Truss Tutorial

T2 – Truss Input Command

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BrDR Tutorial

This tutorial is comprised of 5 Truss Input Command exercises to modify the North Truss in **T1 - Truss Floorbeam Stringer** Example. Solutions are presented after all the exercises.

Exercises Covered

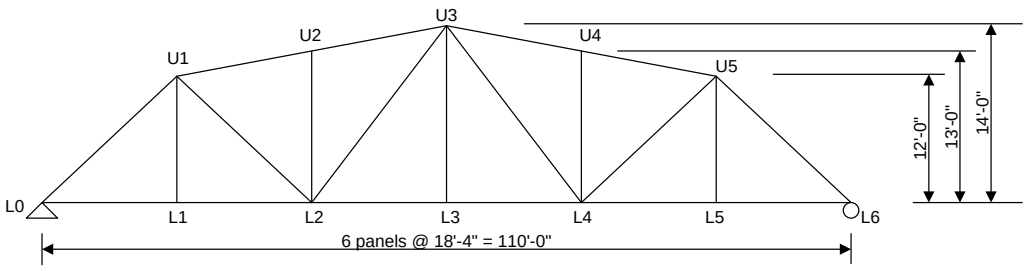
1. Modify truss geometry.
2. Add new member cross section and assign cross section to member.
3. Symmetry command
4. Add point load and additional self-weight.
5. Add member of interest to define deterioration.

Truss description and analysis

Trusses are described in BrDR by entering a text description of the truss in the **BrDR Truss Command Language**. This language contains commands used to describe the truss geometry, members, loads, etc. The **Truss Command Language User Manual** can be accessed from the BrDR Truss window's **Help** topic. This can be accessed by using the F1 key when BrDR **Truss** window is in focus.

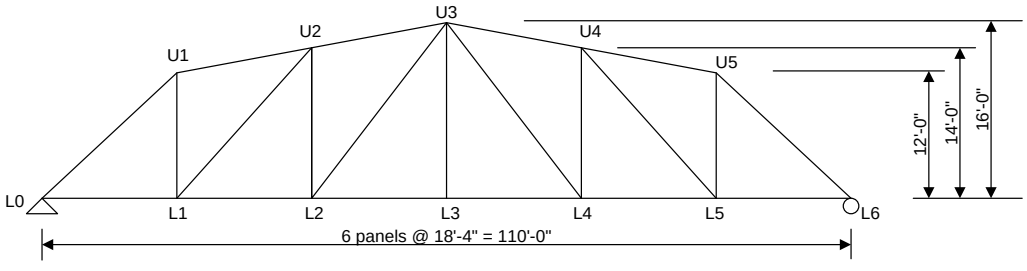
Exercise 1 - Modify truss geometry

The truss geometry described in T1 - Truss Floorbeam Stringer Example is shown below.



Elevation

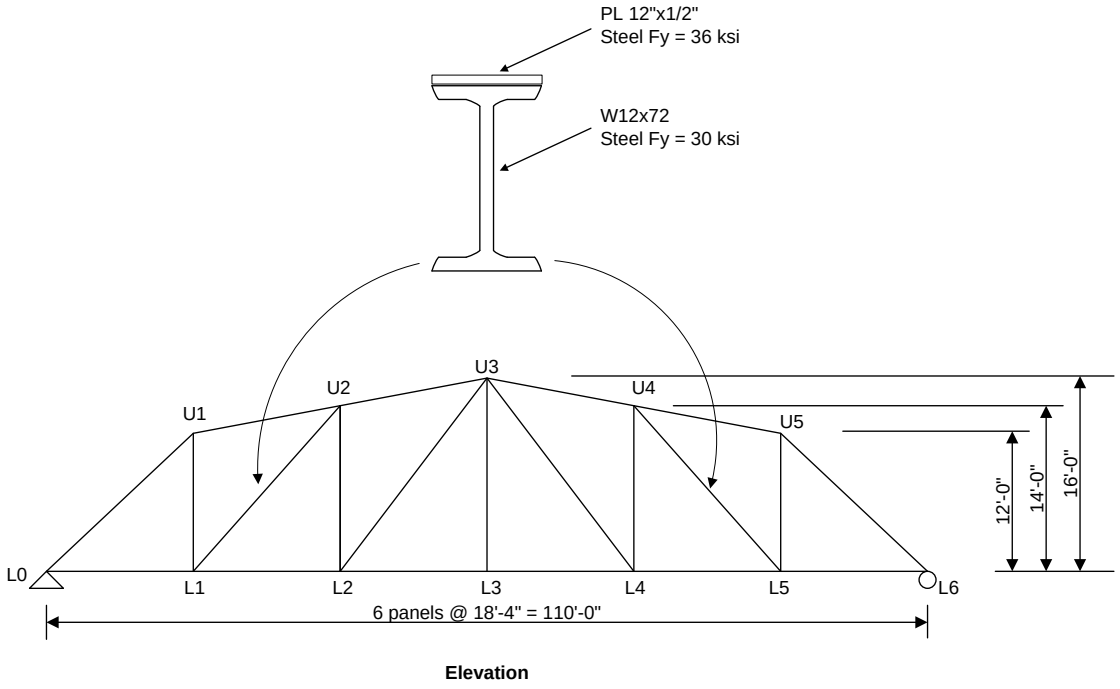
Modify the truss elevations and the second and fifth panels as shown below.



Elevation

Exercise 2 - Add new member cross section and assign cross section to member.

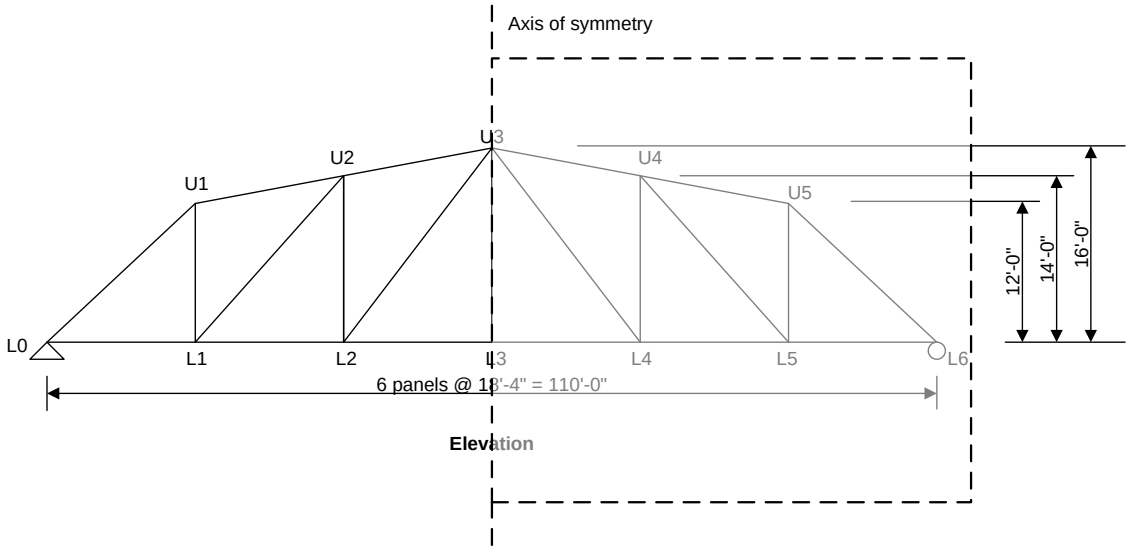
Add the new member cross section as shown below and assign the cross section to the diagonal member in the second and fifth panels of the truss.



Elevation

Exercise 3 - Symmetry command

Use the **Symmetry** command to describe the geometry as shown below.



Exercise 4 - Add point load and additional self-weight.

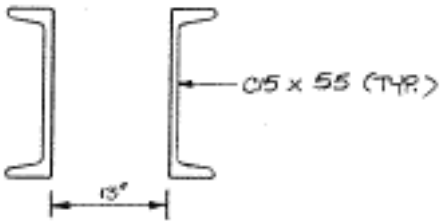
Add the following additional loads to the truss

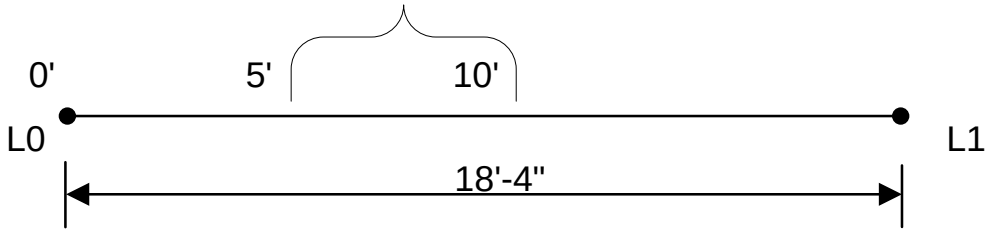
- 10 kip downward vertical DC load at PanelPoint L2.
- Additional 5% self-weight.

Exercise 5 - Add member of interest to define deterioration.

Add a member of interest to describe the following section loss in Member L0L1.

30% thickness section
loss on both channels





Exercise 1 - Modify truss geometry - Solution

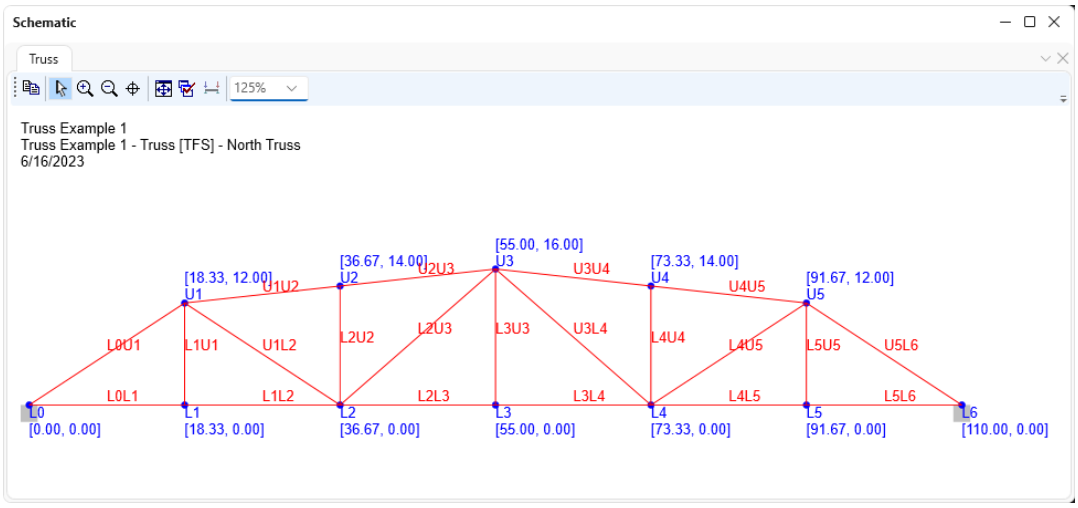
The PanelPoint and Member commands for Exercise 1 are shown below. The modified descriptions are shown in bold text.

```
PanelPoint
L0  Lower  0.0000  0.0
L1  Lower 18.3333 0.0
L2 Lower 36.6667 0.0
L3 Lower 55.0000 0.0
L4 Lower 73.3333 0.0
L5 Lower 91.6667 0.0
L6 Lower 110.0000 0.0
U1 Upper 18.3333 12.0
U2 Upper 36.6667 14.0
U3 Upper 55.0000 16.0
U4 Upper 73.3333 14.0
U5 Upper 91.6667 12.0

Member
L0L1 L0 L1 Section1
L1L2 L1 L2 Section1
L2L3 L2 L3 Section2
L3L4 L3 L4 Section2
L4L5 L4 L5 Section2
L5L6 L5 L6 Section2
L0U1 L0 U1 Section4
U1U2 U1 U2 Section5
U2U3 U2 U3 Section5
U3U4 U3 U4 Section5
U4U5 U4 U5 Section5
U5L6 U5 L6 Section4
L1U1 L1 U1 Section3
U1L2 U1 L2 Section6
L2U2 L2 U2 Section3
```

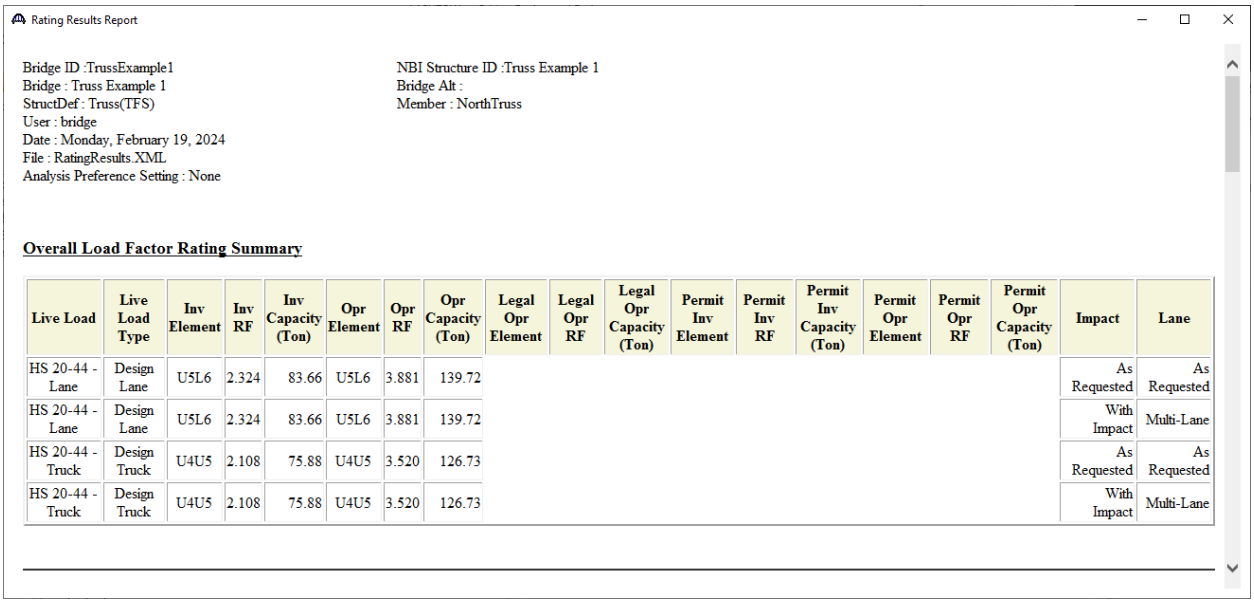
Schematic - Truss

While the truss 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 the truss definition in the Bridge Workspace and select **Schematic** from the menu).



Rating Results Report

Run an LFR analysis using HS 20-44 vehicle in Inventory and Operating on North Truss. A portion of the **Rating Results Report** is shown below.



Rating Results Report

Bridge ID :TrussExample1
Bridge : Truss Example 1
StructDef : Truss(TFS)
User : bridge
Date : Monday, February 19, 2024
File : RatingResults.XML
Analysis Preference Setting : None

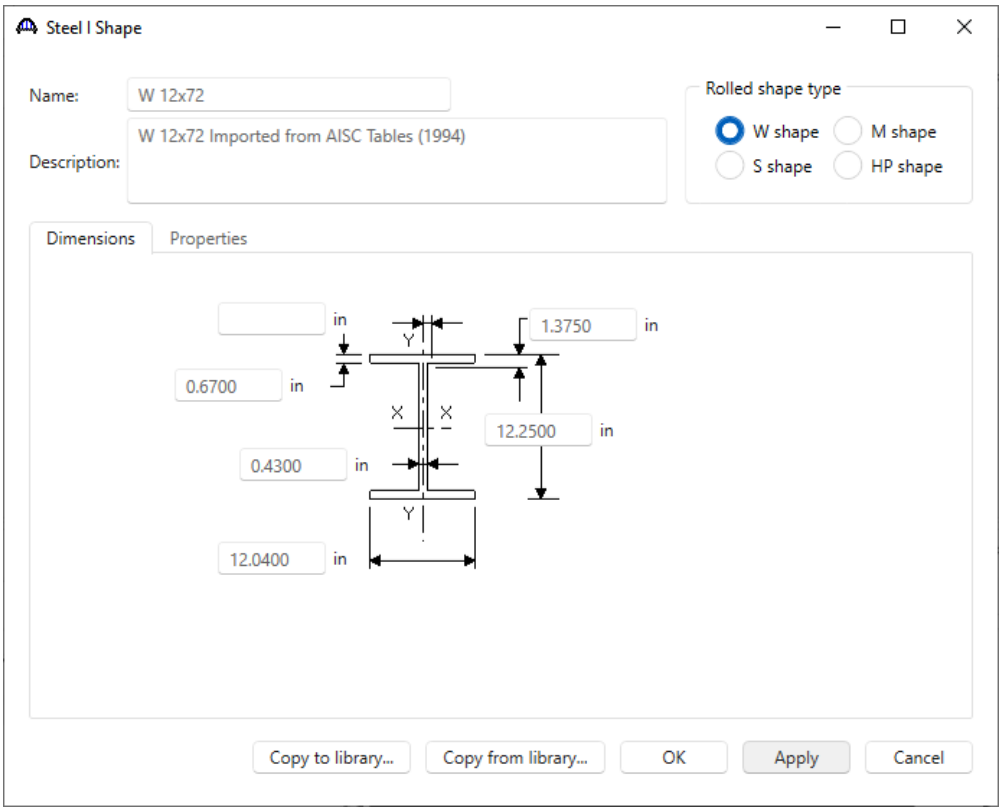
NBI Structure ID :Truss Example 1
Bridge Alt :
Member : NorthTruss

Overall Load Factor Rating Summary

Live Load	Live Load Type	Inv Element	Inv RF	Inv Capacity (Ton)	Opr Element	Opr RF	Opr Capacity (Ton)	Legal Opr Element	Legal Opr RF	Legal Opr Capacity (Ton)	Permit Inv Element	Permit Inv RF	Permit Inv Capacity (Ton)	Permit Opr Element	Permit Opr RF	Permit Opr Capacity (Ton)	Impact	Lane
HS 20-44 - Lane	Design Lane	U5L6	2.324	83.66	U5L6	3.881	139.72										As Requested	As Requested
HS 20-44 - Lane	Design Lane	U5L6	2.324	83.66	U5L6	3.881	139.72										With Impact	Multi-Lane
HS 20-44 - Truck	Design Truck	U4U5	2.108	75.88	U4U5	3.520	126.73										As Requested	As Requested
HS 20-44 - Truck	Design Truck	U4U5	2.108	75.88	U4U5	3.520	126.73										With Impact	Multi-Lane

Exercise 2 - Add new member cross section and assign cross section to member – Solution

The **W 12x72 (1994)** is a new rolled beam shape for the bridge. This needs to be added to the Bridge Workspace tree. Create a new Steel I Shape and use the **Copy from library** button to copy the **W12x72** to this bridge.



The new **MemberCrossSection** and **Member** command for Exercise 2 are shown below. The new and modified descriptions are shown in bold text. The steel material is not specified for the **W 12x72**, the default steel **Truss Steel** will be used. The texts following // are comments and will be ignored.

```
MemberCrossSection
.
.
.
Rolled = Section7
TopFlangePlate
12.0 0.5 Steel2 // Grade 36
Beam "W 12x72"  // Truss Steel

PanelPoint
U1 Upper 18.3333 12.0
U2 Upper 36.6667 14.0
```

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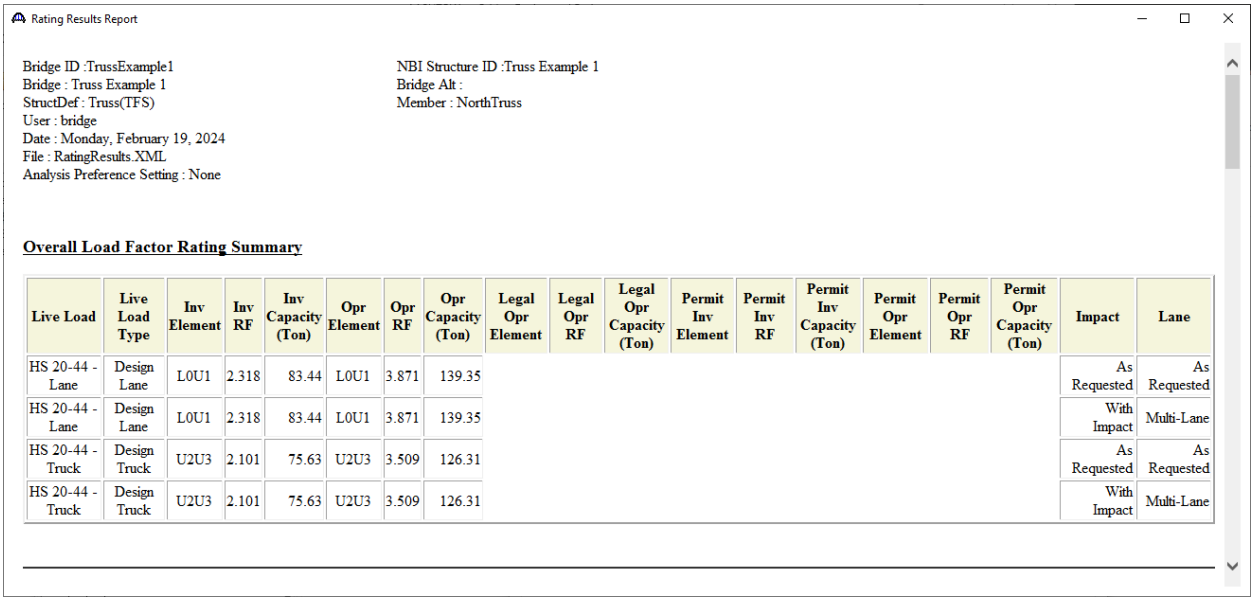
```
U3 Upper 55.0000 16.0
U4 Upper 73.3333 14.0

Member
L0L1 L0 L1 Section1
L1L2 L1 L2 Section1
L2L3 L2 L3 Section2
L3L4 L3 L4 Section2
L4L5 L4 L5 Section2
L5L6 L5 L6 Section2
L0U1 L0 U1 Section4
U1U2 U1 U2 Section5
U2U3 U2 U3 Section5
U3U4 U3 U4 Section5
U4U5 U4 U5 Section5
U5L6 U5 L6 Section4
L1U1 L1 U1 Section3
U2L1 U2 L1 Section7
L2U2 L2 U2 Section3
```

Rating Results Report

Run an LFR analysis using HS 20-44 vehicle in Inventory and Operating on North Truss. A portion of the **Rating Results Report** is shown below.



Rating Results Report

Bridge ID :TrussExample1
Bridge : Truss Example 1
StructDef : Truss(TFS)
User : bridge
Date : Monday, February 19, 2024
File : RatingResults.XML
Analysis Preference Setting : None

NBI Structure ID :Truss Example 1
Bridge Alt :
Member : NorthTruss

Overall Load Factor Rating Summary

Live Load	Live Load Type	Inv Element	Inv RF	Inv Capacity (Ton)	Opr Element	Opr RF	Opr Capacity (Ton)	Legal Opr Element	Legal Opr RF	Legal Opr Capacity (Ton)	Permit Inv Element	Permit Inv RF	Permit Inv Capacity (Ton)	Permit Opr Element	Permit Opr RF	Permit Opr Capacity (Ton)	Impact	Lane
HS 20-44 - Lane	Design Lane	L0U1	2.318	83.44	L0U1	3.871	139.35										As Requested	As Requested
HS 20-44 - Lane	Design Lane	L0U1	2.318	83.44	L0U1	3.871	139.35										With Impact	Multi-Lane
HS 20-44 - Truck	Design Truck	U2U3	2.101	75.63	U2U3	3.509	126.31										As Requested	As Requested
HS 20-44 - Truck	Design Truck	U2U3	2.101	75.63	U2U3	3.509	126.31										With Impact	Multi-Lane

Exercise 3 - Symmetry command - Solution

The new descriptions are shown in bold text. The deleted descriptions are crossed-out.

Symmetry Even

```
PanelPoint
L0 Lower  0.0000 0.0
L1 Lower 18.3333 0.0
L2 Lower 36.6667 0.0
L3 Lower 55.0000 0.0
~~L4 Lower 73.3333 0.0~~
~~L5 Lower 91.6667 0.0~~
~~L6 Lower 110.0000 0.0~~
U1 Upper 18.3333 12.0
U2 Upper 36.6667 14.0
U3 Upper 55.0000 16.0
~~U4 Upper 73.3333 14.0~~
~~U5 Upper 91.6667 12.0~~

Member
L0L1 L0 L1 Section1
L1L2 L1 L2 Section1
L2L3 L2 L3 Section2
~~L3L4 L3 L4 Section2~~
~~L4L5 L4 L5 Section2~~
~~L5L6 L5 L6 Section2~~
L0U1 L0 U1 Section4
U1U2 U1 U2 Section5
U2U3 U2 U3 Section5
~~U3U4 U3 U4 Section5~~
~~U4U5 U4 U5 Section5~~
~~U5L6 U5 L6 Section4~~
L1U1 L1 U1 Section3
U2L1 U2 L1 Section7
L2U2 L2 U2 Section3
L2U3 L2 U3 Section6
L3U3 L3 U3 Section3
~~U3L4 U3 L4 Section6~~
```

~~L4U4 L4 U4 Section3~~

~~L4U5 L4 U5 Section6~~

~~L5U5 L5 U5 Section3~~

```
Support
L0 Pinned
```

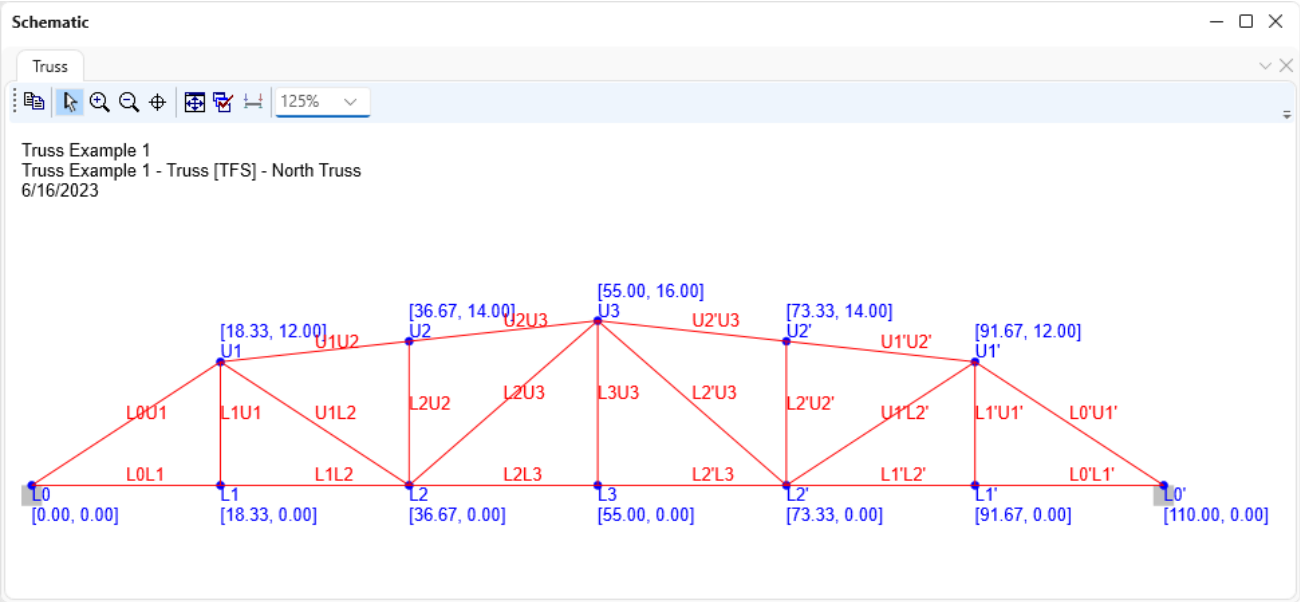
~~L6 Roller~~

Schematic - Truss

While the truss 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 the truss definition in the Bridge Workspace and select **Schematic** from the menu). The schematic of the truss reflects the symmetrical geometry. Only half the truss will be displayed in the schematic if the truss verification failed. The panel points and members on the right hand side are generated by the Symmetry command.

Notes for the Symmetry command:

- The command generates symmetrical geometry, user defined loads (specified in PanelPointLoad command) and supports.
- Generated symmetrical supports will be pinned supports by default (i.e., x and y translations will be restrained).
- The command will also handle supports and panel point load that are on the axis of symmetry.



Exercise 4 - Add point load and additional self-weight - Solution

The PanelPointLoad and AdditionalSelfLoad commands for Exercise 4 are shown below. The new descriptions are shown in bold text. Use **#** as a place holder for optional value if it is followed by some input.

Symmetry Even

```
PanelPoint
L0 Lower  0.0000 0.0
L1 Lower 18.3333 0.0
L2 Lower 36.6667 0.0
L3 Lower 55.0000 0.0
~~L4 Lower 73.3333 0.0~~
~~L5 Lower 91.6667 0.0~~
~~L6 Lower 110.0000 0.0~~
U1 Upper 18.3333 12.0
U2 Upper 36.6667 14.0
U3 Upper 55.0000 16.0
~~U4 Upper 73.3333 14.0~~
~~U5 Upper 91.6667 12.0~~

Member
L0L1 L0 L1 Section1
L1L2 L1 L2 Section1
L2L3 L2 L3 Section2
~~L3L4 L3 L4 Section2~~
~~L4L5 L4 L5 Section2~~
~~L5L6 L5 L6 Section2~~
L0U1 L0 U1 Section4
U1U2 U1 U2 Section5
U2U3 U2 U3 Section5
~~U3U4 U3 U4 Section5~~
~~U4U5 U4 U5 Section5~~
~~U5L6 U5 L6 Section4~~
L1U1 L1 U1 Section3
U2L1 U2 L1 Section7
L2U2 L2 U2 Section3
L2U3 L2 U3 Section6
L3U3 L3 U3 Section3
```

~~U3L4 U3 L4 Section6~~

~~L4U4 L4 U4 Section3~~

~~L4U5 L4 U5 Section6~~

~~L5U5 L5 U5 Section3~~

Support

L0 Pinned

~~L6 Roller~~

PanelPointLoad

L2 DC 0.0 -10.0

AdditionalSelfLoad # 5.0

LLDistribution

Dead Load Analysis Report

Run an LFR analysis using HS 20-44 vehicle in Inventory and Operating on North Truss. A portion of the **Dead Load Analysis Report** is shown below.

Dead Load Analysis Report

Load Case: SelfWeight DC
Load ID: 5

Nodal Loads

Node	X Force (kip)	Y Force (kip)	Z Force (kip)	X Moment (kip-ft)	Y Moment (kip-ft)	Z Moment (kip-ft)
1	0.000	-2.640	0.000	0.000	0.000	0.000
2	0.000	-2.614	0.000	0.000	0.000	0.000
3	0.000	-4.350	0.000	0.000	0.000	0.000
4	0.000	-3.585	0.000	0.000	0.000	0.000
5	0.000	-4.688	0.000	0.000	0.000	0.000
6	0.000	-3.692	0.000	0.000	0.000	0.000
7	0.000	-5.201	0.000	0.000	0.000	0.000
8	0.000	-3.585	0.000	0.000	0.000	0.000
9	0.000	-4.688	0.000	0.000	0.000	0.000
10	0.000	-4.350	0.000	0.000	0.000	0.000
11	0.000	-2.614	0.000	0.000	0.000	0.000
12	0.000	-2.640	0.000	0.000	0.000	0.000

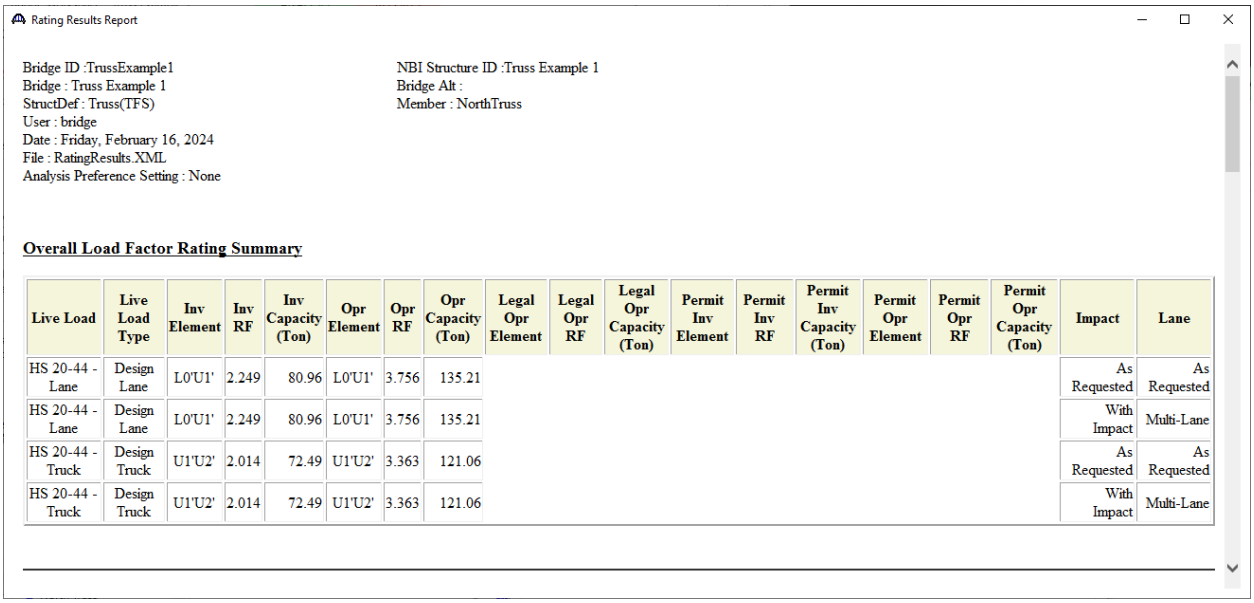
Load Case: Superstructure DC
Load ID: 6

Nodal Loads

Node	X Force (kip)	Y Force (kip)	Z Force (kip)	X Moment (kip-ft)	Y Moment (kip-ft)	Z Moment (kip-ft)
5	0.000	-10.000	0.000	0.000	0.000	0.000
9	0.000	-10.000	0.000	0.000	0.000	0.000

Rating Results Report

Run an LFR analysis using the HS 20-44 vehicle in Inventory and Operating on North Truss. A portion of the **Rating Results Report** is shown below.



Rating Results Report

Bridge ID :TrussExample1
Bridge : Truss Example 1
StructDef : Truss(TFS)
User : bridge
Date : Friday, February 16, 2024
File : RatingResults.XML
Analysis Preference Setting : None

NBI Structure ID :Truss Example 1
Bridge Alt :
Member : NorthTruss

Overall Load Factor Rating Summary

Live Load	Live Load Type	Inv Element	Inv RF	Inv Capacity (Ton)	Opr Element	Opr RF	Opr Capacity (Ton)	Legal Opr Element	Legal Opr RF	Legal Opr Capacity (Ton)	Permit Inv Element	Permit Inv RF	Permit Inv Capacity (Ton)	Permit Opr Element	Permit Opr RF	Permit Opr Capacity (Ton)	Impact	Lane
HS 20-44 - Lane	Design Lane	L0'U1'	2.249	80.96	L0'U1'	3.756	135.21										As Requested	As Requested
HS 20-44 - Lane	Design Lane	L0'U1'	2.249	80.96	L0'U1'	3.756	135.21										With Impact	Multi-Lane
HS 20-44 - Truck	Design Truck	U1'U2'	2.014	72.49	U1'U2'	3.363	121.06										As Requested	As Requested
HS 20-44 - Truck	Design Truck	U1'U2'	2.014	72.49	U1'U2'	3.363	121.06										With Impact	Multi-Lane

Exercise 5 - Add member of interest to define deterioration - Solution

The MemberOfInterest command for Exercise 5 is shown below. The new descriptions are shown in bold text.

```
Symmetry Even

PanelPoint
L0 Lower  0.0000 0.0
L1 Lower 18.3333 0.0
L2 Lower 36.6667 0.0
L3 Lower 55.0000 0.0
~~L4 Lower 73.3333 0.0~~
~~L5 Lower 91.6667 0.0~~
~~L6 Lower 110.0000 0.0~~
U1 Upper 18.3333 12.0
U2 Upper 36.6667 14.0
U3 Upper 55.0000 16.0
~~U4 Upper 73.3333 14.0~~
~~U5 Upper 91.6667 12.0~~

Member
L0L1 L0 L1 Section1
L1L2 L1 L2 Section1
L2L3 L2 L3 Section2
~~L3L4 L3 L4 Section2~~
~~L4L5 L4 L5 Section2~~
~~L5L6 L5 L6 Section2~~
L0U1 L0 U1 Section4
U1U2 U1 U2 Section5
U2U3 U2 U3 Section5
~~U3U4 U3 U4 Section5~~
~~U4U5 U4 U5 Section5~~
~~U5L6 U5 L6 Section4~~
L1U1 L1 U1 Section3
U2L1 U2 L1 Section7
L2U2 L2 U2 Section3
L2U3 L2 U3 Section6
L3U3 L3 U3 Section3
~~U3L4 U3 L4 Section6~~
```

~~L4U4 L4 U4 Section3~~
~~L4U5 L4 U5 Section6~~
~~L5U5 L5 U5 Section3~~

Support
L0 Pinned
~~L6 Roller~~

PanelPointLoad
L2 DC 0.0 -10.0

AdditionalSelfLoad # 5.0

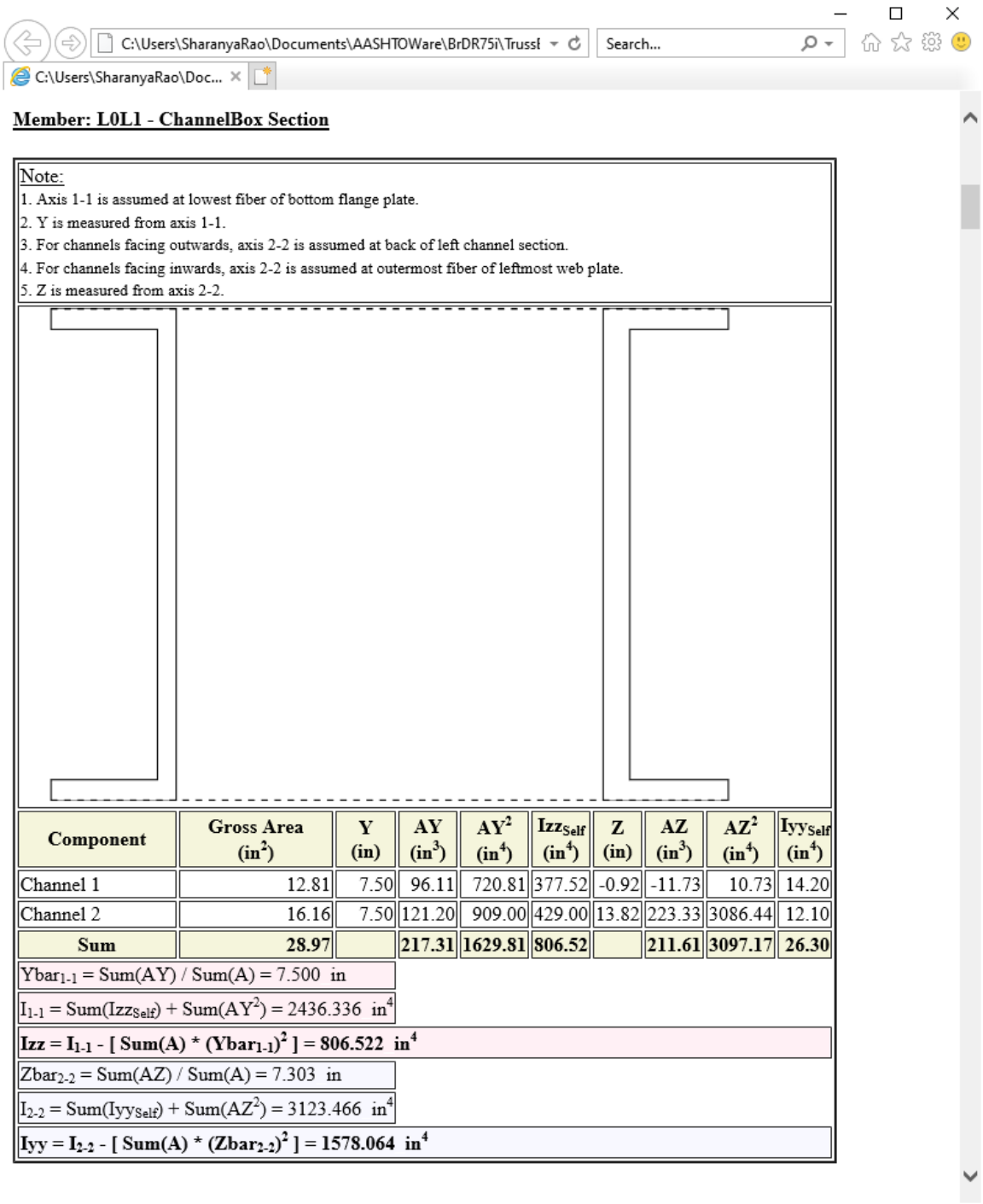
LLDistribution
OneLane 0.805 0.5
MultiLane 1.27 1.0

MemberOfInterest
L0L1
Deterioration
Channels
Left Web 30.0 0.0 L0 5.0 10.0

(See next page for results)

Truss Member Section Property Report

Run an LFR analysis using the HS 20-44 vehicle in Inventory and Operating on North Truss. A portion of the **Truss Member Section Property Report** is shown below. The section properties of Member L0L1 reflect the deterioration.



Member: L0L1 - ChannelBox Section

Note:
1. Axis 1-1 is assumed at lowest fiber of bottom flange plate.
2. Y is measured from axis 1-1.
3. For channels facing outwards, axis 2-2 is assumed at back of left channel section.
4. For channels facing inwards, axis 2-2 is assumed at outermost fiber of leftmost web plate.
5. Z is measured from axis 2-2.

Component	Gross Area (in^2)	Y (in)	AY (in^3)	AY^2 (in^4)	Izz_{Self} (in^4)	Z (in)	AZ (in^3)	AZ^2 (in^4)	Iyy_{Self} (in^4)
Channel 1	12.81	7.50	96.11	720.81	377.52	-0.92	-11.73	10.73	14.20
Channel 2	16.16	7.50	121.20	909.00	429.00	13.82	223.33	3086.44	12.10
Sum	**28.97**		**217.31**	**1629.81**	**806.52**		**211.61**	**3097.17**	**26.30**

$Ybar_{1-1} = Sum(AY) / Sum(A) = 7.500$ in

$I_{1-1} = Sum(Izz_{Self}) + Sum(AY^2) = 2436.336$ in^4

$Izz = I_{1-1} - [Sum(A) * (Ybar_{1-1})^2] = 806.522$ in^4

$Zbar_{2-2} = Sum(AZ) / Sum(A) = 7.303$ in

$I_{2-2} = Sum(Iyy_{Self}) + Sum(AZ^2) = 3123.466$ in^4

$Iyy = I_{2-2} - [Sum(A) * (Zbar_{2-2})^2] = 1578.064$ in^4