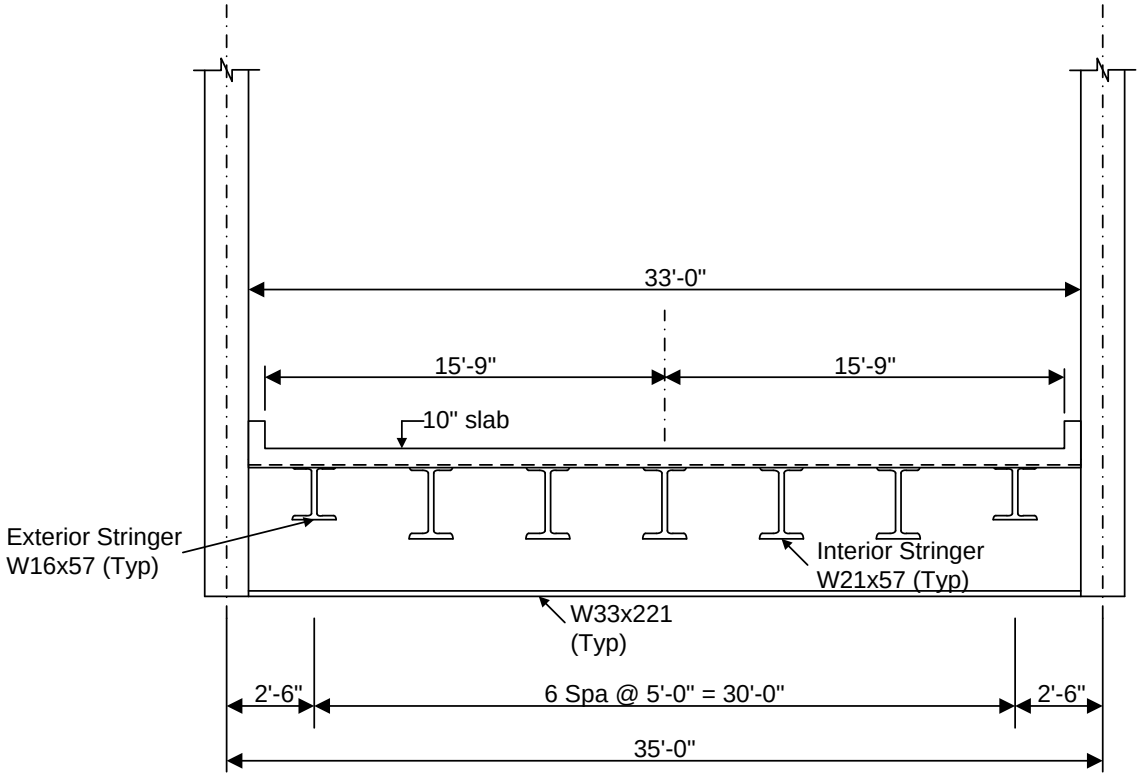
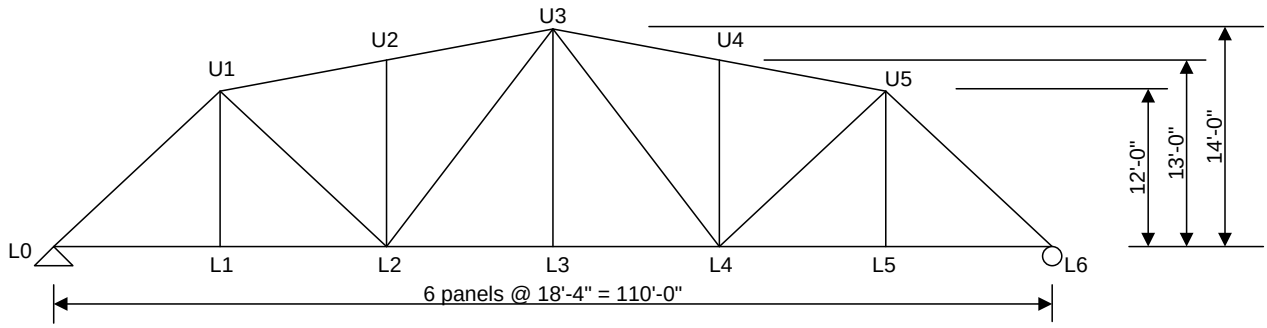
AASHTOWare BrR 6.8

Truss Tutorial

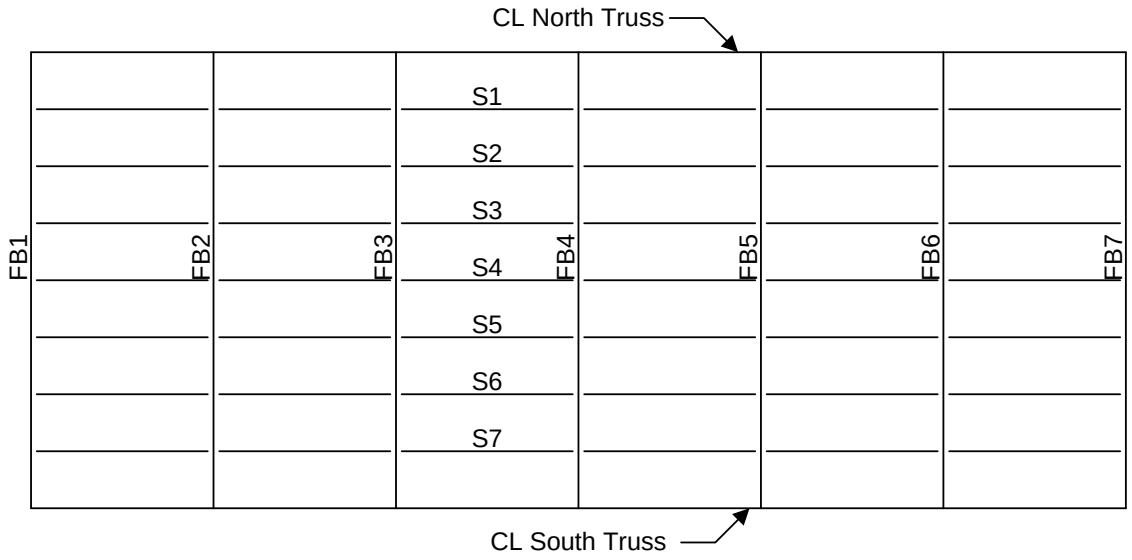
T1 – Truss Floorbeam Stringer Example



Typical Section

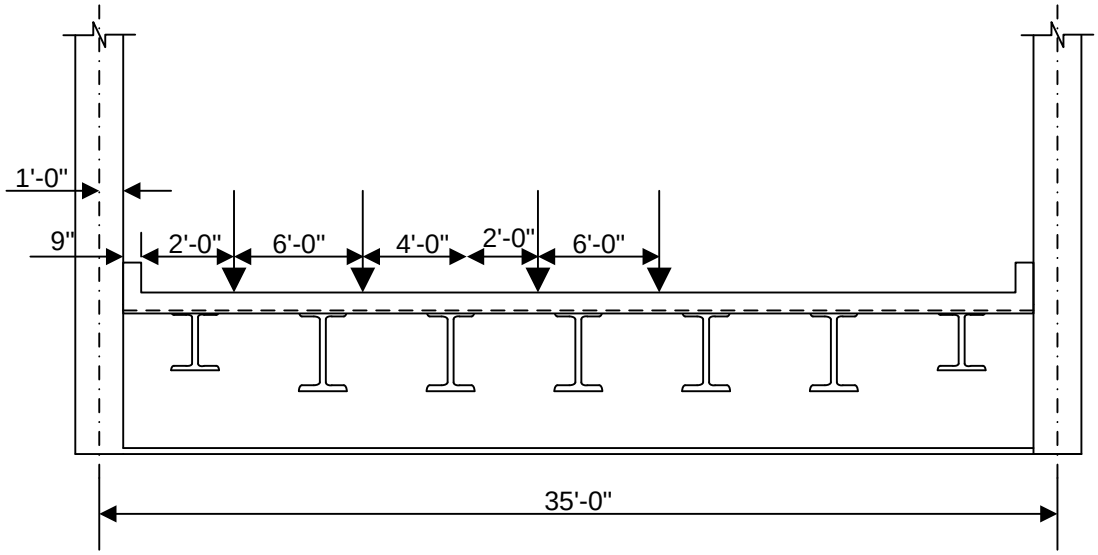


Elevation



Plan View

Truss Live Load Distribution Factors



Force

1 Lane DF = (31.25 + 25.25)/35 = 1.61 wheels

Multi Lane DF = (31.25 + 25.25 + 19.25 + 13.25)/35 = 2.54 wheels

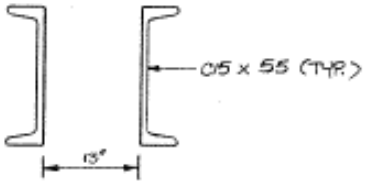
Deflection

1 Lane DF = 2 wheels/2 trusses = 1.0 wheels

Multi Lane DF = 4 wheels/2 trusses = 2.0 wheels

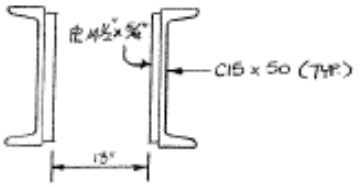
2. Truss Members

i. L_0L_1, L_1L_2, L_4L_5, L_5L_6



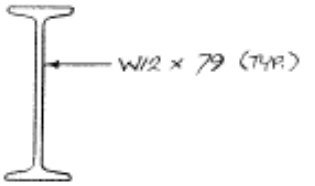
$A = 2(16.16) = 32.32\ in^2$

ii. L_2L_3, L_3L_4



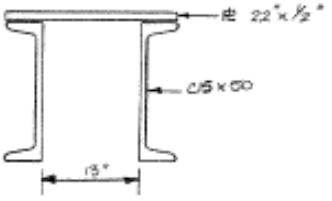
$A = 2\left[14.69 + 14\tfrac{1}{2}(\tfrac{5}{8})\right]$
$= 47.51\ in^2$

iii. L_1U_1, L_2U_2, L_3U_3, L_4U_4, L_5U_6



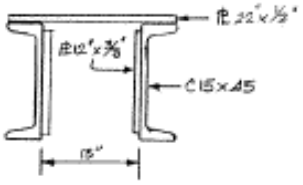
$A = 23.22\ in^2$

IV. L_0U_1, L_6L_6



$A = 2(14.69) + (22 \times \tfrac{1}{2})$
$= 40.38\ in^2$

V. U_1L_2, L_2U_3, U_3L_4, L_4U_5



$A = 2\left[13.22 + 12(\tfrac{3}{8})\right] + (22" \times \tfrac{1}{2}")$
$= 46.44\ in^2$

VI. U_1L_2, L_2U_3, U_3L_4, L_4U_5

$A = 19.1\ in^2$

BrR Training

T1 – Truss Floorbeam Stringer Example

This example describes entering a truss-floorbeam-stringer system and performing a rating of the truss.

Topics covered:

- Truss description and analysis
- Truss-floorbeam-stringer system superstructure
- Truss line superstructures

Note: It is assumed that the user is familiar with BrR and its Bridge Workspace. Therefore, this example does not go into great detail explaining the Bridge Workspace and detailed entry into windows not particular to a truss.

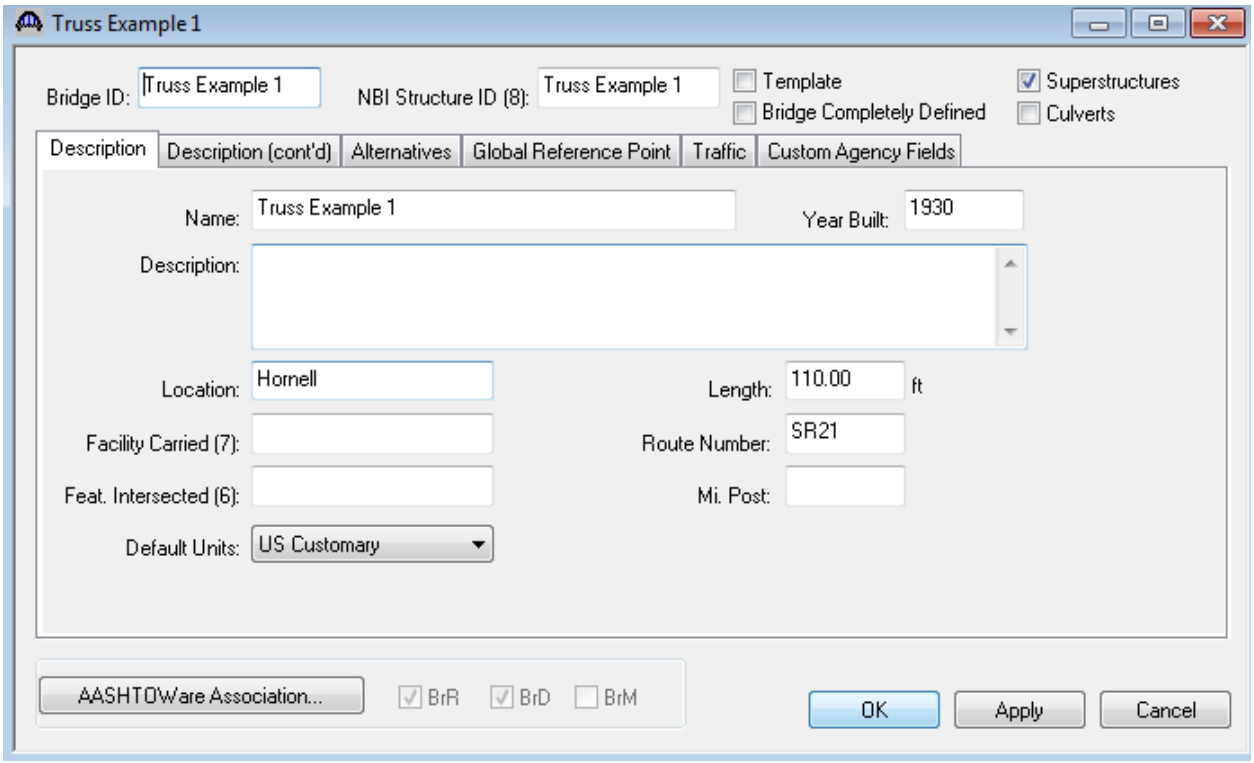
Truss Description and Analysis

Trusses are described in BrR by entering a text description of the truss in the BrR Truss Command Language. This command language contains commands to describe the truss geometry, members, loads, etc. The Truss Command Language User Manual can be accessed from the BrR Truss window's help topic.

BrR analyzes and rates trusses using the BrR Truss analysis engine. You cannot currently pick an alternate engine to perform the analysis. The BrR Truss analysis engine analyzes a finite element model of the truss and computes rating factors using the Load Factor method. The truss is analyzed for axial force only, bending due to load eccentricity is not considered.

Truss-Floorbeam-Stringer System Superstructure

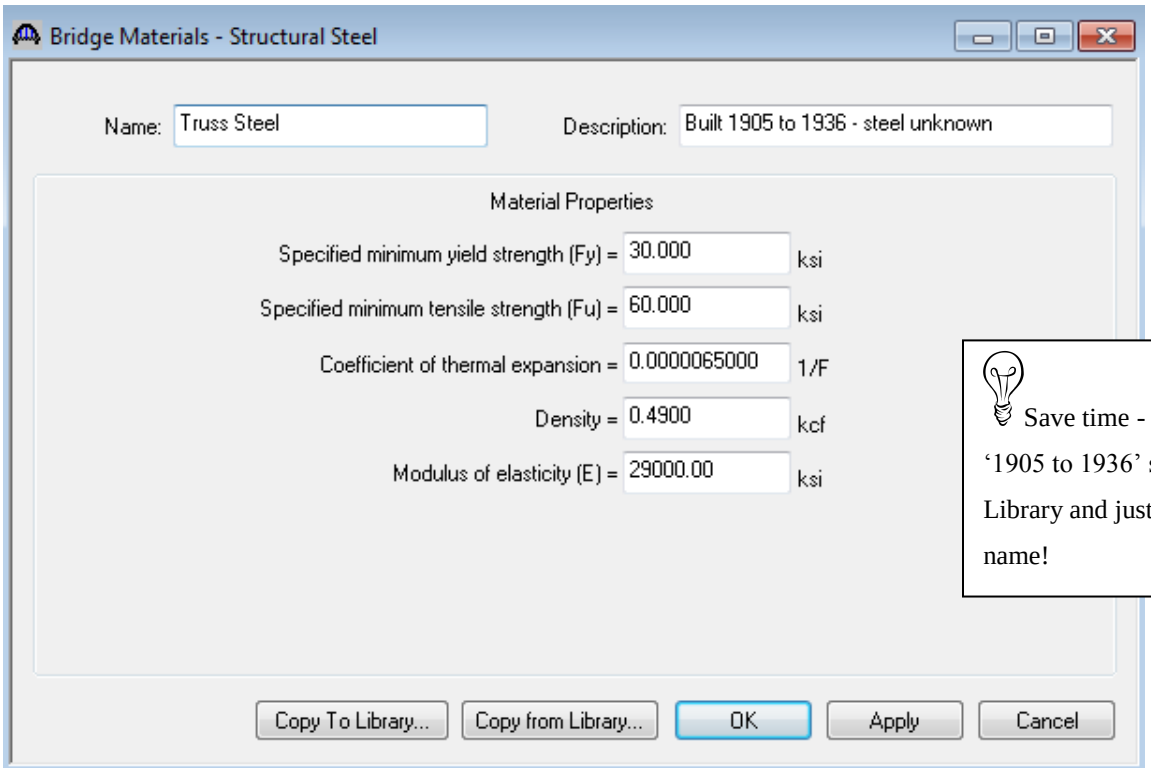
From the Bridge Explorer, select File/New/New Bridge to create a new bridge. Enter the following description data:



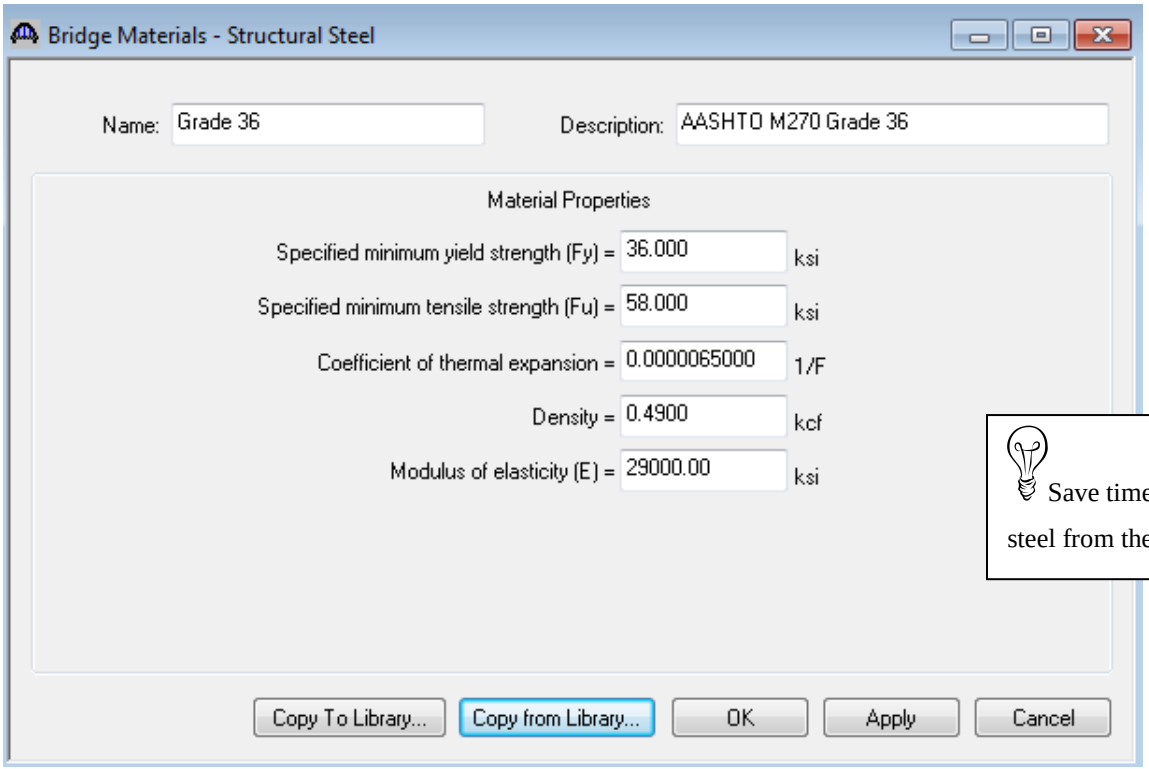
Close the window by clicking OK. This saves the data to memory and closes the window.

> The text description of the truss will include the following steel material and shape names that we enter here in the BrR BWS. You have to be sure that the names in the BWS exactly match the names you use in the truss text description.

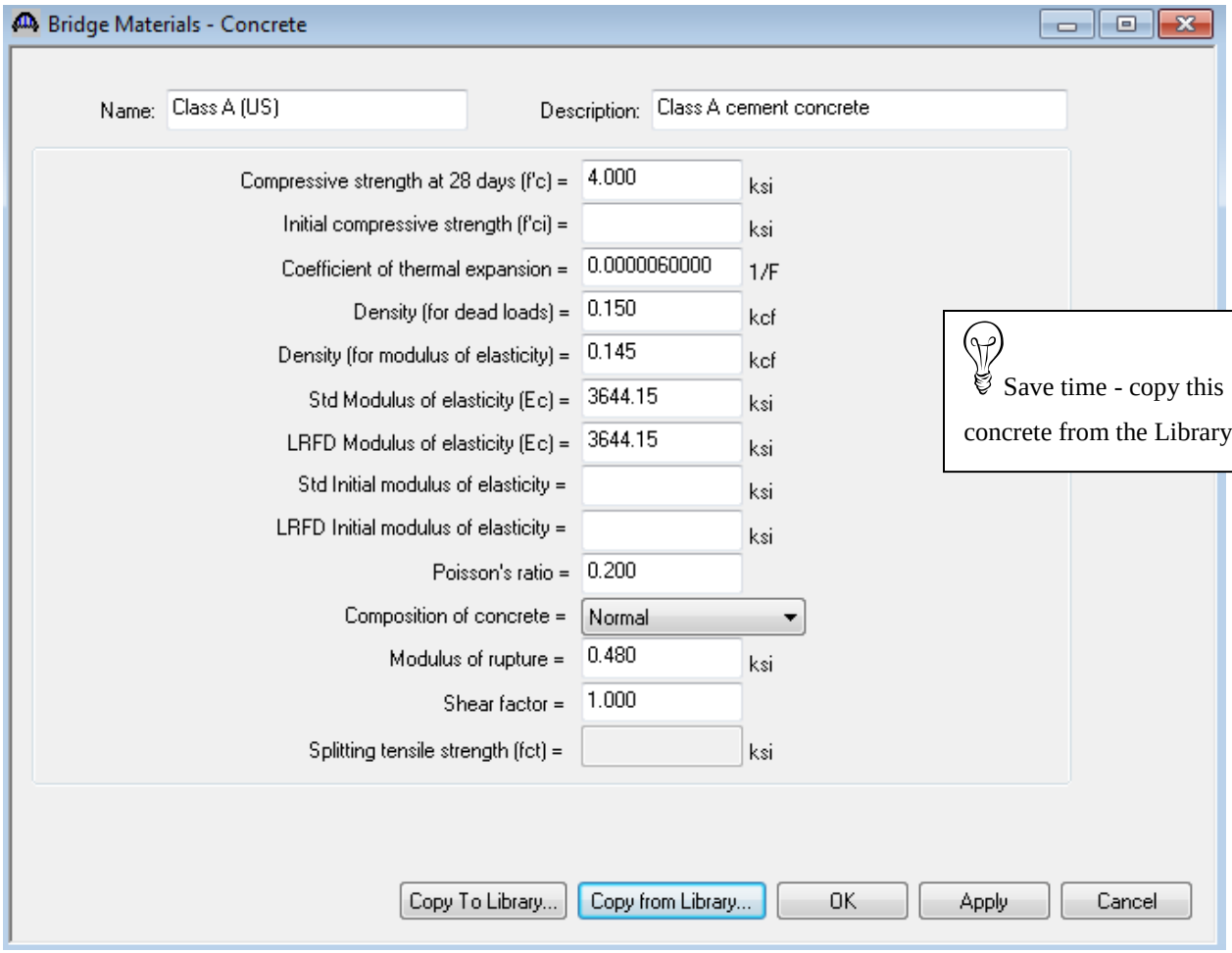
Create the following materials for the bridge:



Save time - copy the '1905 to 1936' steel from the Library and just change its name!

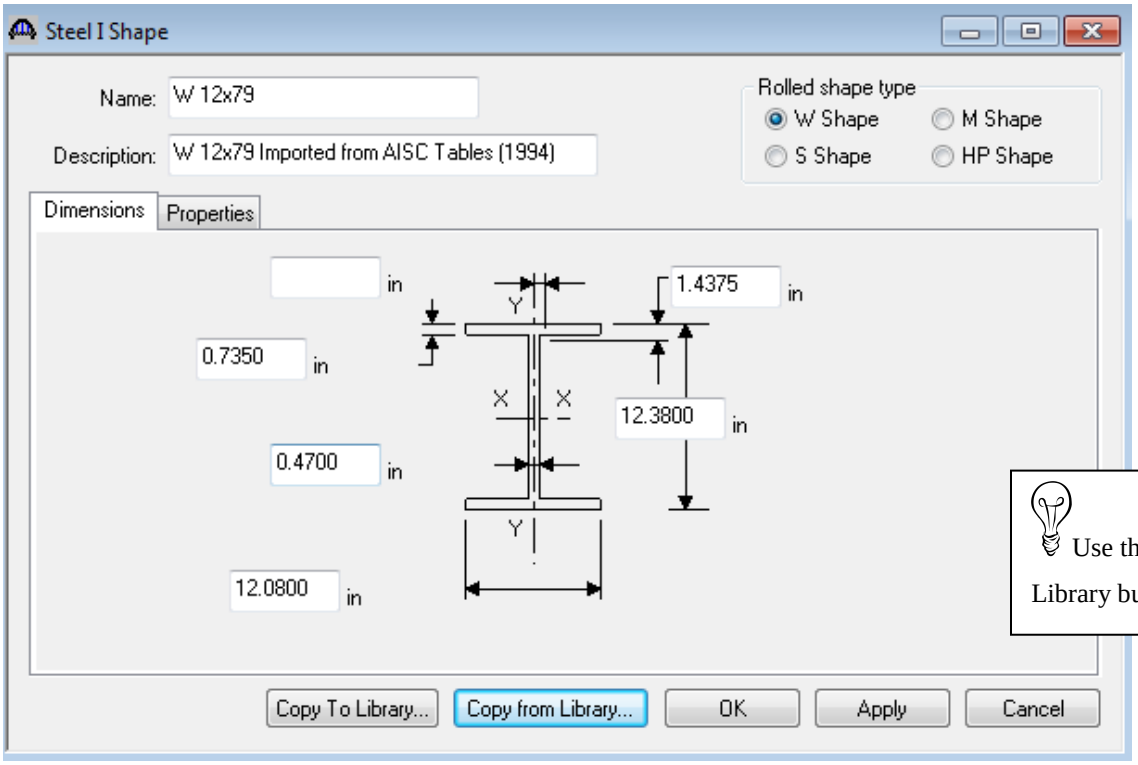


Save time - copy this steel from the Library!



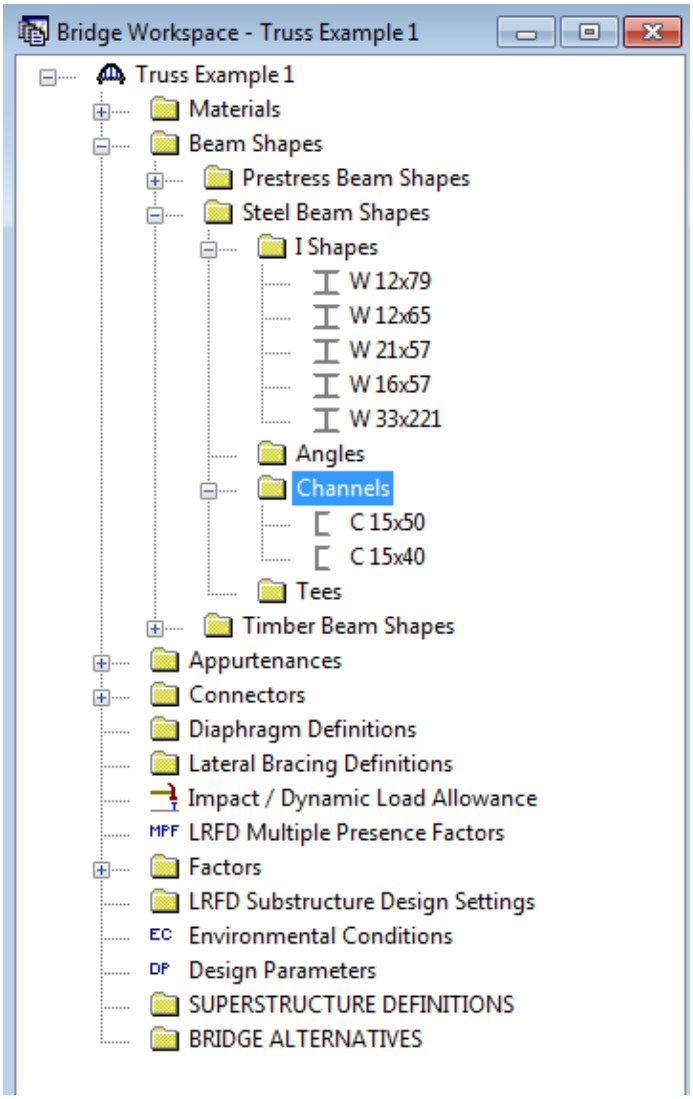
Save time - copy this concrete from the Library!

Now we need to add steel shapes to our bridge. Open the Steel I Shape window and use the Copy from Library button to copy the W12x79 to our bridge.

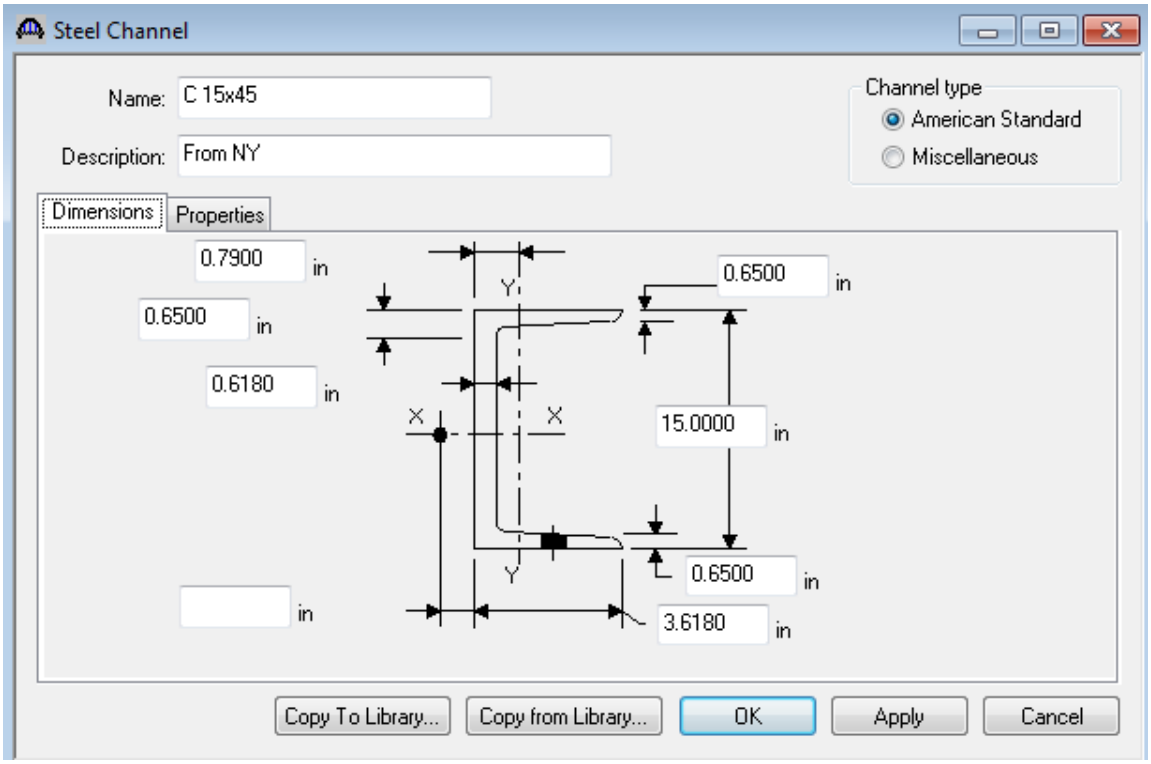


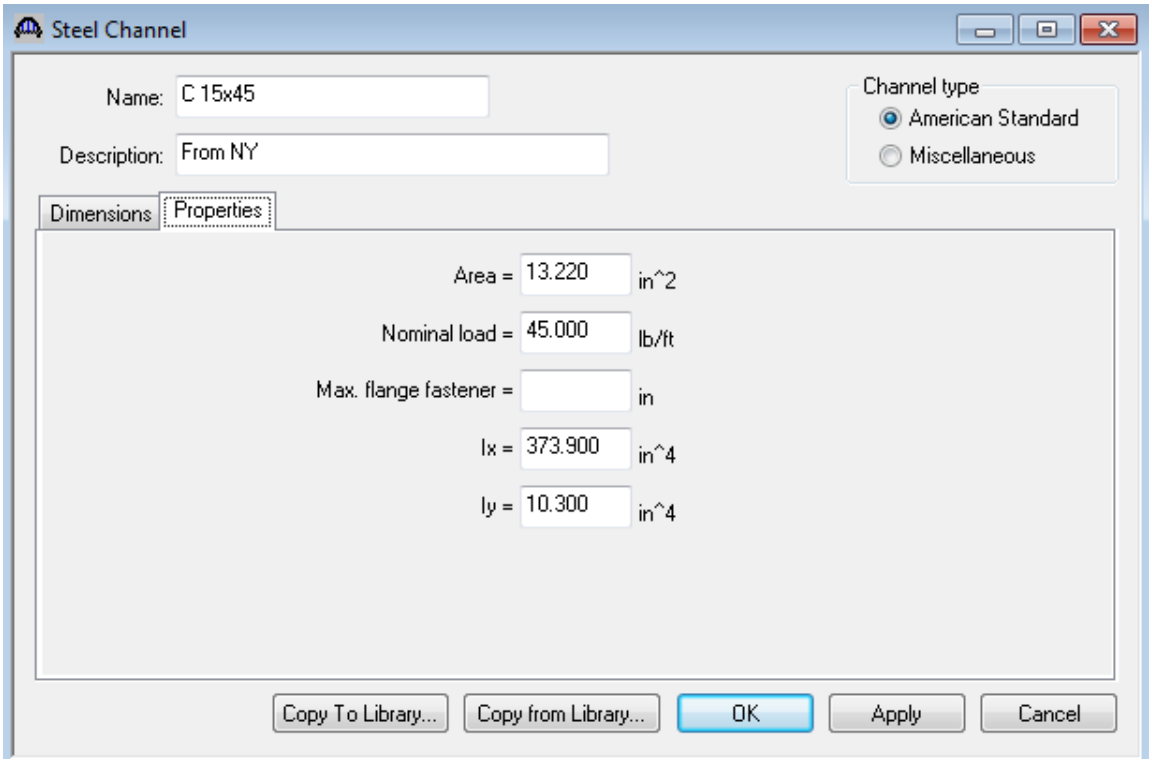
Use the Copy from Library button!

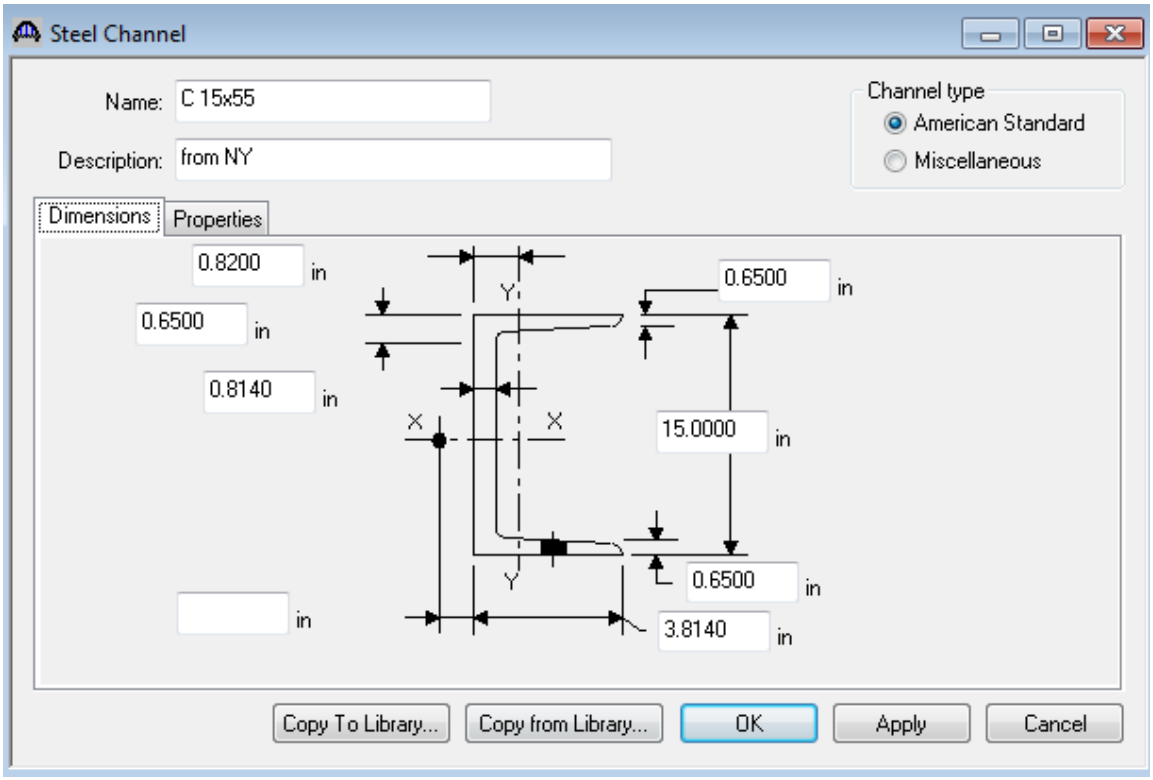
Follow the same procedure to copy the following steel shapes to our bridge:

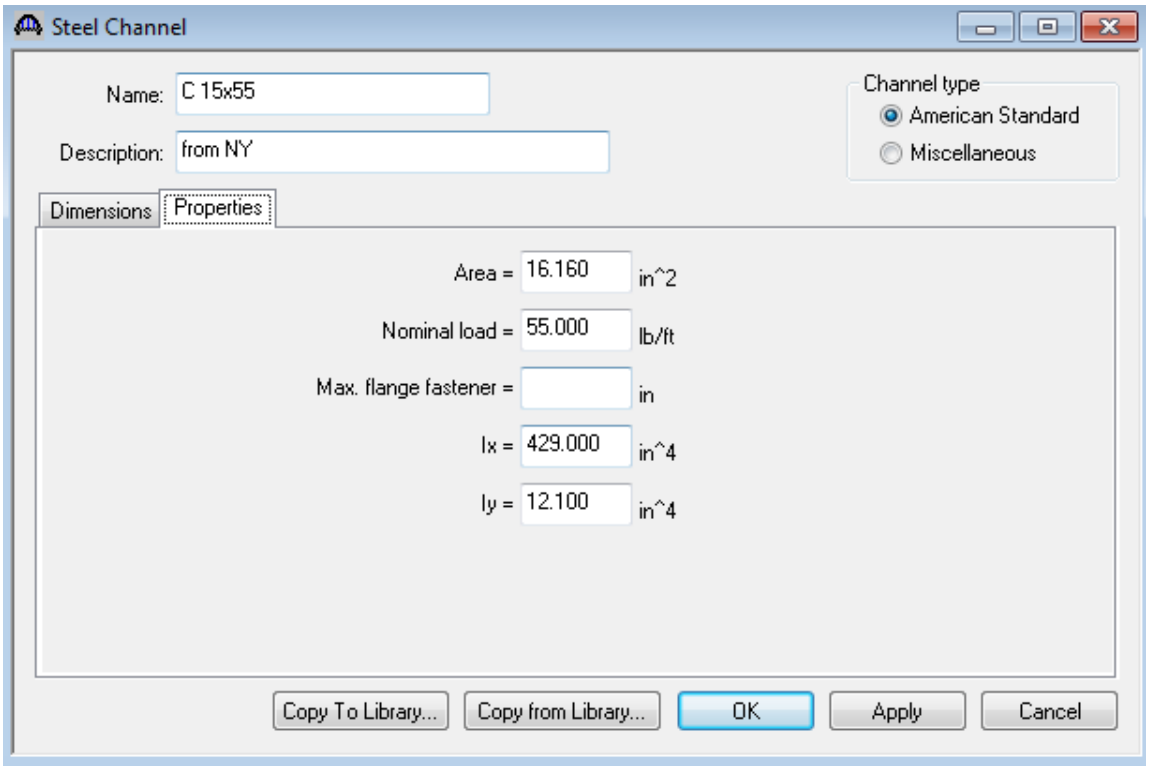


The following 2 channel shapes are not in the Standard Library and must be entered manually:

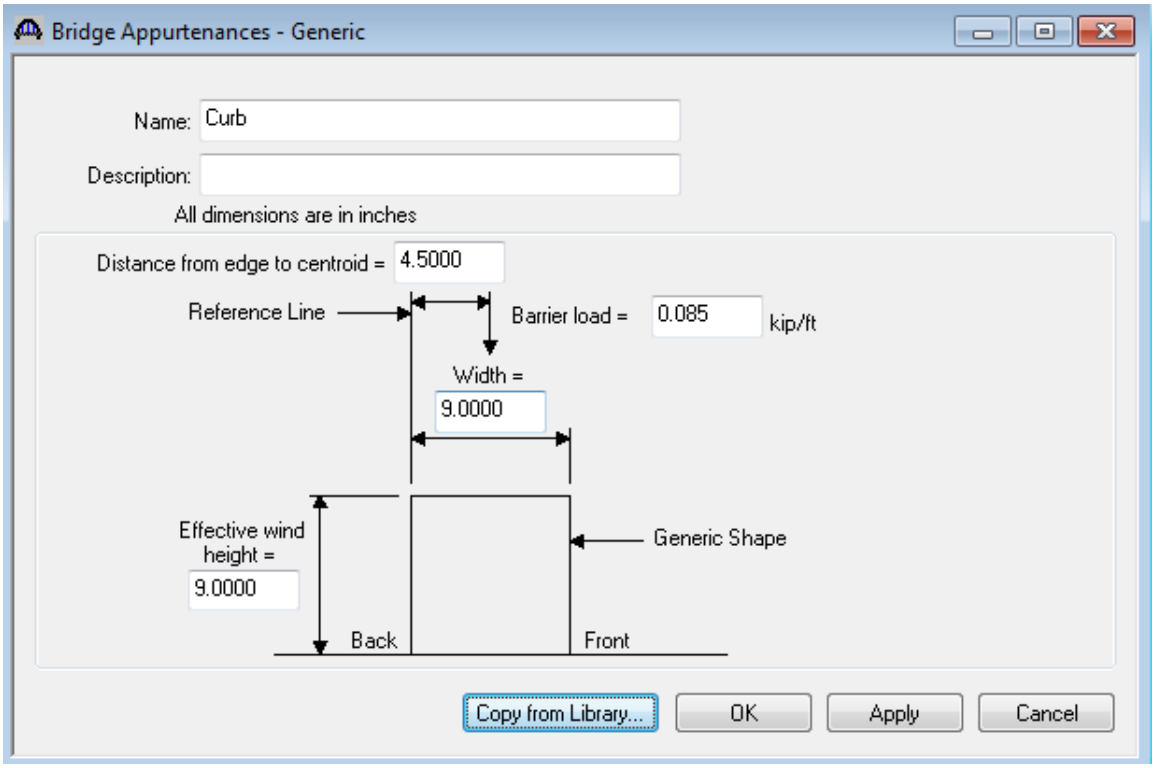




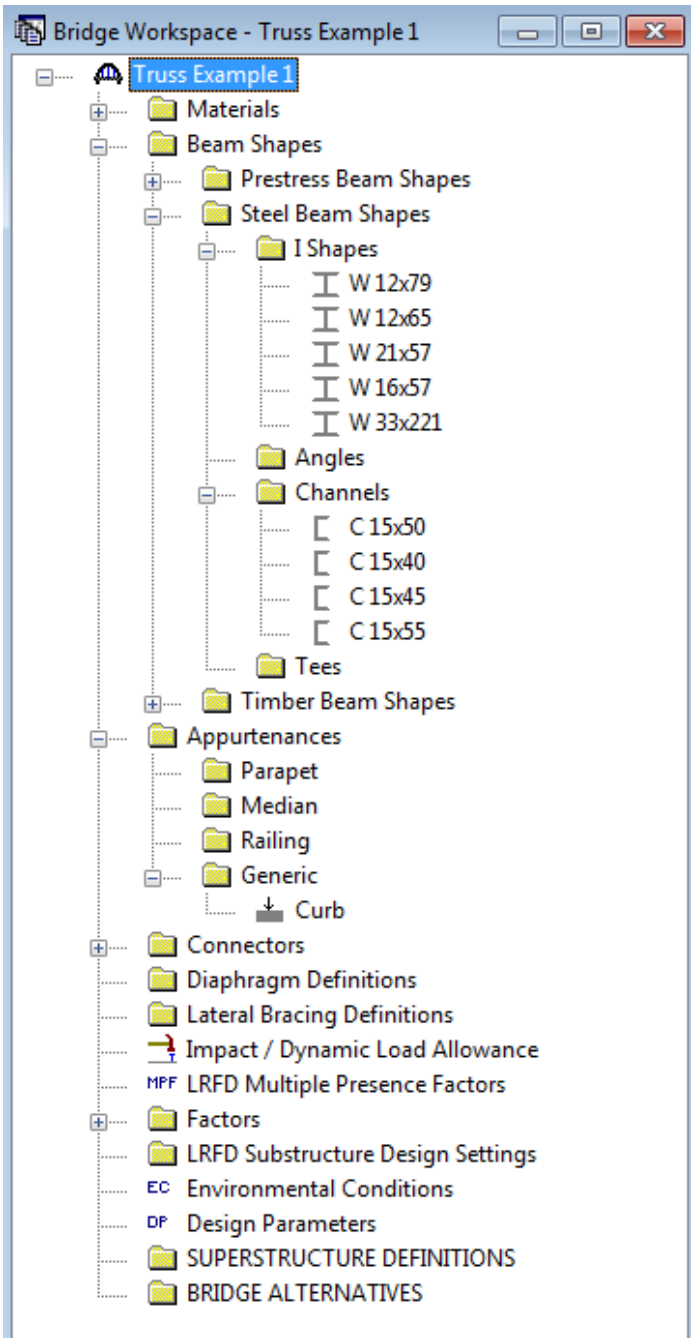

Steel Channel
Name: C 15x55
Description: from NY
Channel type
American Standard
Miscellaneous
Dimensions
Properties
0.8200 in
0.6500 in
0.8140 in
0.6500 in
15.0000 in
0.6500 in
3.8140 in
in
X
X
Y
Y
Copy To Library...
Copy from Library...
OK
Apply
Cancel


Steel Channel
Name: C 15x55
Description: from NY
Channel type
American Standard
Miscellaneous
Dimensions
Properties
Area = 16.160 in^2
Nominal load = 55.000 lb/ft
Max. flange fastener = in
Ix = 429.000 in^4
Iy = 12.100 in^4
Copy To Library...
Copy from Library...
OK
Apply
Cancel

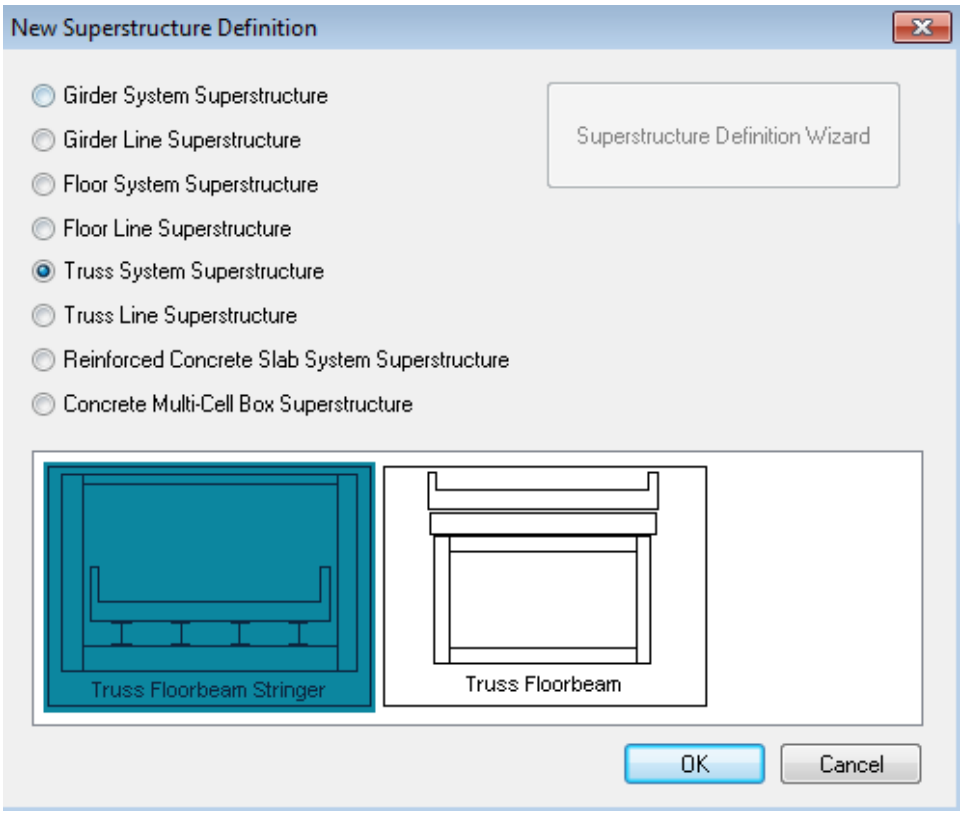
Enter the following Generic appurtenance to model the curb on our structure.



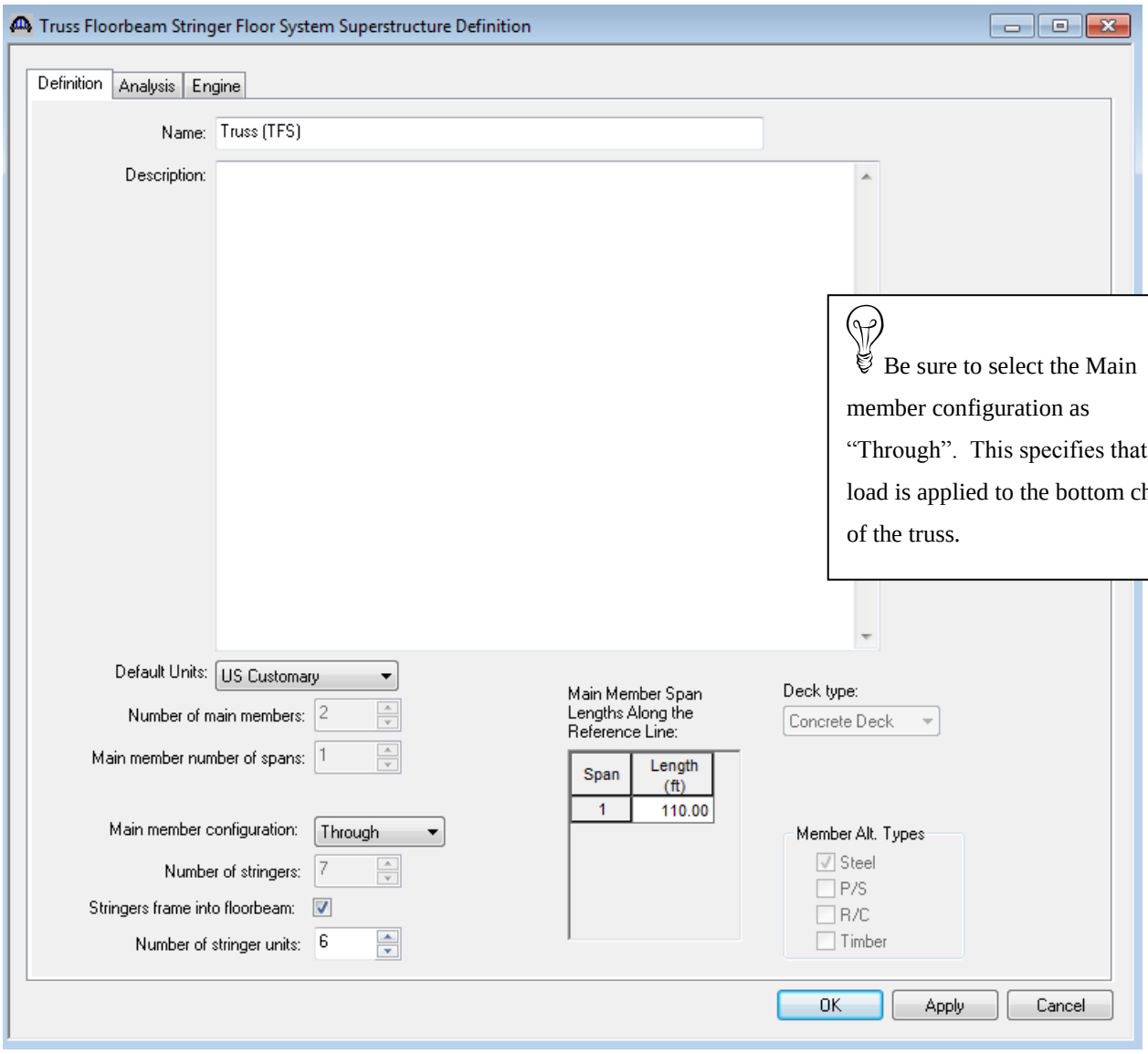
The Bridge Workspace now appears as follows:



We are now ready to create our truss-floorbeam-stringer superstructure definition. Double click on "SUPERSTRUCTURE DEFINITIONS".

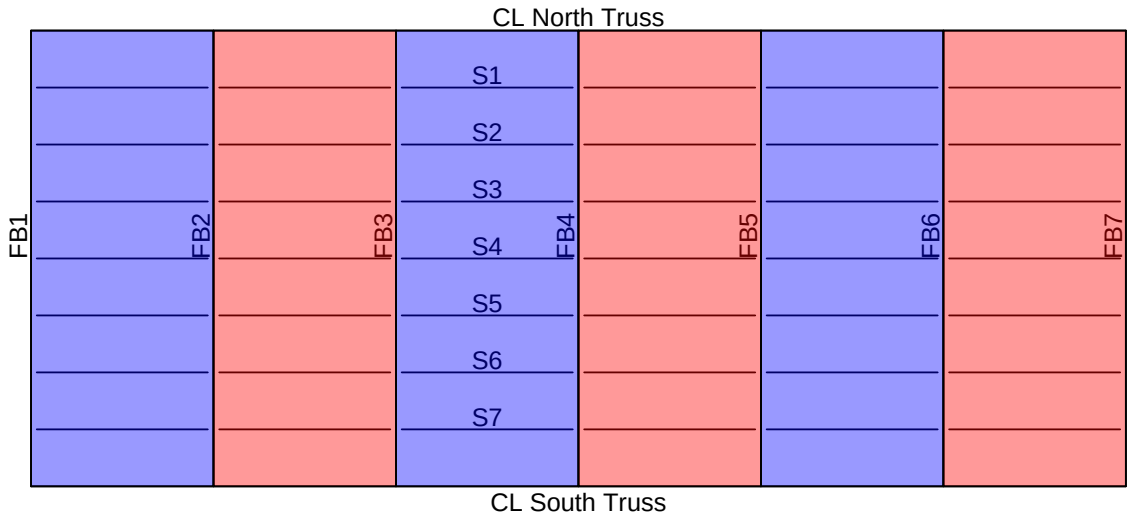


Enter the following information to describe the superstructure definition:

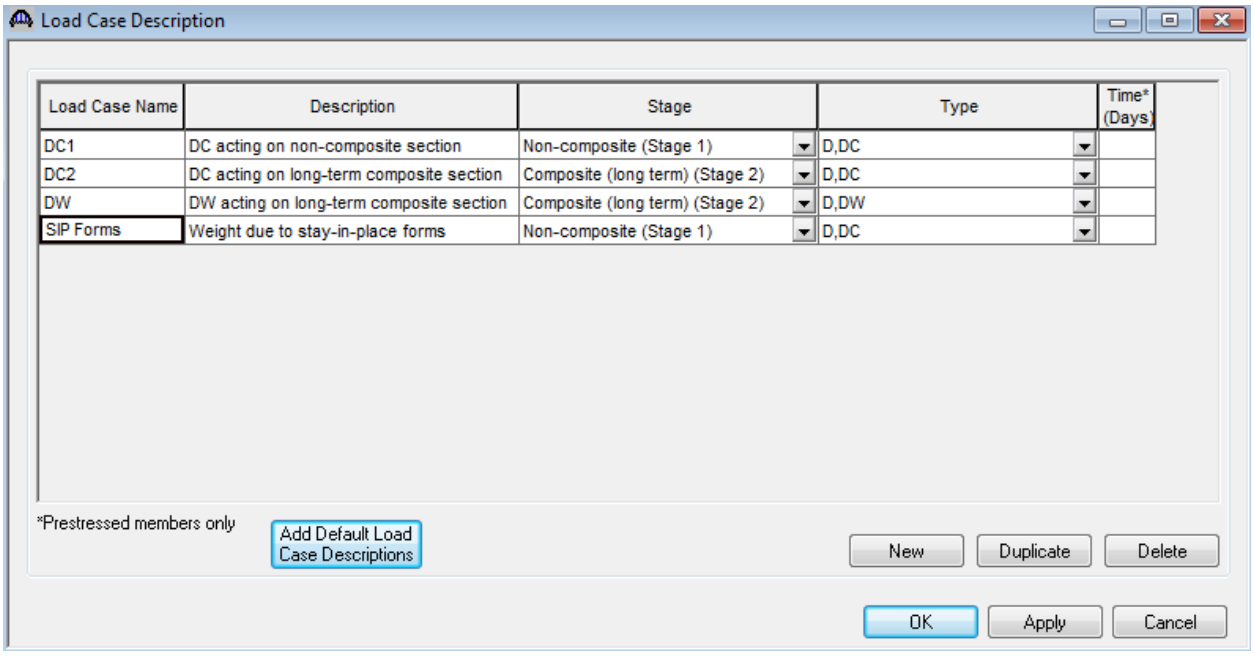


Be sure to select the Main member configuration as "Through". This specifies that live load is applied to the bottom chord of the truss.

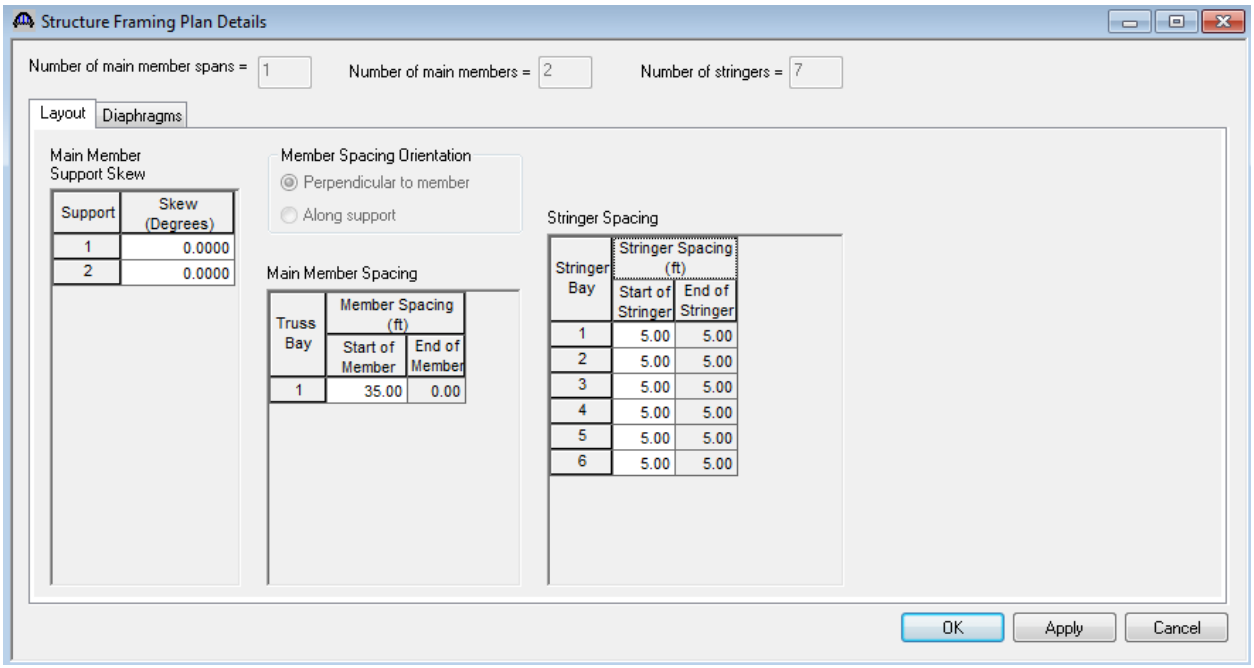
Stringer Units are the portions of the structure where the stringers are to be analyzed as structurally continuous units. In this structure, the stringers are simple spans and there are 6 stringer units.



Use the ‘Add Default Load Descriptions’ button to create the following load cases:

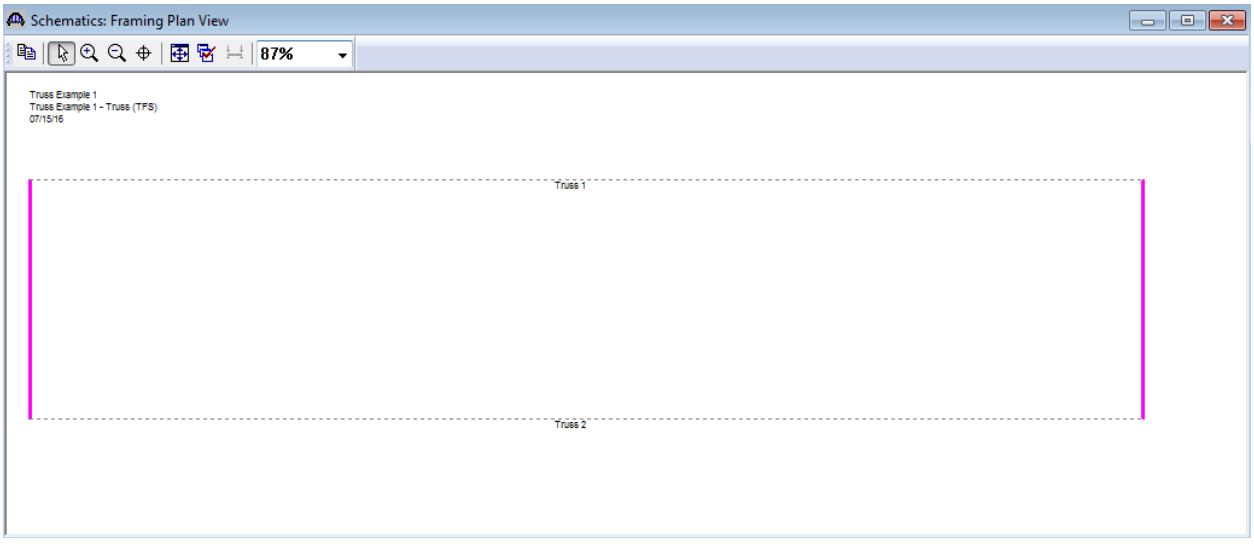


Enter the truss spacing and stringer spacing as follows:

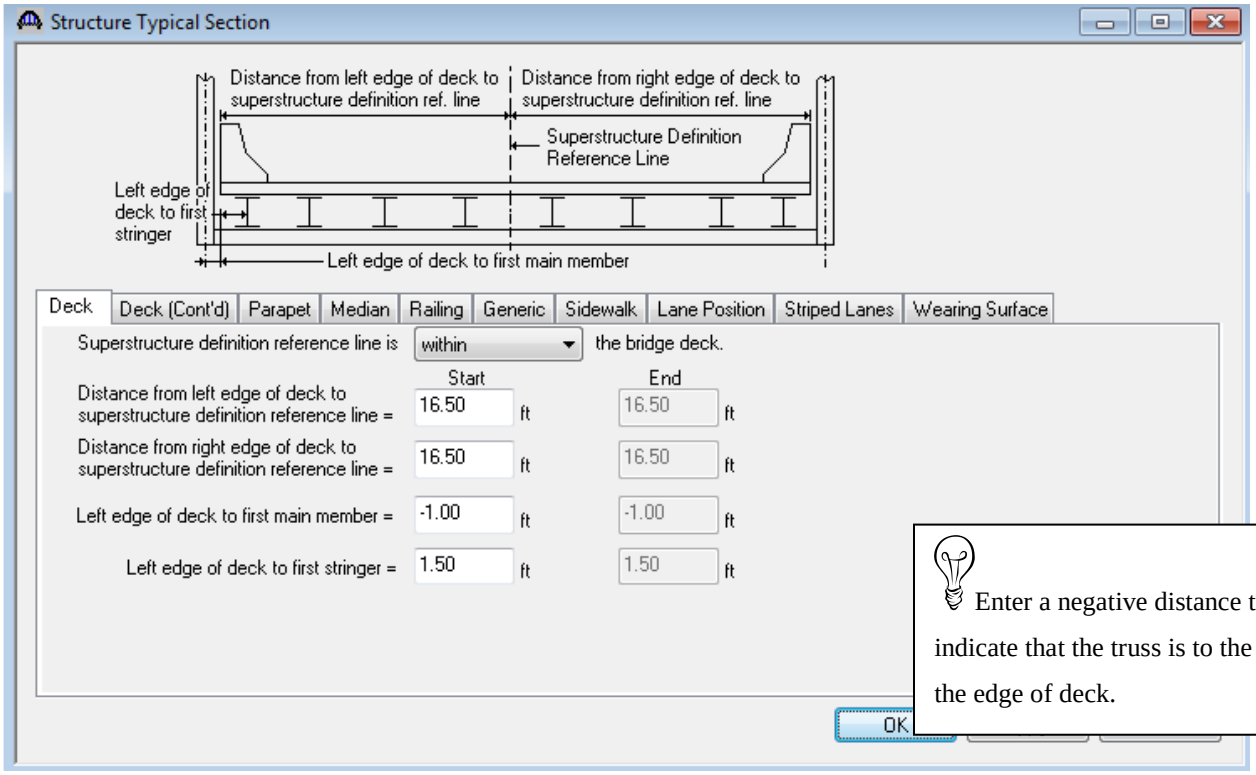


This structure does not have diaphragms or lateral bracing on the truss members so no data is entered on the Diaphragms tab.

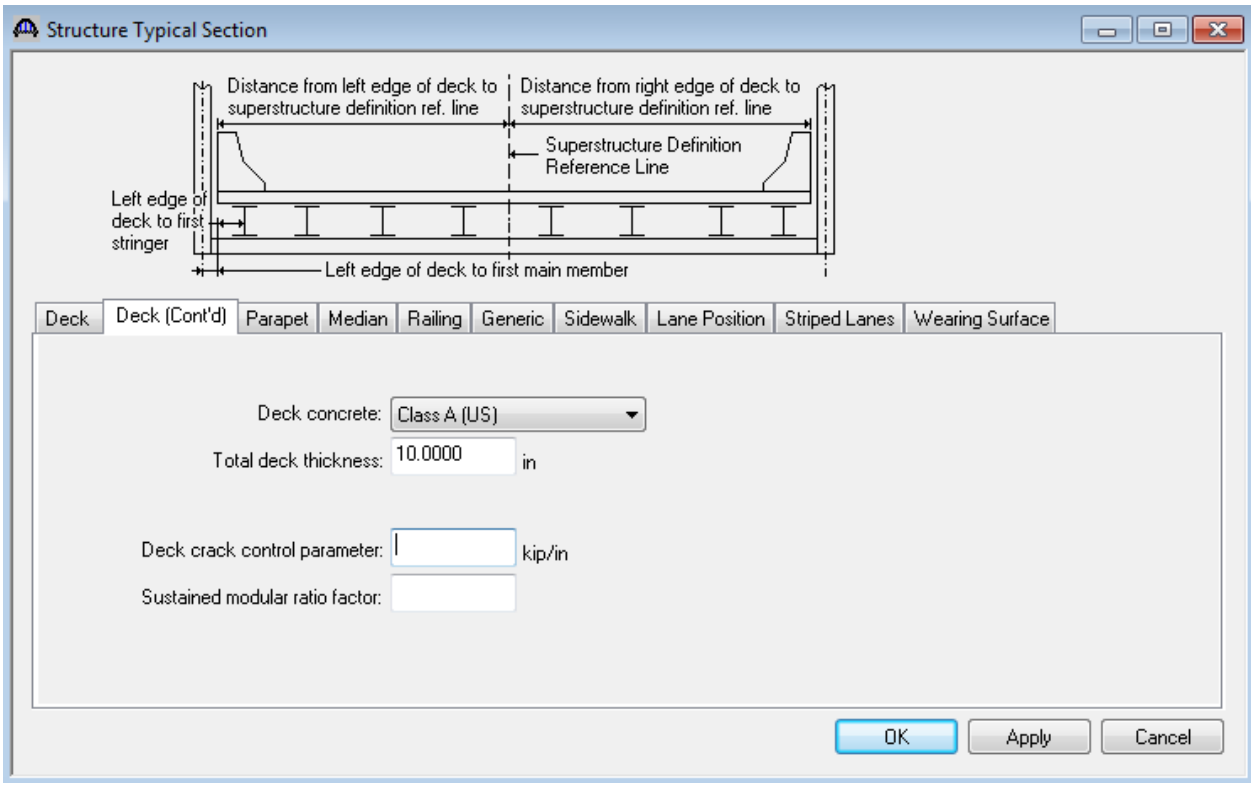
If we look at the schematic for the framing plan we see that not much is drawn. This is due to the fact that we have not created our floorbeams yet nor specified where the stringers are.

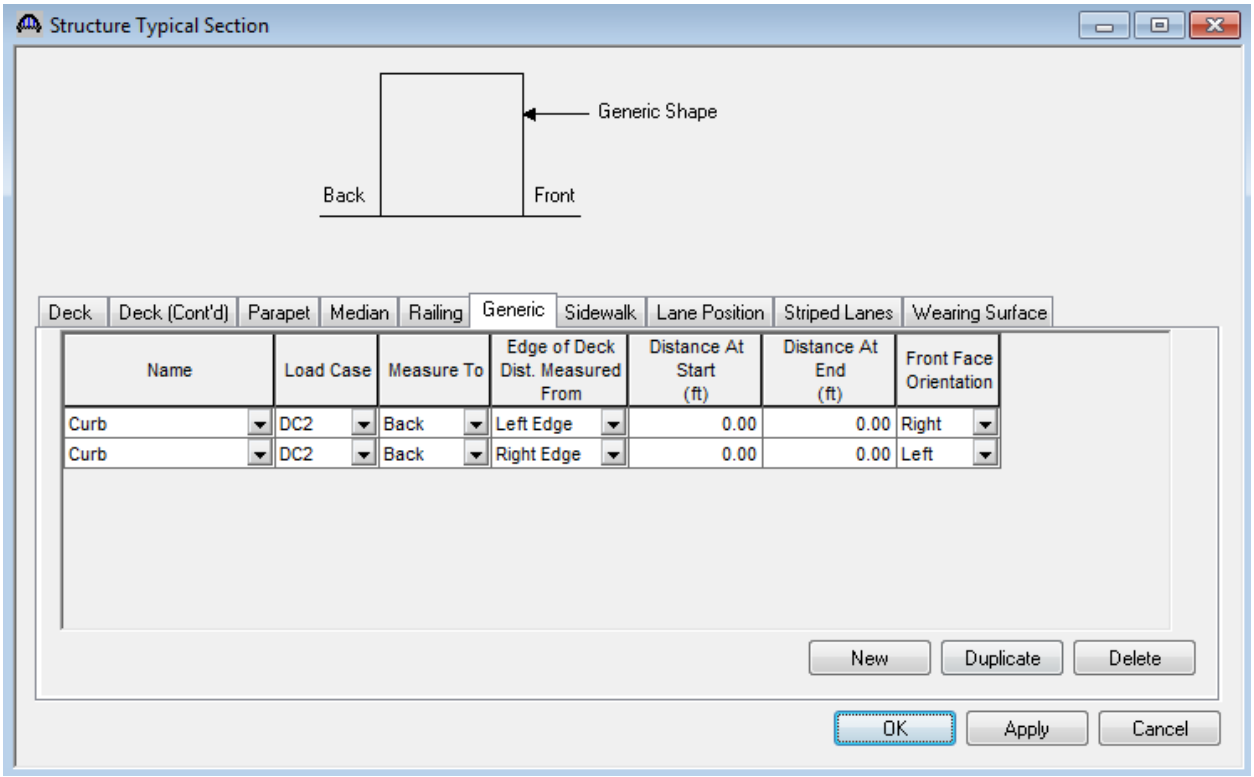


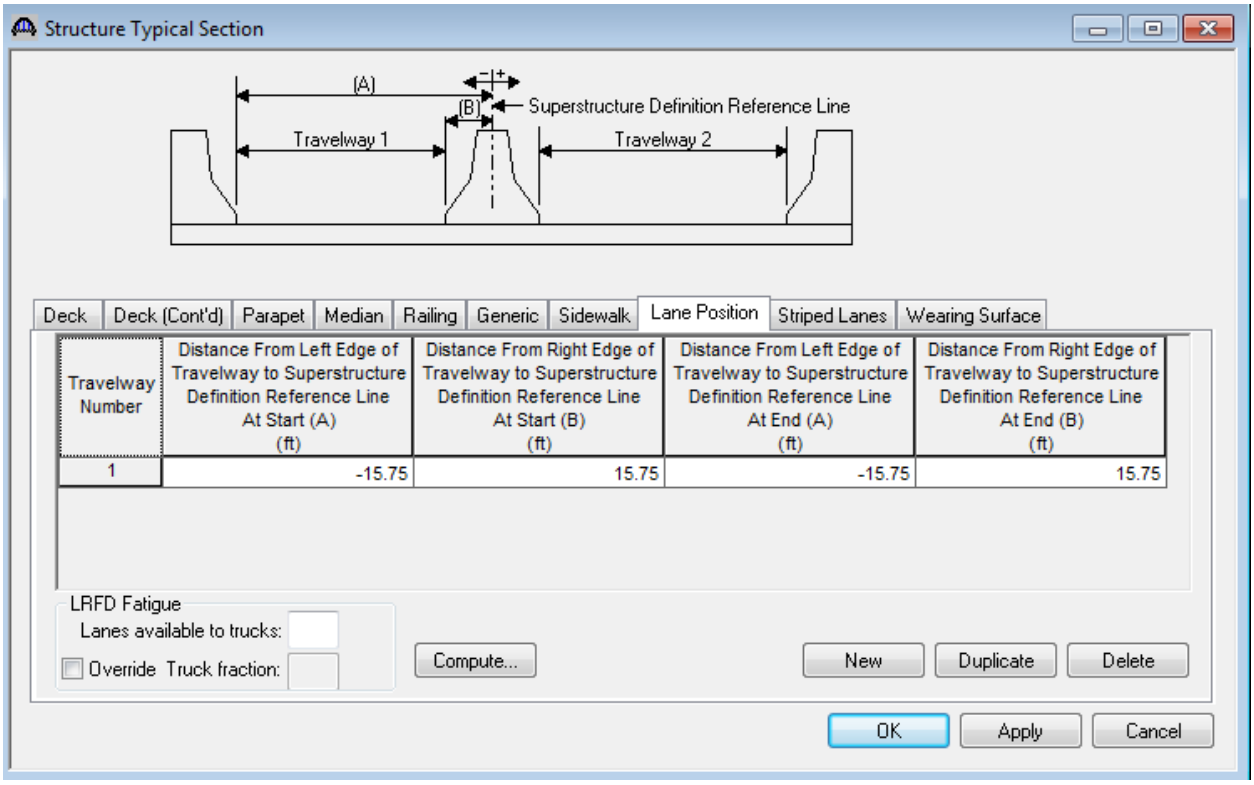
Enter the following data on the Structure Typical Section to locate the truss and stringers with respect to the left edge of the deck.



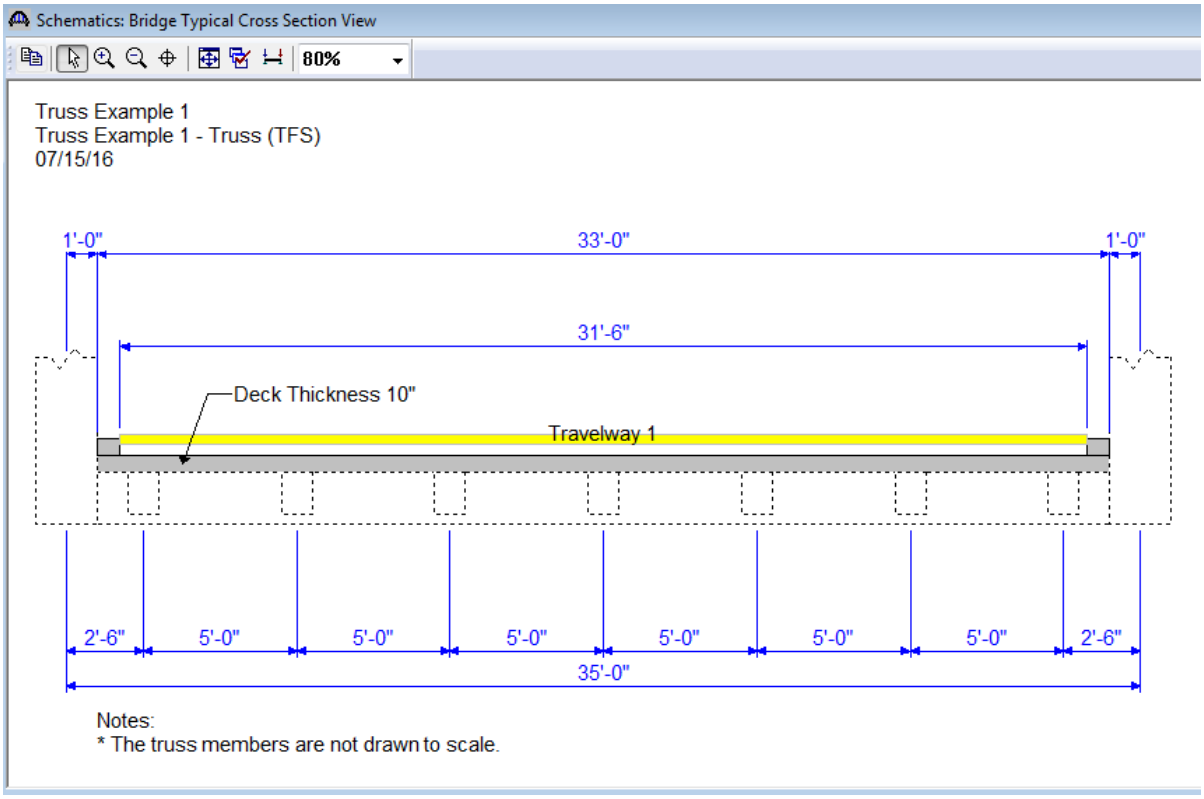
Enter the remaining structure typical section data as shown below:



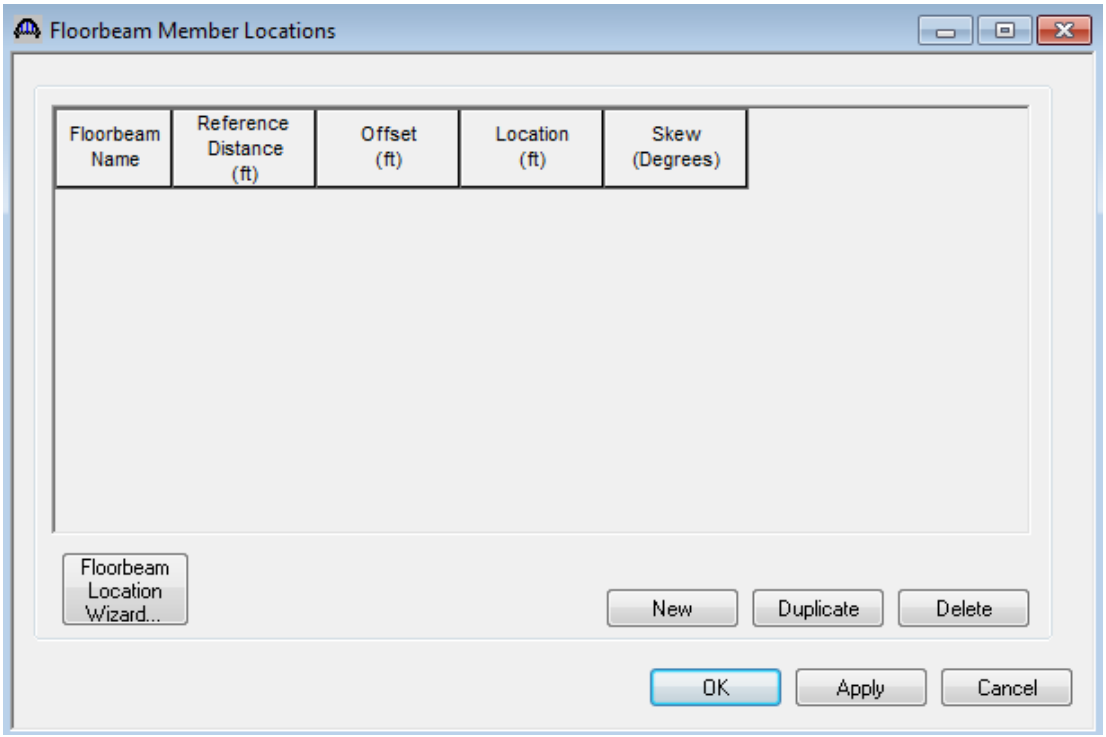


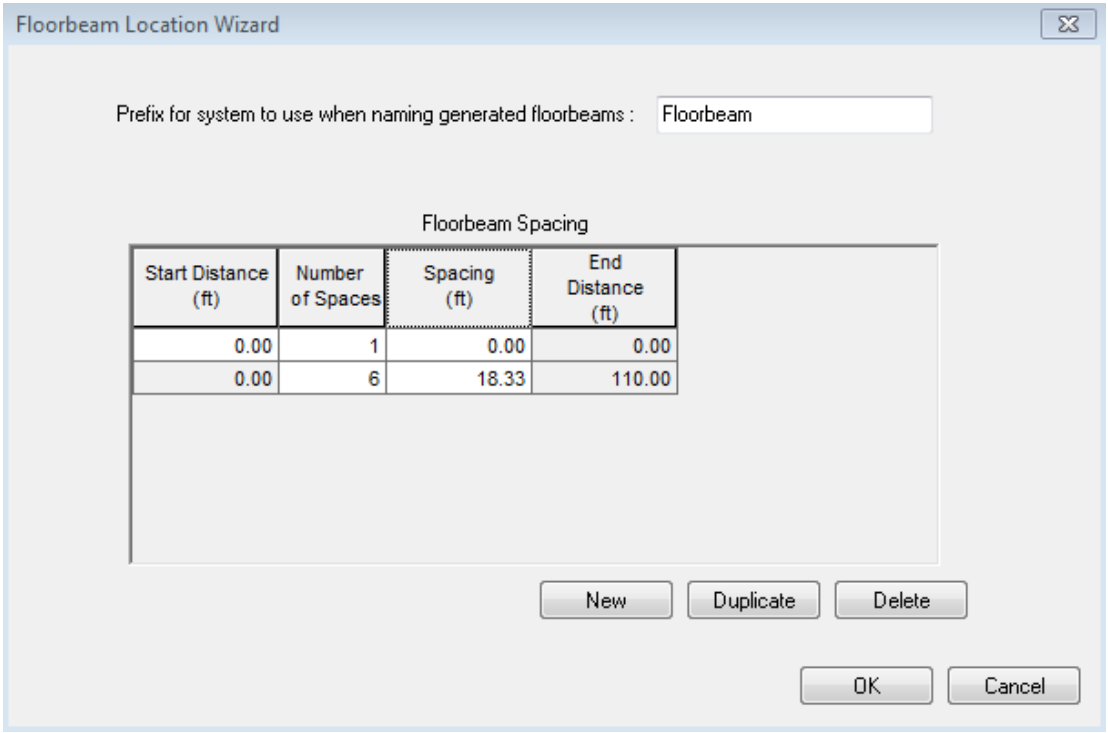


The Structure Typical Section now appears as follows:

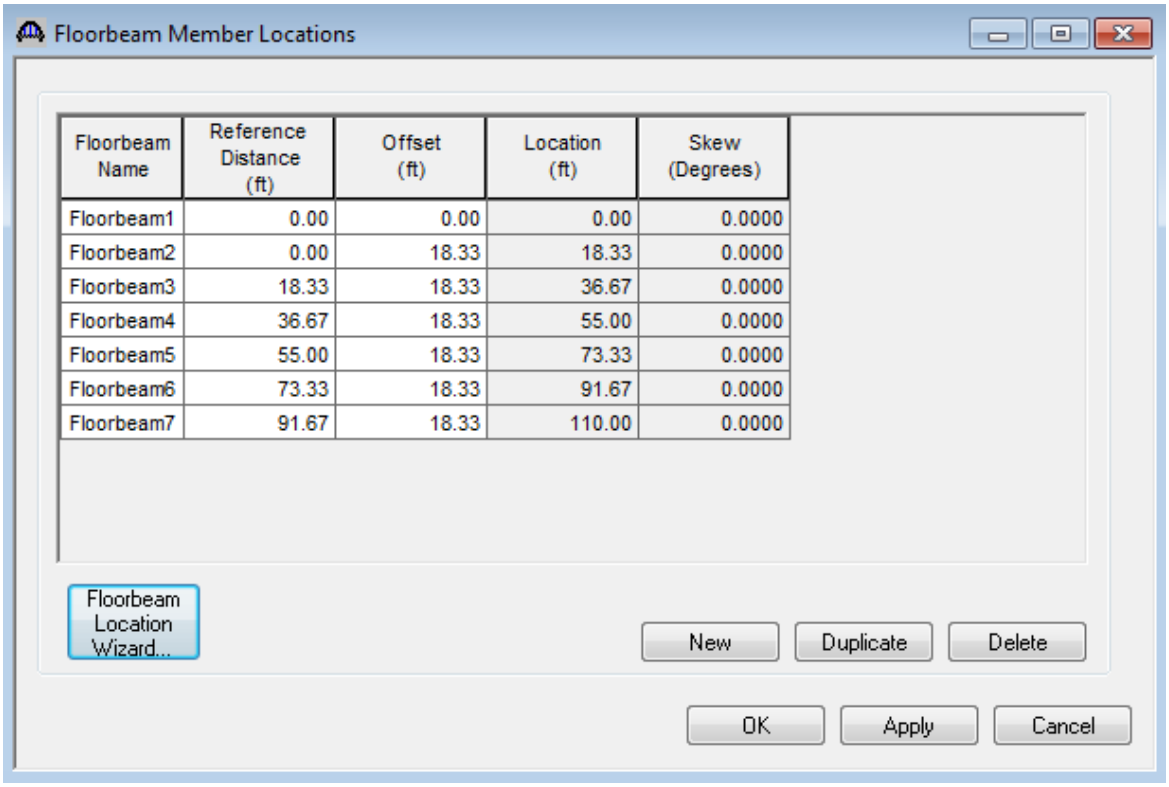


Open the Floorbeam Member Locations window and use the ‘Floorbeam LocationWizard’ button to specify where the floorbeams are located.

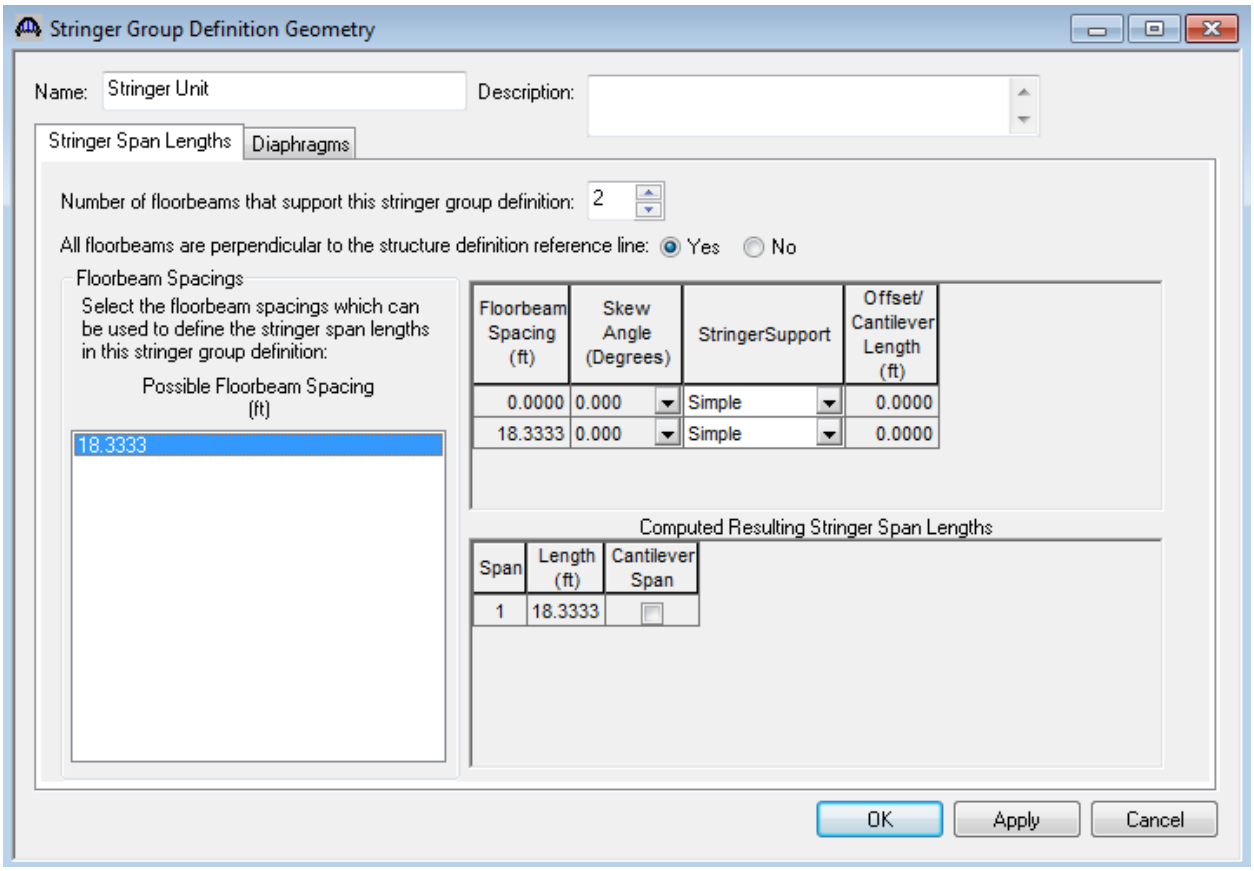




The following floorbeam member locations are created using the wizard.

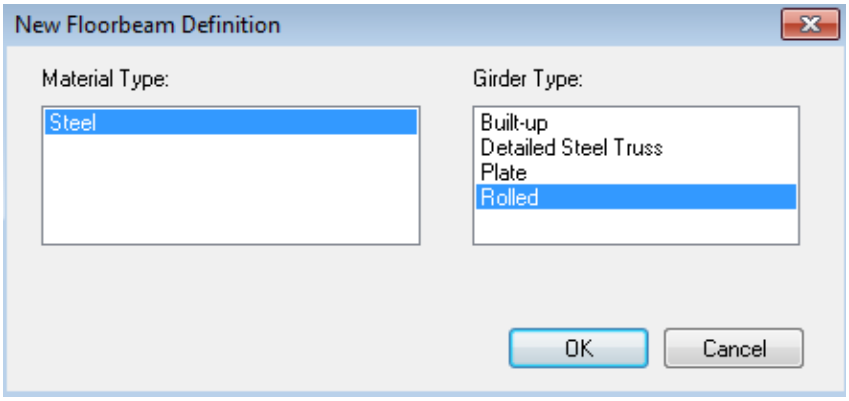


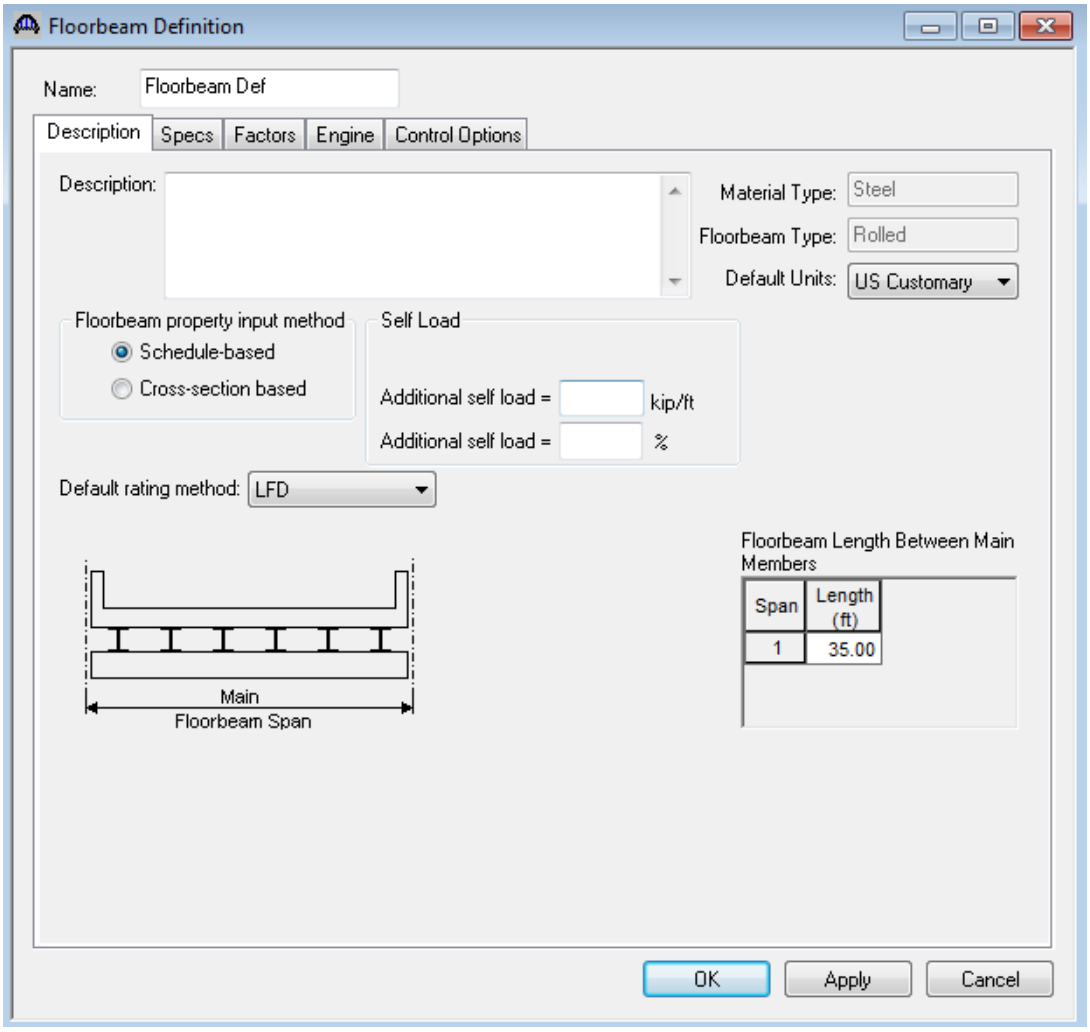
Enter the following data to describe the Stringer Group Definition. A stringer group definition contains data regarding a portion of the structure where the stringers are structurally continuous. The stringers in this structure all have the same span data. They are simple spans and are supported by 2 floorbeams. You can create one stringer group definition to contain this geometry data and then later apply this stringer group definition to all 6 stringer units in your structure.



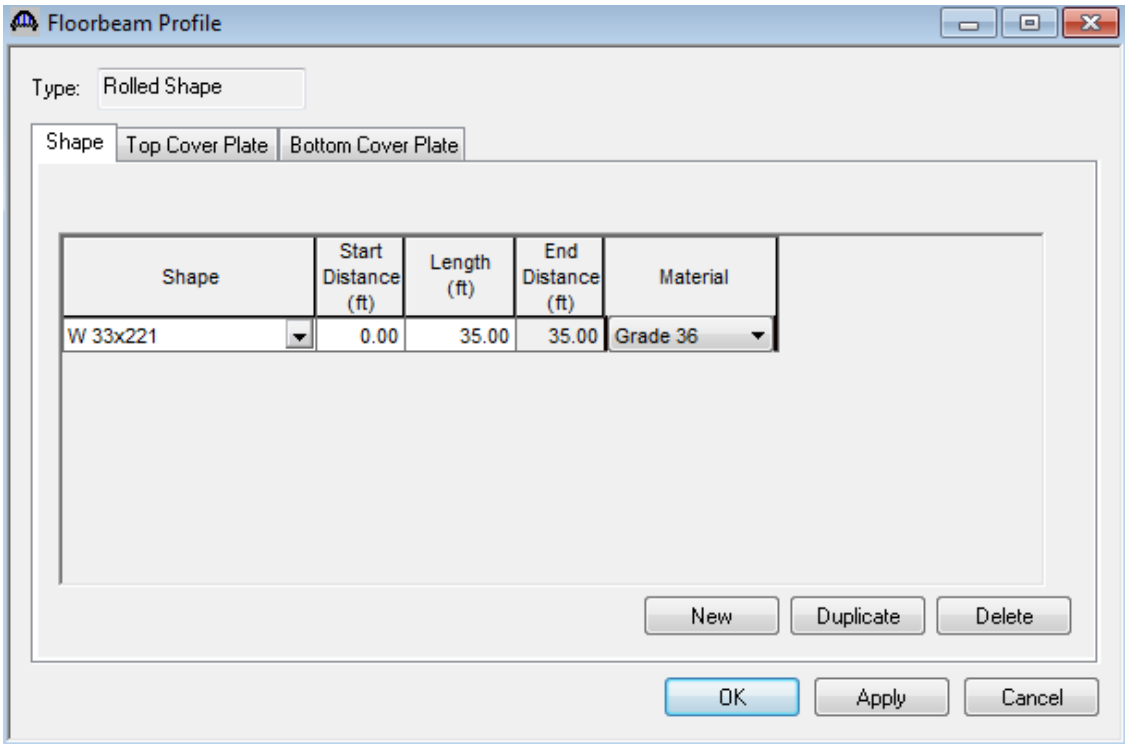
Describing a Floorbeam Definition:

Create a new floorbeam definition and describe it as follows. This floorbeam definition will be used for all of the floorbeams in the structure.



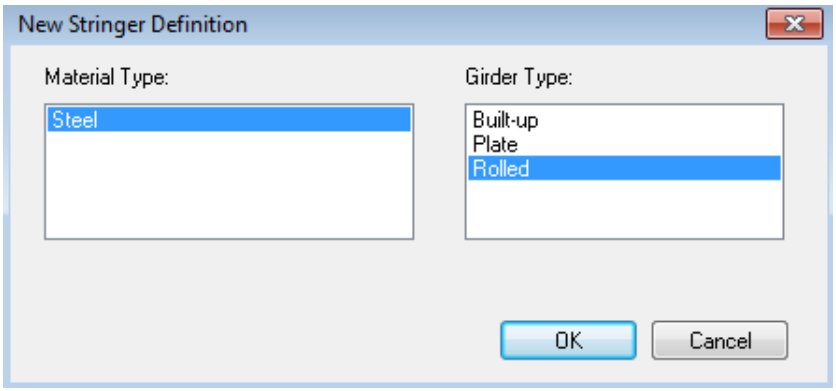


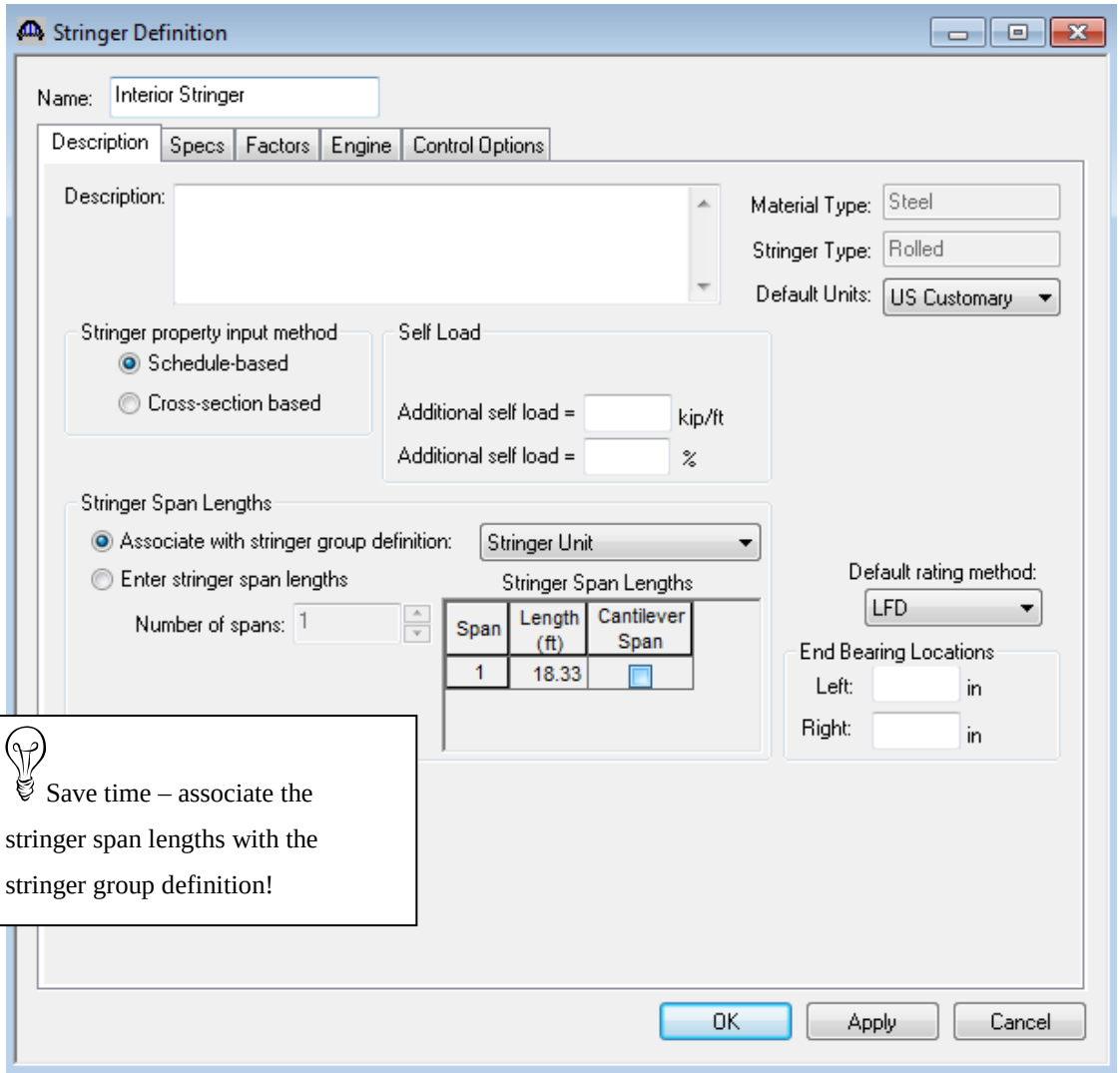
Describe the floorbeam profile as follows. The floorbeam is non-composite so we do not have to enter any data on the Deck Profile window.



Describing a Stringer Definition:

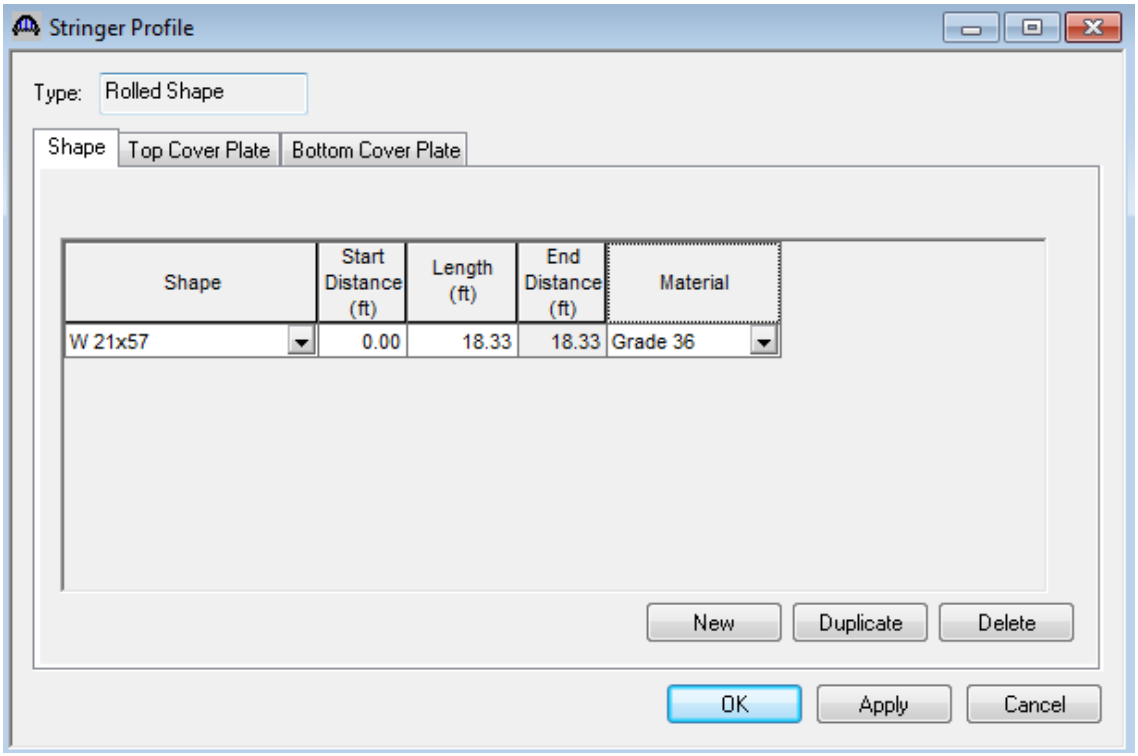
Create a new stringer definition and describe it as follows.



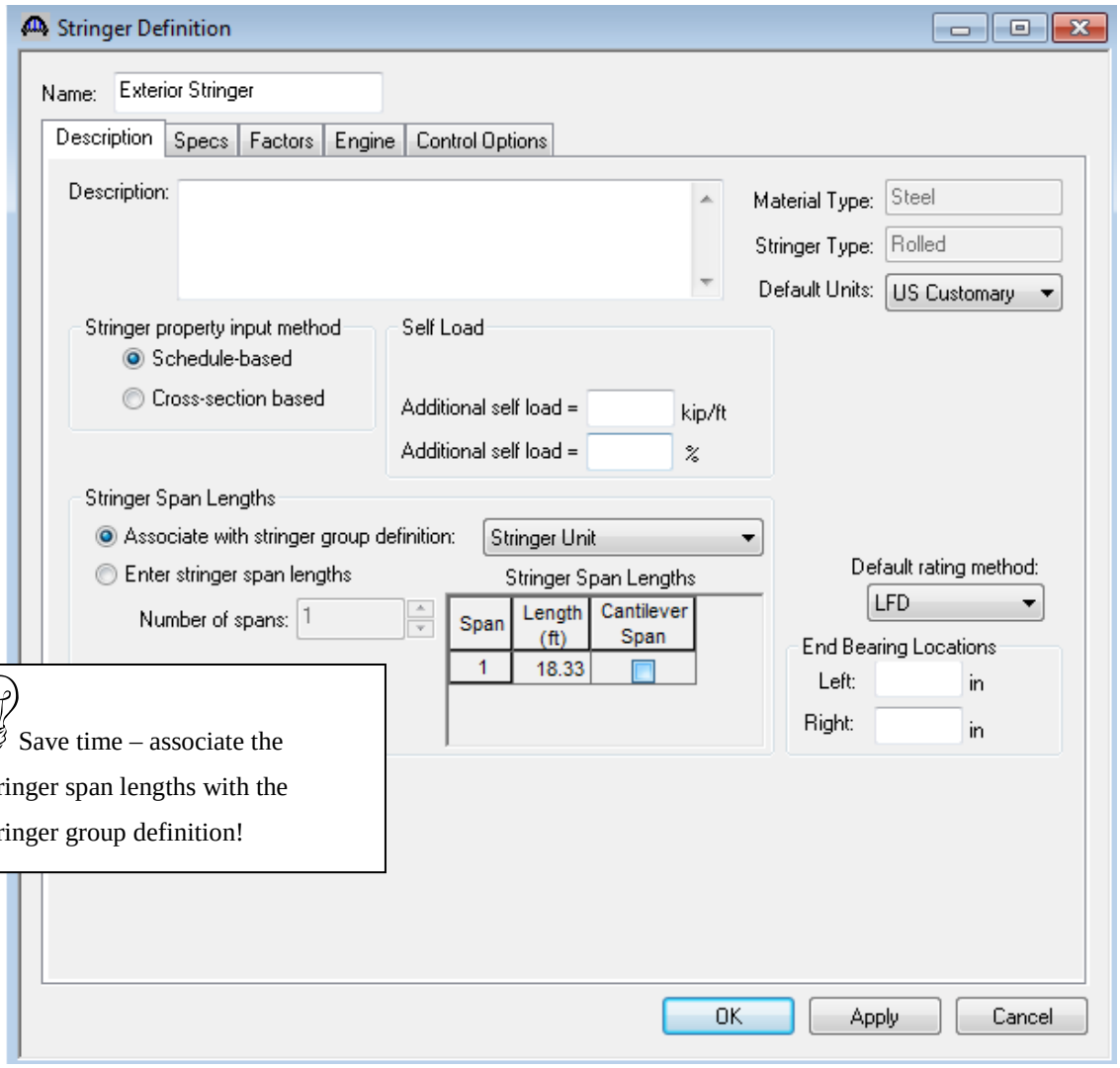


Save time – associate the stringer span lengths with the stringer group definition!

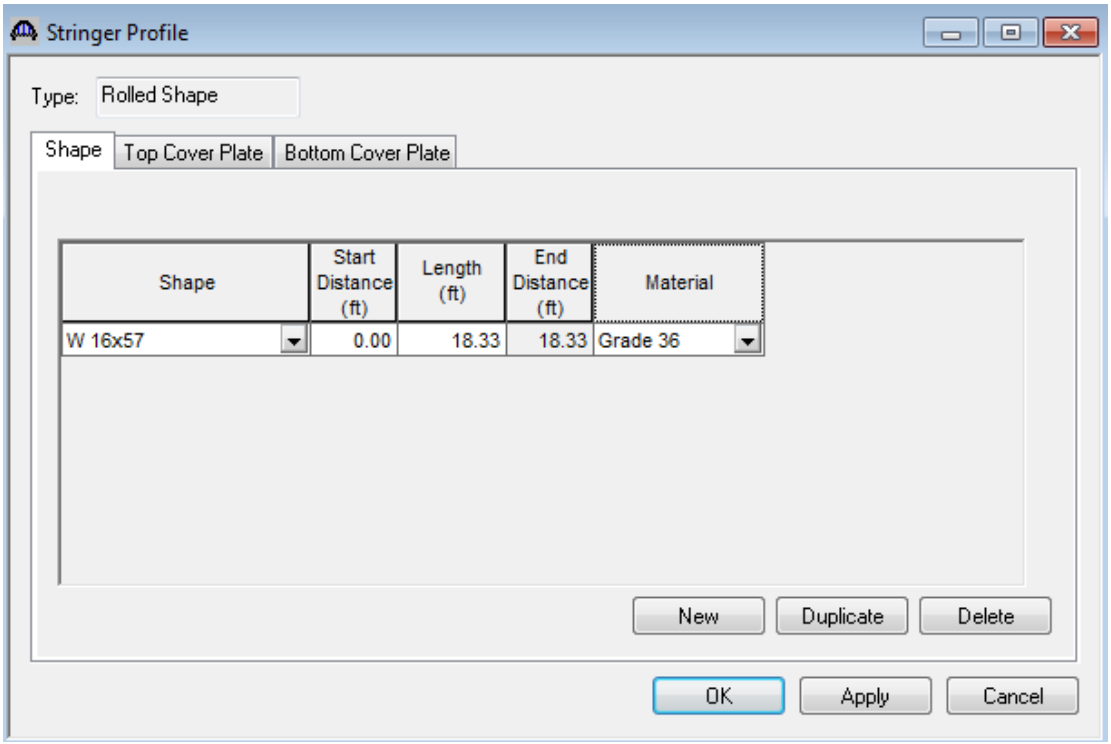
Describe the stringer profile as follows. The stringer is non-composite so we do not have to enter any data on the Deck Profile window.



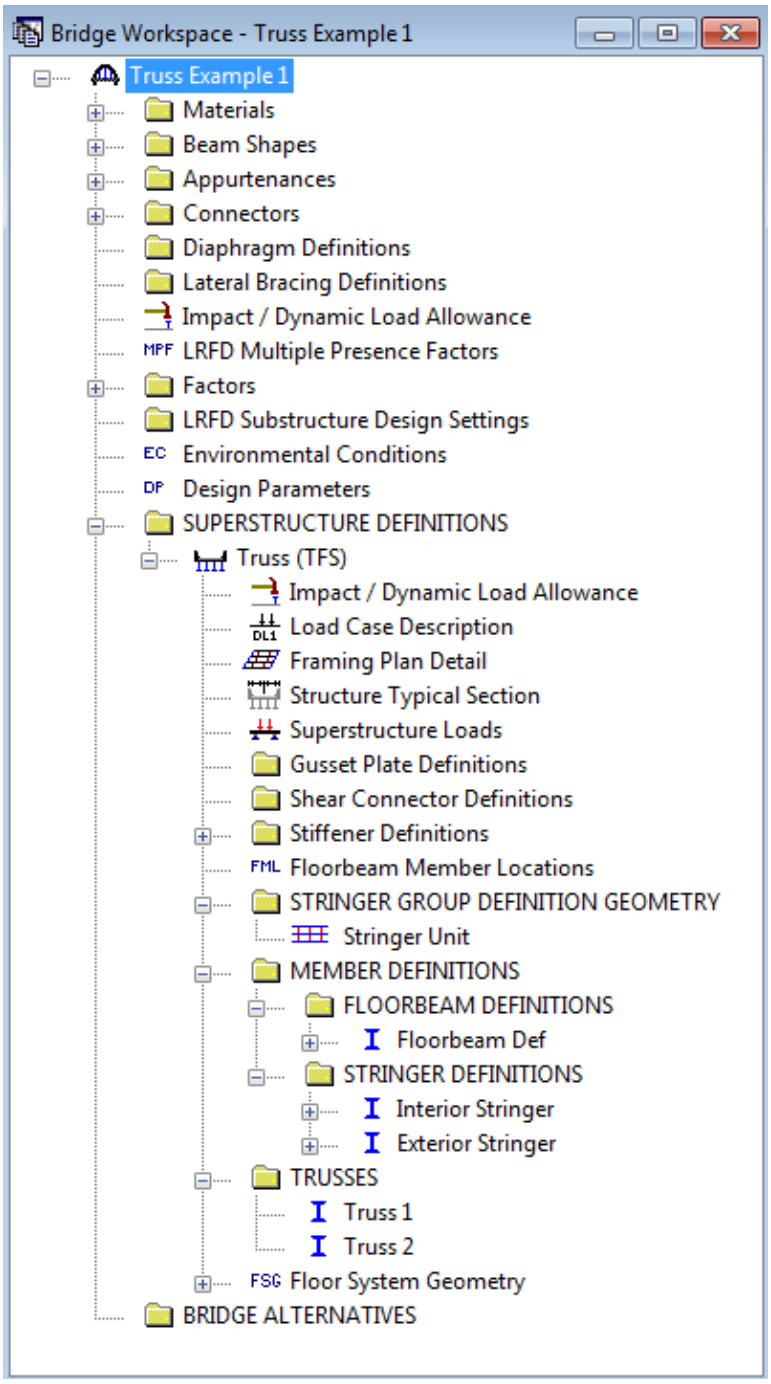
Create a stringer definition to be used for the exterior stringers in the same manner.



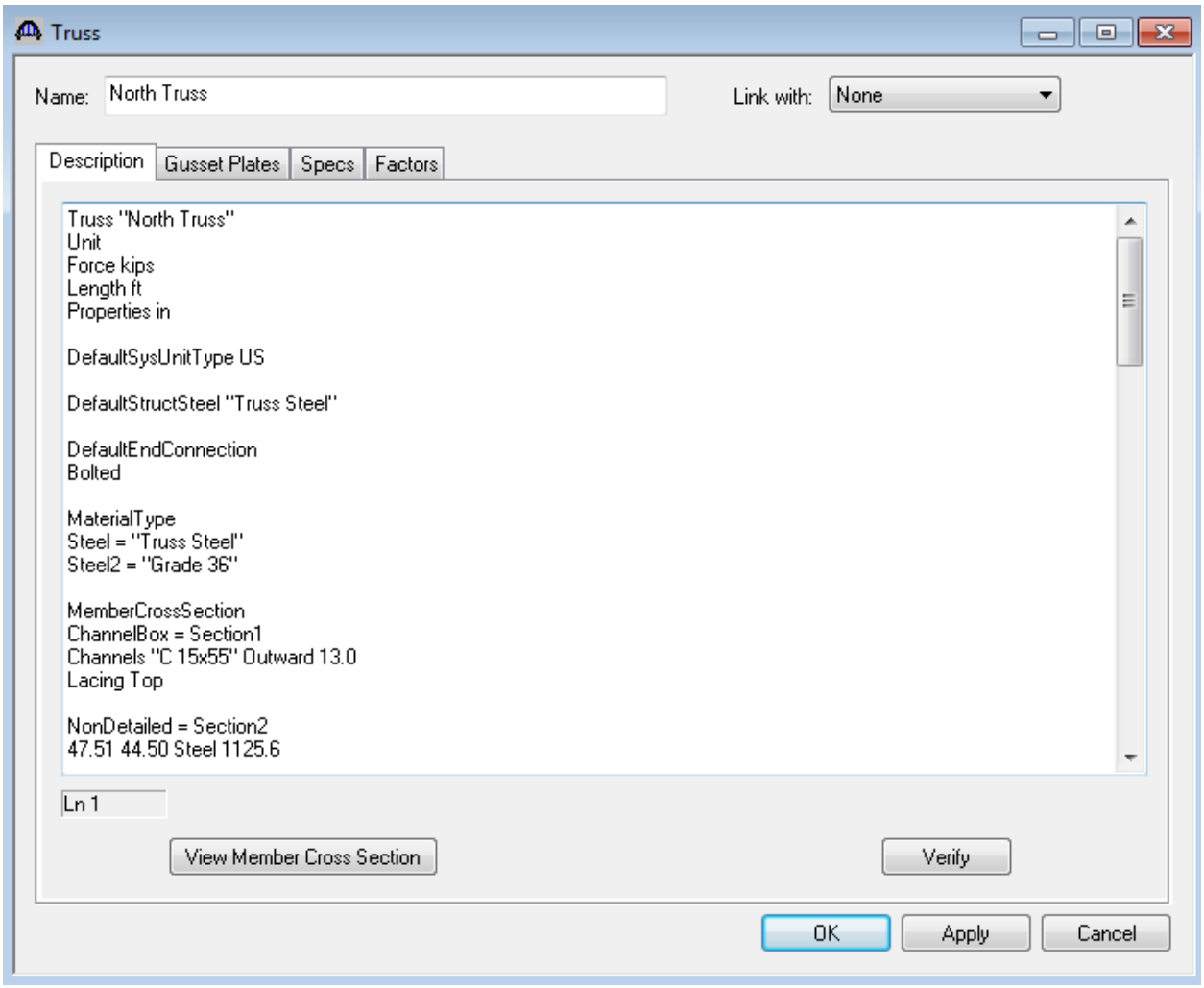
Save time – associate the stringer span lengths with the stringer group definition!


Stringer Profile
Type:
Rolled Shape
Shape
Top Cover Plate
Bottom Cover Plate
Shape
Start Distance (ft)
Length (ft)
End Distance (ft)
Material
W 16x57
0.00
18.33
18.33
Grade 36
New
Duplicate
Delete
OK
Apply
Cancel

The Bridge Workspace tree now appears as follows:



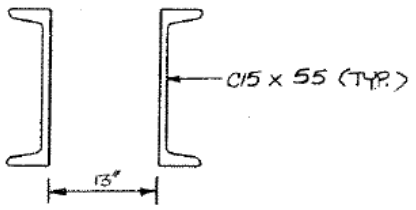
Open the ‘Truss 1’ window and change the name of the truss to “North Truss’. Enter the text description shown on the next pages.

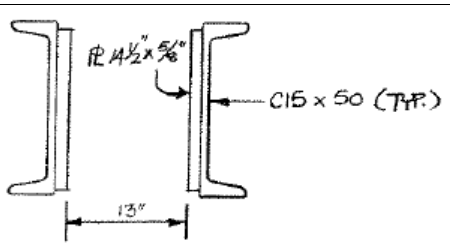
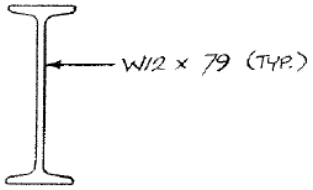
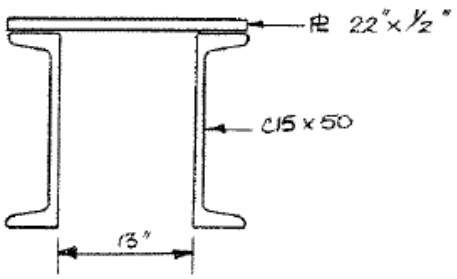
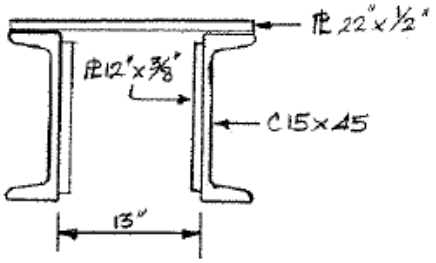


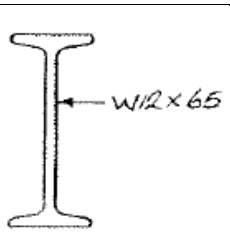
The ‘Verify’ button will read your text description of the truss and verify the syntax of the commands you have input.

The following is a copy of the truss definition described using the BrR Truss Command Language. A description of the command language and its syntax is available by opening the BrR help for the Truss window.

Some of the commands are described in detail below. The name of the command is shown in bold text.

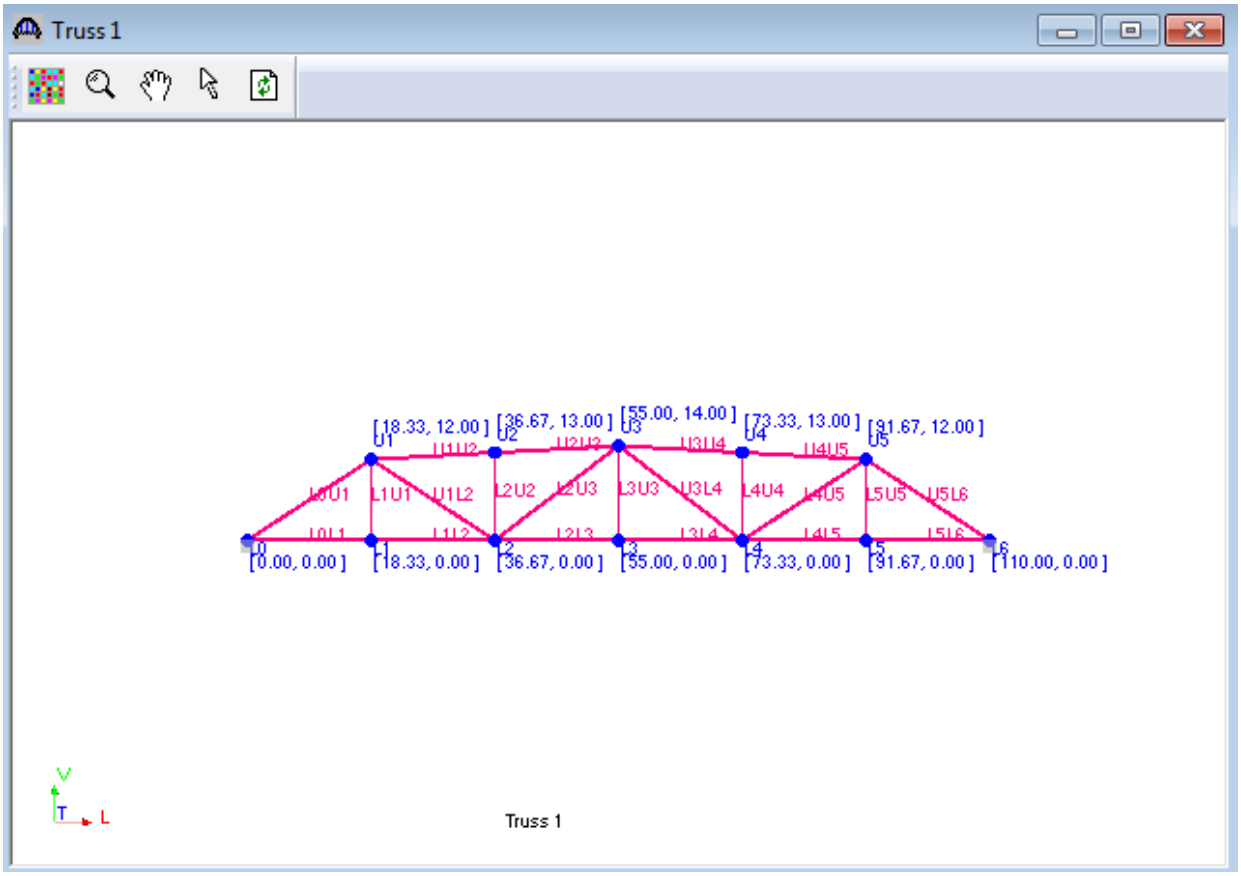
Command	**Comments**
Truss "North Truss"	
Unit Force kips Length ft Properties in	
DefaultSysUnitType US	
DefaultStructSteel "Truss Steel"	The steel material 'Truss Steel' from the BrR BWS will be used as the default steel material if you do not enter a steel material in later commands. The double quotations around "Truss Steel" indicate that Truss Steel is defined in the BrR BWS.
DefaultEndConnection Bolted	Used to determine the effective length factor K
MaterialType Steel = "Truss Steel" Steel2 = "Grade 36"	Wherever 'Steel' appears in later commands, the properties from the 'Truss Steel' in the BWS will be used. This command is a shortcut way to specify a steel material. This is useful for some of the steel materials in the BrR Library whose names are lengthy.
MemberCrossSection ChannelBox = Section1 Channels "C 15x55" Outward 13.0 Lacing Top	

NonDetailed = Section2 47.51 44.50 Steel 1125.6	 Entered as a NonDetailed section instead of describing each plate. We only have to enter the gross, net area and moment of inertia of the section in this command.
Rolled = Section3 Beam "W 12x79"	
ChannelBox = Section4 TopFlangePlate 22.0 0.5 Steel2 Channels "C 15x50" Outward 13.0 Lacing Bottom	 The top cover plate uses ‘Steel2’ instead of the default steel.
ChannelBox = Section5 TopFlangePlate 22.0 0.5 LeftWebPlate 12.0 0.375 RightWebPlate 12.0 0.375 Channels "C 15x45" Outward 13.0 Connection Bolted 1.50 Lacing Bottom	 1.50 in^2 will be deducted from the gross area for the connection holes.

Rolled = Section6 Beam "W 12x65"	
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 13.0 U3 Upper 55.0000 14.0 U4 Upper 73.3333 13.0 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 L2U3 L2 U3 Section6 L3U3 L3 U3 Section3	Members are identified by the panel points that they connect and cross sections are assigned to the members in this command.

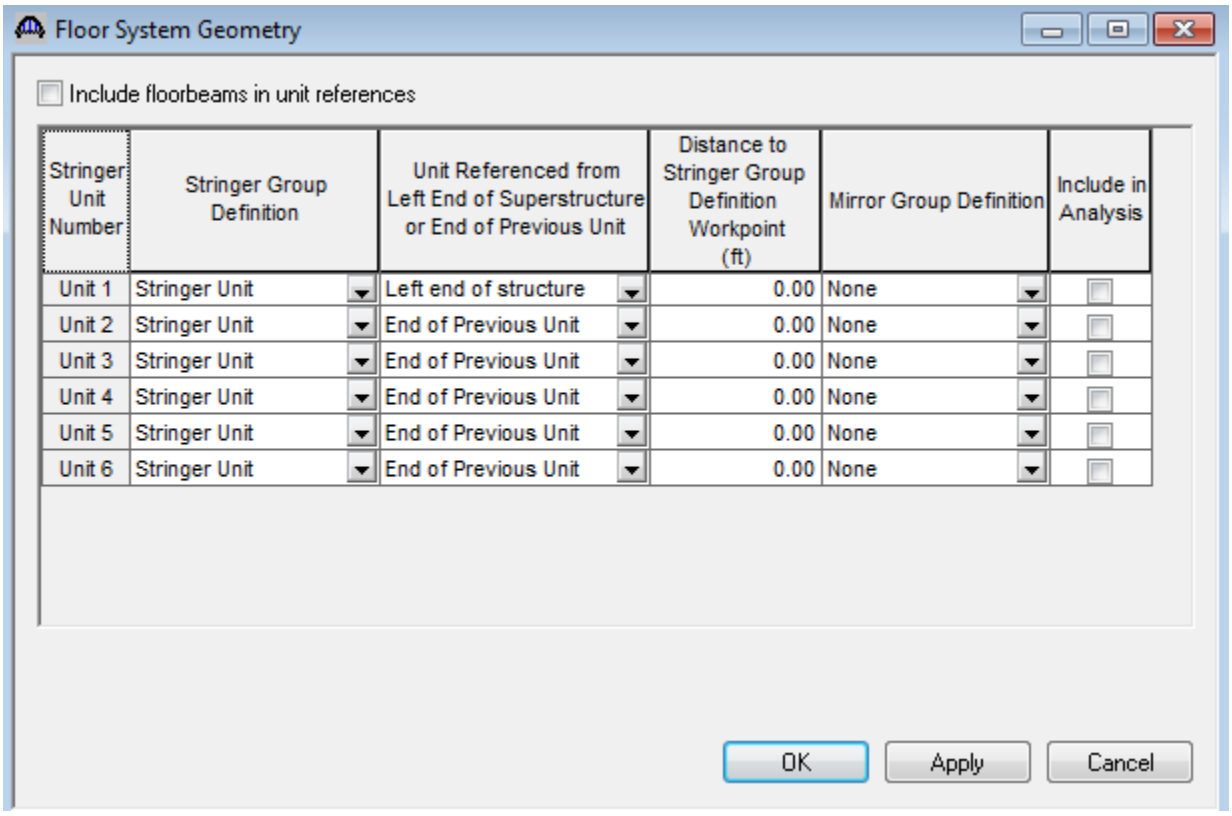
U3L4 U3 L4 Section6 L4U4 L4 U4 Section3 L4U5 L4 U5 Section6 L5U5 L5 U5 Section3	
Support L0 Pinned L6 Roller	
LLDistribution OneLane 0.805 0.5 MultiLane 1.27 1.0	Lane distribution factors

A schematic of the truss is available by selecting the 'View schematic' toolbar button when the truss is highlighted in the Bridge Workspace tree.



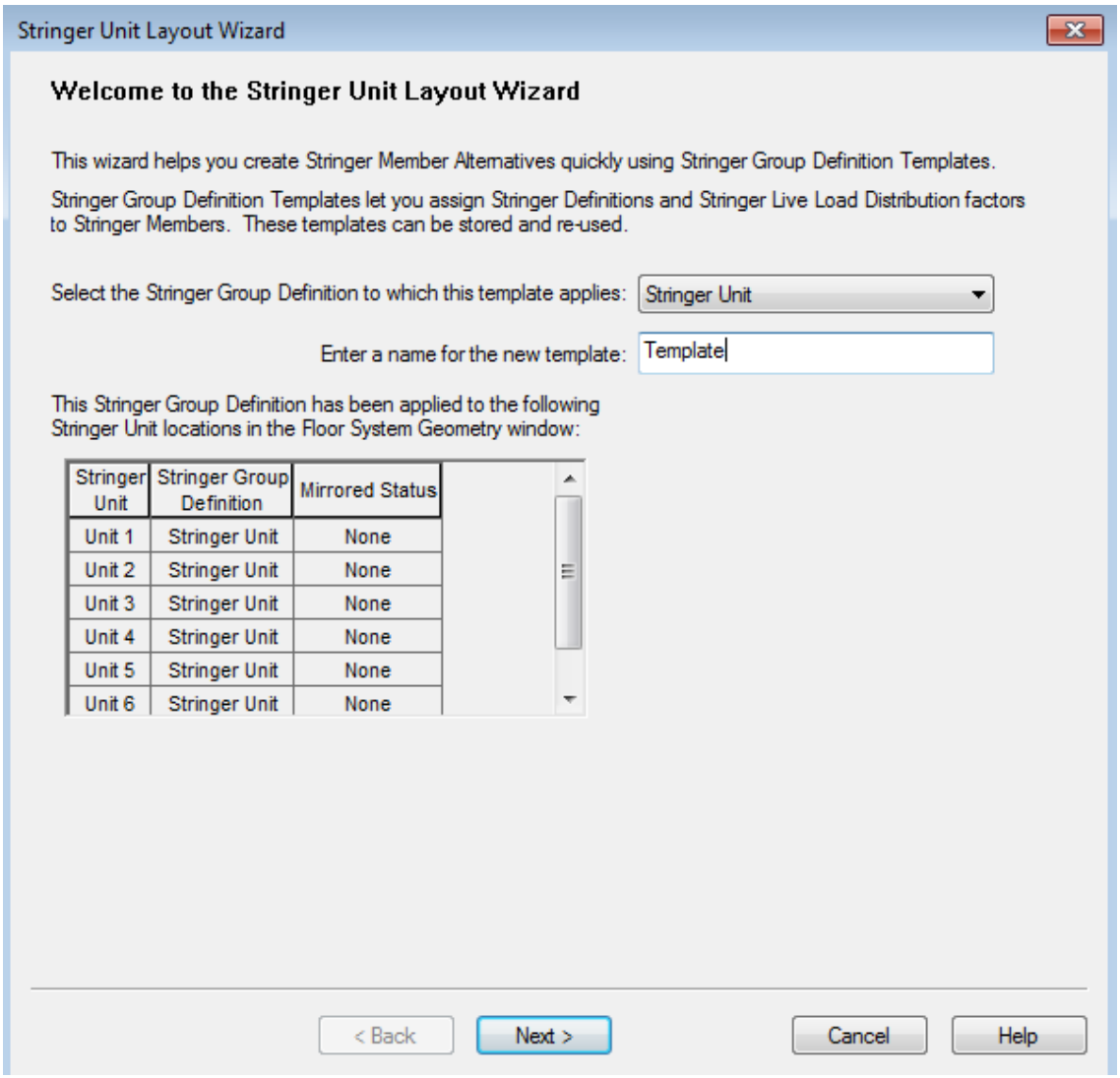
We can now finish describing the floor system (floorbeams and stringers) for this structure. If the floorbeams and stringers are described, BrR will be able to compute the dead load of the floor system and apply it to the truss during the truss analysis.

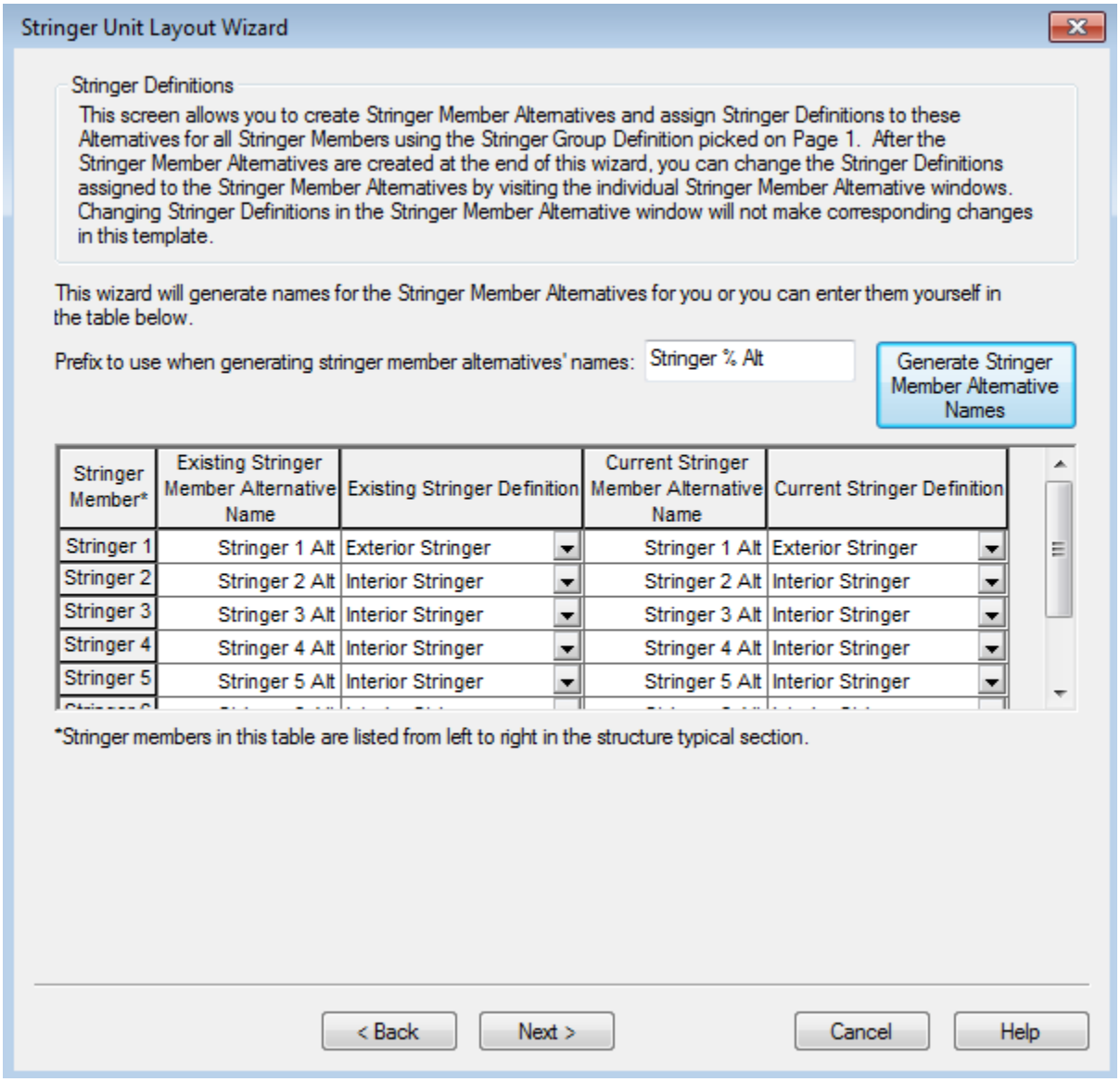
When we first open this Floor System Geometry window, we know the total number of stringer members in this structure is 42 since there are 6 stringer units and each unit contains 7 stringers. We don't know where the stringer members are located along the length of the structure nor do we know how long each stringer is. The stringer members in the structure are all located at the beginning of the structure and do not have any length to them until a stringer group definition is assigned to the stringer units. The stringer group definition defines the stringer span lengths. Assigning stringer group definitions to the stringer units also locates the stringer members along the length of the structure. Click F1 while this window is open to view examples illustrating how to assign stringer group definitions to stringer units.



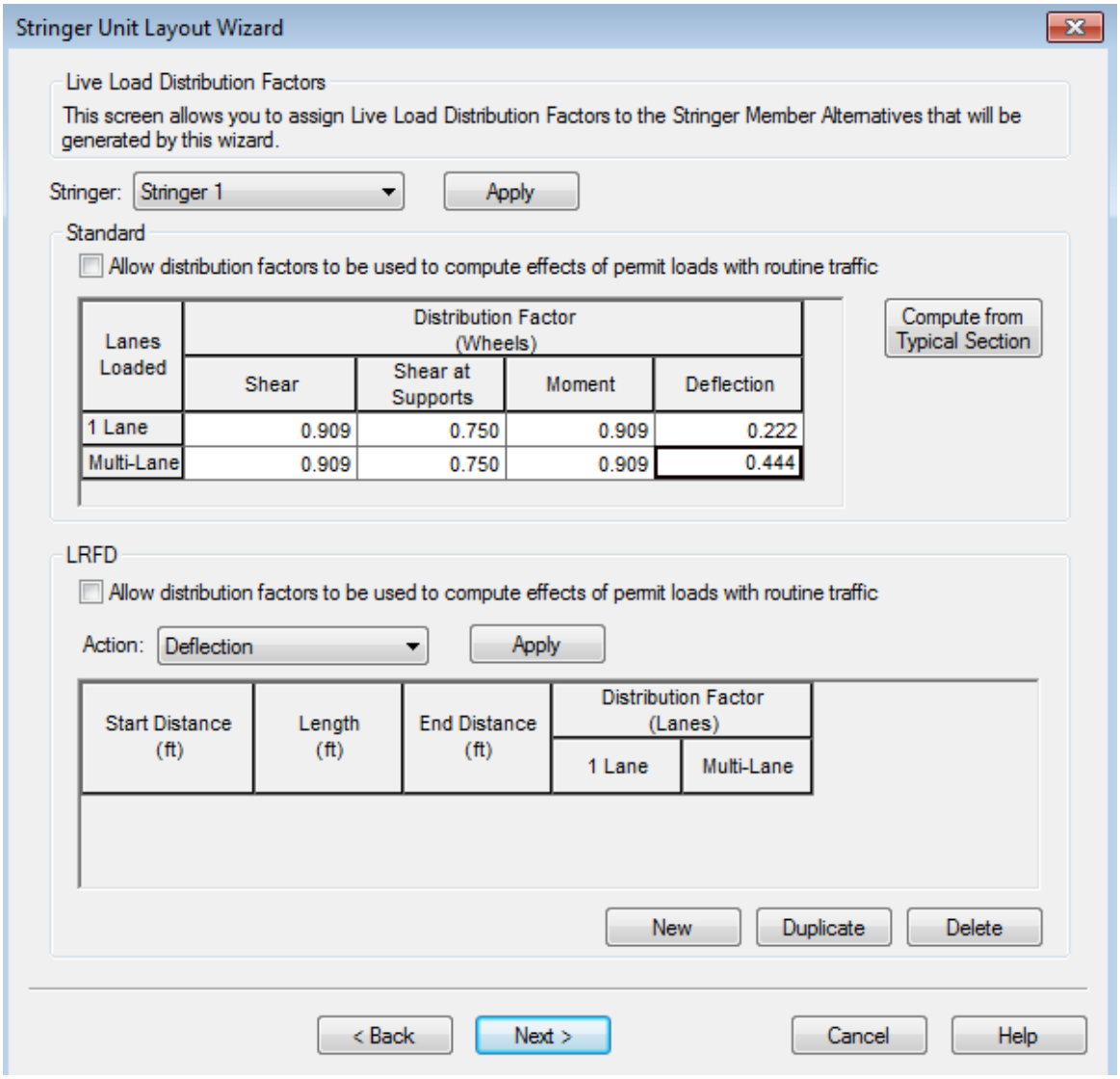
Click on STRINGER UNIT LAYOUT then click on the following button

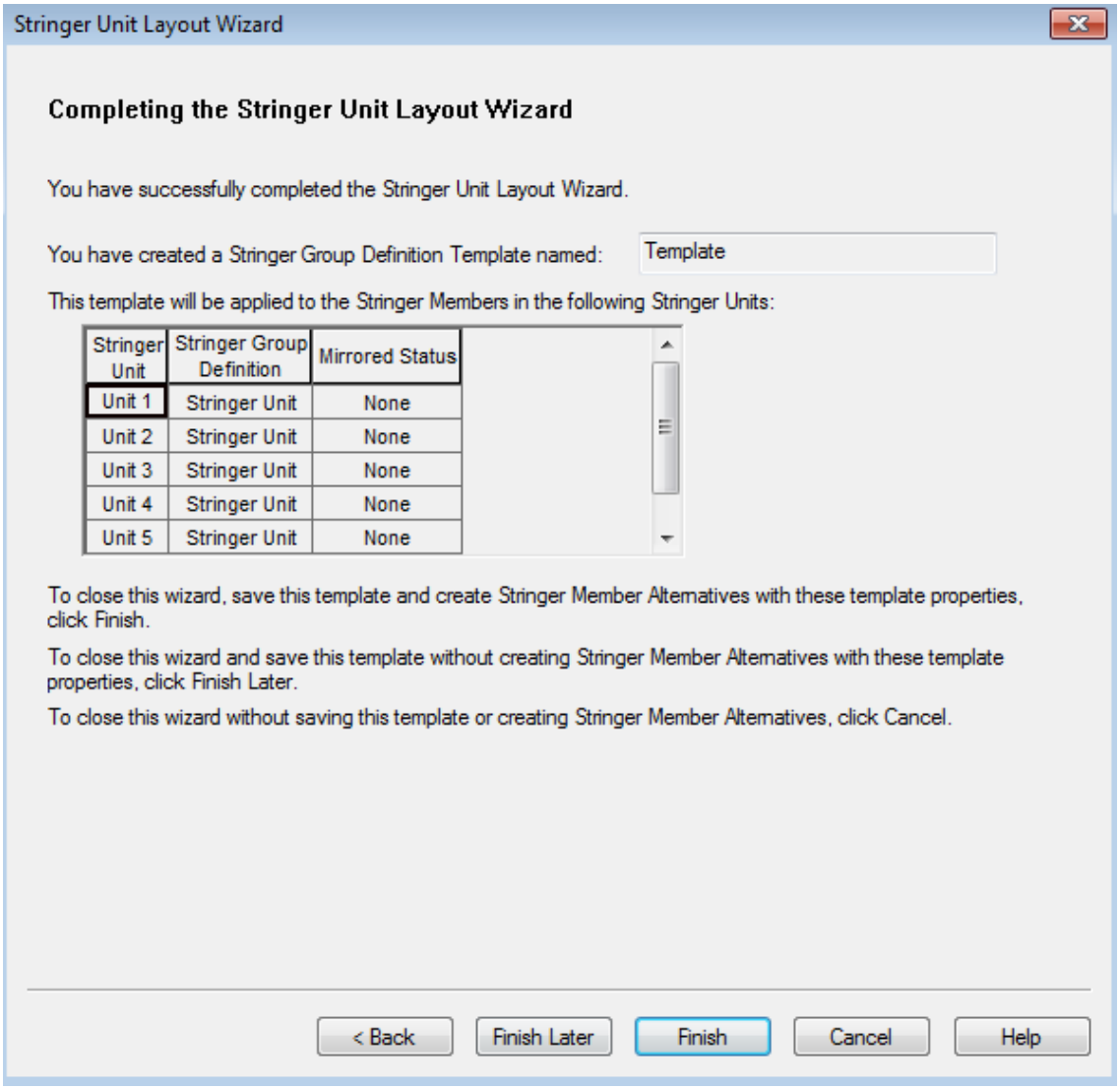
Use the Stringer Member Alternative wizard to create Stringer Member Alternatives.



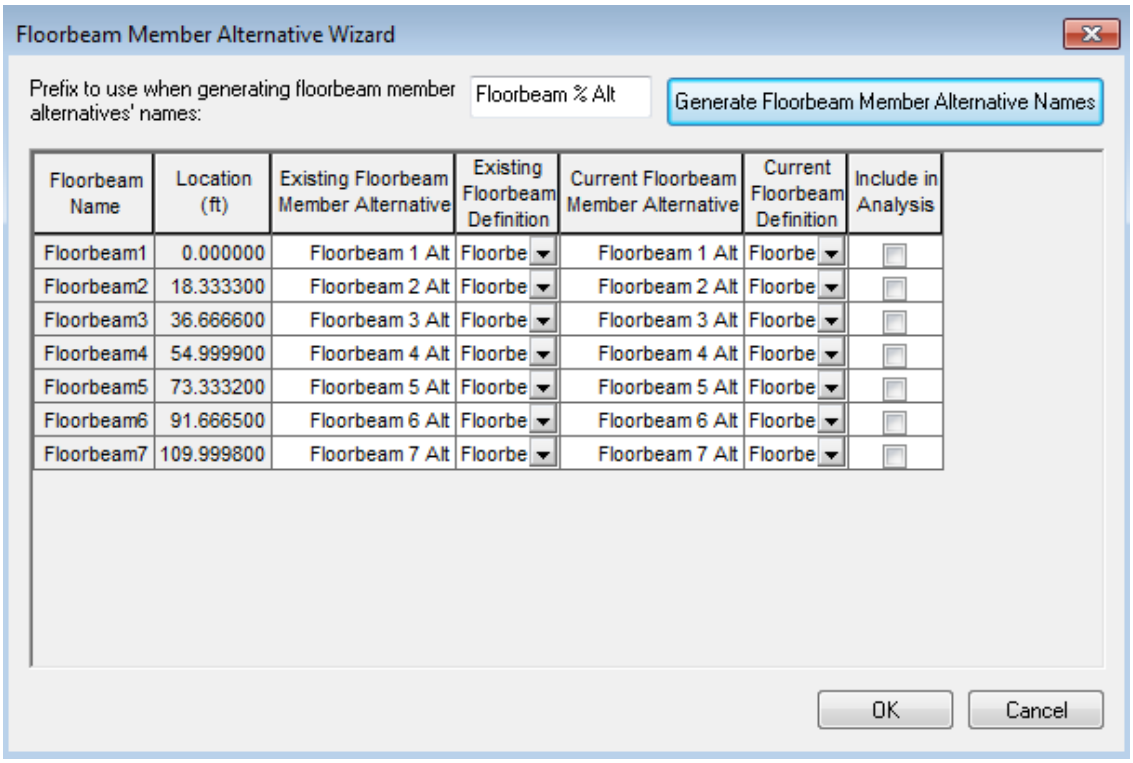

Stringer Unit Layout Wizard
Stringer Definitions
This screen allows you to create Stringer Member Alternatives and assign Stringer Definitions to these Alternatives for all Stringer Members using the Stringer Group Definition picked on Page 1. After the Stringer Member Alternatives are created at the end of this wizard, you can change the Stringer Definitions assigned to the Stringer Member Alternatives by visiting the individual Stringer Member Alternative windows. Changing Stringer Definitions in the Stringer Member Alternative window will not make corresponding changes in this template.
This wizard will generate names for the Stringer Member Alternatives for you or you can enter them yourself in the table below.
Prefix to use when generating stringer member alternatives' names:
Stringer % Alt
Generate Stringer Member Alternative Names
Stringer Member*
Existing Stringer Member Alternative Name
Existing Stringer Definition
Current Stringer Member Alternative Name
Current Stringer Definition
Stringer 1
Stringer 1 Alt
Exterior Stringer
Stringer 1 Alt
Exterior Stringer
Stringer 2
Stringer 2 Alt
Interior Stringer
Stringer 2 Alt
Interior Stringer
Stringer 3
Stringer 3 Alt
Interior Stringer
Stringer 3 Alt
Interior Stringer
Stringer 4
Stringer 4 Alt
Interior Stringer
Stringer 4 Alt
Interior Stringer
Stringer 5
Stringer 5 Alt
Interior Stringer
Stringer 5 Alt
Interior Stringer
*Stringer members in this table are listed from left to right in the structure typical section.
< Back
Next >
Cancel
Help

Select each stringer and use the Compute from Typical Section button to compute the stringer live load distribution factors.



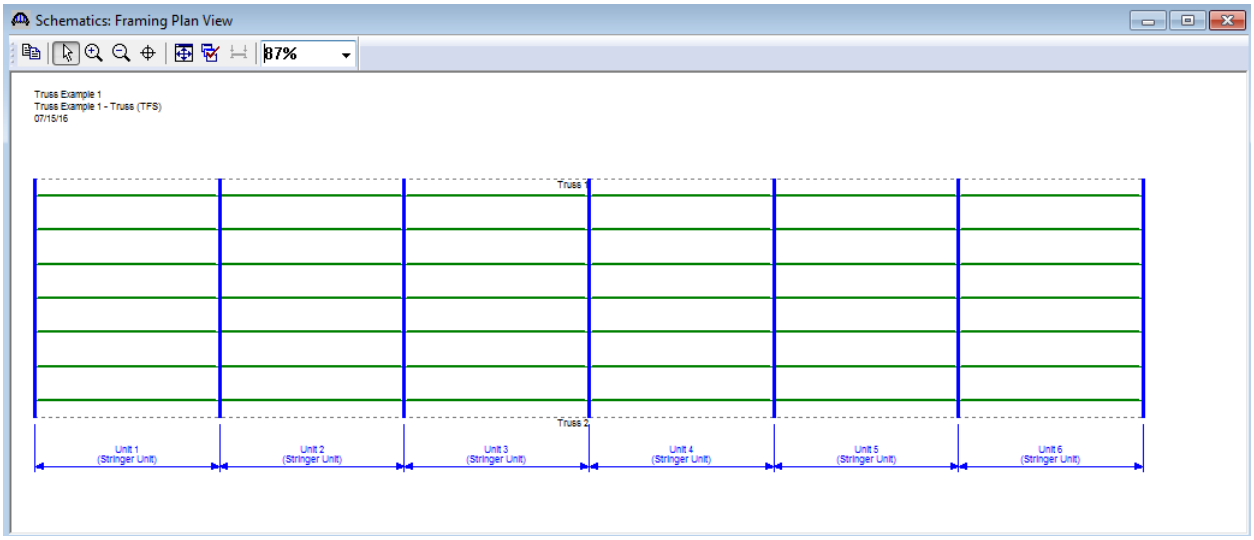

Stringer Unit Layout Wizard
Completing the Stringer Unit Layout Wizard
You have successfully completed the Stringer Unit Layout Wizard.
You have created a Stringer Group Definition Template named:
Template
This template will be applied to the Stringer Members in the following Stringer Units:
Stringer Unit
Stringer Group Definition
Mirrored Status
Unit 1
Stringer Unit
None
Unit 2
Stringer Unit
None
Unit 3
Stringer Unit
None
Unit 4
Stringer Unit
None
Unit 5
Stringer Unit
None
To close this wizard, save this template and create Stringer Member Alternatives with these template properties, click Finish.
To close this wizard and save this template without creating Stringer Member Alternatives with these template properties, click Finish Later.
To close this wizard without saving this template or creating Stringer Member Alternatives, click Cancel.
< Back
Finish Later
Finish
Cancel
Help

Now use the Floorbeam Member Alternative Wizard to create floorbeam member alternatives.

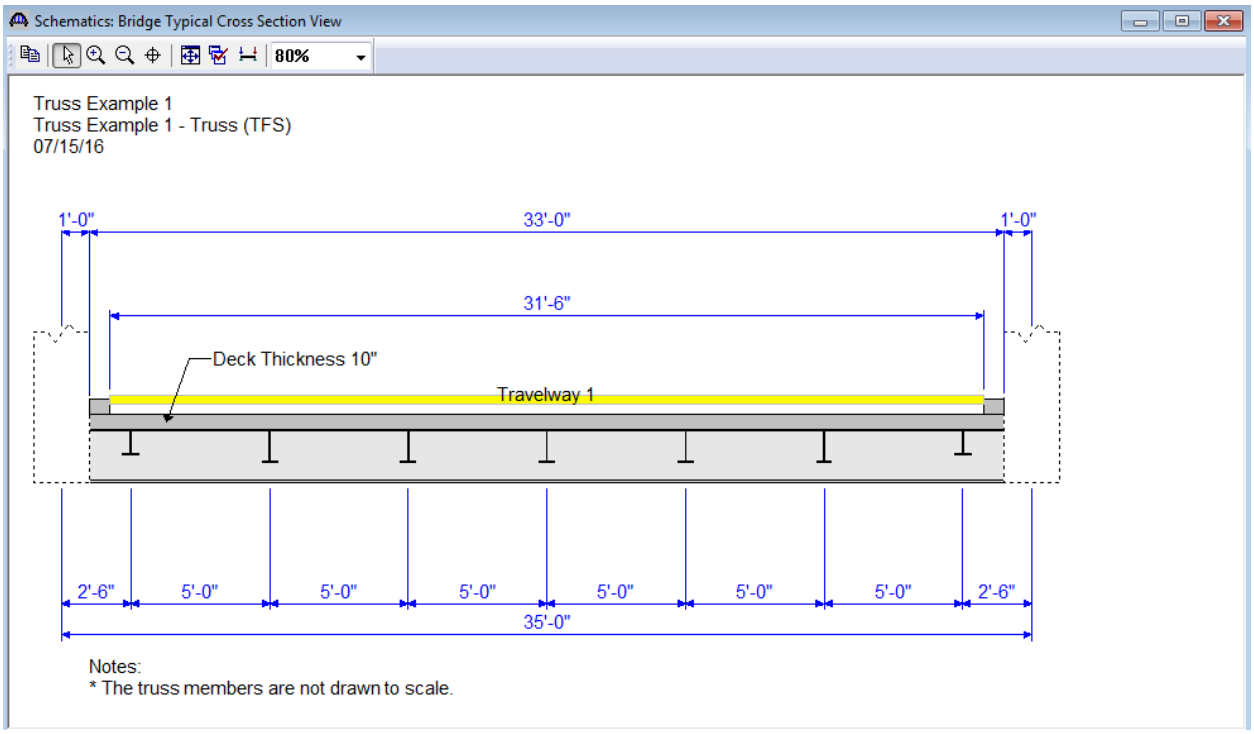


Floorbeam Name	Location (ft)	Existing Floorbeam Member Alternative	Existing Floorbeam Definition	Current Floorbeam Member Alternative	Current Floorbeam Definition	Include in Analysis
Floorbeam1	0.000000	Floorbeam 1 Alt	Floorbe	Floorbeam 1 Alt	Floorbe	
Floorbeam2	18.333300	Floorbeam 2 Alt	Floorbe	Floorbeam 2 Alt	Floorbe	
Floorbeam3	36.666600	Floorbeam 3 Alt	Floorbe	Floorbeam 3 Alt	Floorbe	
Floorbeam4	54.999900	Floorbeam 4 Alt	Floorbe	Floorbeam 4 Alt	Floorbe	
Floorbeam5	73.333200	Floorbeam 5 Alt	Floorbe	Floorbeam 5 Alt	Floorbe	
Floorbeam6	91.666500	Floorbeam 6 Alt	Floorbe	Floorbeam 6 Alt	Floorbe	
Floorbeam7	109.999800	Floorbeam 7 Alt	Floorbe	Floorbeam 7 Alt	Floorbe	

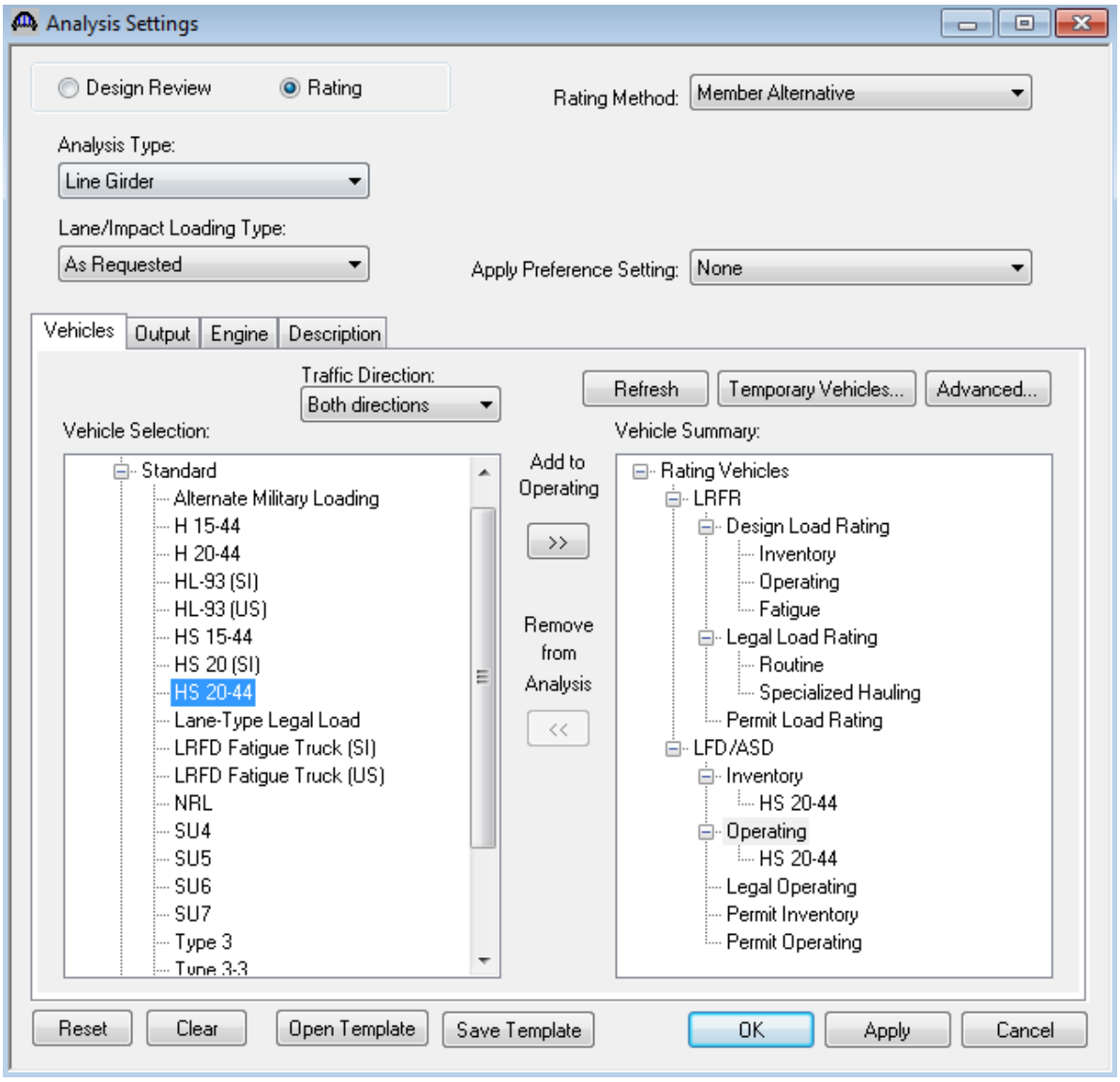
The Framing Plan Schematic now appears as follows:



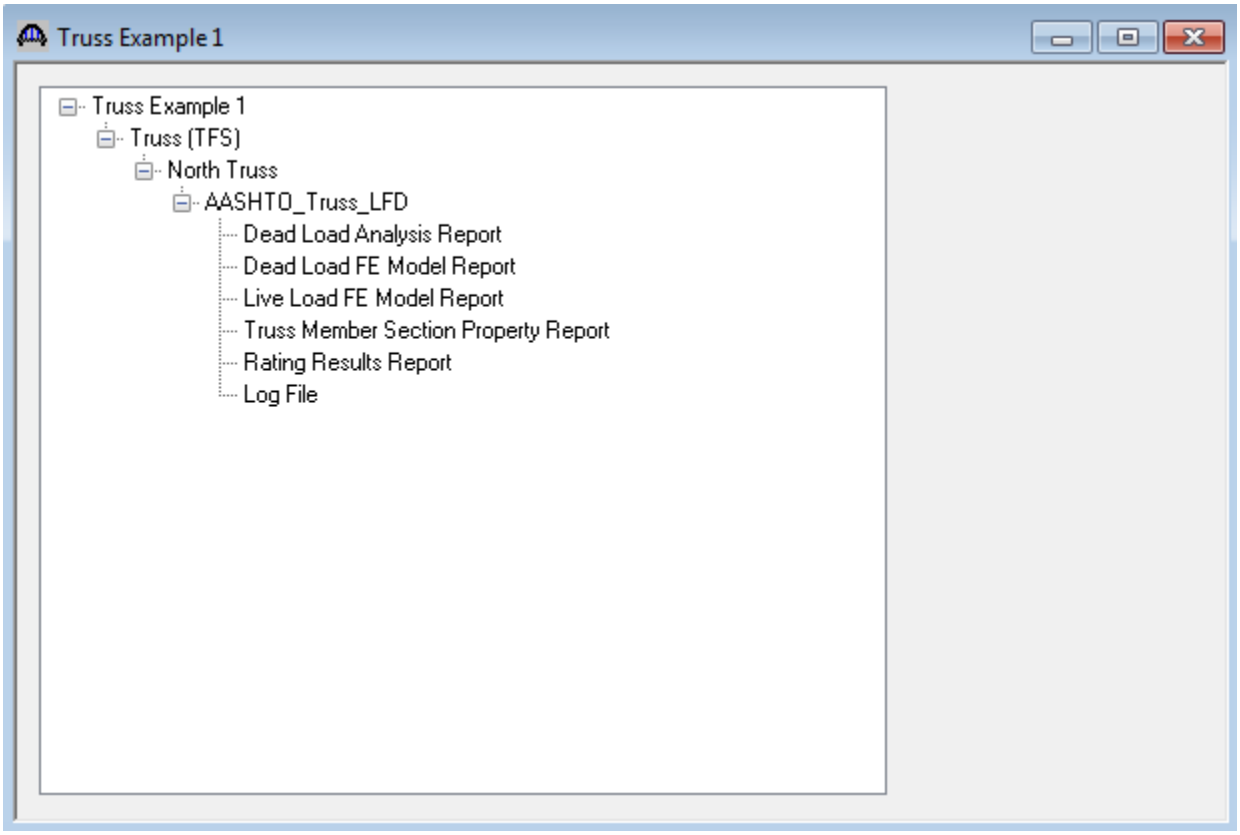
The Structure Typical Section appears as follows:



Select the HS 20 vehicle for the analysis.

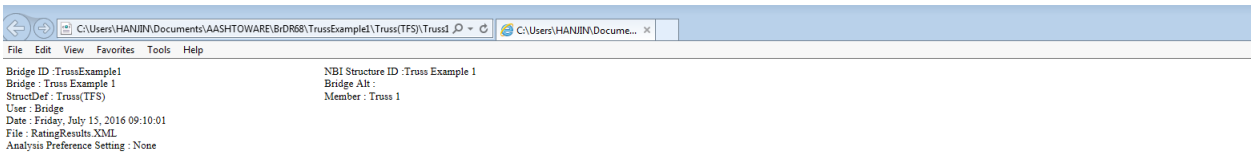


Select the ‘North Truss’ in the BWS tree and select the ‘Analyze’ toolbar button to analyze the truss. An analysis progress dialog will appear with messages related to the analysis. After the analysis you can view the output files by selecting the ‘View latest analysis output’ toolbar button.



The ‘Live Load Analysis Detail’ and ‘Live Load Analysis Summary’ files contain data related to the live loading of the truss influence lines. The ‘FE Model for DeadLoad Analysis’ report contains the truss finite element model and dead load analysis. The ‘Section Property Report” contains data related to the computed and user input truss member section properties. The ‘Rating Results’ file contains the rating results for the truss. The ‘Log file’ is the analysis log produced when the analysis is run. This file may contain errors and warnings that should be reviewed.

A portion of the Rating Results output report is shown below.



Bridge ID :TrussExample1
Bridge : Truss Example 1
StructDef : Truss(TFS)
User : Bridge
Date : Friday, July 15, 2016 09:10:01
File : RatingResults.XML
Analysis Preference Setting : None

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

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	U1L2	2.209	79.53	U1L2	3.689	132.81										As Requested	As Requested
HS 20-44 - Lane	Design Lane	U1L2	2.209	79.53	U1L2	3.689	132.81										With Impact	Multi-Lane
HS 20-44 - Truck	Design Truck	U1L2	1.888	67.96	U1L2	3.153	113.50										As Requested	As Requested
HS 20-44 - Truck	Design Truck	U1L2	1.888	67.96	U1L2	3.153	113.50										With Impact	Multi-Lane

---

Live Load: HS 20-44 - Lane (Design Lane)

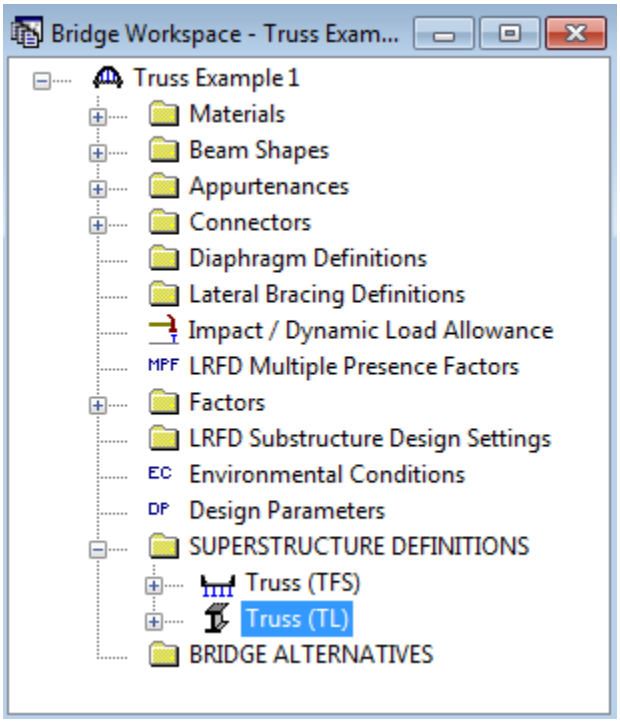
Detailed Truss Member Rating Results

LL Scale Factor = 1.00
Adjacent Vehicle LL Factor = 0.00
Inventory:
A1 = 1.30, A2 = 2.17
Operating:
A1 = 1.30, A2 = 1.30
Note: Rating factor is outputted as 99.00 when it is greater than 99

Member	Truss Element	DL Force (kip)	LL Force				Capacity		Adj Veh Demand		One Lane LLDF	Multi Lane LLDF	Inv RF	Opr RF	Legal Opr RF	Permit Inv RF	Permit Opr RF
			Comp. (kip)	IF	Tens. (kip)	IF	Comp. (kip)	Tens. (kip)	Comp. (kip)	Tens. (kip)							
L0L1	Lower-Chord	208.24			67.73	1.21		969.60				1.270	3.086	5.153			
L1L2	Lower-Chord	208.24			67.73	1.21		969.60				1.270	3.086	5.153			
L2L3	Lower-Chord	323.55			104.50	1.21		1335.00				1.270	2.617	4.370			
L3L4	Lower-Chord	323.55			104.50	1.21		1335.00				1.270	2.617	4.370			
L4L5	Lower-Chord	209.45			67.73	1.21		1335.00				1.270	4.692	7.836			
L5L6	Lower-Chord	209.45			67.73	1.21		1335.00				1.270	4.692	7.836			
U1U2	Upper-Chord	-309.41	-100.18	1.21			-1155.29					1.270	2.248	3.754			

Truss Line Superstructures

The Bridge Workspace tree for a truss-floorbeam-stringer line superstructure definition is shown below.



In a truss line superstructure definition, the relationship between the truss and floor system is not defined. Therefore, you must enter the floor system dead loads that act on the truss yourself. These loads are computed as follows:

Deck Dead Load on Truss

Deck DL = 10”/12 * 33.0’ * 0.150pcf = 4.125 kip/ft

L0, L6: 18.33’/2 * 4.125 k/ft / 2 trusses = 18.90 kips

L1, L2, L3, L4, L5: 18.33’ * 4.125 k/ft / 2 trusses = 37.81 kips

Curb Dead Load on Truss

Curb DL = 85 lb/ft

L0, L6: 18.33’/2 * 0.085 k/ft * 2 curbs / 2 trusses = 0.78 kips

L1, L2, L3, L4, L5: 18.33’ * 0.085 k/ft * 2 curbs / 2 trusses = 1.56 kips

Floorbeam Dead Load on Truss

Floorbeam DL = 221 lb/ft*35 ft = 7735 lb

L0, L1, L2, L3, L4, L5, L6: 7.735 kips / 2 trusses = 3.87 kips

Stringer Dead Load on Truss

Exterior Stringer DL = 57 lb/ft

Interior Stringer DL = 57 lb/ft

L0, L6: 7 stringers * 0.057 kip/ft * 18.33'/2 / 2 trusses = 1.83 kips

L1, L2, L3, L4, L5: 7 stringers * 0.057 kip/ft * 18.33' / 2 trusses = 3.66 kips

The truss command language description for the truss line is the same as the description for the truss system with the addition of a command to describe the user computed floor system dead loads. The following is the PanelPointLoad command used to describe the floor system dead load acting on the truss. This command comes after the Support command.

PanelPointLoad

L0 DC 0.0 -25.38

L1 DC 0.0 -46.90

L2 DC 0.0 -46.90

L3 DC 0.0 -46.90

L4 DC 0.0 -46.90

L5 DC 0.0 -46.90

L6 DC 0.0 -25.38