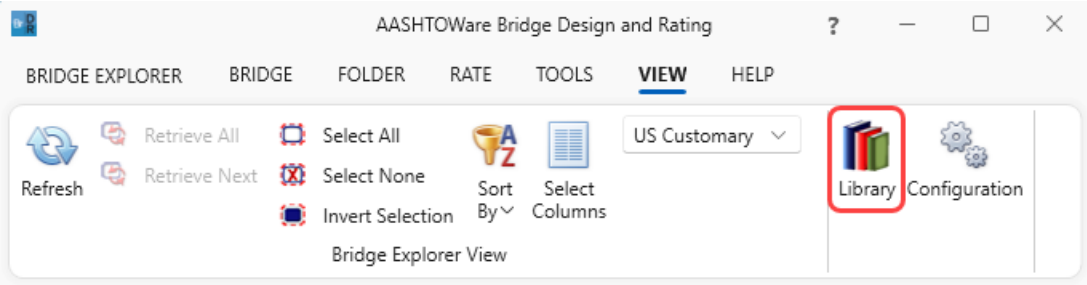
BrDR Tutorial

Topics Covered

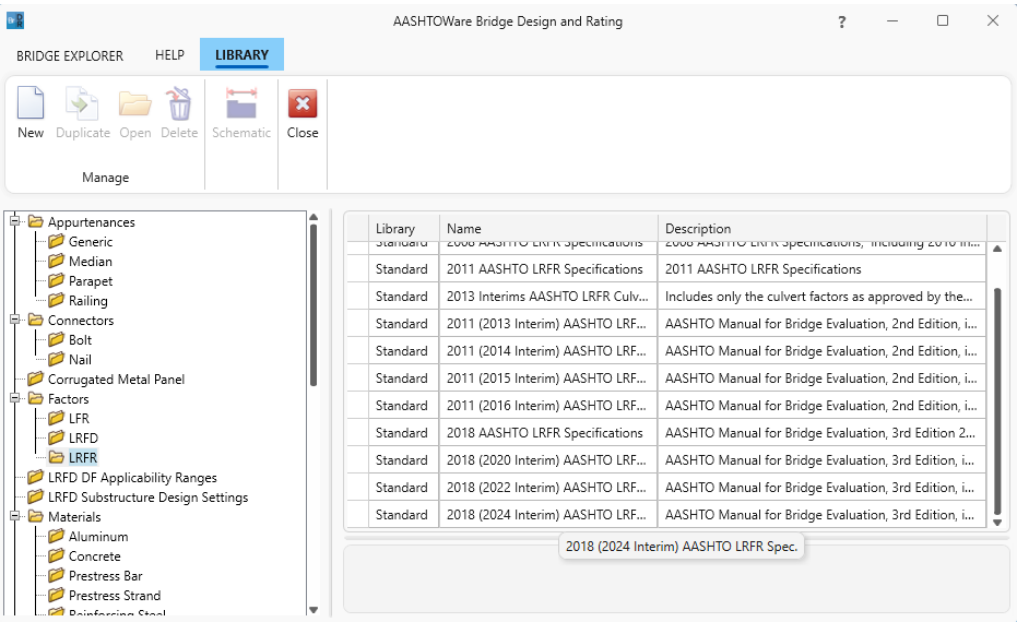
- Gusset plate LRFR factors and LFR factors
- Enter a gusset plate definition
- Assign a gusset plate definition at a panel point
- Perform truss rating with gusset plates and review the results
- Using Manual for Bridge Evaluation, 3rd Edition with 2024 interims
- Using AASHTO LRFD Bridge Design Specifications, 10th Edition

Gusset plate LRFR factors and LFR factors

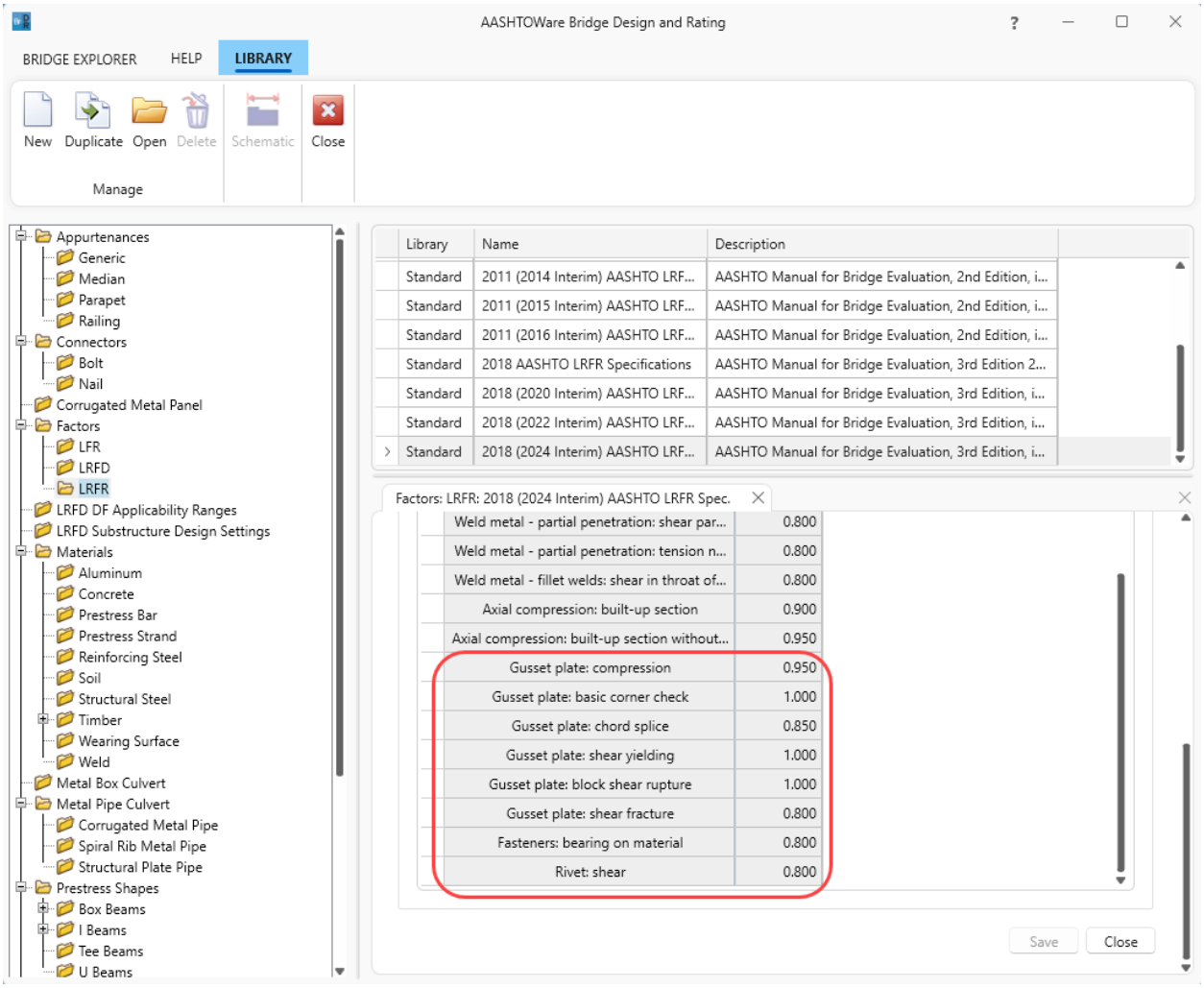
Start BrDR and open the **Library** from the **VIEW** ribbon as shown below.



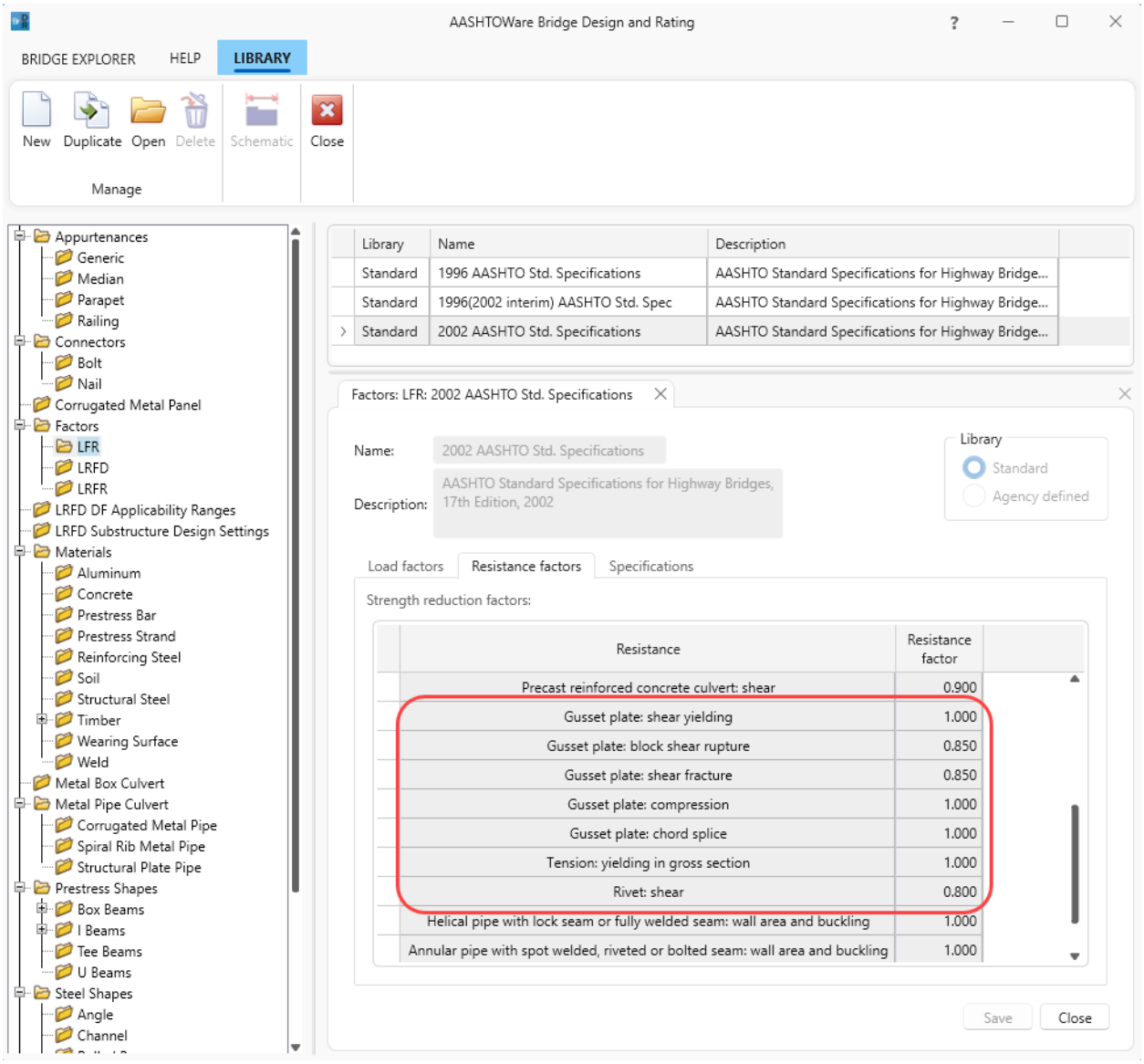
Select the **LRFR** node under **Factors** to view all the **Standard** LRFR factors as shown below.



Double click on the **2018 (2024 interim) AASHTO LRFR Spec**. to open the following window and select the **Steel** tab. The gusset plate LRFR resistance factors are listed at the bottom of the table.

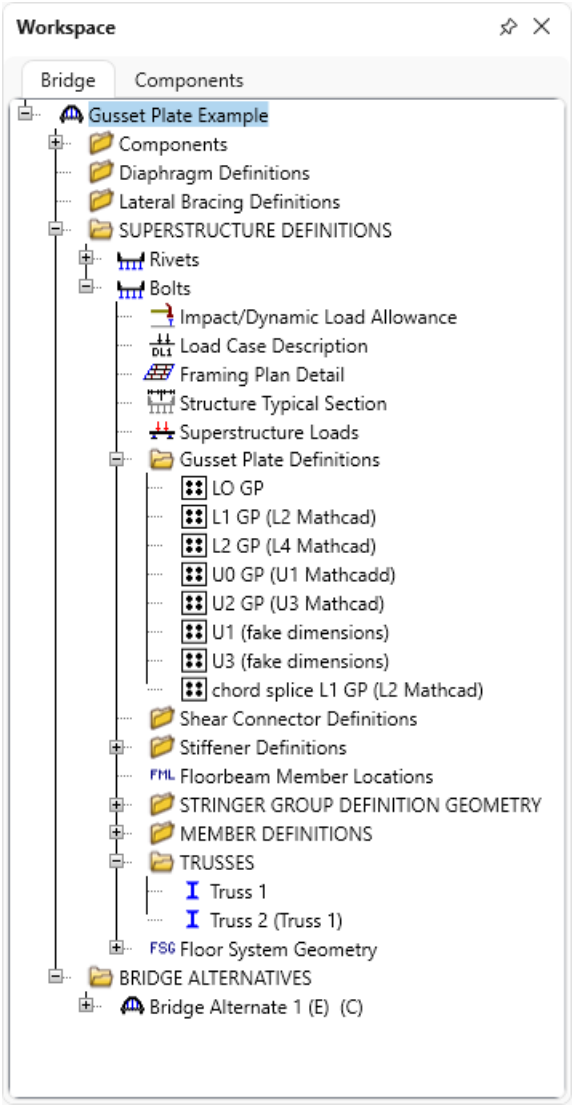

AASHTOWare Bridge Design and Rating
BRIDGE EXPLORER
HELP
LIBRARY
New
Duplicate
Open
Delete
Schematic
Close
Manage
Appurtenances
Generic
Median
Parapet
Railing
Connectors
Bolt
Nail
Corrugated Metal Panel
Factors
LFR
LRFD
LRFR
LRFD DF Applicability Ranges
LRFD Substructure Design Settings
Materials
Aluminum
Concrete
Prestress Bar
Prestress Strand
Reinforcing Steel
Soil
Structural Steel
Timber
Wearing Surface
Weld
Metal Box Culvert
Metal Pipe Culvert
Corrugated Metal Pipe
Spiral Rib Metal Pipe
Structural Plate Pipe
Prestress Shapes
Box Beams
I Beams
Tee Beams
U Beams
Library
Name
Description
Standard
2011 (2014 Interim) AASHTO LRF...
AASHTO Manual for Bridge Evaluation, 2nd Edition, i...
Standard
2011 (2015 Interim) AASHTO LRF...
AASHTO Manual for Bridge Evaluation, 2nd Edition, i...
Standard
2011 (2016 Interim) AASHTO LRF...
AASHTO Manual for Bridge Evaluation, 2nd Edition, i...
Standard
2018 AASHTO LRFR Specifications
AASHTO Manual for Bridge Evaluation, 3rd Edition 2...
Standard
2018 (2020 Interim) AASHTO LRF...
AASHTO Manual for Bridge Evaluation, 3rd Edition, i...
Standard
2018 (2022 Interim) AASHTO LRF...
AASHTO Manual for Bridge Evaluation, 3rd Edition, i...
Standard
2018 (2024 Interim) AASHTO LRF...
AASHTO Manual for Bridge Evaluation, 3rd Edition, i...
Factors: LRFR: 2018 (2024 Interim) AASHTO LRFR Spec.
Weld metal - partial penetration: shear par...
0.800
Weld metal - partial penetration: tension n...
0.800
Weld metal - fillet welds: shear in throat of...
0.800
Axial compression: built-up section
0.900
Axial compression: built-up section without...
0.950
Gusset plate: compression
0.950
Gusset plate: basic corner check
1.000
Gusset plate: chord splice
0.850
Gusset plate: shear yielding
1.000
Gusset plate: block shear rupture
1.000
Gusset plate: shear fracture
0.800
Fasteners: bearing on material
0.800
Rivet: shear
0.800
Save
Close

Similarly, click on **LFR** to view the LFR standard factors. Double click on the **2002 AASHTO Std. Specifications** to open the following window and select the **Resistance factors** tab. The gusset plate LFR resistance factors are listed in the table as shown below.



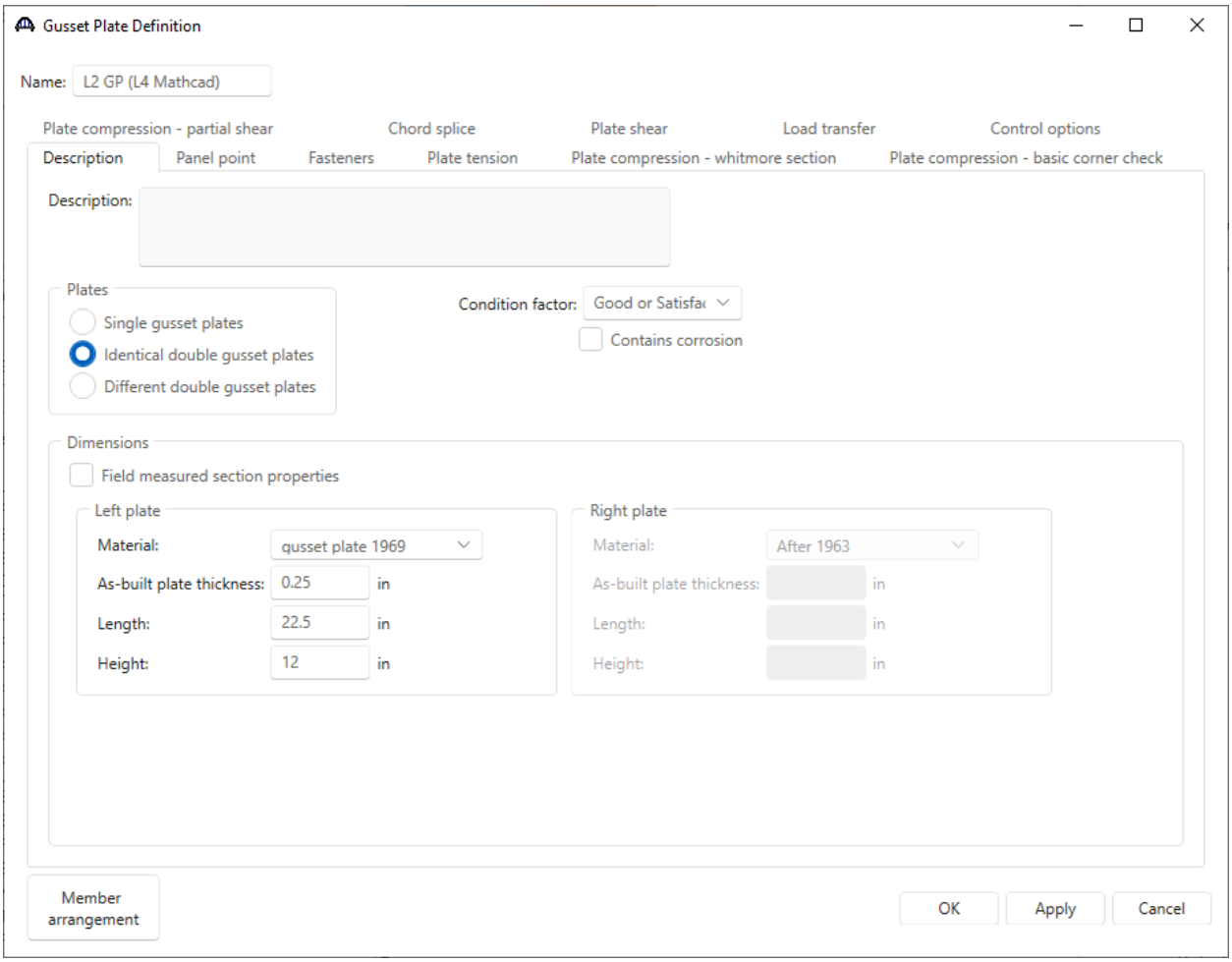
Enter gusset plate definition

From the **Bridge Explorer**, double click on **BID 28 Gusset Plate Example** to open this bridge. Expand **Bolts** Superstructure definition and the **Gusset Plate Definitions** node in the **Bridge Workspace** tree as shown below.



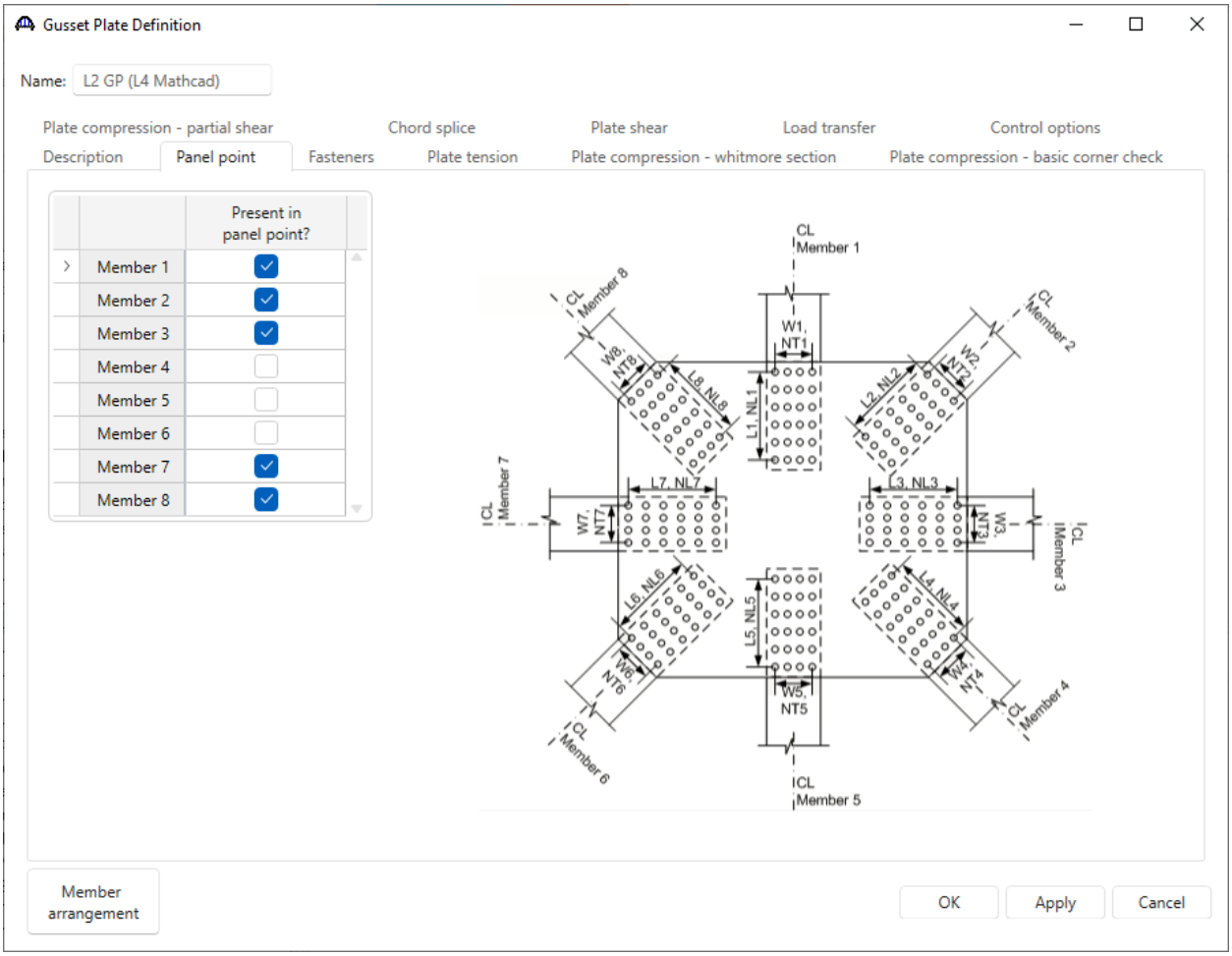
Gusset Plate Definition - Description

Double click on the **L2 GP (L4 Mathcad)** to open the **Gusset Plate Definition** window. **Identical double gusset plates** is selected for this gusset plate definition and the **Material** and **Dimensions** are entered for the **Left plate**. **Left plate** is the plate on the left side of the connection when looking stations ahead. **Right plate** is the plate on the right side of the connection when looking stations ahead. If **Different double gusset plates is selected**, the right plate details must be entered. If **Identical double gusset plates is selected** and **Contains corrosion** is checked, the right plate details must be entered.



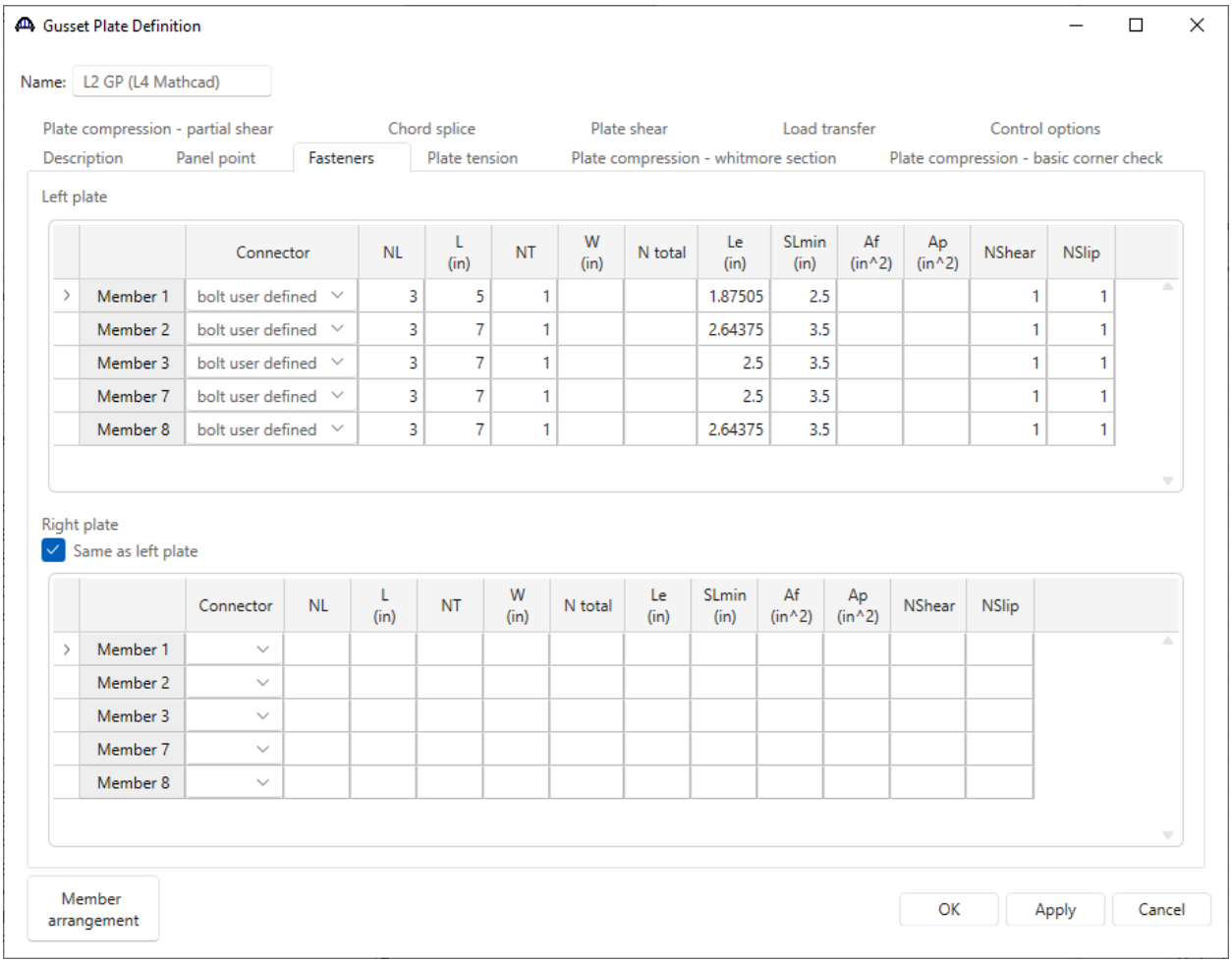
Gusset Plate Definition – Panel point

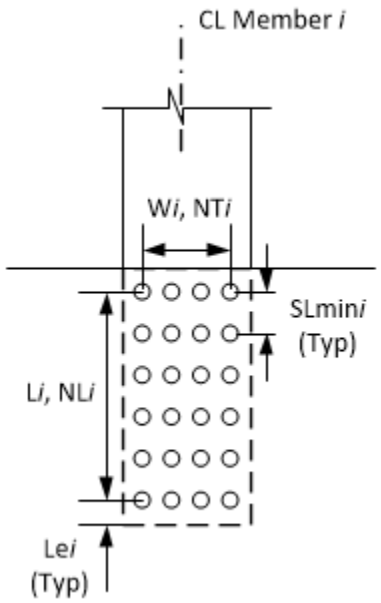
Navigate to the **Panel point** tab of this window. This tab specifies the arrangement of truss members present in the gusset plate definition. Member 1,2,3,7 and 8 are present in this gusset plate definition. The truss member arrangement will be validated when the **Gusset Plate Definition** is assigned to a **Panel Point**.



Gusset Plate Definition – Fasteners

Navigate to the **Fasteners** tab of this window. Only truss members present in this definition are listed in the tables. **Same as left plate** is checked specifying the fasteners information for the **Right Plate** is the same as the **Left Plate**.





NL = Number of fasteners in a row along the longitudinal axis of the truss member.

L = Length between extreme fasteners in a row along the longitudinal axis of the truss member.

NT = Number of fasteners in a row along the transverse axis of the truss member.

W = Width between extreme fasteners in a row along the transverse axis of the truss member.

N Total = Total number of fasteners in the connection. Computed as NLxNT if left blank.

Le = Distance between center of last fastener and end of gusset plate measured in the direction of the applied bearing force (along the longitudinal axis of the truss member).

SLmin =Minimum center-to-center spacing of fasteners along the longitudinal axis of the truss member.

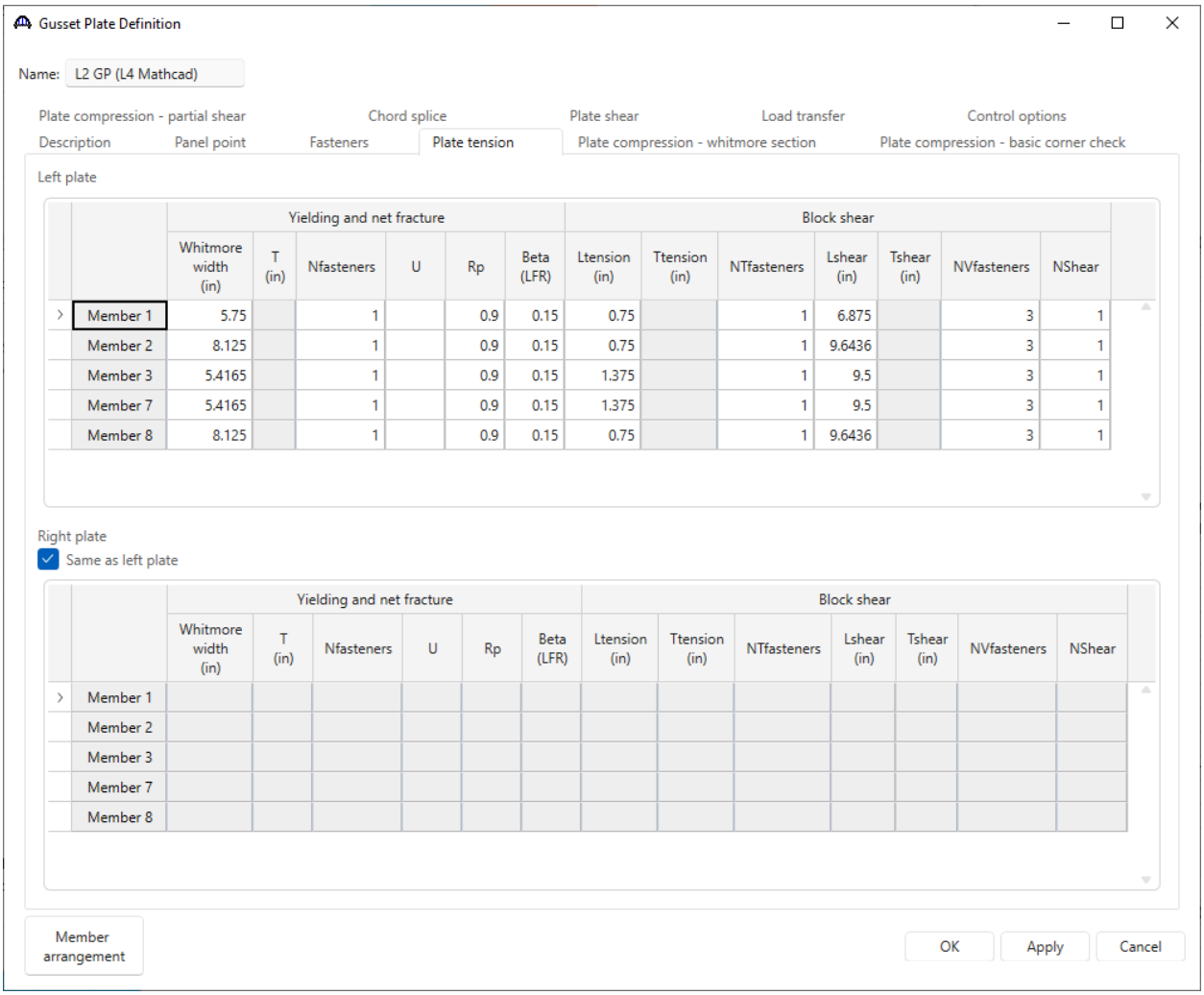
Af, Ap = Used to compute the fastener shear resistance reduction factor in MBE 6A.6.12.6.2. Leave Af and Ap blank if the reduction factor should not be computed.

NShear = Number of shear planes per fastener.

NSlip = Number of slip planes per fastener.

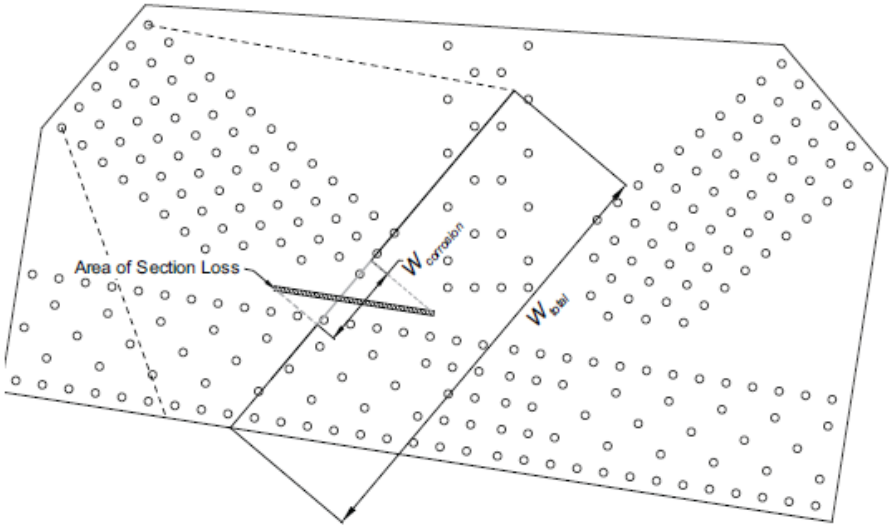
Gusset Plate Definition – Plate tension

Navigate to the **Plate tension** tab of this window. T, Ttension and Tshear are disabled and defaulted to the As-built plate thickness when **Contains corrosion** is not checked in the **Description** tab.



Yielding and Net Fracture:

Whitmore Width = Width of the Whitmore section. If left blank, computed as W + 2L x tan30° where W is the transverse width between extreme fasteners. Refer to MBE Figure 6A.6.12.6.8-1 and Figure C6A.6.5-1. The user should verify that the computed Whitmore Width Cannot be truncated due to the edge of the gusset plate.



T = Thickness of the gusset plate along the Whitmore section.

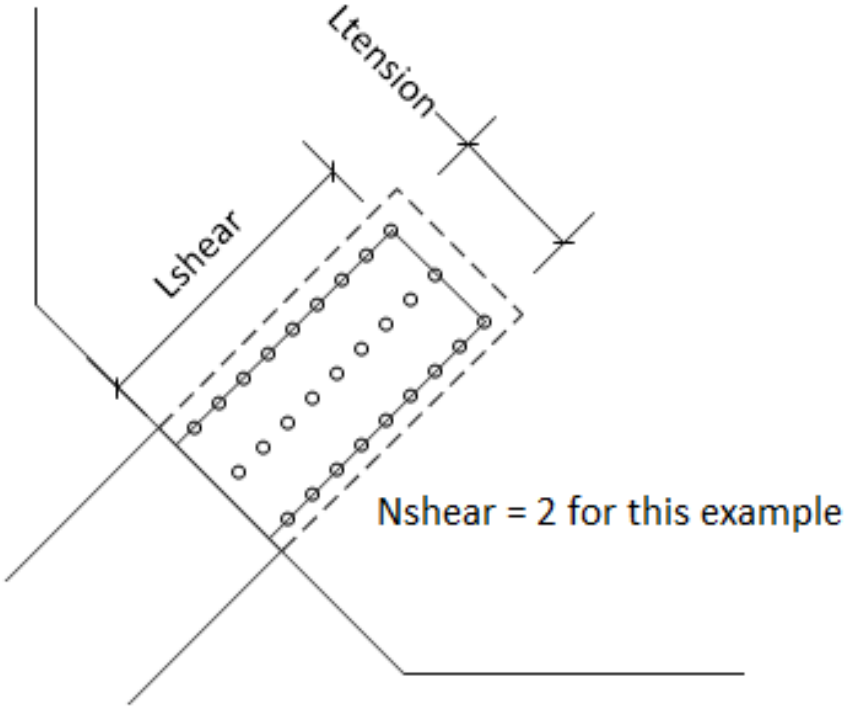
Nfasteners = Number of fasteners along the Whitmore section. Used to compute the net area of the Whitmore section. Defaults to NT if left blank.

U = Shear lag reduction factor. Defaults to 1.0 if left blank.

Rp = Reduction factor for holes. Defaults to values in MBE 6A.6.12.6.8-1 based on the assigned bolt definition if left blank.

Beta = LFR adjustment factor from MBE L6B.2.6.5. Defaults to value from spec if left blank.

Block Shear:



Ltension	= Length of the tension plane.
Ttension	= Thickness of the gusset plate along the tension plane.
NTfasteners	= Number of fasteners along the tension plane.
Lshear	= Length of the shear plane.
Tshear	= Thickness of the gusset plate along the shear plane.
NVfasteners	= Number of fasteners along the shear plane.
Nshear	= Number of shear planes

Gusset Plate Definition – Plate compression

Navigate to the **Plate compression** tab of this window. T, T_M, T_R and T_L are disabled and defaulted to the As-built plate thickness when **Contains corrosion** is not checked in the **Description** tab.

This tab contains input fields for Whitmore section and truncated Whitmore section. Whitmore section is used for LFR analysis and is the default compression method of LRFR analysis.

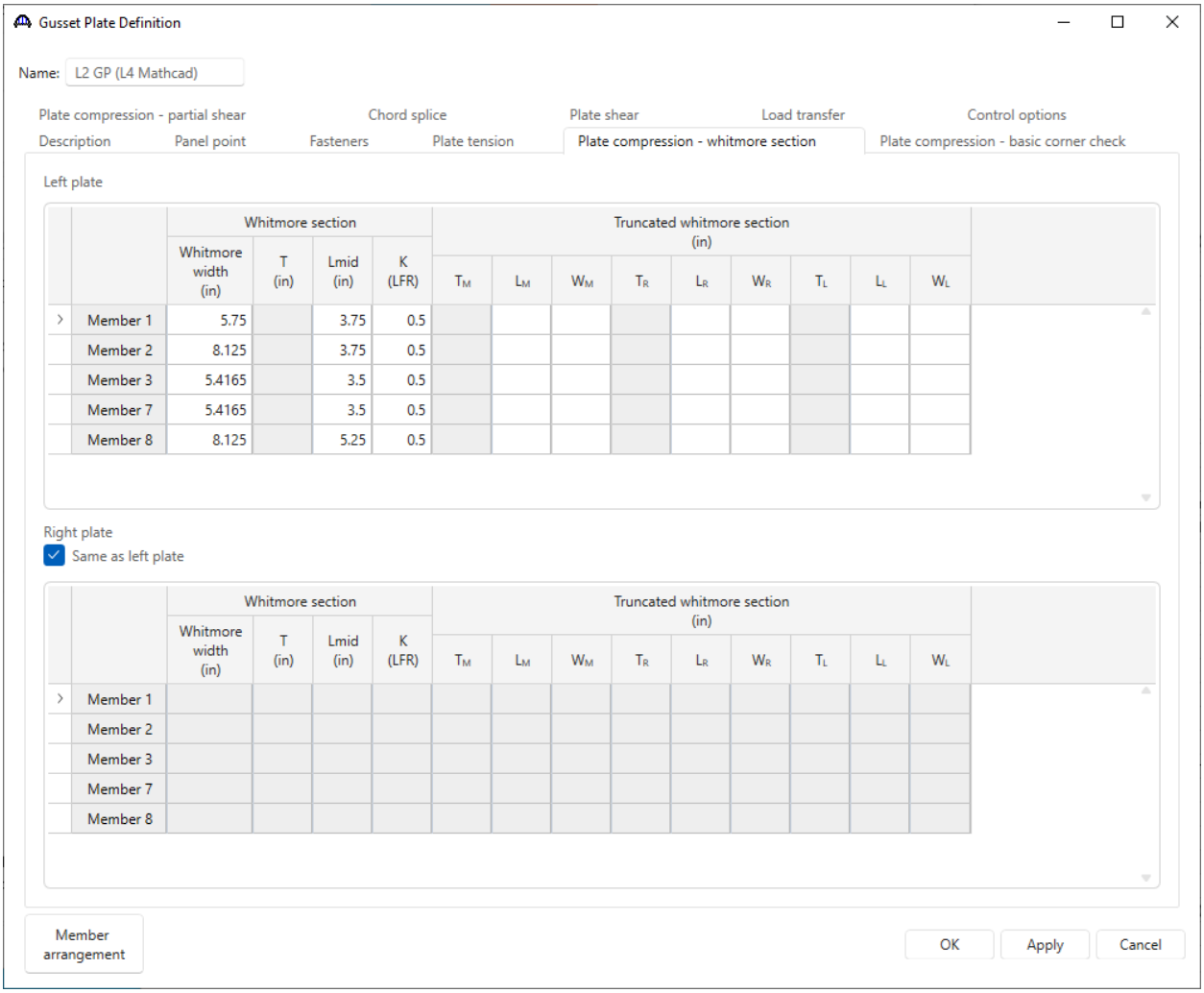


Plate Compression – Whitmore Section

Whitmore Width = Width of the Whitmore section. Computed as W + 2L x tan30° if left blank. Refer to MBE Figure 6A.6.12.6.7a-1.

T = Thickness of the gusset plate along the Whitmore section.

Lmid = Distance from the middle of the Whitmore section to the nearest member fastener line in the direction of the member

K = Column effective length factor. Defaults to 0.5 if left blank.

Plate Compression – Truncated Whitmore Section (LRFR only)

If the Whitmore section for a specific member is not truncated or if the Basic Corner Check method is to be used for a specific member, no input is required in these fields for that member.

L_M, L_R and L_L = Distance from the middle, right or left of the truncated Whitmore section to the nearest fastener line. Refer to MBE Figure 6A.6.12.6.7-1.

W_M, W_R and W_L = Width of the middle, right or left portion of the truncated Whitmore section as shown in MBE Figure 6A.6.23.6.7-1.

T_M, T_R and T_L = Thickness of gusset plate along the corresponding portion of the truncated Whitmore section.

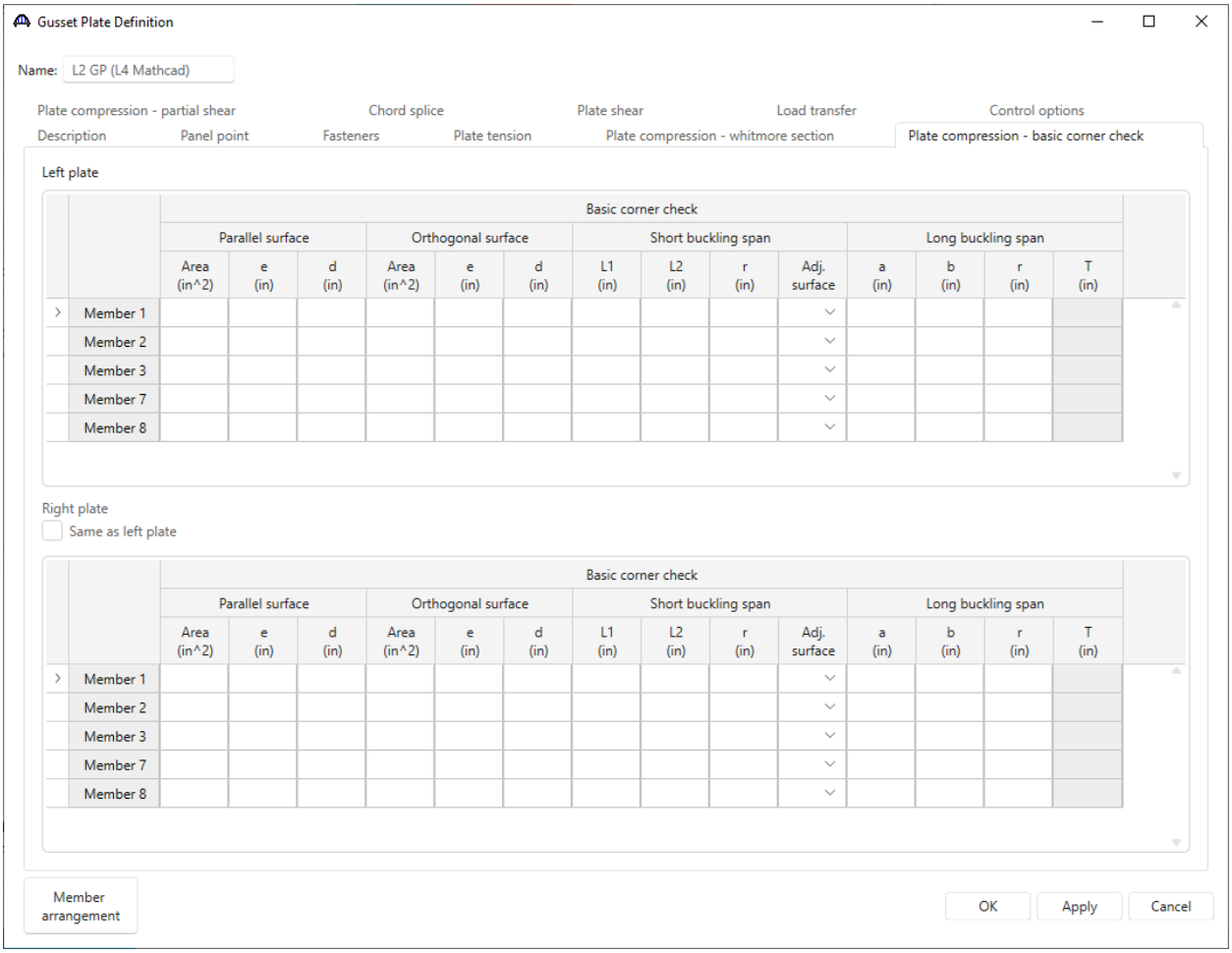


Plate Compression – Basic Corner Check (LRFR Only)

This input is used for LRFR analysis when the **Basic corner check** is selected in the **Control options** tab. If the Basic Corner Check compression analysis is not applicable for a specific member or if this option is not enabled in the **Control options** tab, no input is required in these fields for that member.

Parallel Surface and Orthogonal Surface

These values correspond to the surface that is parallel or orthogonal to the chord member. Refer to MBE Figure 6A.6.12.6.7b-1.

Area = Area of the surface that is parallel or orthogonal to the chord member.

e = Distance from the work point to the plane of the parallel or orthogonal surface as shown in MBE Figure 6A.6.12.6.7b-1.

d = Distance from the work point to the centroid of the parallel or orthogonal surface as shown in MBE Figure 6A.6.12.6.7b-1.

Short Buckling Span

L1 = Unbraced length for column buckling of the short buckling span measured orthogonally to surface with smaller of the unbraced plate buckling lengths. Distance is from the intersection of the member centerline with the row of rivets nearest work point to nearest member edge. Refer to MBE Figure 6A.6.12.6.7b-2.

L2 = Unbraced length for column buckling of the short buckling span measured orthogonally to surface with smaller of the unbraced plate buckling lengths. Distance is from the intersection of member centerline with the leading member edge to nearest fastener of another truss member. Refer to MBE Figure 6A.6.12.6.7b-2.

r = Radius of gyration for short buckling span. Defaults to As-built plate thickness / sqrt (12.0) if left blank.

Adj. Surface = Surface adjacent with short buckling span (parallel or orthogonal surface to the chord). The other surface will be considered to be adjacent to the long buckling span.

Long Buckling Span

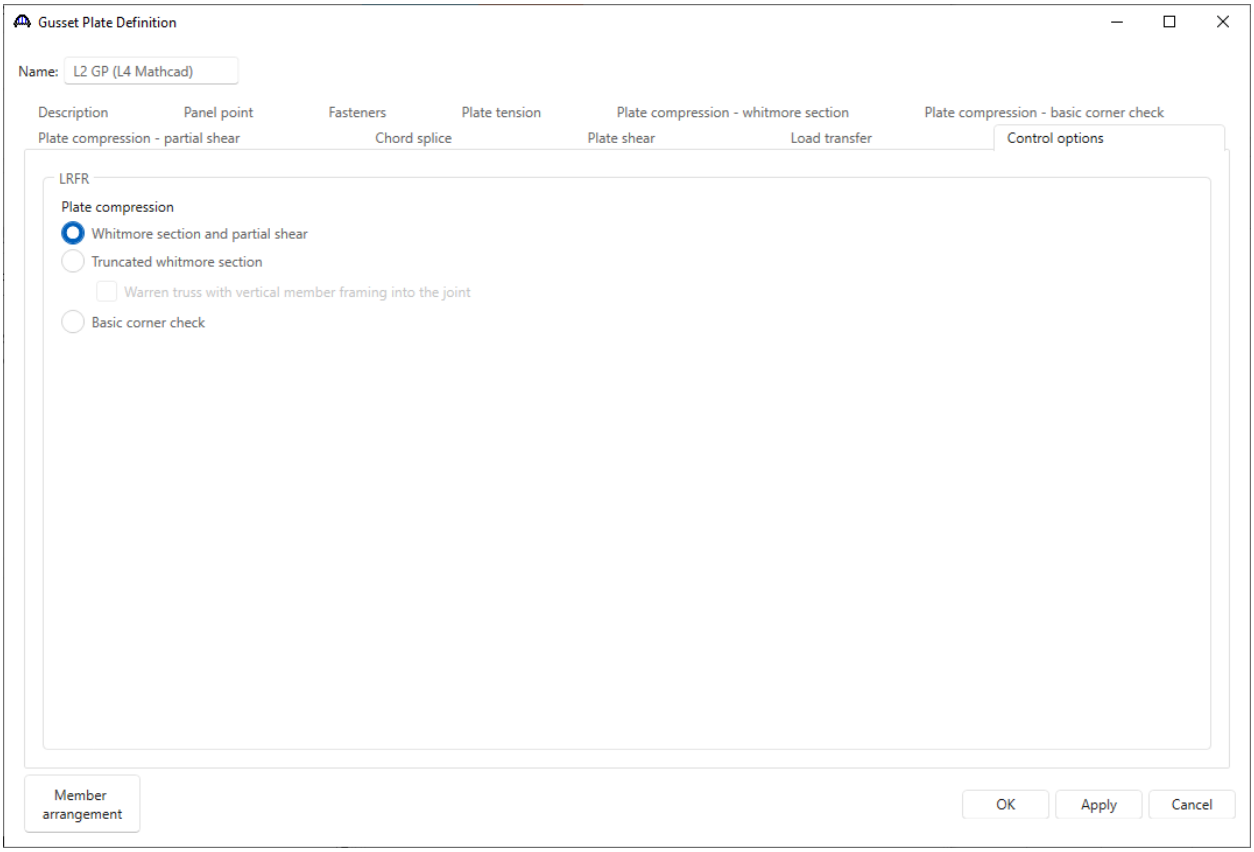
a = Plate buckling length. Refer to MBE Figure 6A.6.12.6.7b-1.

b = Plate buckling width. Refer to MBE Figure 6A.6.12.6.7b-1.

r = Radius of gyration for long buckling span. Defaults to As-built plate thickness / sqrt (12.0) if left blank.

T = Thickness of plate at long buckling span.

Gusset Plate Definition – Control Options (LRFR Only)



The default selection for plate compressive resistance is **Whitmore section and partial shear**.

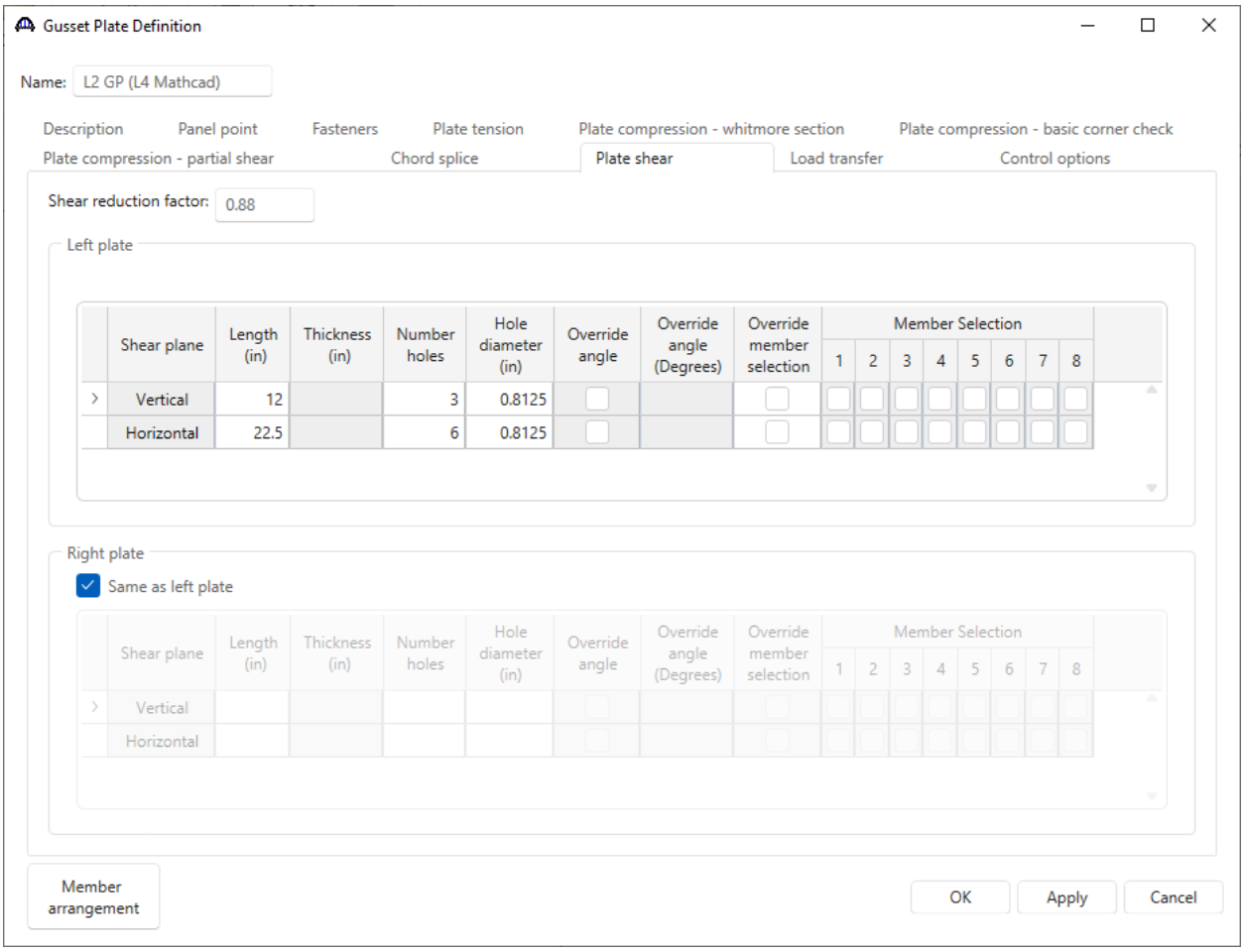
Truncated Whitmore section and **Basic corner check** are only applicable for specific geometric configurations. If the Whitmore section is not truncated or if the basic corner check is not applicable for a specific member, values need not be entered for **Truncated Whitmore section** and **Basic corner check** for that member.

If **Truncated Whitmore section** is selected, but no Truncated Whitmore section values are entered for a specific member, compression analysis for that member will default back to **Whitmore section and partial shear.** The **Truncated Whitmore section** compression resistance method will however be used for members that have values entered for **Truncated Whitmore section** compressive resistance.

If **Basic corner check** is selected, but no values are entered for a specific member or if the member is not adjacent to a chord member, compression analysis for that member will default back to **Truncated Whitmore section** (if values are entered) or **Whitmore Section and partial shear** if values for **Truncated Whitmore section** are not entered. The **Basic corner check** compressive resistance method will be used for members that have values entered for this compressive resistance method and are adjacent to a chord member.

Gusset Plate Definition – Plate shear

Navigate to the **Plate shear** tab of this window. Thickness is disabled and defaulted to the As-built plate thickness when **Contains corrosion** is not checked in the **Description** tab. The user has the responsibility to determine the critical shear plane locations based on such factors as member configuration and deterioration.



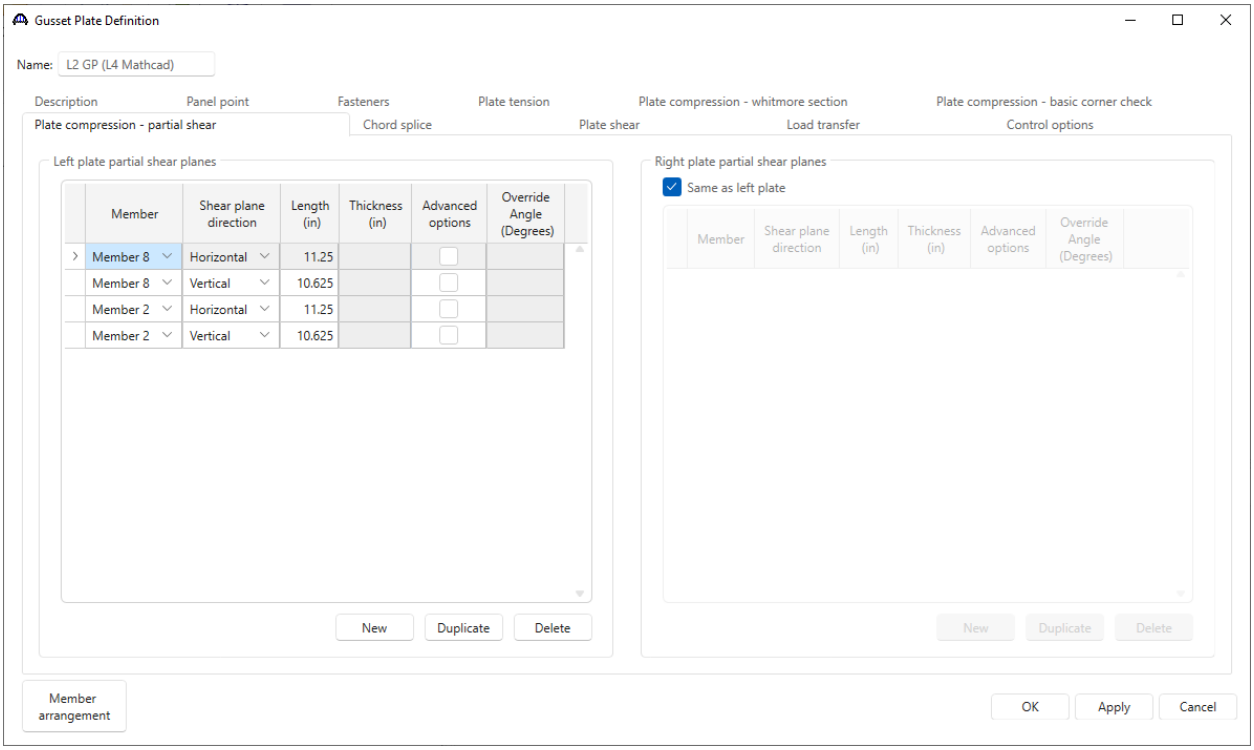
Shear reduction factor = Shear reduction factor for the gusset plate. Defaults to 0.88.

<u>Vertical Shear Plane and Horizontal Shear Plane:</u>

Length	= Length of the shear plane.
Thickness	= Thickness of the gusset plate along the shear plane.
Number of Holes	= Number of holes in the shear plane for the shear rupture check.
Hole Diameter	= Diameter of holes in the shear plane.

Gusset Plate Definition – Plate partial shear

Navigate to the **Plate partial shear** tab of this window.

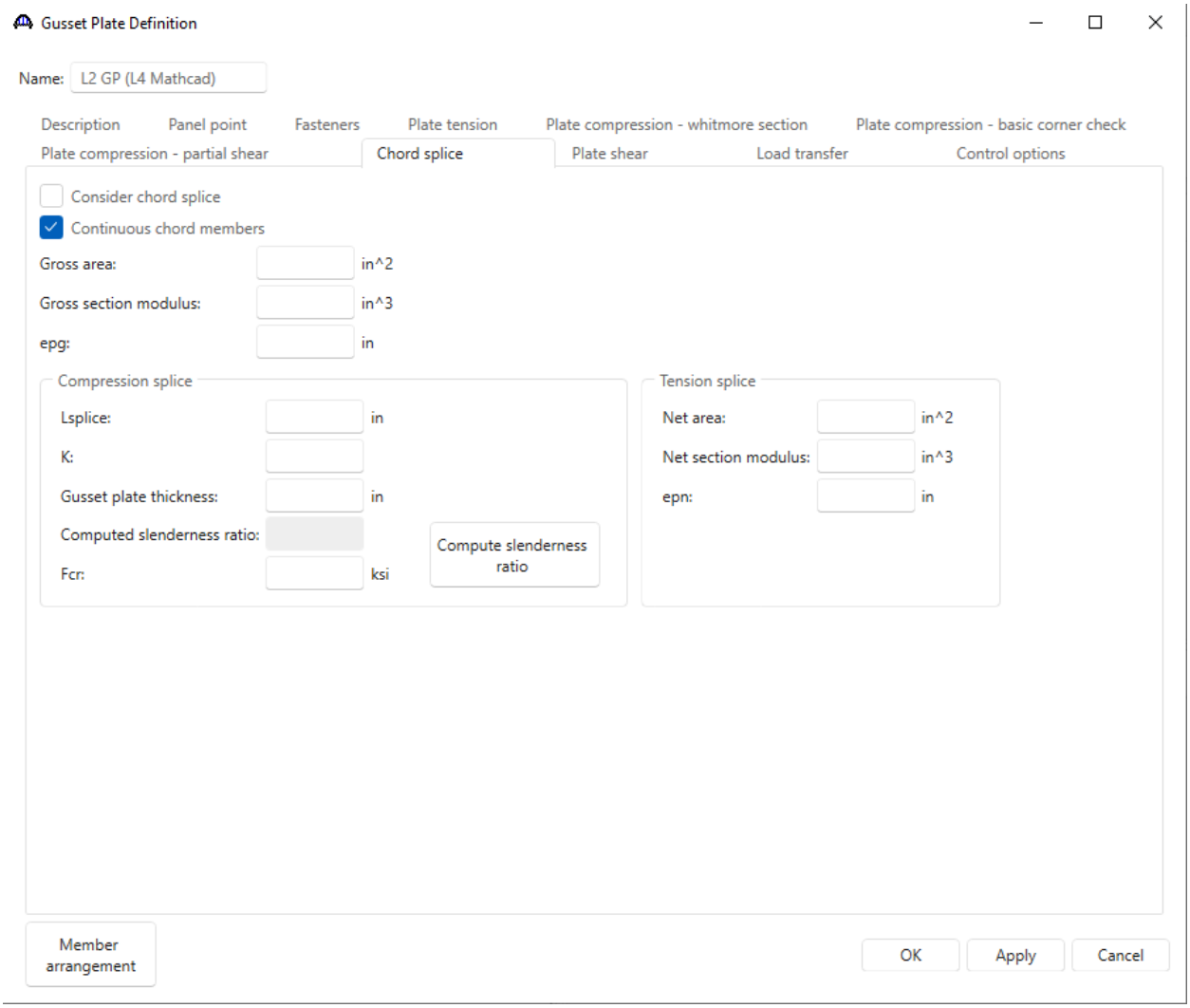


Partial Shear Planes:

Member	=	Specify the compression member for which the defined shear plane should be checked.
Shear Plane Direction	=	Specify the direction of the partial shear plane.
Length	=	Length of the partial shear plane.
Thickness	=	Thickness of the gusset plate along the partial shear plane.

Gusset Plate Definition – Chord splice

Navigate to the **Chord splice** tab of this window.



Consider chord splice = Check this box if the chord splice articles should be considered.

Continuous chord members = Check this box if the chord is continuous at this gusset plate. If the chord is continuous, there is no need to check the vertical shear plane capacity. This does not affect % load transfer. If checked, the horizontal shear plane force calculation will be along the corresponding chord member. If not checked, the horizontal shear plane force calculation will be with respect to true horizontal.

Gross area = Gross area, Ag, of all plates in the cross-section intersecting the spliced plane.

Gross section modulus = Gross section modulus, Sg, of all plates in the cross-section intersecting the spliced plane. Use the section modulus that corresponds to the edge of the splice (top or bottom) that sees the maximum axial plus bending stress.

epg = Distance between the centroid of the gross cross-section and the resultant force perpendicular to the spliced plane.

Compression Splice:

Lsplice = Center-to-center distance between the first lines of fasteners in adjoining chords.

K = Effective column length factor. Defaults to 0.5 if left blank.

Gusset plate thickness = Thickness of the gusset plate. Used to compute the slenderness ratio. Defaults to the minimum of left and right As-built plate thickness if left blank.

Computed slenderness ratio = The computed slenderness ratio of the chord splice.

Fcr = If the computed slenderness ratio is less than 25 as per MBE 6A.6.12.6.9-2, the Fcr is set to Fy.

Tension Splice:

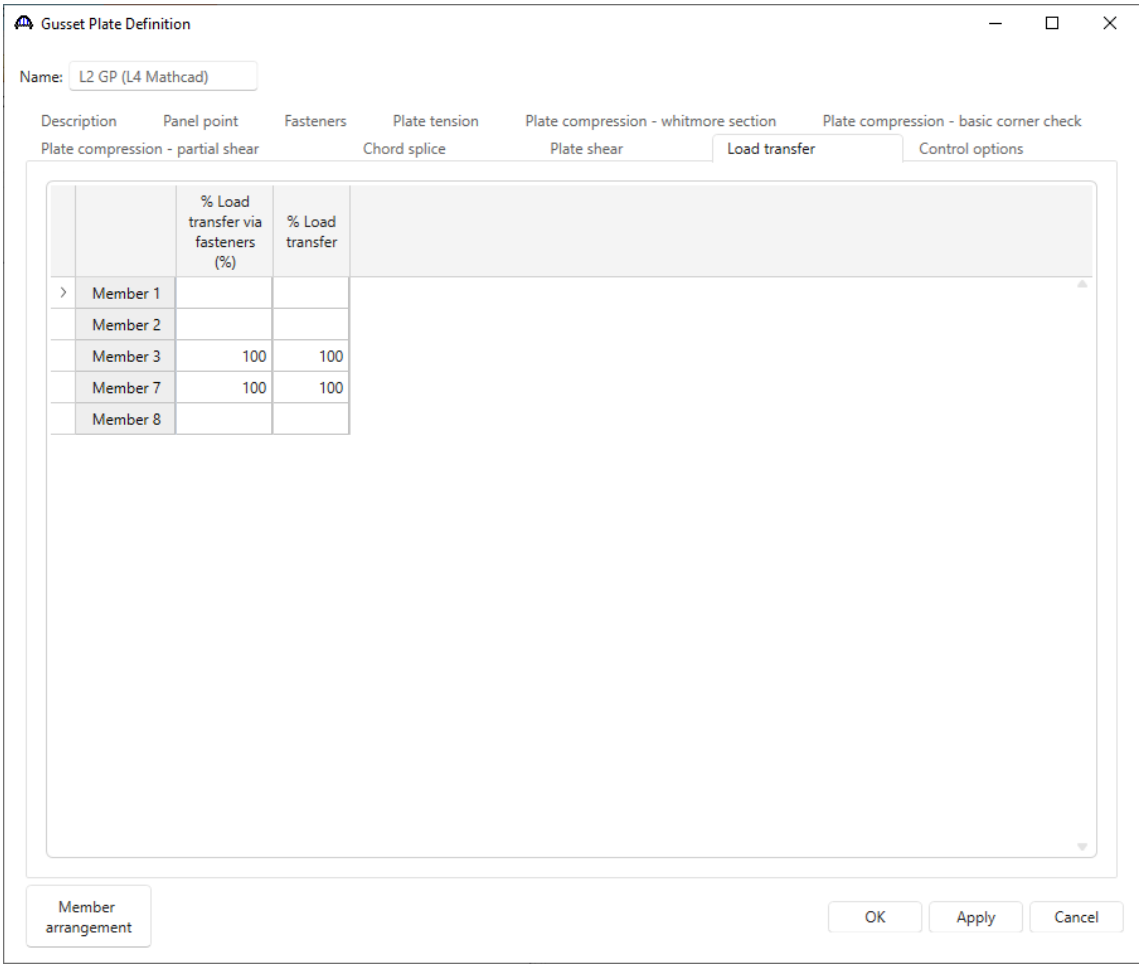
Net area = Net area, An, of all plates in the cross-section intersecting the spliced plane.

Net section modulus = Net section modulus, Sn, of all plates in the cross-section intersecting the spliced plane. Use the section modulus that corresponds to the edge of the splice (top or bottom) that sees the maximum axial plus bending stress.

epn = Distance between the centroid of the net cross-section and the resultant force perpendicular to the spliced plane.

Gusset Plate Definition – Load transfer

Navigate to the **Load transfer** tab of this window.



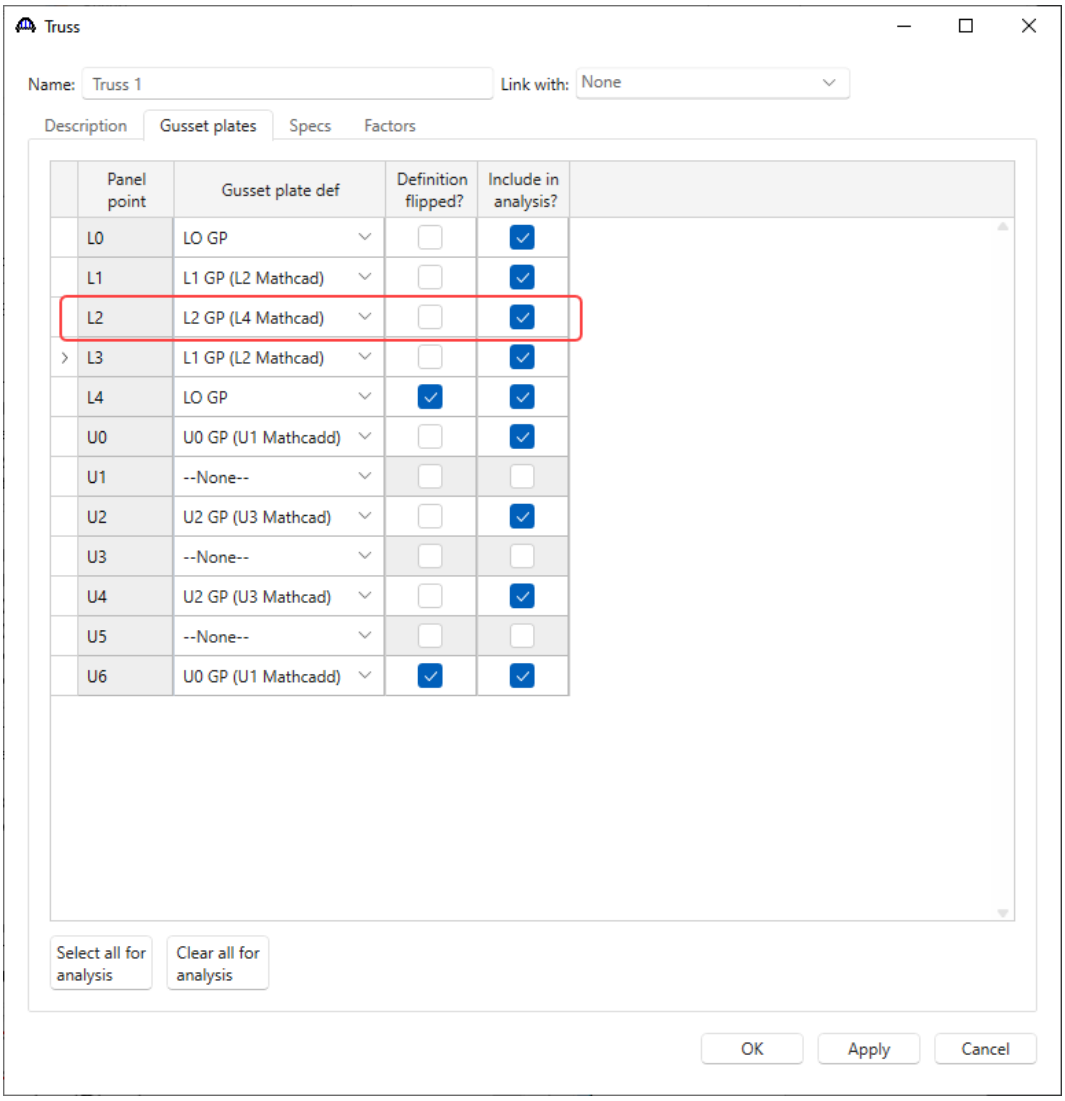
% Load Transfer via Fasteners = The dead and live loads used in the fastener rating equations will be adjusted by this percentage. Defaults to 100% if left blank.

% Load Transfer = The dead and live loads used in the gusset plate rating equations will be adjusted by this percentage. Defaults to 100% if left blank.

Close the **L2 GP (L4 Mathcad) Gusset Plate Definition** window by clicking either the **OK** or the **Cancel** button.

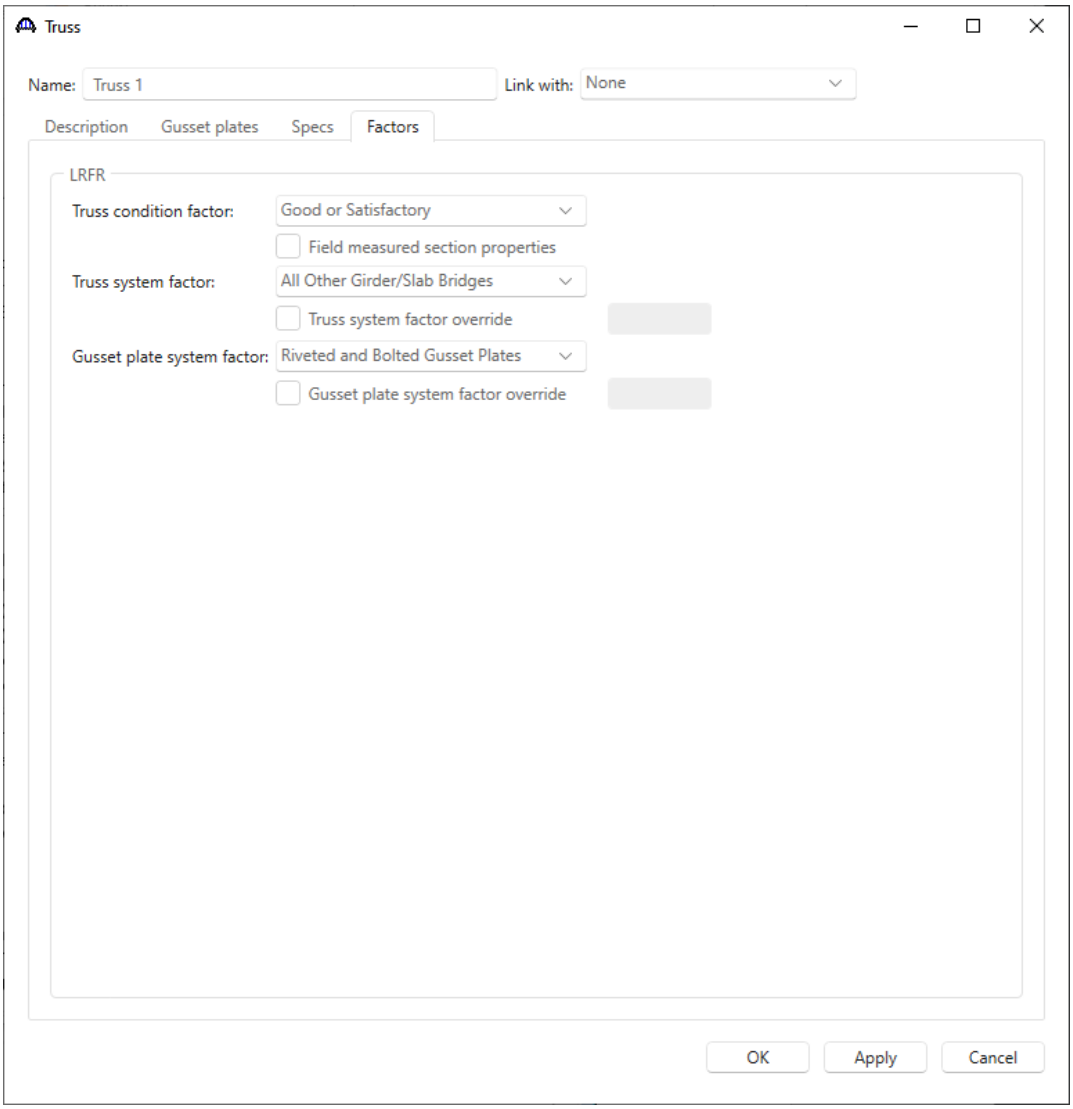
Truss - Gusset plates

Expand the **TRUSSES** folder in the **Bridge Workspace** tree. Open the **Truss 1** window and navigate to the **Gusset plates** tab. The **L2 GP (L4 Mathcad)** Gusset Plate Definition is assigned to the **L2 Panel point**. The **L2** panel point's gusset plate is included in the truss analysis. If the **Definition Flipped?** option is checked, the member arrangement in the assigned **Gusset Plate Definition** will be flipped vertically. The gusset plate definition's member arrangement will be validated against the panel point's member arrangement when **OK** or **Apply** is clicked.



Truss - Factors

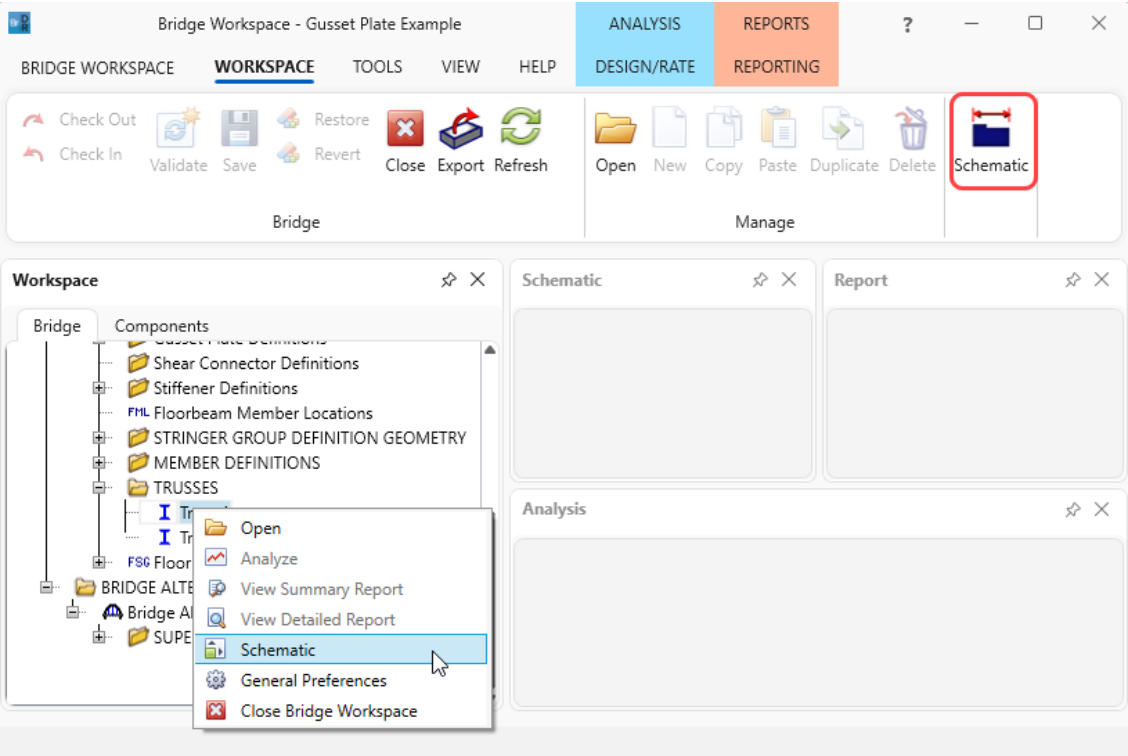
Navigate to the **Factors** tab of this window. The **Gusset plate system factor** is defaulted to **Riveted and Bolted Gusset Plates.**



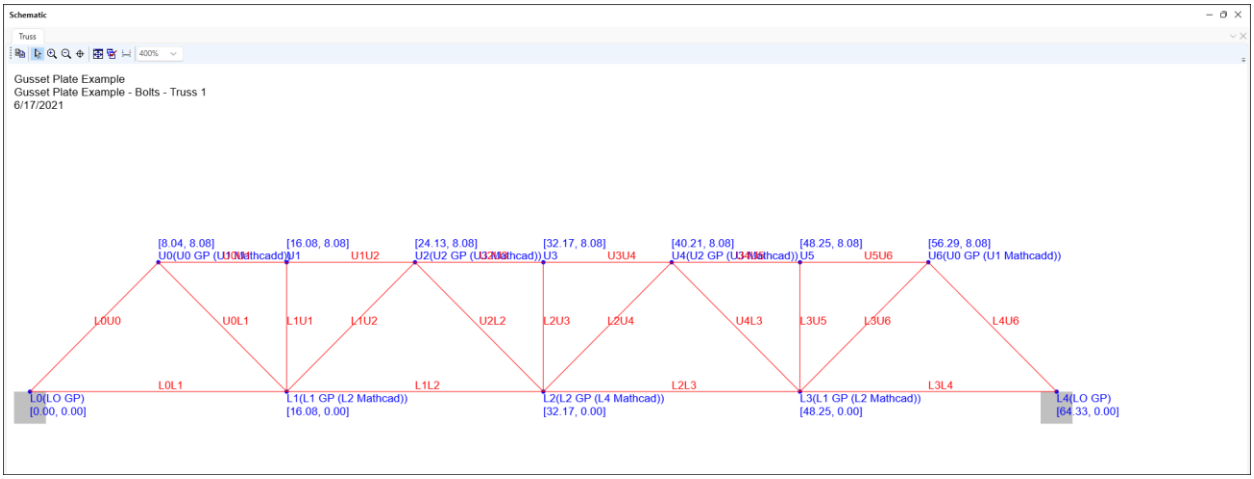
Close the **Truss** window by clicking either the **OK** or the **Cancel** button.

Schematic - Truss 1

Select **Truss 1** in the **Bridge Workspace** tree and click the **Schematic** button in the **WORKSPACE** ribbon (or right click and select **Schematic**) to view the schematic of this truss definition as shown below.

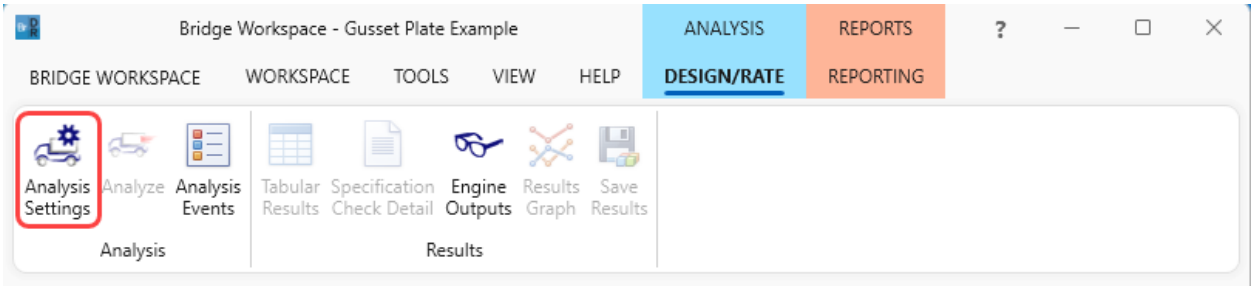


The panel point is labeled with the assigned Gusset plate definition.

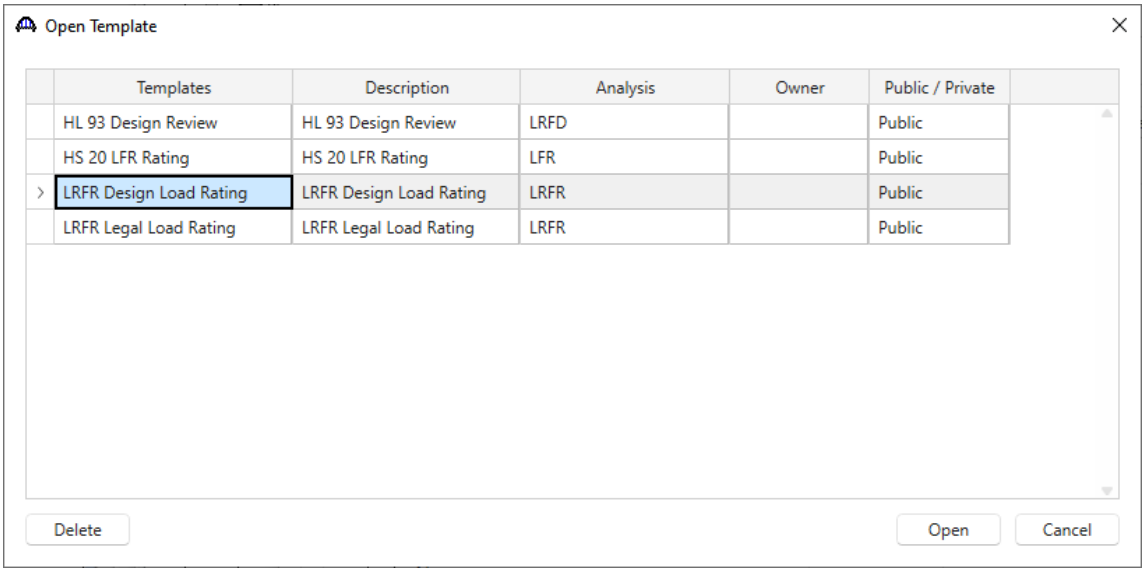


LRFR Analysis

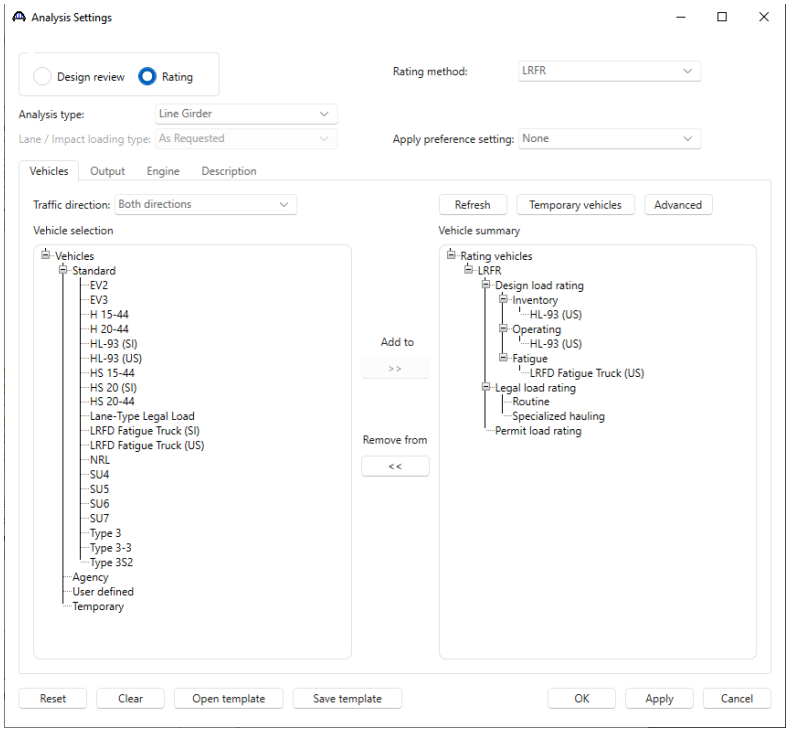
To perform an LRFR rating on **Truss 1**, click the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon. The **Analysis Settings** windows shows up.



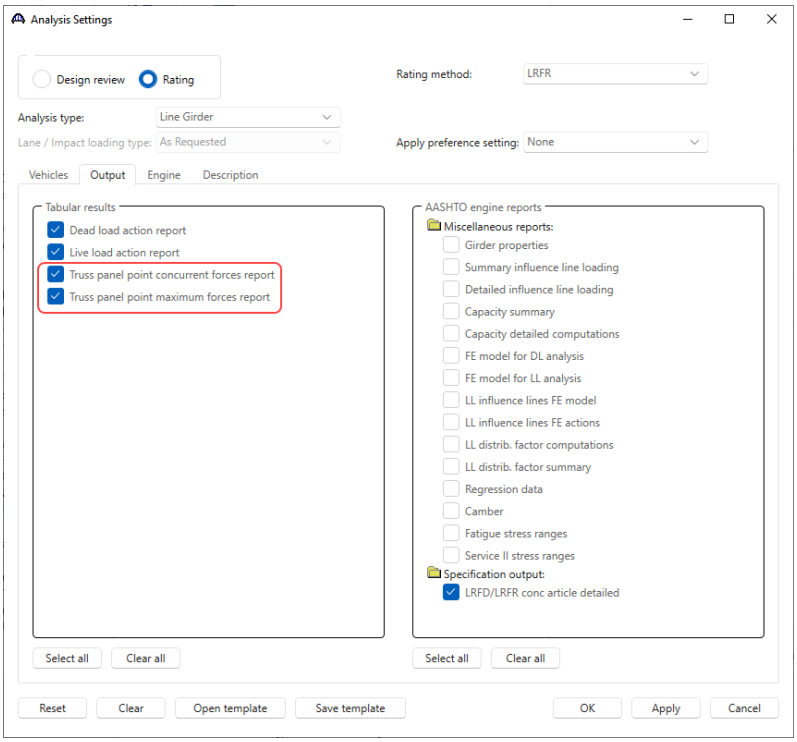
Click on the **Open template** button in the **Analysis Settings** window. The following window opens. Select the **LRFR Design Load Rating** template and click the **Open** button to apply the template.



The **Analysis Settings** window gets updated as shown below.

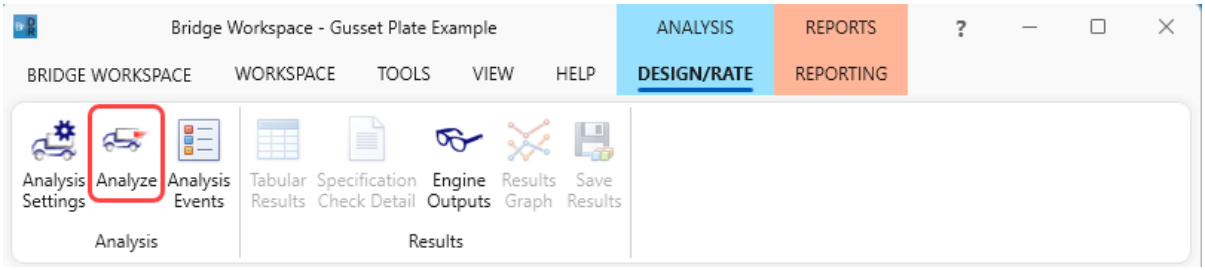


Navigate to the **Output** tab of this window and select the **Truss panel point concurrent forces report** and **Truss panel point maximum forces report.**



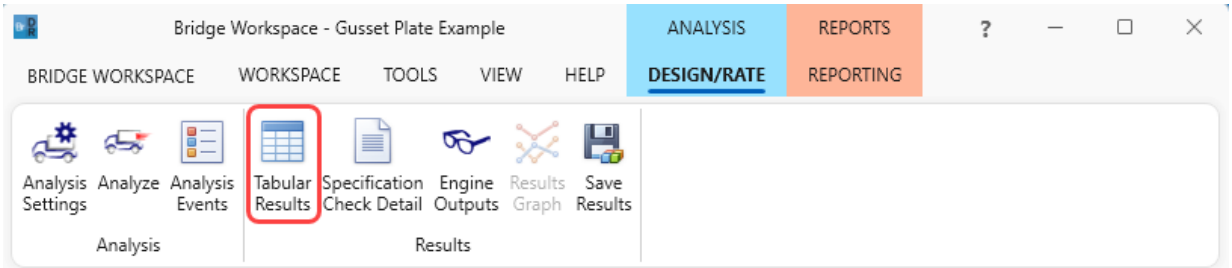
Click **OK** to apply the analysis settings and close the window.

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.

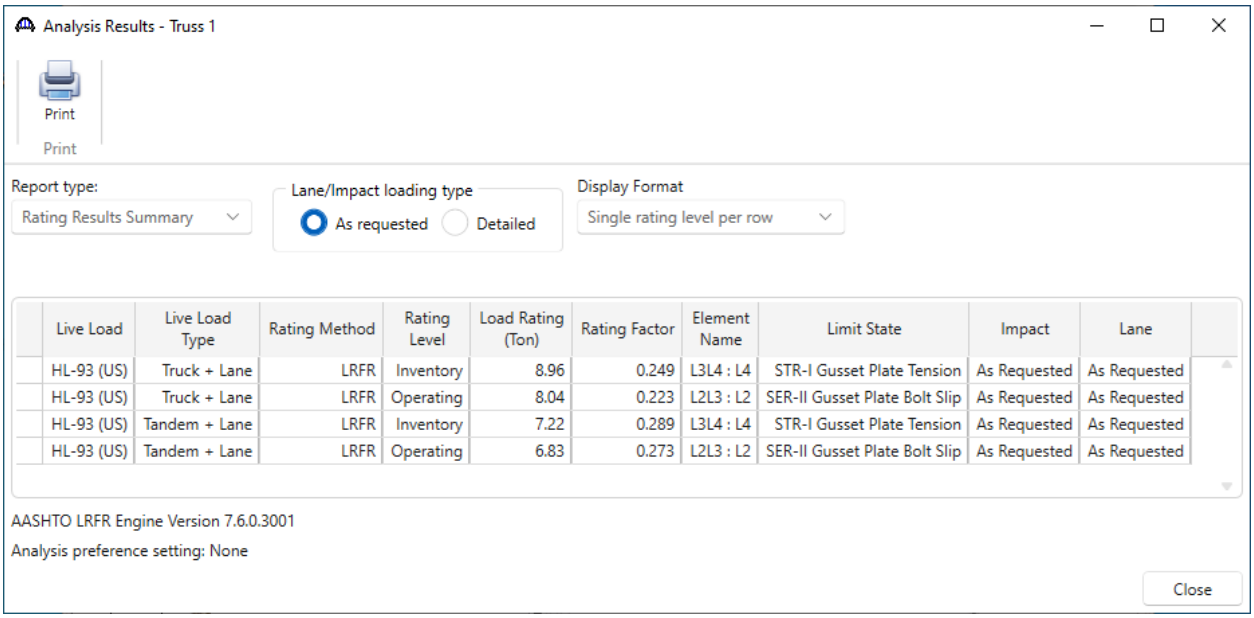


Tabular Results

When the rating analysis 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.

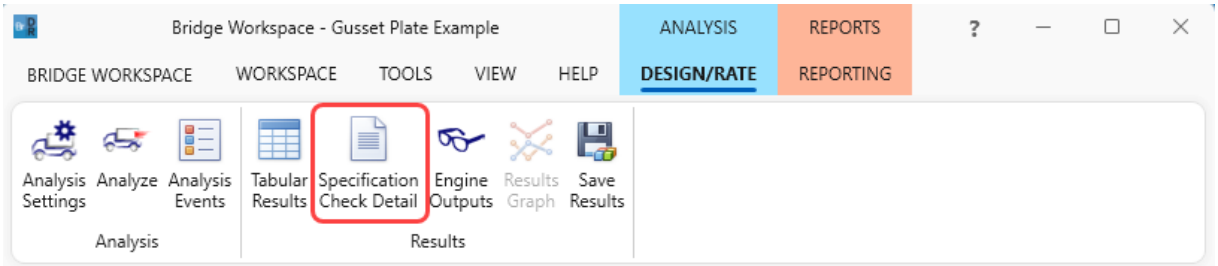


The **Analysis Results** shown below will open. This window shows the critical rating factor considering all truss members and the panel point gusset plates that were included in the analysis. The limit states specific to gusset plate are Gusset Plate Fastener, Gusset Plate Bolt Slip, Gusset Plate Tension, Gusset Plate Compression, Gusset Plate Vertical Shear and Gusset Plate Horizontal Shear. The Rating Results Summary is the only report type available.

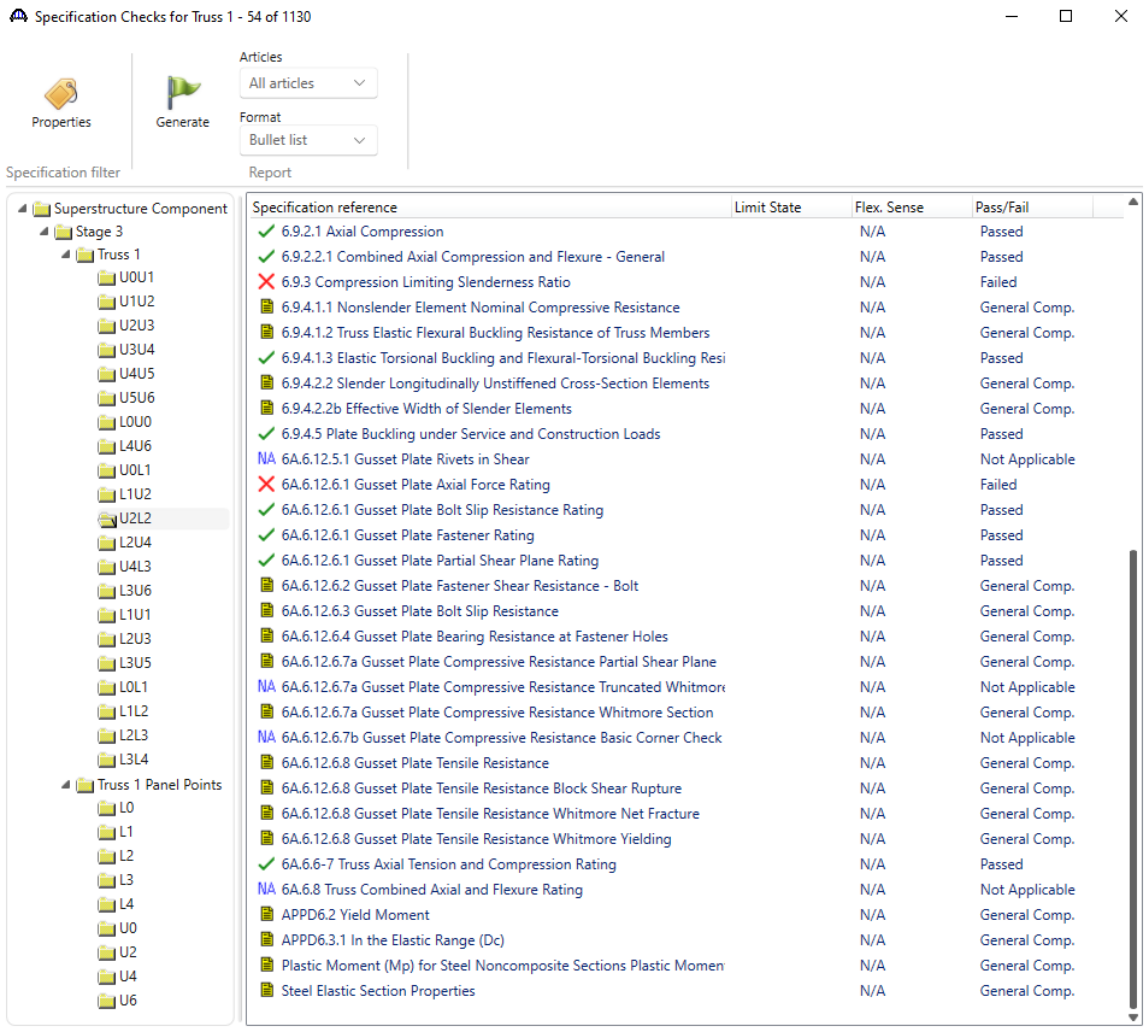


Specification Check Detail

From the **Results** tab of the ribbon, click on **Specification Check Detail** to open the **Specification Checks** window.



Gusset plate specification articles specific to a member and the member loads (like fasteners, tension and compression) are listed under the truss member. Gusset plate specification articles that are for the gusset plate and all loads coming into the gusset plate (like shear and chord splice) will be listed under the panel point.



The following list of LRFR specification articles will be checked for gusset plates. The implementation of these articles is described in detail in the **AASHTO LRFR Truss Method of Solution Manual's** Appendix B.

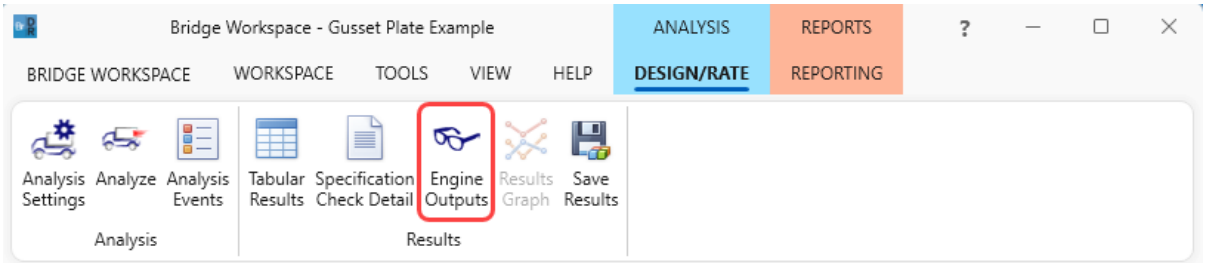
MBE Article	Description
6A.6.12.6.2	Fastener Shear Resistance
6A.6.12.5.1	Rivets in Shear
6A.6.12.6.3	Bolt Slip Resistance
6A.6.12.6.4	Bearing Resistance at Fastener Holes
6A.6.12.6.6	Gusset Plate Shear Resistance
6A.6.12.6.7a	Gusset Plate Compressive Resistance – Partial Shear Plane
6A.6.12.6.7a	Gusset Plate Compressive Resistance – Whitmore Section
6A.6.12.6.7a	Gusset Plate Compressive Resistance – Truncated Whitmore Section
6A.6.12.6.7b	Gusset Plate Compressive Resistance – Basic Corner Check
6A.6.12.6.8	Gusset Plate Tensile Resistance – Block Shear Rupture
6A.6.12.6.8	Gusset Plate Tensile Resistance – Whitmore Yielding
6A.6.12.6.9	Chord Splices – Compressive Resistance
6A.6.12.6.9	Chord Splices – Tensile Resistance
6A.6.12.6.1	Resistance Reduction for DL/LL Ratio

The following list of LFR specification articles will be checked for gusset plates. The implementation of these articles is described in detail in the **AASHTO LFD Truss Method of Solution Manual's** Appendix A.

MBE Article	Description
L6B.2.6.1	Fasteners – Shear
L6B.2.6.1	Fasteners – Rivets in Shear
L6B5.3.1	Bolt Slip Resistance
L6B.2.6.1	Fasteners – Bearing
L6B.2.6.3	Gusset Plate Shear Resistance
L6B.2.6.3	Gusset Plate Shear Resistance – Partial Shear Plane
L6B.2.6.4	Gusset Plate Compressive Resistance
L6B.2.6.5	Gusset Plate Tensile Resistance – Block Shear Rupture
L6B.2.6.5	Gusset Plate Tensile Resistance – Whitmore Yielding
L6B.2.6.6	Chord Splices – Compressive Resistance
L6B.2.6.6	Chord Splices – Tensile Resistance

Engine Outputs

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



The **Gusset Plate Section Property Report** contains a listing of the gusset plate data. In the **Rating Results Report**, the **Overall Rating Summary** lists the critical rating results considering the truss member and panel point rating results. For each live load type, the detail truss member rating results, detail panel point rating results, panel point shear action, panel point chord splice action, and panel point shear and chord splice rating results are listed.