MDOT Camelback Bridge Example

AASHTOWare Bridge Rating

May 2022

Contents

This tutorial was created on behalf of MDOT by the Center for Technology & Training, please contact loadrating@mtu.edu for assistance or visit http://loadrating.michiganltap.org/ for more information.

Background

What follows is a general guide for modeling a camelback bridge in AASHTOWare Bridge Rating (BR). The sample bridge was taken from a set of MDOT standard plans for a 60-ft reinforced concrete girder with a 22-ft roadway. A similar approach can be applied to other standard lengths. The tutorial methodology should be adapted accordingly for any modifications to the standard plan and for the specific rebar present in the bridge.

This tutorial is being provided by the Michigan Department of Transportation (herein referred to as MDOT) as a courtesy service to contractors, consultants and local agency bridge owners. In preparation of this tutorial, MDOT has endeavored to offer current, correct and clearly expressed information. However, error may occur. MDOT expressly disclaims any liability, of any kind, for any reason, that might arise out of the use of this tutorial.

Assumptions/Limitations

This tutorial is prepared based on the assumption that the bridge is in a pristine, un-deteriorated state and was built in accordance with the construction plans. All load ratings must reflect the current condition of the structure. The load rating engineer should perform a field evaluation to confirm the correctness of the plans and use engineering judgment to determine whether any observed deterioration may affect the structural capacity of the bridge.

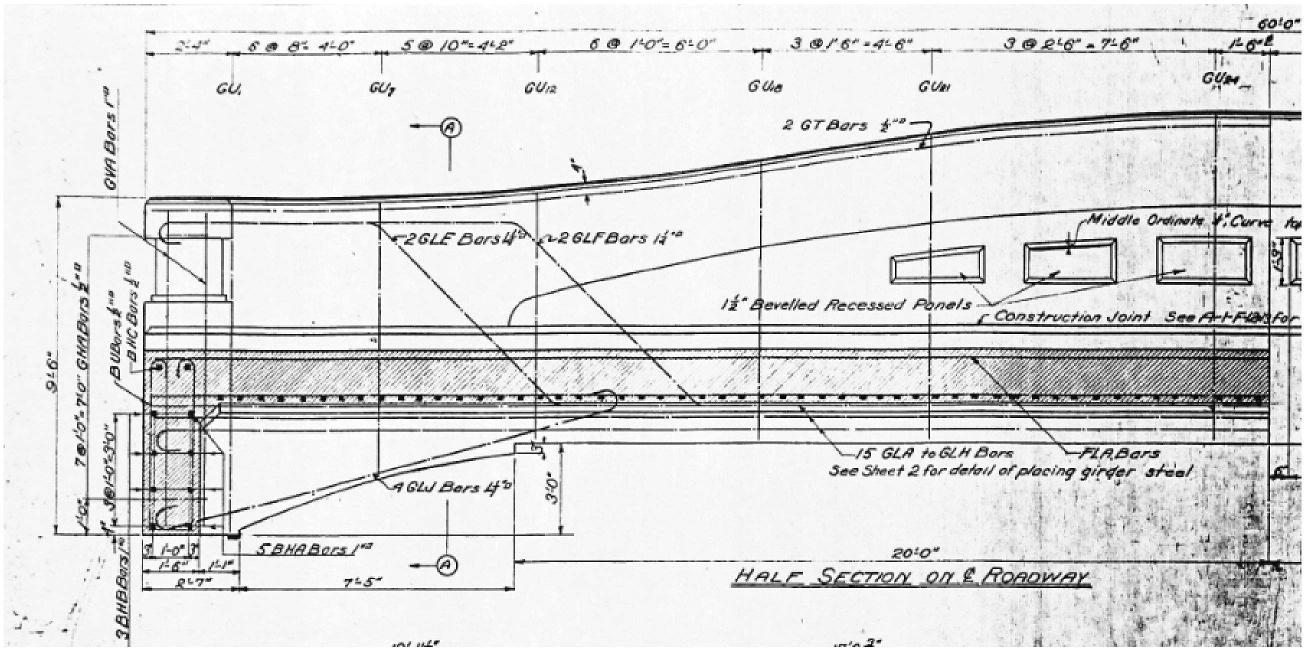
In a more traditional girder arrangement the compression zone of each girder is laterally braced by the bridge deck. The camelback bridge design results in an un-braced compression zone. This situation is not addressed by AASHTOWare Bridge Rating. Should there be evidence of distress in the compression zone of a camelback beam; a more detailed finite element model may be warranted.

The deck is conservatively considered for weight only, and contributes no structural capacity to the bridge as modeled in this tutorial. For situations where additional capacity is needed in the bridge, a portion of the deck slab can be considered as a structural part of the girder, subject to the limitations of AASHTO Section 8. Note that BR calculates the weight of the structural portion of the deck, so it should be deducted from the additional self-load entered on the Member Alternative Description screen.

Material properties have been assumed, according to the age of the bridge, using the Michigan Bridge Analysis Guide (BAG). The most recent bridge design revision date from the standard plans was 1922, which was assumed to coincide with construction for the purpose of determining material properties.

BAG, Table 10.28: 1922-1935 Grade A Concrete:
$f'c = 3$ ksi
$Es/Ec = n = 12$

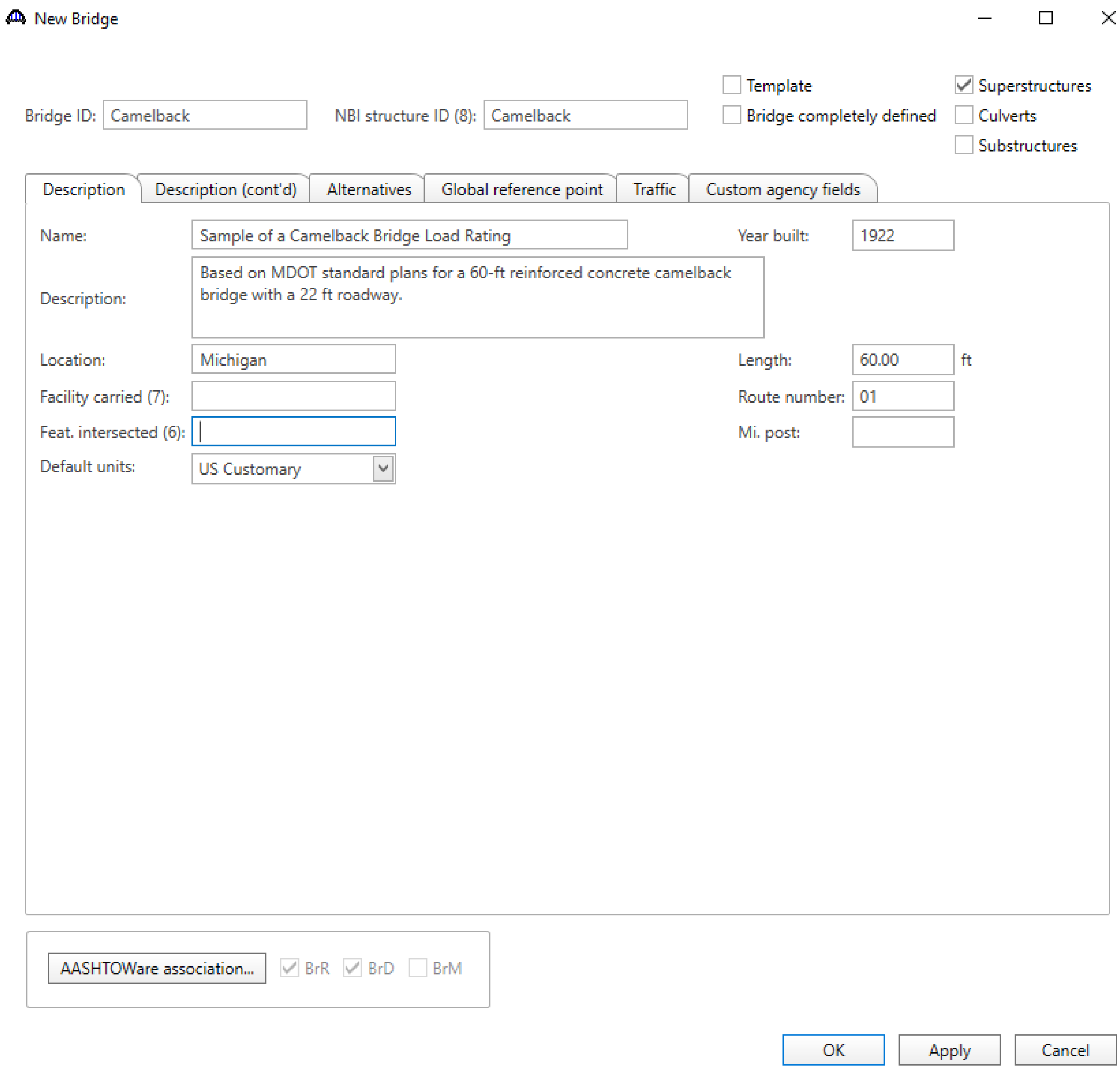
BAG, Table 10.26: Structural or unknown grade prior to 1954:
$fy = 33$ ksi



Elevation

General Bridge Information

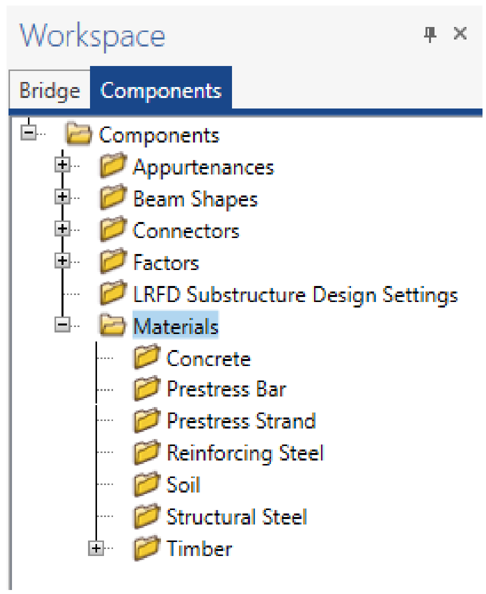
From BR’s Bridge Explorer window, create a new bridge by selecting *File/New/New Bridge* and enter the following description data:



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

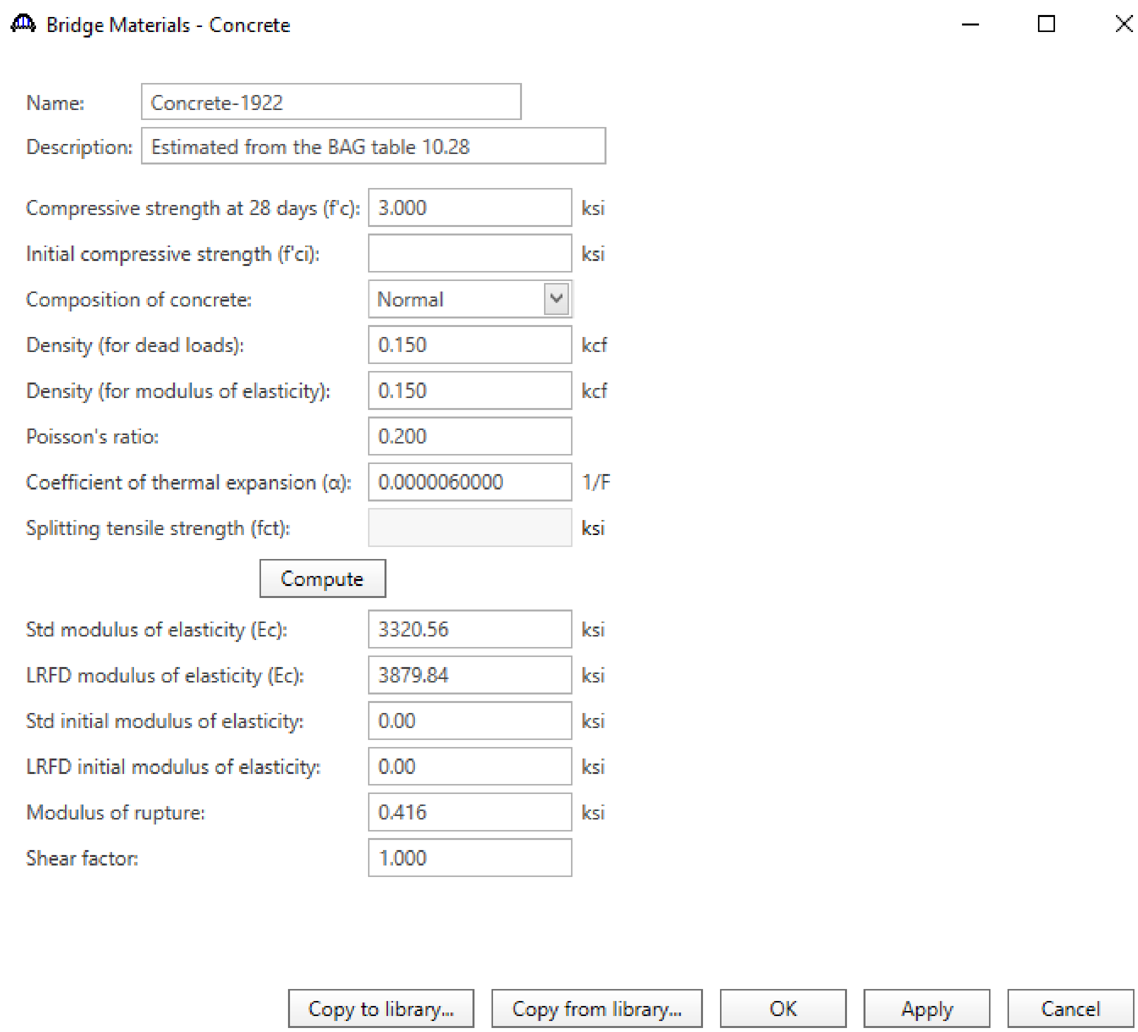
Material Properties

Enter the materials to be used by members of the bridge by clicking on **+** to expand the tree for Materials, listed under the Components tab in the Workspace window. The tree with the expanded Materials branch is shown below:



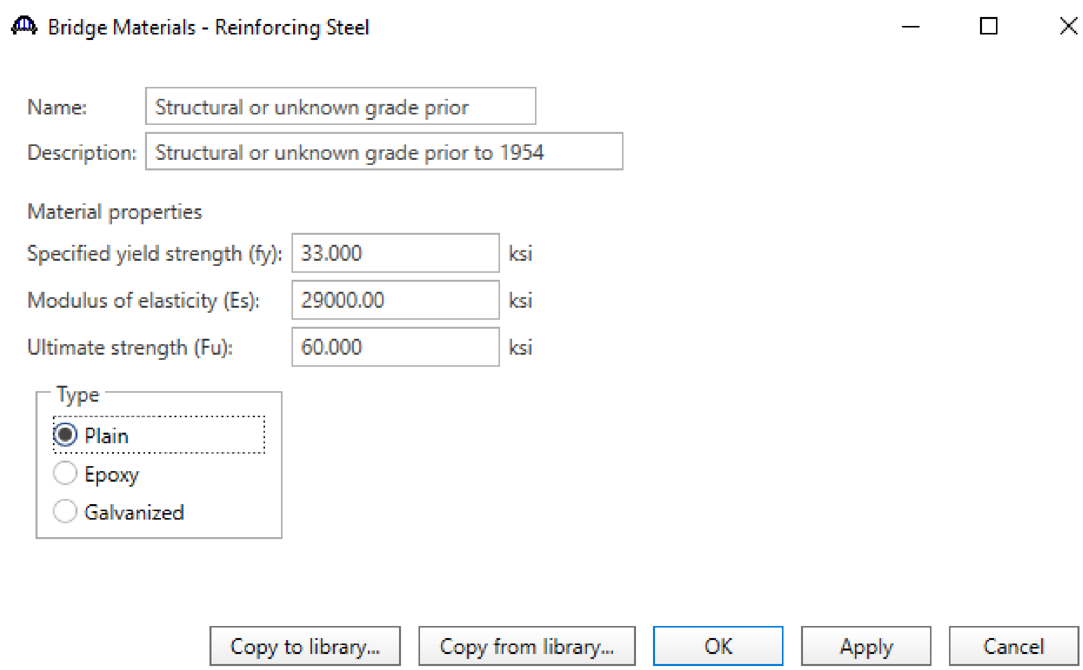
To add a new concrete material click on **Concrete** in the tree and select *File/New* from the menu (or right mouse click on **Concrete** and select *New*).

Enter the data shown in the window below.



Click **OK** to save the data to memory and close the window.

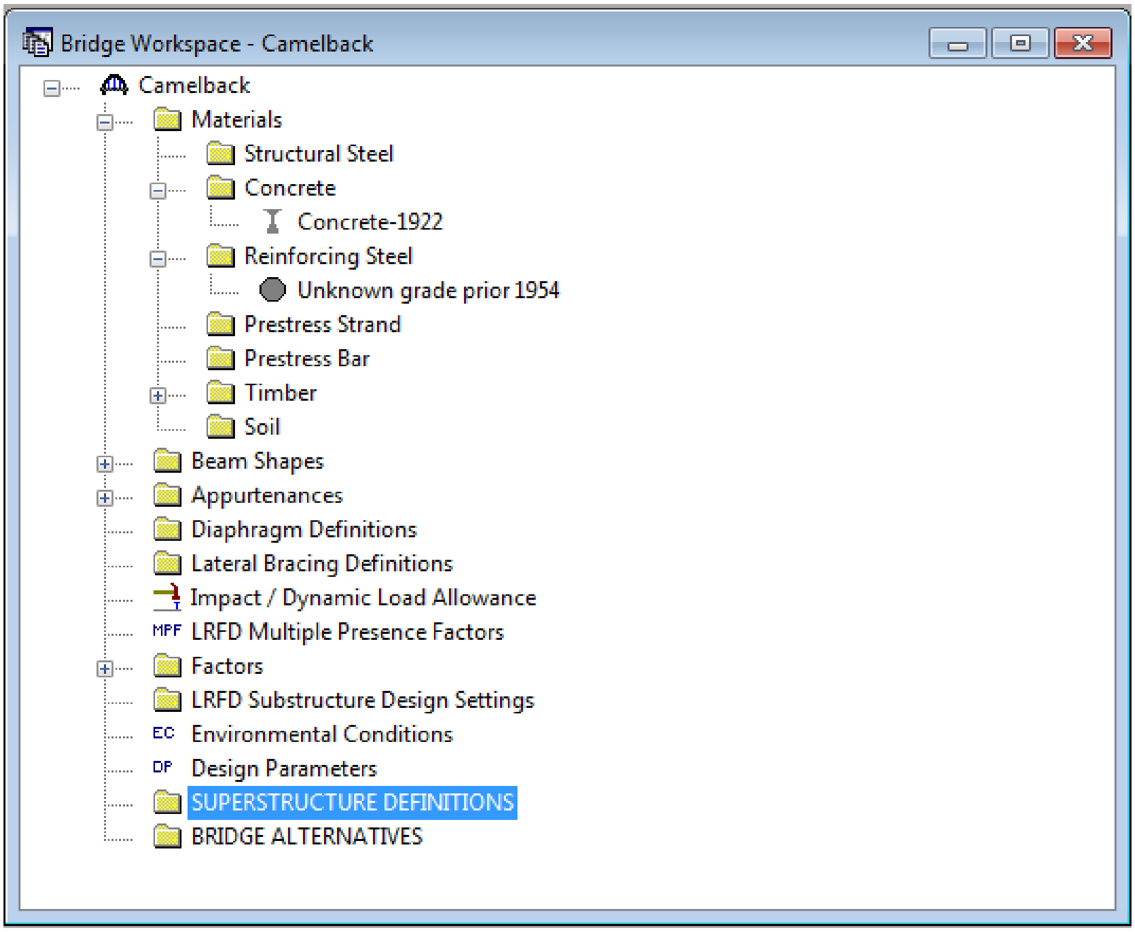
Double click on **Reinforcing Steel** in the bridge tree. The reinforcing steel may be copied from the library. Select the **Copy from Library…** button and choose the appropriate material from the list. The window will look like that shown below:



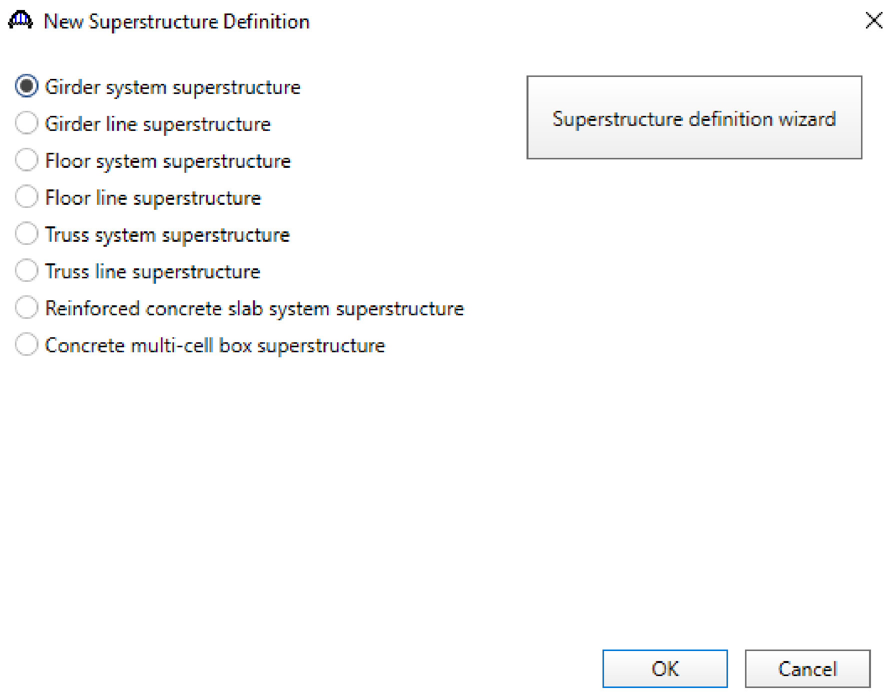
Click **OK** to save the data to memory and close the window.

Superstructure Definition

The default impact factors will be used so we can skip to **Structure Definition**, listed under the Bridge tab in the Workspace window.

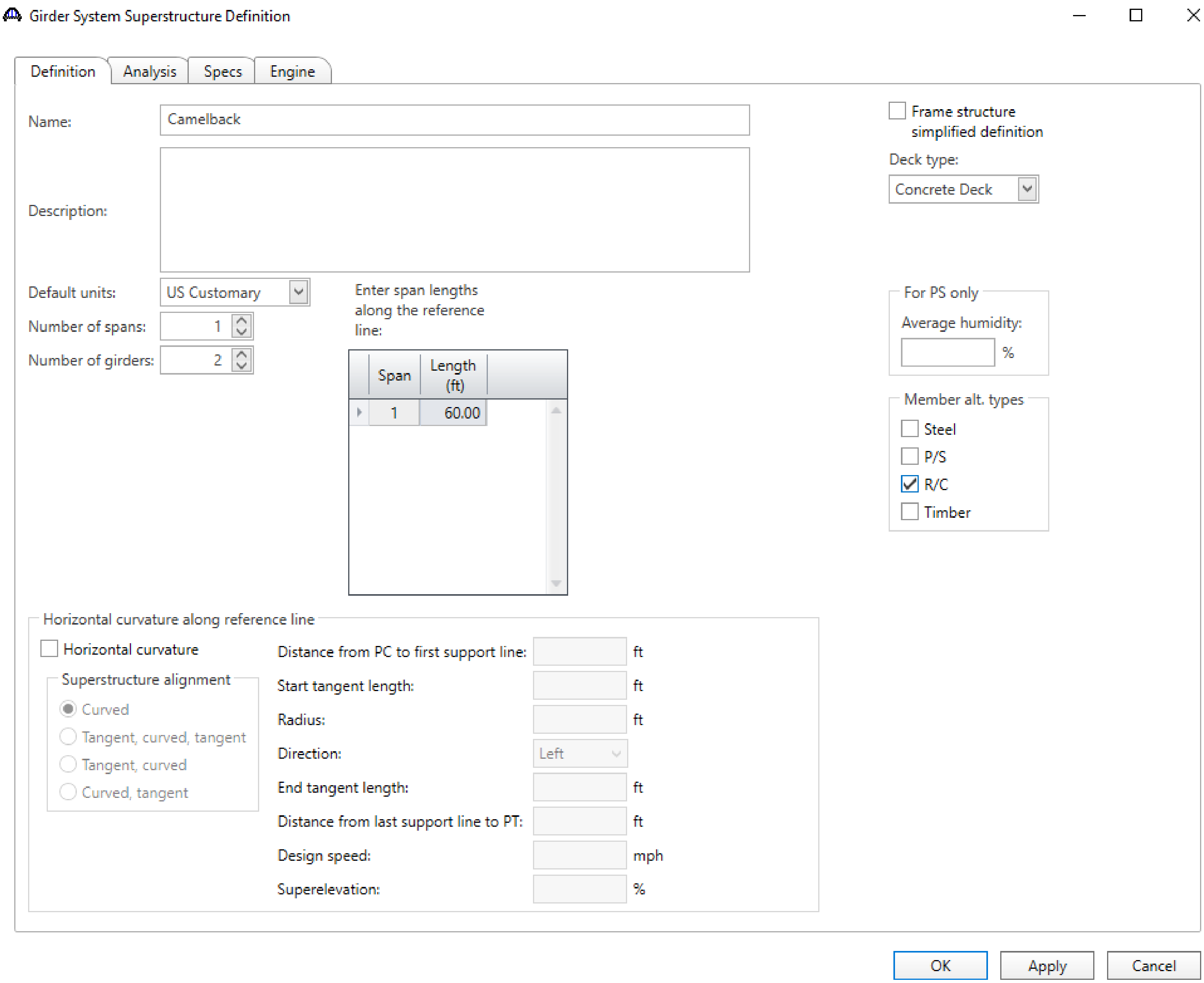


Doubleclick on **SUPERSTRUCTURE DEFINITIONS** to create a new structure definition. The following dialog will open.



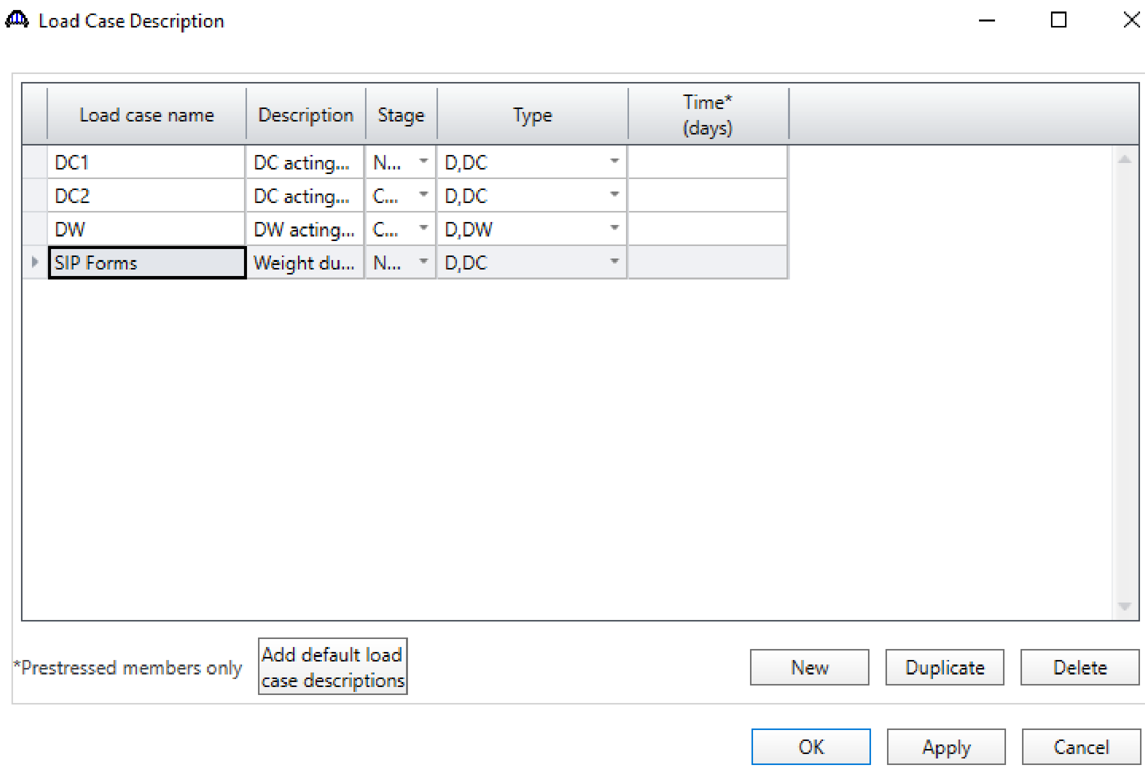
Select **Girder System Superstructure** and the Structure Definition window will open. Enter the data shown below:

Click **OK** to save the data to memory and close the window.


Girder System Superstructure Definition
Definition
Analysis
Specs
Engine
Name:
Camelback
Description:
Default units:
US Customary
Number of spans:
1
Number of girders:
2
Enter span lengths along the reference line:
Span
Length (ft)
1
60.00
Frame structure simplified definition
Deck type:
Concrete Deck
For PS only
Average humidity:
%
Member alt. types
Steel
P/S
R/C
Timber
Horizontal curvature along reference line
Horizontal curvature
Superstructure alignment
Curved
Tangent, curved, tangent
Tangent, curved
Curved, tangent
Distance from PC to first support line:
ft
Start tangent length:
ft
Radius:
ft
Direction:
Left
End tangent length:
ft
Distance from last support line to PT:
ft
Design speed:
mph
Superelevation:
%
OK
Apply
Cancel

Load Case Descriptions

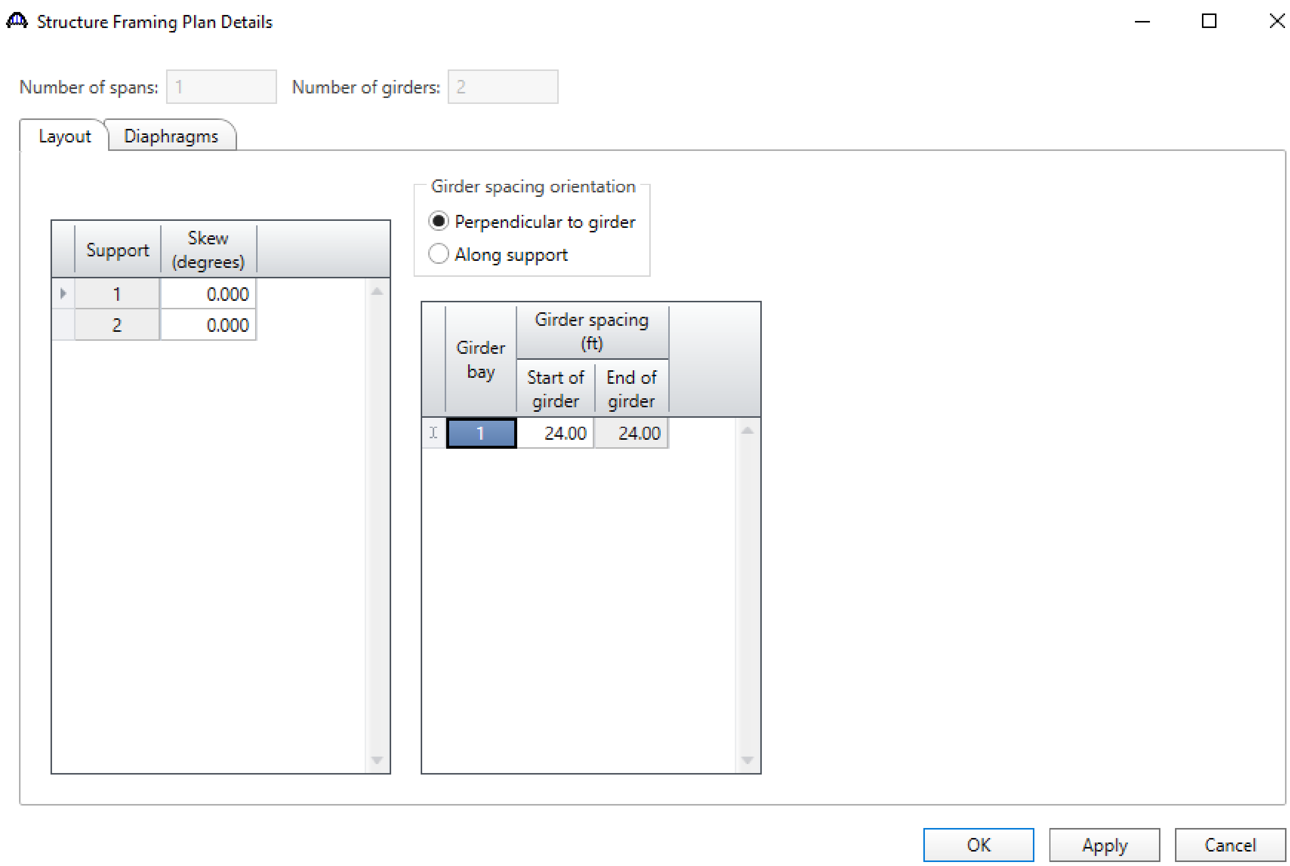
Click **Load Case Description** in the bridge tree by expanding the Superstructure Definition branch to define the dead load cases. Select **Add Default Load Case Descriptions**. The completed Load Case Description window is shown below.



Click **OK** to save the data to memory and close the window.

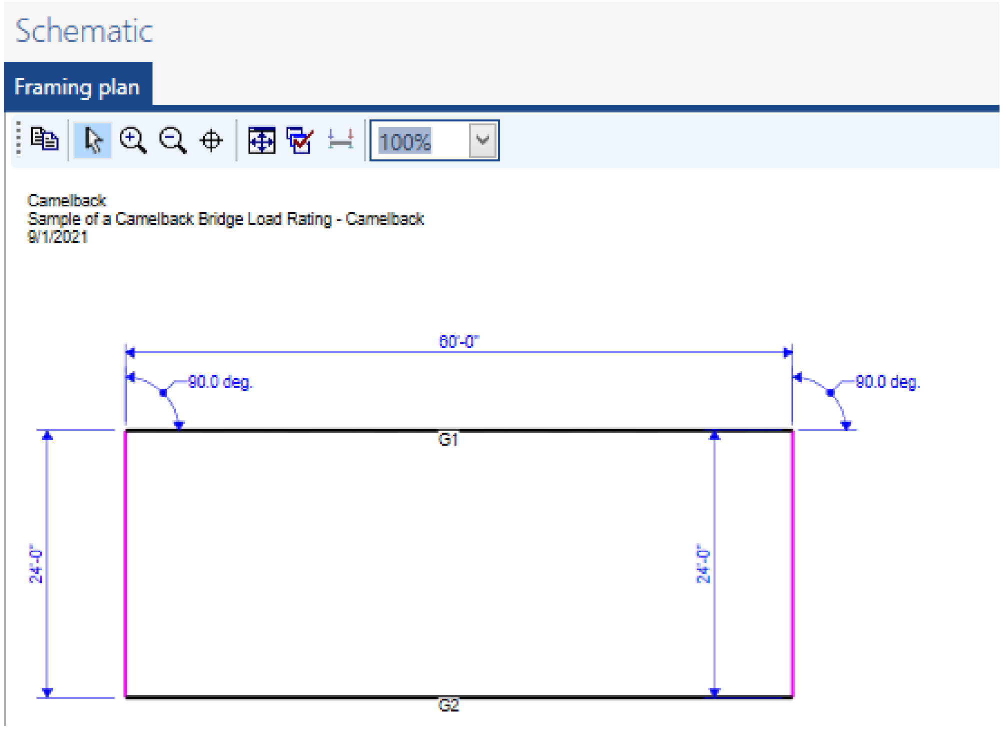
Framing Plan Details

Double-click **Framing Plan Detail** in the tree to describe the framing plan. Enter the data shown below.



Select **OK** to close the window.

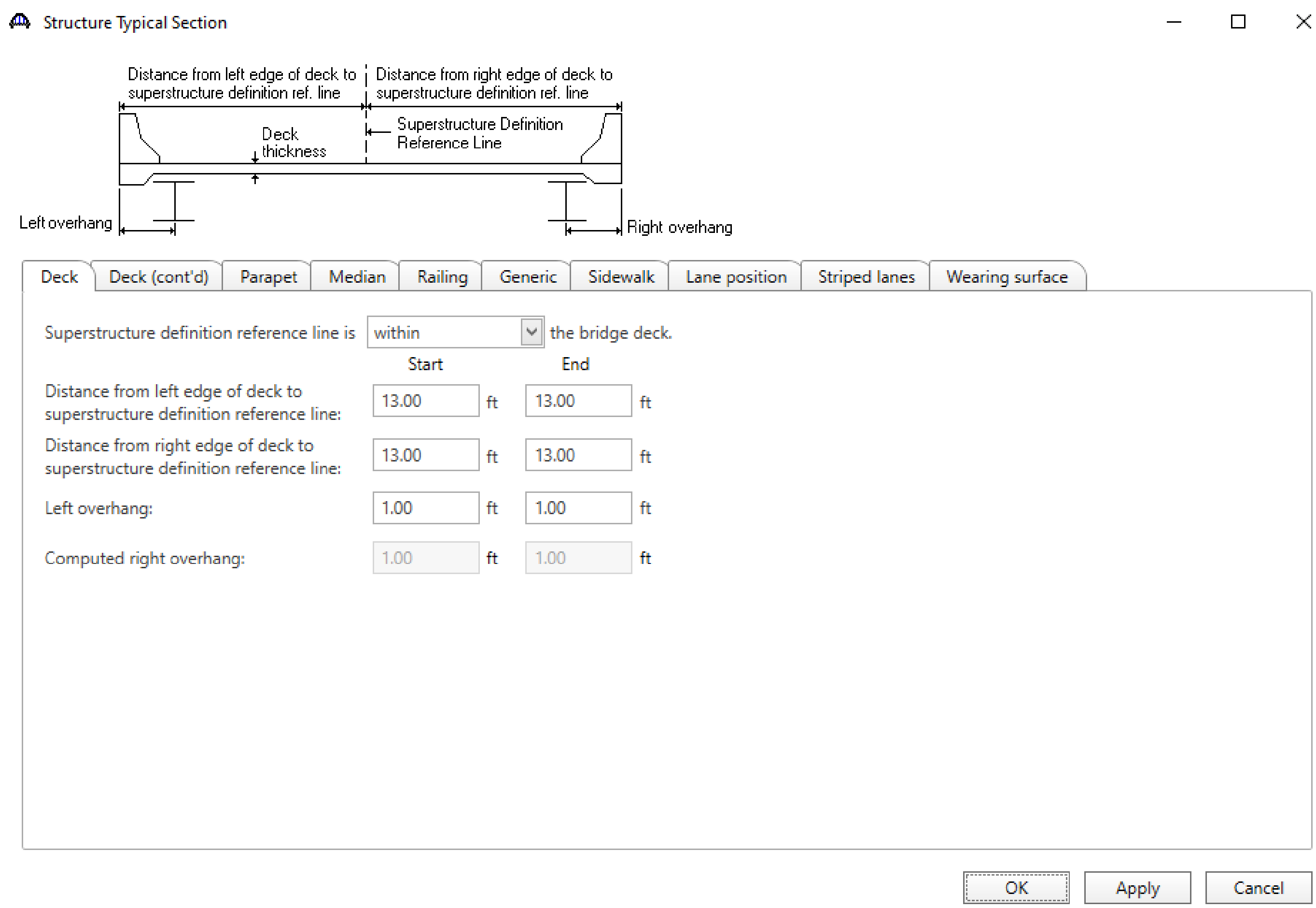
It is always a good idea to check the schematic after entering the framing plan detail information. Do this by selecting the **schematic** button while **framing plan detail** is highlighted in the bridge workspace tree. Alternatively, you may select *Bridge/schematic* while the **framing plan detail** is highlighted.



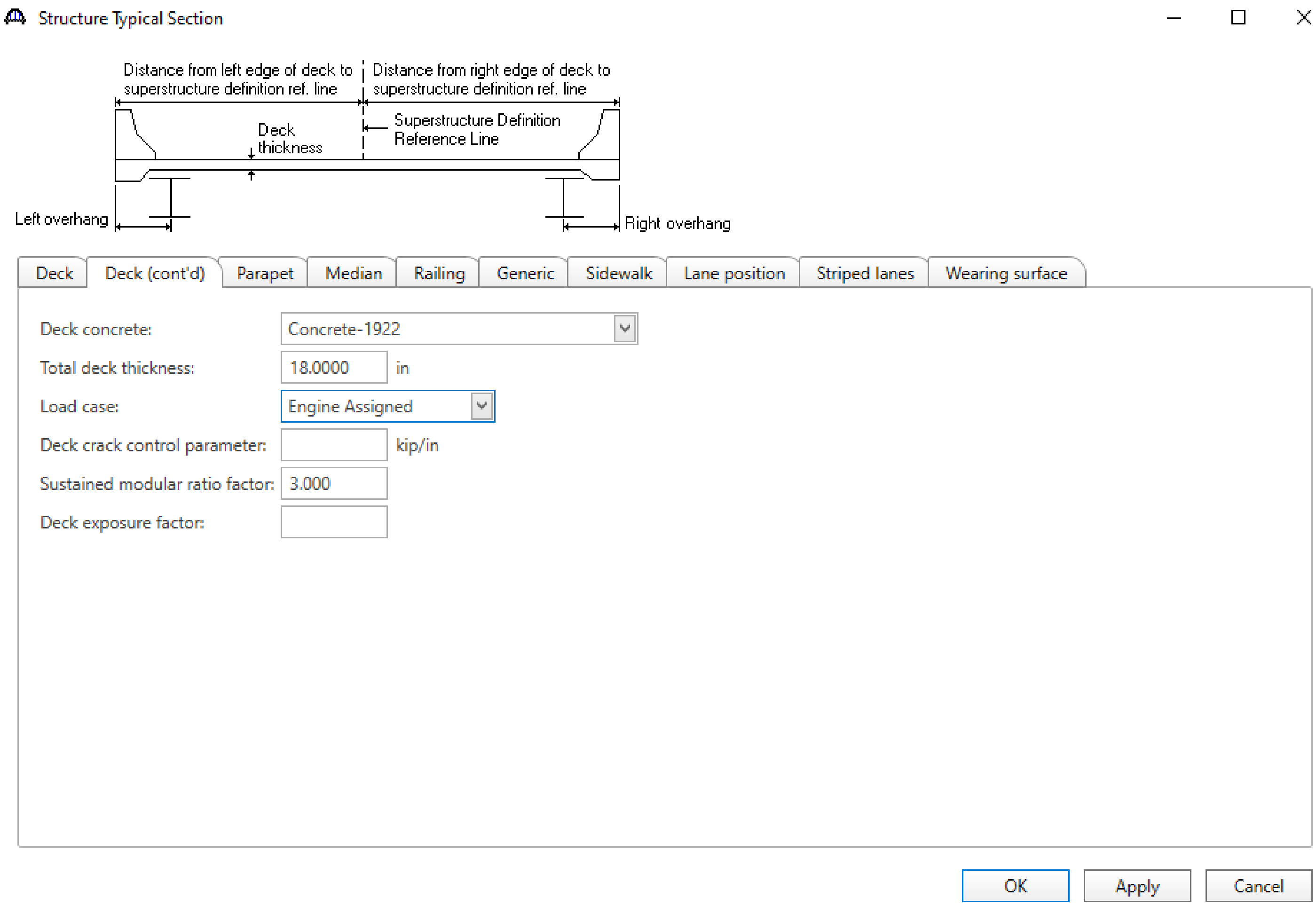
Typical Section

Next define the structure typical section by double-clicking **Structure Typical Section** in the Bridge Workspace tree. Input the data describing the typical section as shown below.

Deck Geometry

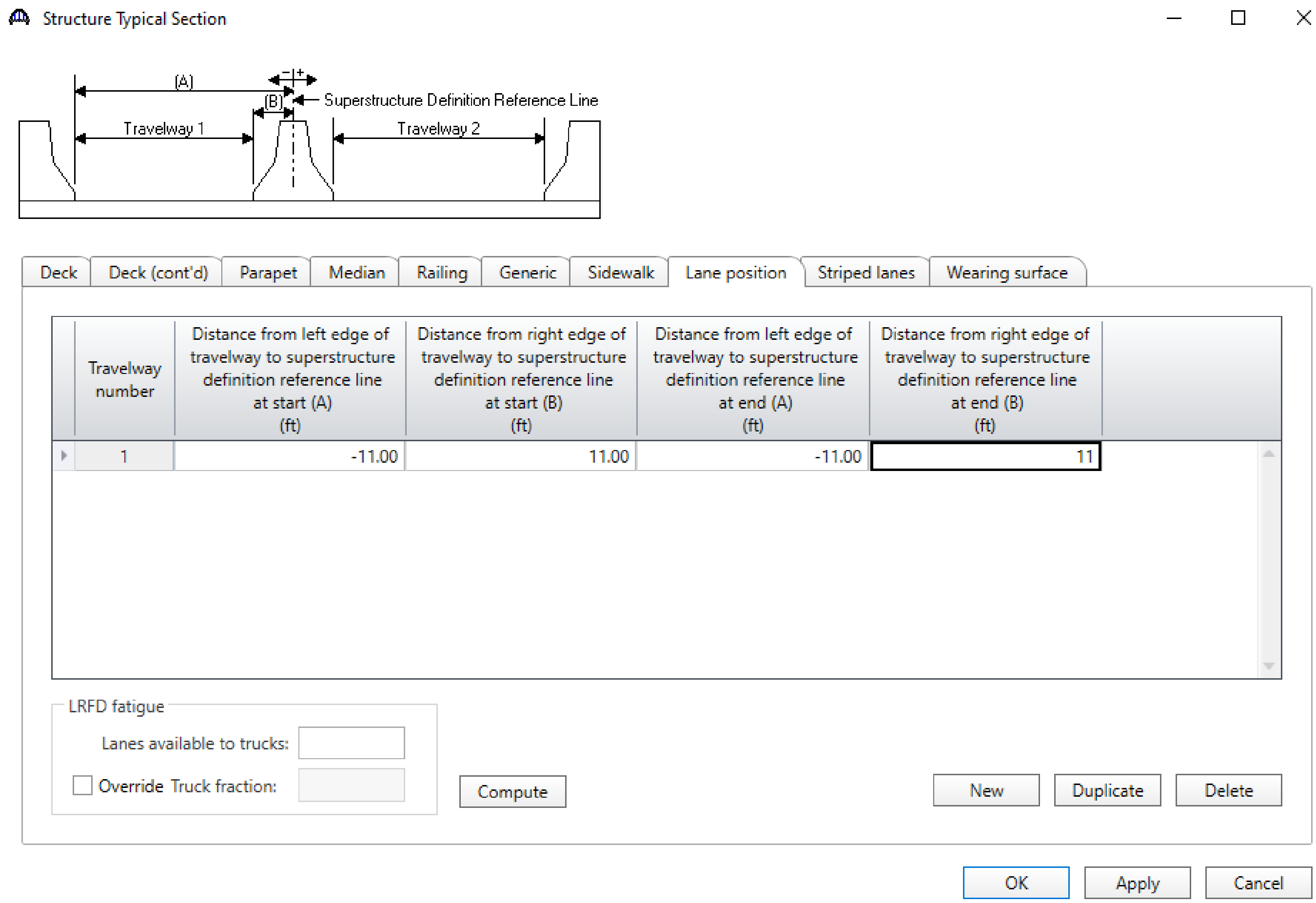


The **Deck (cont'd)** tab is used to enter information about the deck concrete and thickness. The material to be used for the deck concrete is selected from the list of bridge materials described in the Background section.


Structure Typical Section
Distance from left edge of deck to superstructure definition ref. line
Distance from right edge of deck to superstructure definition ref. line
Deck thickness
Superstructure Definition Reference Line
Left overhang
Right overhang
Deck
Deck (cont'd)
Parapet
Median
Railing
Generic
Sidewalk
Lane position
Striped lanes
Wearing surface
Deck concrete:
Concrete-1922
Total deck thickness:
18.0000
in
Load case:
Engine Assigned
Deck crack control parameter:
kip/in
Sustained modular ratio factor:
3.000
Deck exposure factor:
OK
Apply
Cancel

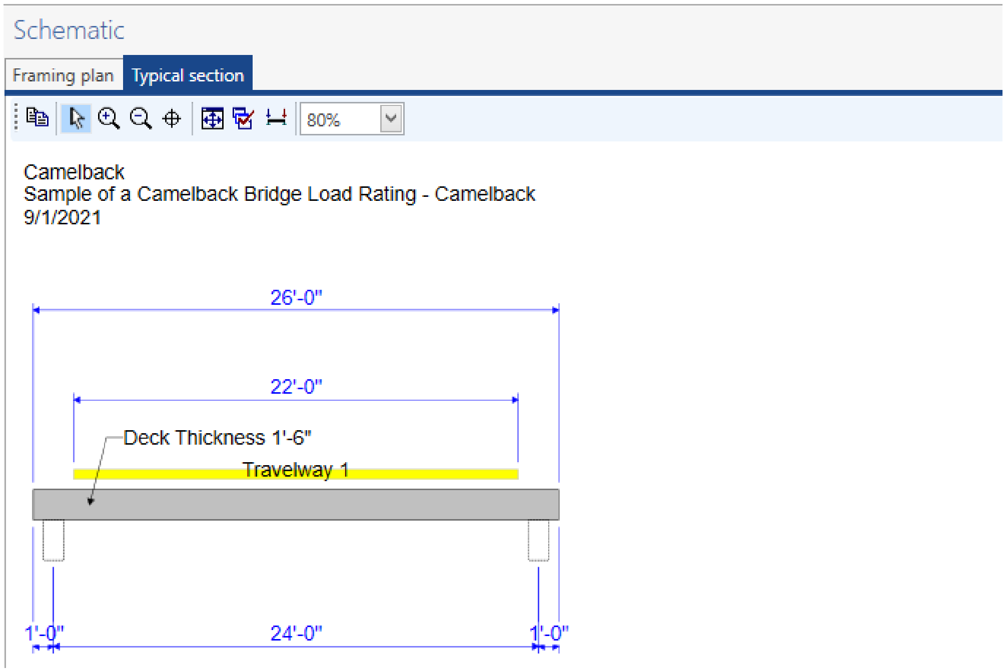
Lane Positions

Select the **Lane Position** tab. Manually enter the width of the travelway as shown in the figure below



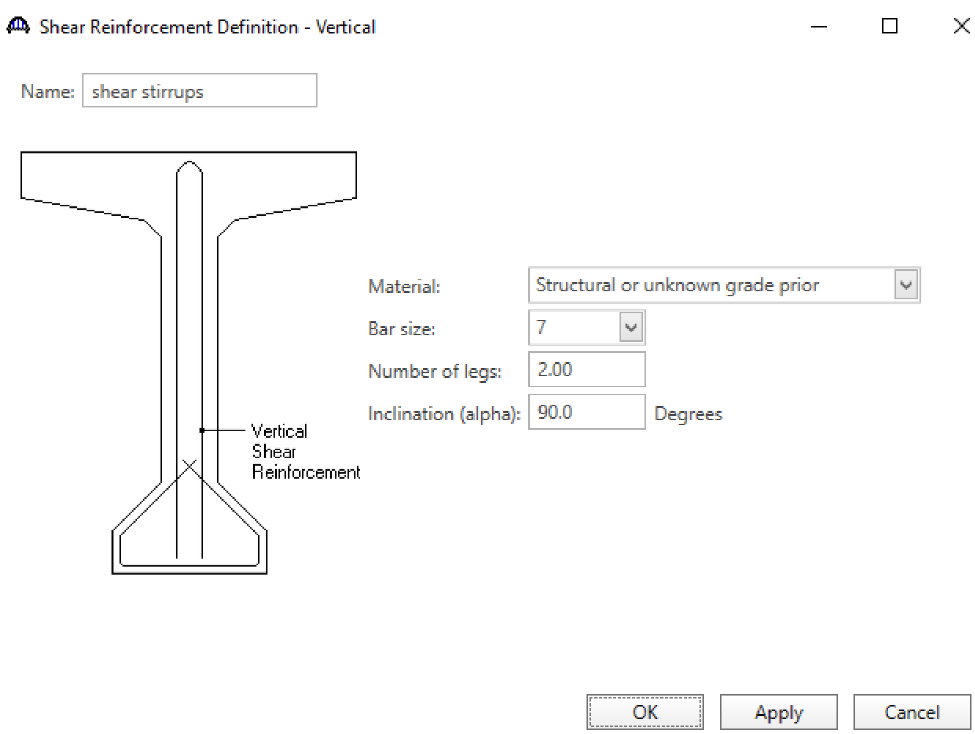
Click **OK** to save the data to memory and close the window.

It is also a good idea to check the schematic after entering the structure typical section information. This is done in the same manner as was used to check the schematic of the framing plan details. Note that for reinforced concrete structures a generic beam shape is used to represent the beam.



Shear Reinforcement

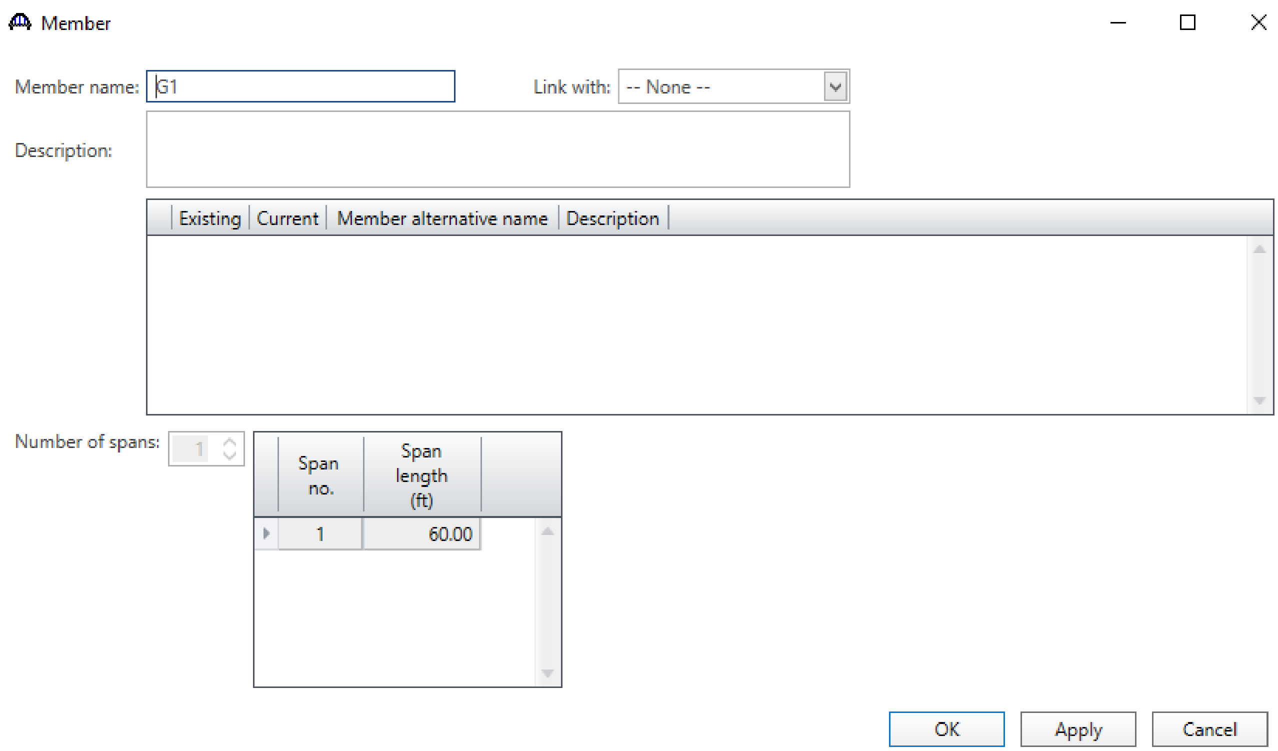
Now define the vertical shear reinforcement by double-clicking on **Vertical** (under **Shear Reinforcement Definitions** in the tree). Define the reinforcement as shown below.



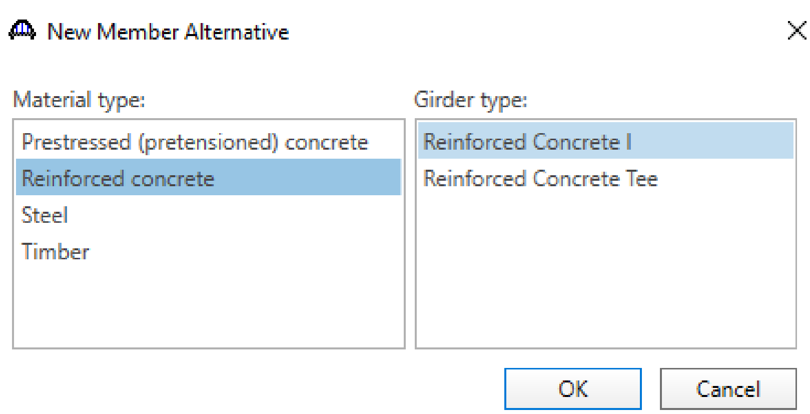
Click **OK** to save to memory and close the window.

Member Descriptions

The Member window shows the data that was generated when the structure definition was created. No changes are required at this time. The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this member (as shown below).



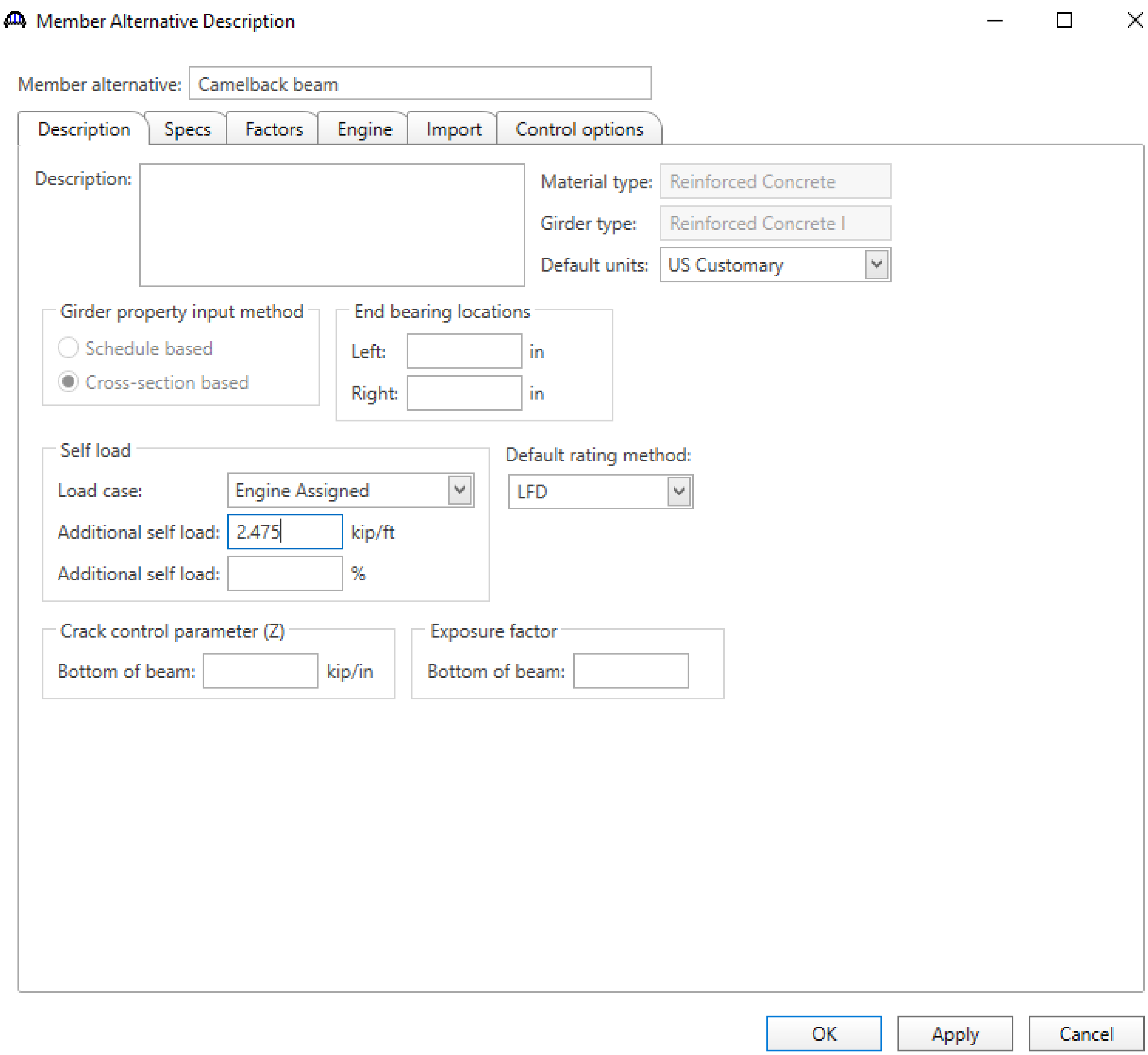
Double-click **MEMBER ALTERNATIVES** in the tree to create a new alternative. The New Member Alternative dialog shown below will open. Select **Reinforced Concrete** for the Material Type and **Reinforced Concrete I** for the Girder Type.



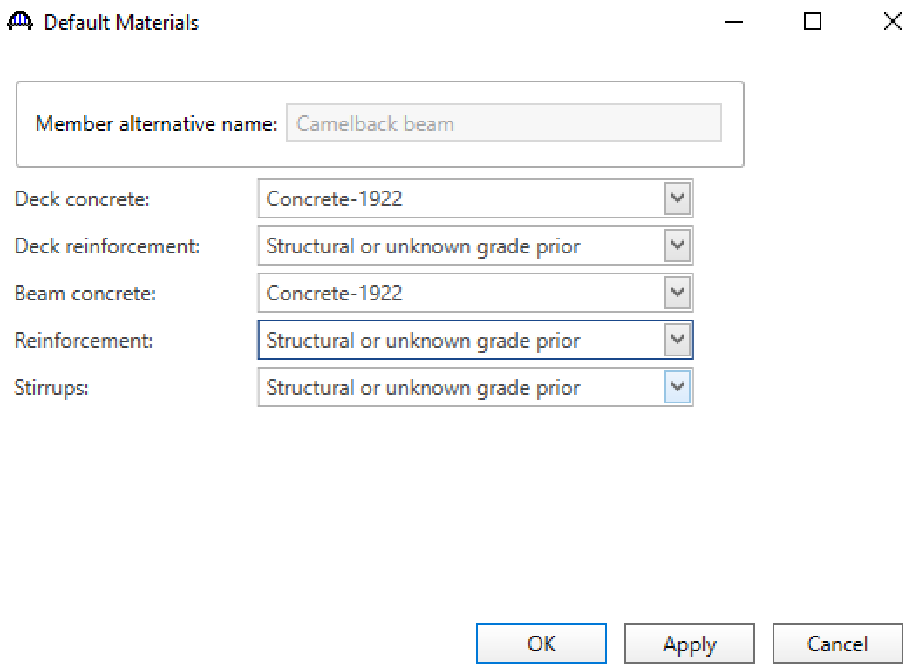
Click **OK** to close the dialog and create a new member alternative.

The Member Alternative Description window will open. Enter the appropriate data as shown below. Note: BR 6.4.1 will not automatically calculate and include the self-weight of the deck. Therefore, you must estimate the weight of the deck and apply it to the beam as an additional self-load. In this example, the deck is 1.5 feet thick and spans 22 feet between beams. Therefore, the additional self-load can be approximated as 11 ft*1.5 ft*0.150 k/ft^3 = 2.475 k/ft, which is entered below.

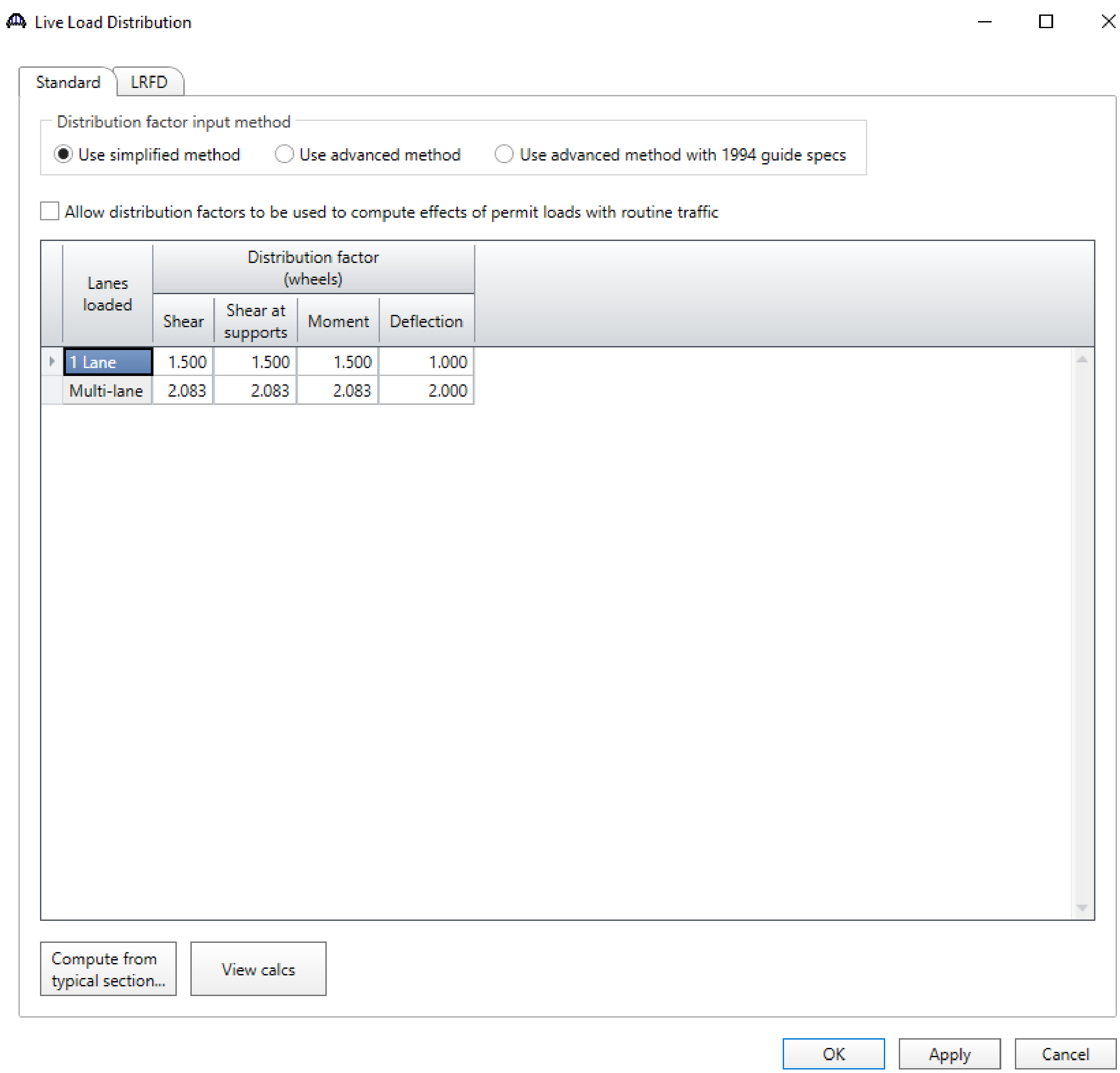
By entering the deck weight at this location you are assuming that the deck and slabs were cast as a single unit while supported by false work. If this condition does not appear to be true for your particular bridge you should instead add the deck weight as an additional uniform load under the **Member Loads** tab.



Expand **Member Alternatives** and **camelback beam (E)(C)** portions of the tree. The default materials for the member alternative must be defined. Enter data as shown in the figure below.



Open the **Live Load Distribution** window from the tree beneath **camelback beam**.

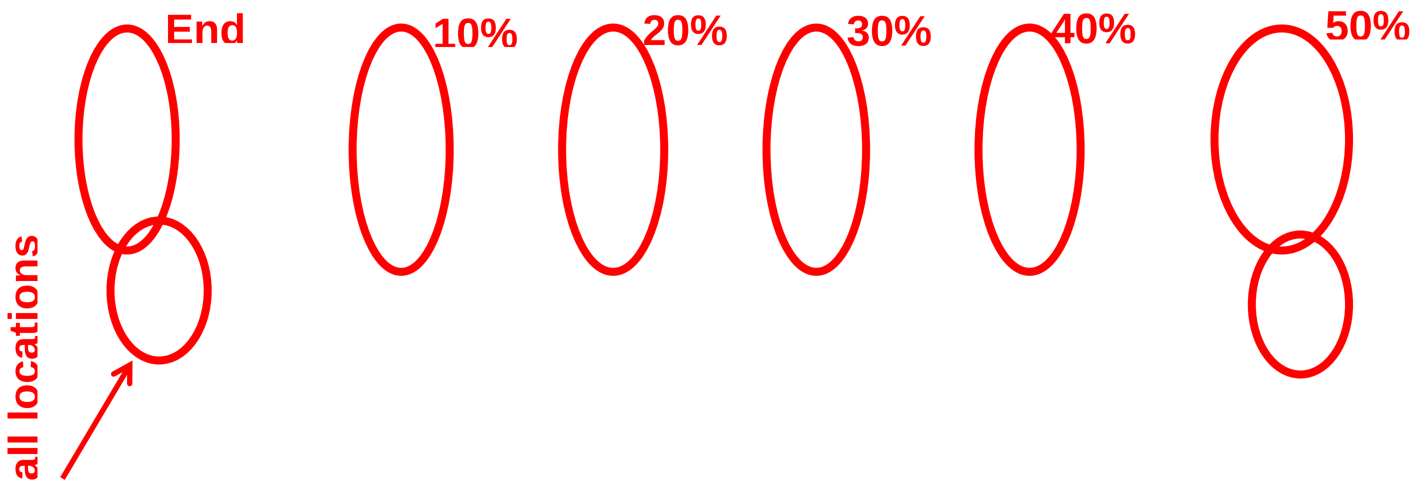


If we try to use the **Compute from Typical Section** button on the Live Load Distribution **Standard tab** to populate the LFD live load distribution factors for this member alternative, we will receive a message that BR cannot calculate the distribution factors because beam shapes are not assigned to adjacent member alternatives.

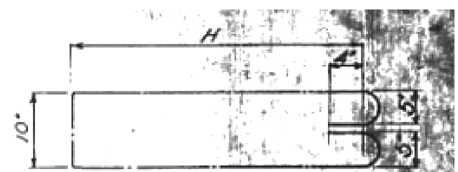
You must revisit this window after the member alternative has been created for the other side of the bridge. Then the **Compute from Typical Section** button will compute the distribution factors for you.

Cross Sections

The camelback shape will be modeled as a series of cross sections located at discrete points. Cross sections should be determined for 10th points along the length of the bridge. An elevation of half the bridge and half sections for the end and center of the bridge are shown below along with a rebar schedule for interpretation of the reinforcing steel identified in the half sections. The cross section can be modeled as an I-beam. Use the elevation to determine the flange and web heights and the half section to determine the flange and web width and the rebar placement. If the section contains square reinforcing bars substitute those with the largest modern rebar size that produces an equal or lesser cross sectional area. In this example; No. 11 rebar (1.56 in^2) was used to represent 1.25-in square rebar (1.56-in^2). Additional rebar could be added to bring the total cross sectional area of steel in the model to what is found in the bridge provided no deterioration has occurred. Pay careful attention to any changes in rebar placement at the different cross sections. Steel reinforcing plans and elevations along with bending diagrams have been shown to provide the necessary information to ensure proper rebar locating at each section.



Elevation showing dimensions of the top flange/web at various cross sections



GU, to GU24 Bars 7/8"				
Mark	No.	H	Length	Weight
GU.	4	8'-7"	20'-0"	164
" 2	4	8'-4"	19'-6"	159
" 3	4	8'-2"	19'-2"	157
" 4	4	7'-11"	18'-8"	153
" 5	4	7'-8"	18'-2"	149
" 6	4	7'-6"	17'-10"	146
" 7	4	7'-3"	17'-4"	142
" 8	4	7'-1"	17'-0"	139
" 9	4	6'-10"	16'-6"	135
" 10	4	6'-7"	16'-0"	131
" 11	4	6'-5"	15'-8"	128
" 12	4	6'-3"	15'-4"	125
" 13	4	6'-3"	15'-4"	125
" 14	4	6'-5"	15'-8"	128
" 15	4	6'-6"	15'-10"	129
" 16	4	6'-8"	16'-2"	132
" 17	4	6'-10"	16'-6"	135
" 18	4	7'-0"	16'-10	138
" 19	4	7'-3"	17'-4"	142
" 20	4	7'-6"	17'-10"	146
" 21	4	7'-8"	18'-2"	149
" 22	4	7'-10"	18'-6"	151
" 23	4	8'-1"	19'-0"	155
" 24	4	8'-2"	19'-2"	157
Total				3415#

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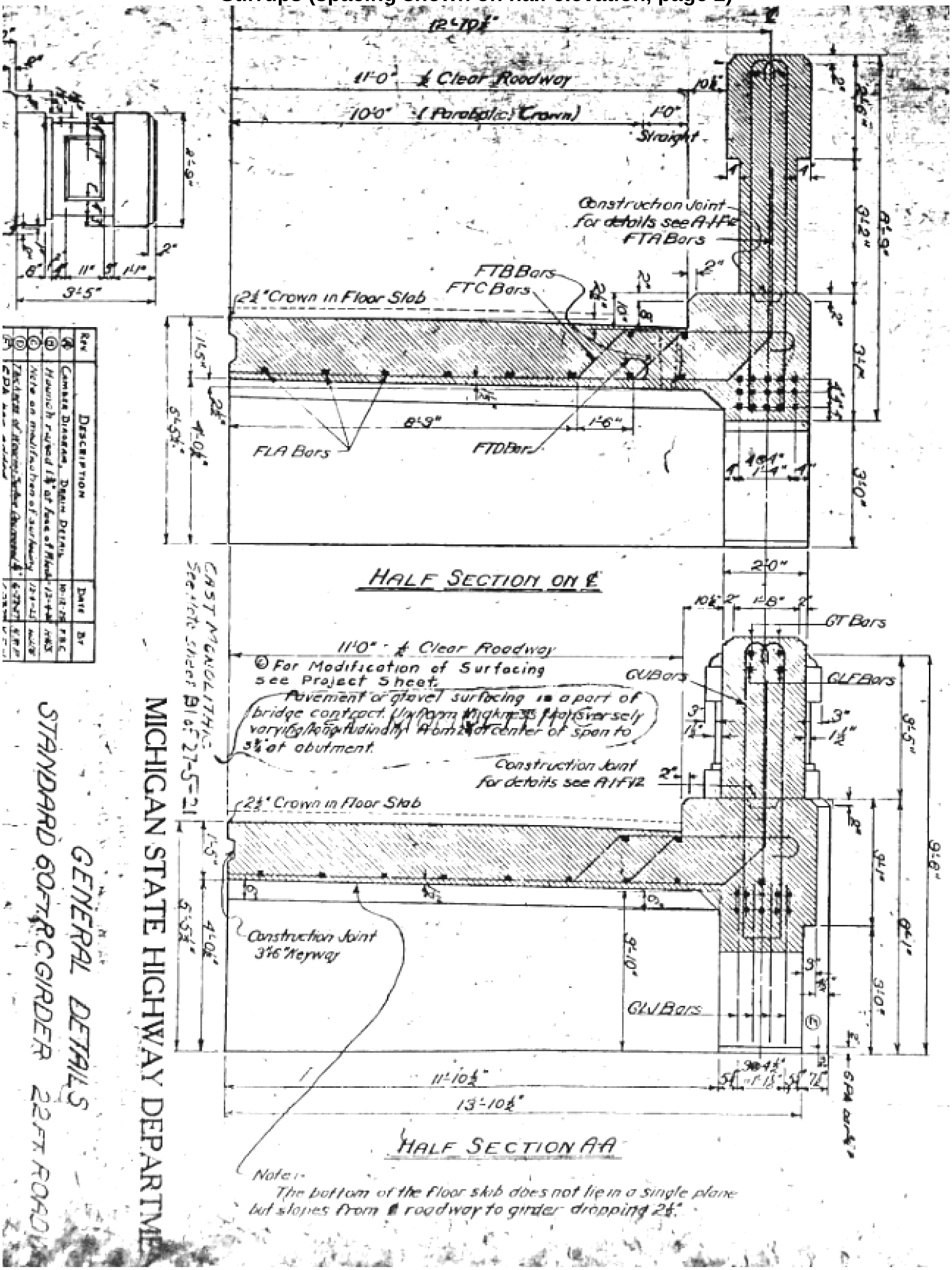
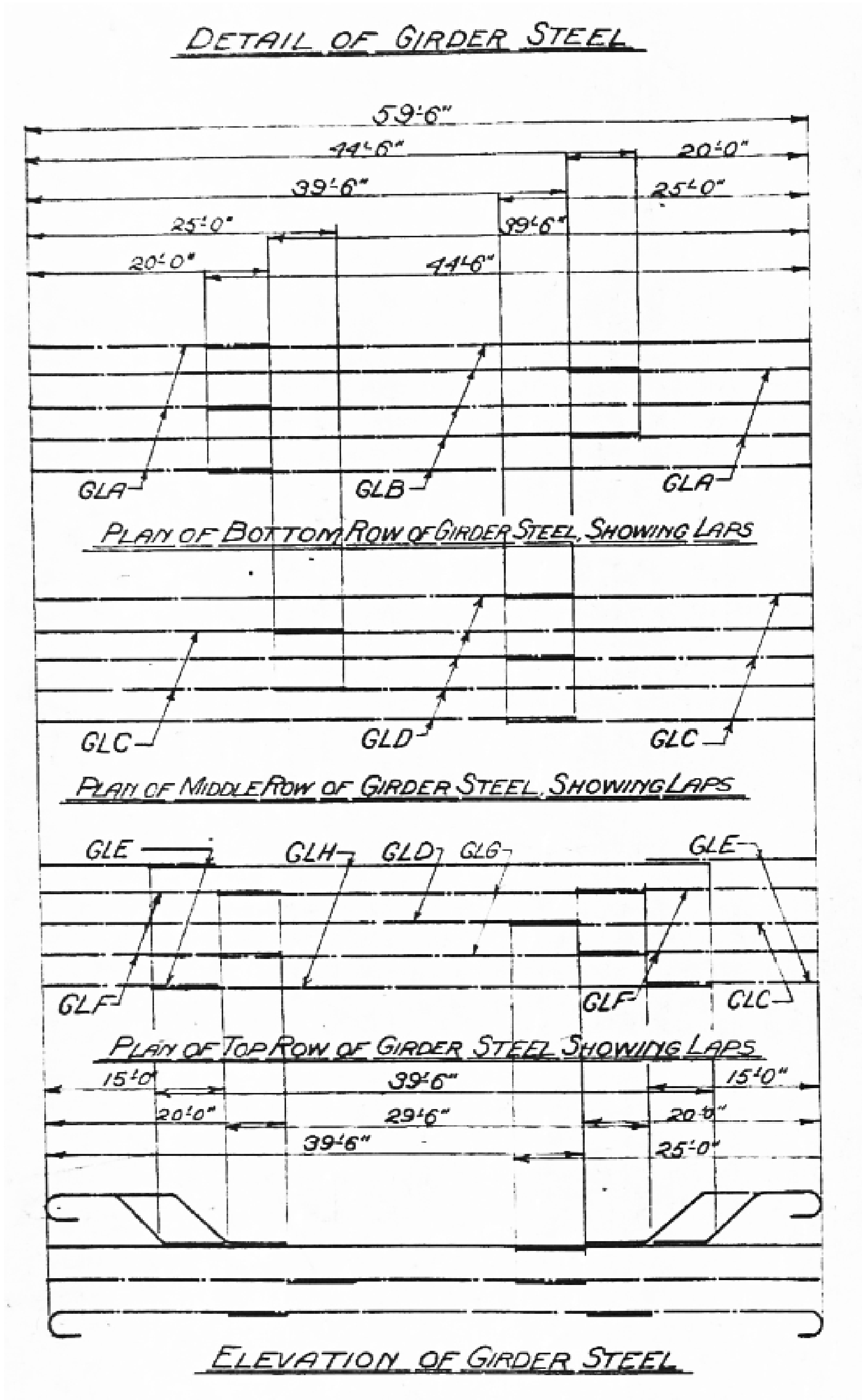
Stirrups (spacing shown on half elevation, page 2)



Cross-Sections at End and Mid-Span

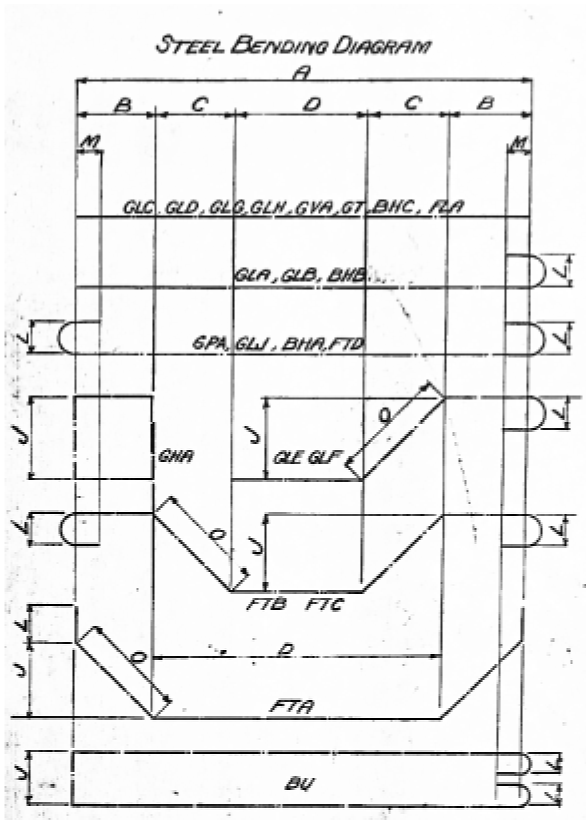


Longitudinal Steel Placement

Note: From the elevation we see that the rebar in the third row from the bottom changes depth over the length of the bridge. The two outer bars (GLE) are located higher in the section and then drop down, followed by the two inner bars (GLF). The center bar (GLC/CLD) remains at the same location over the length. This has been reflected in the cross sections modeled in BR (details on the next page).

BILL OF STEEL BARS

LOCATION	MARK	A	B	C	D	L"	J	M	O	No	Size	Kind	Length	Weight
GIRDER	GLA	20'0"				7½"		5"		10	1¼"	Def	21'5"	1138
	GLB	44'2"				7½		5"		10	1¼"	"	45'7"	2422
	GLC	25'0"								12	1¼"	"	25'0"	1594
	GLD	39'6"								12	1¼"	"	39'6"	2518
	GLE		4'10"	4'10"	5'0"	7½"	4'10"	5"	6'10"	8	1¼"	"	18'1"	768
	GLF		9'10"	4'10"	5'0"	7½"	4'10"	5"	6'10"	8	1¼"	"	23'1"	981
	GLG	29'6"								4	1¼"	"	29'6"	627
	GLH	39'6"								4	1¼"	"	39'6"	839
	GLJ	12'9"				7½"		5"		76	1¼"	"	15'7"	1324
	GT	32'0"								8	⅞"	"	32'0"	218
	GU	See Table of GU Bars										"		3415
	GHA		1'4"				1'7½"			32	½"	"	6'11"	188
	GVA	9'0"								16	1"	"	9'0"	490

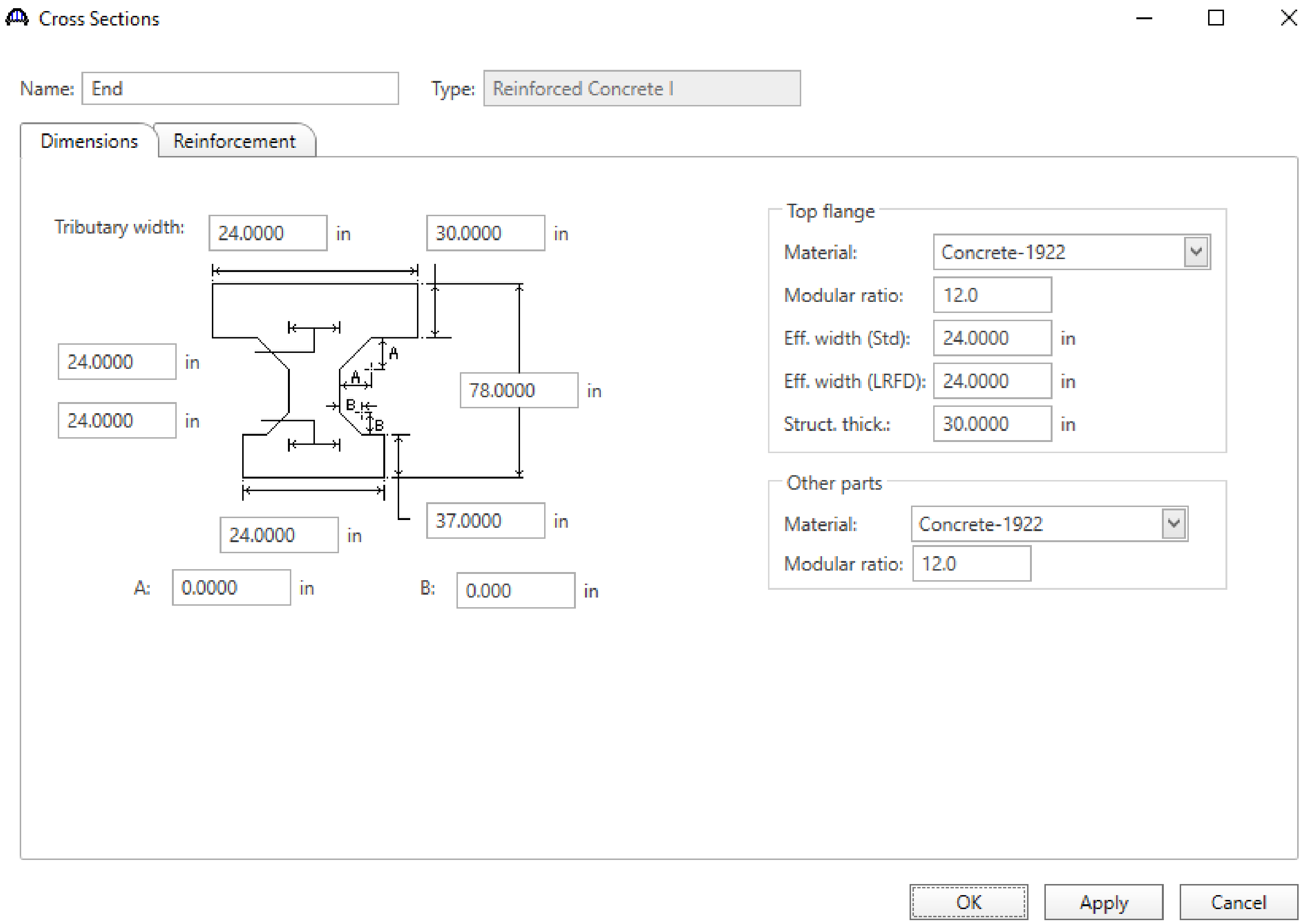


Description and Bending Details of Longitudinal Girder Reinforcing Steel

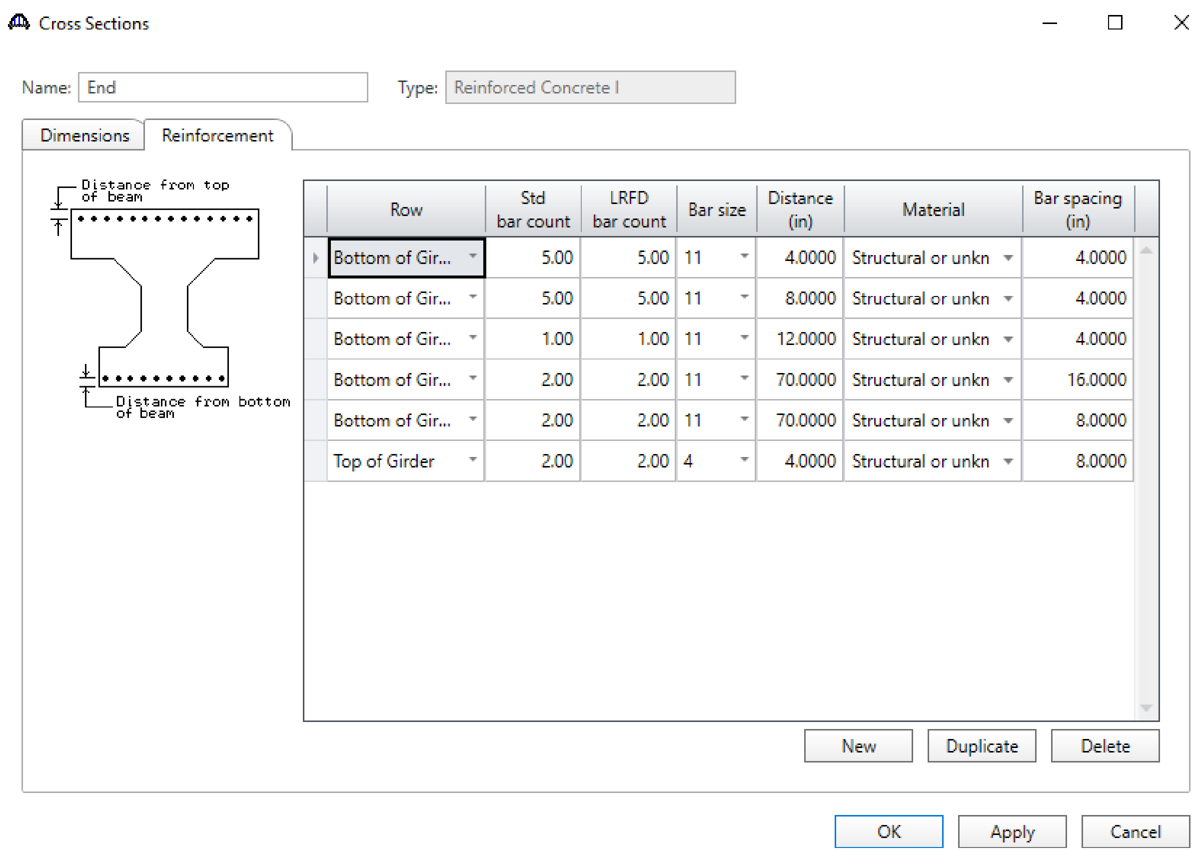
Cross Section Locations:

End - GLE and GLF both up 4'-10" from the 3rd row (70" from bottom of beam)
10% - GLE @ 3'-8" from the 3rd row (56" from bottom), GLF @ 4'-10" from 3rd row (70" from bottom)
20% - GLE @ 3rd row (12" from bottom), GLF @ 2'-8" from 3rd row (44" from bottom)
30% - GLE and GLF @ 3rd row (12 inches from bottom of beam)

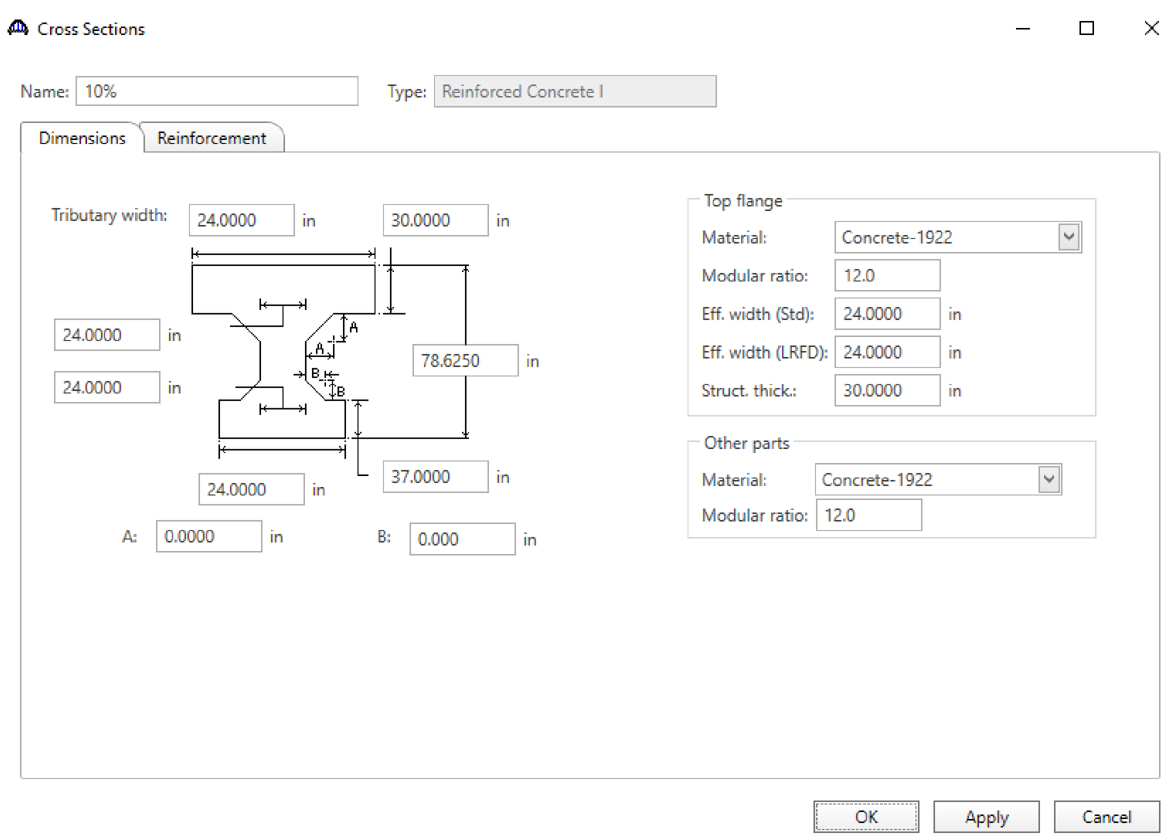
Next describe the beam by double-clicking on **Cross Sections** in the tree. The Cross Sections windows with the cross sections identified from the plans are shown below. Remember to enter rebar locations as appropriate for the cross section, keeping in mind that these may change over the length of the bridge. In the following cross sections, the #4 rebar at the top of the section was assumed based on scale from the plans.

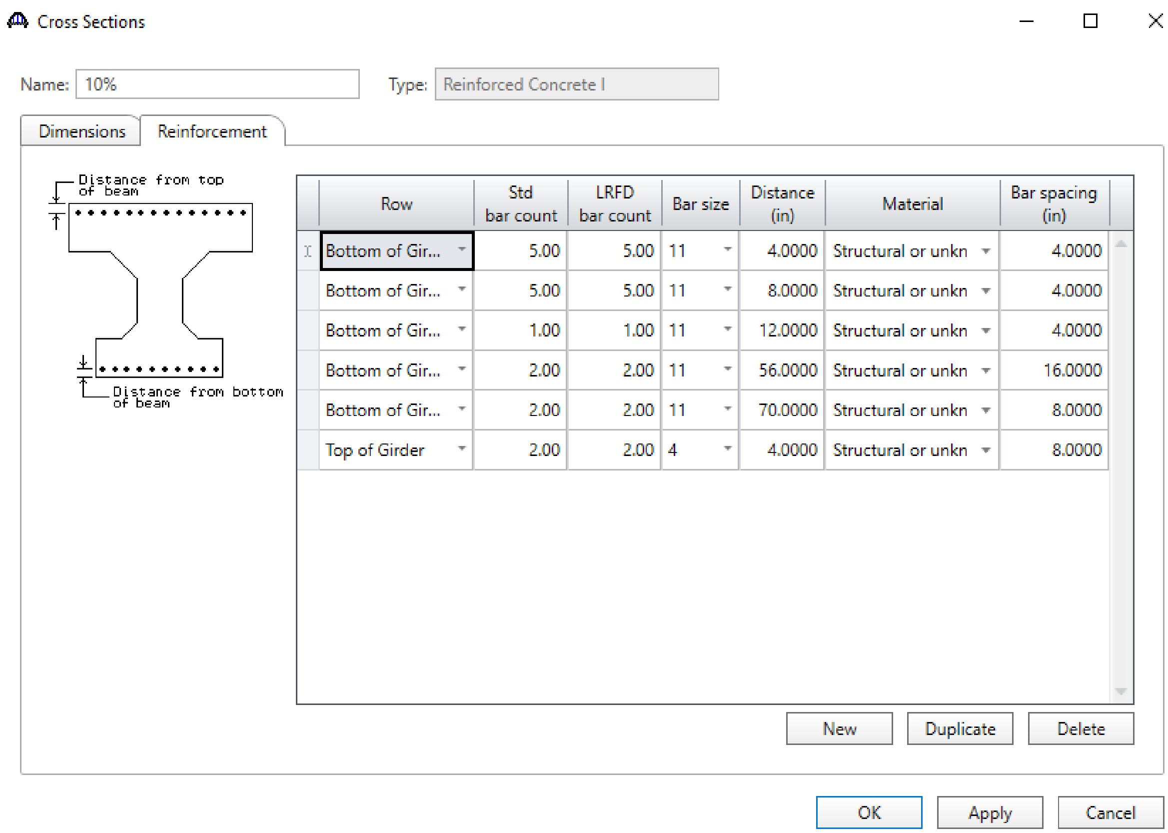


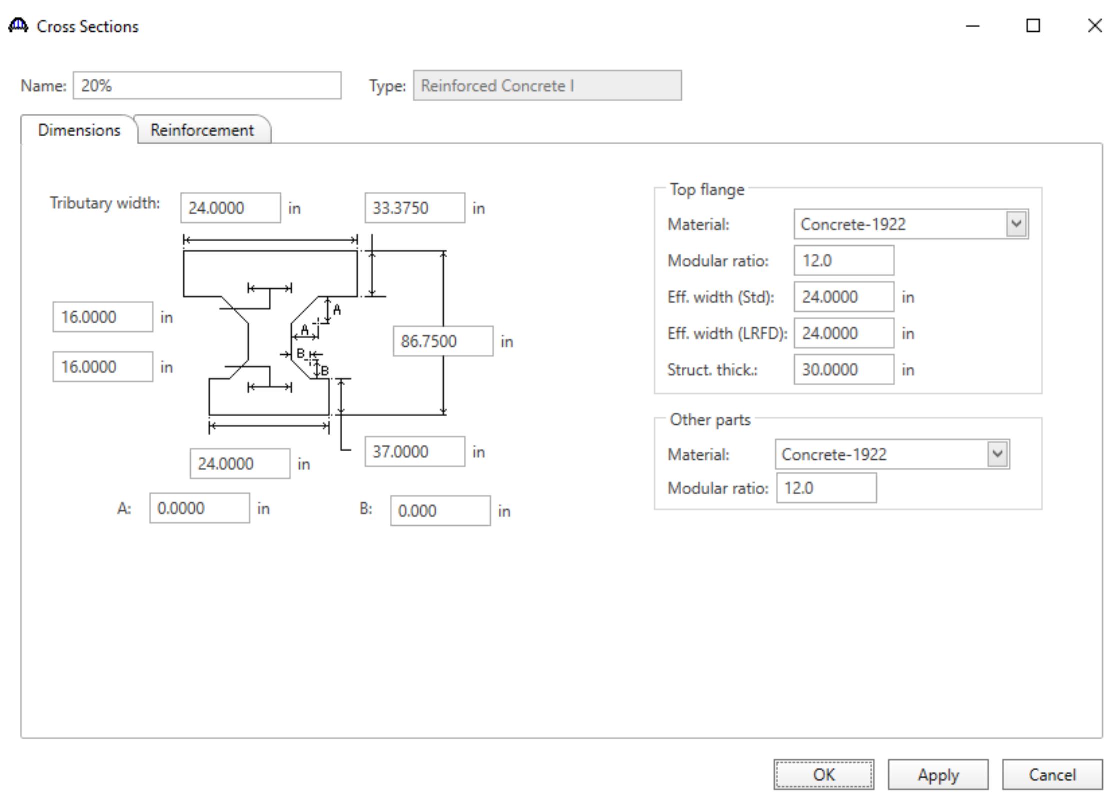
Cross Sections
Name: End
Type: Reinforced Concrete I
Dimensions
Reinforcement
Tributary width: 24.0000 in
30.0000 in
24.0000 in
24.0000 in
78.0000 in
24.0000 in
37.0000 in
A: 0.0000 in
B: 0.000 in
Top flange
Material: Concrete-1922
Modular ratio: 12.0
Eff. width (Std): 24.0000 in
Eff. width (LRFD): 24.0000 in
Struct. thick.: 30.0000 in
Other parts
Material: Concrete-1922
Modular ratio: 12.0
OK
Apply
Cancel

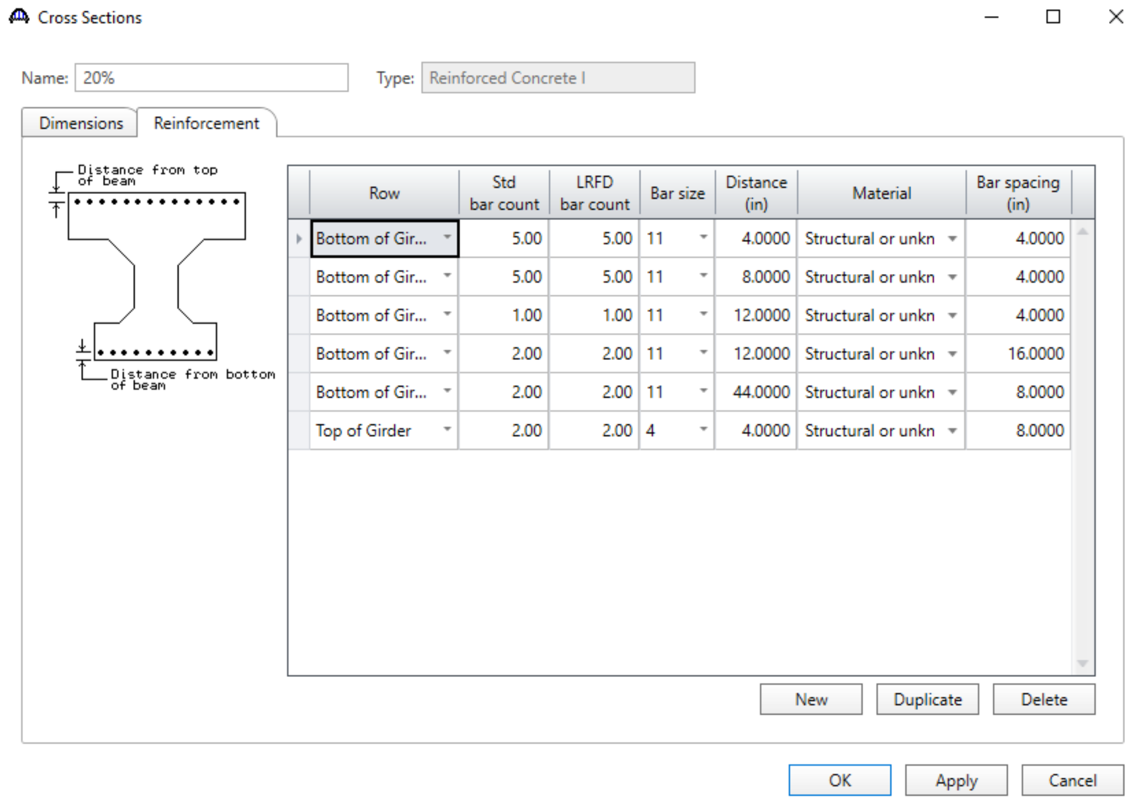


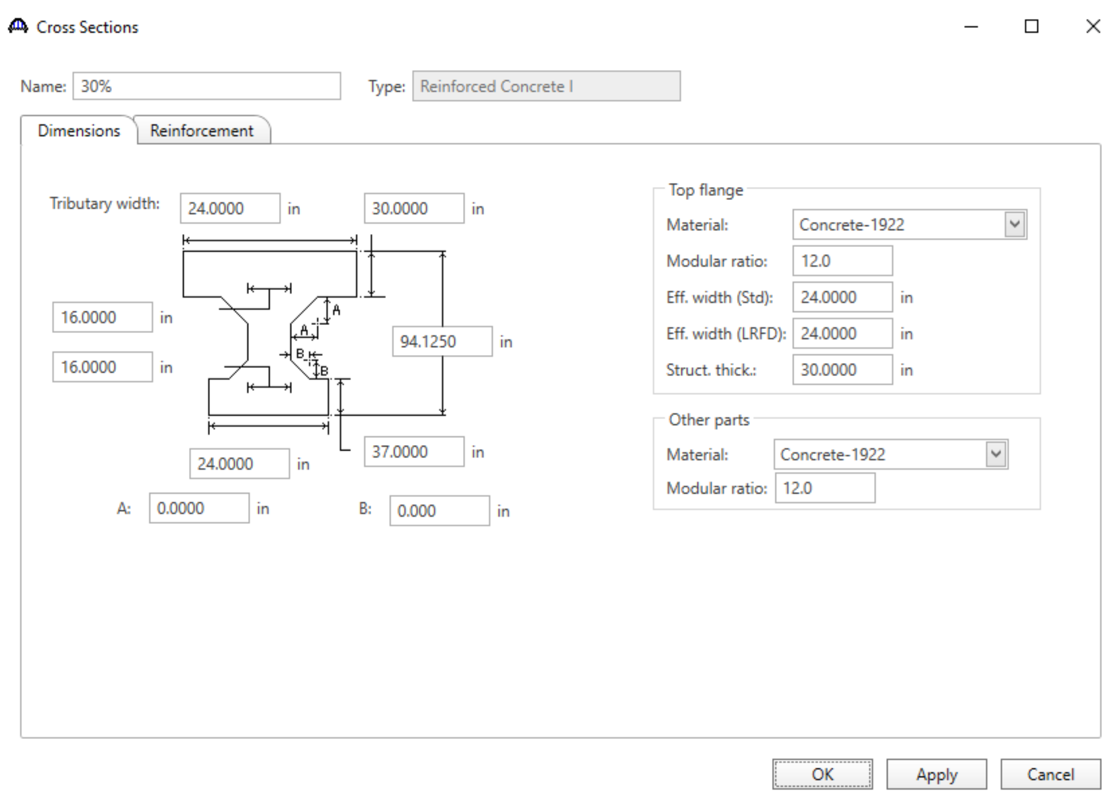
Row	Std bar count	LRFD bar count	Bar size	Distance (in)	Material	Bar spacing (in)
Bottom of Gir...	5.00	5.00	11	4.0000	Structural or unkn	4.0000
Bottom of Gir...	5.00	5.00	11	8.0000	Structural or unkn	4.0000
Bottom of Gir...	1.00	1.00	11	12.0000	Structural or unkn	4.0000
Bottom of Gir...	2.00	2.00	11	70.0000	Structural or unkn	16.0000
Bottom of Gir...	2.00	2.00	11	70.0000	Structural or unkn	8.0000
Top of Girder	2.00	2.00	4	4.0000	Structural or unkn	8.0000

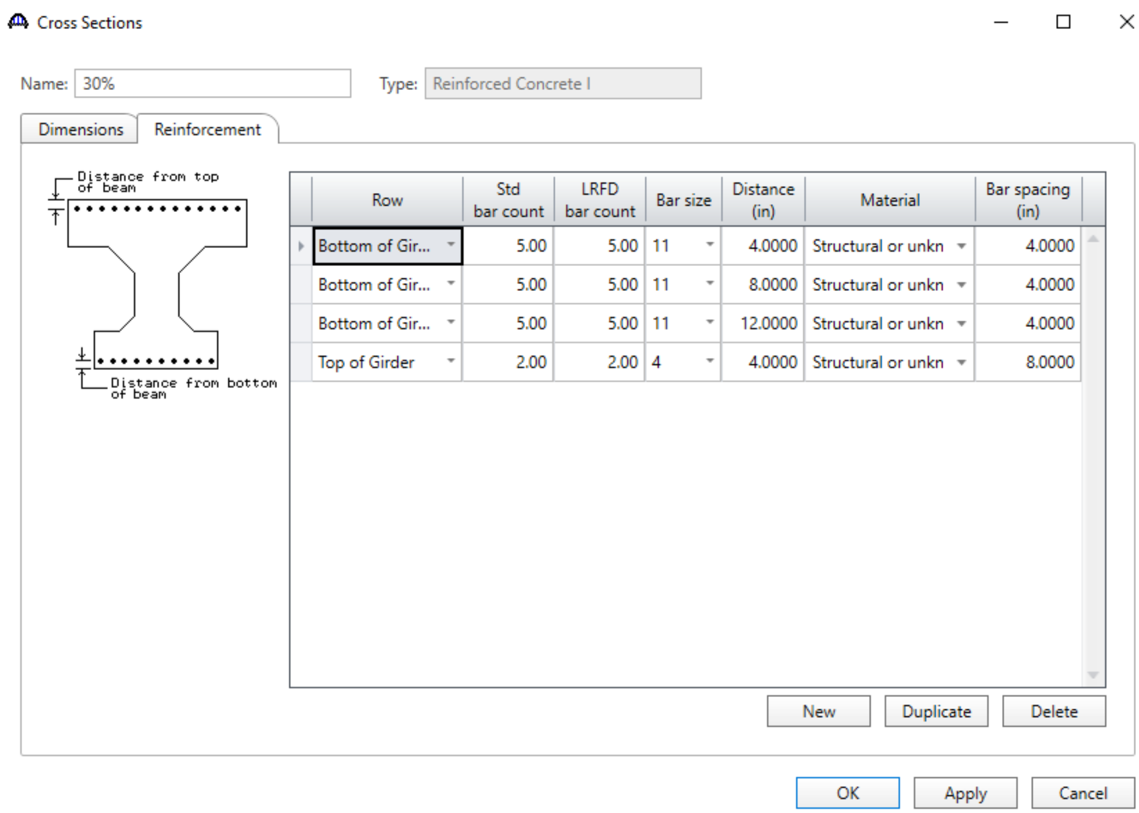


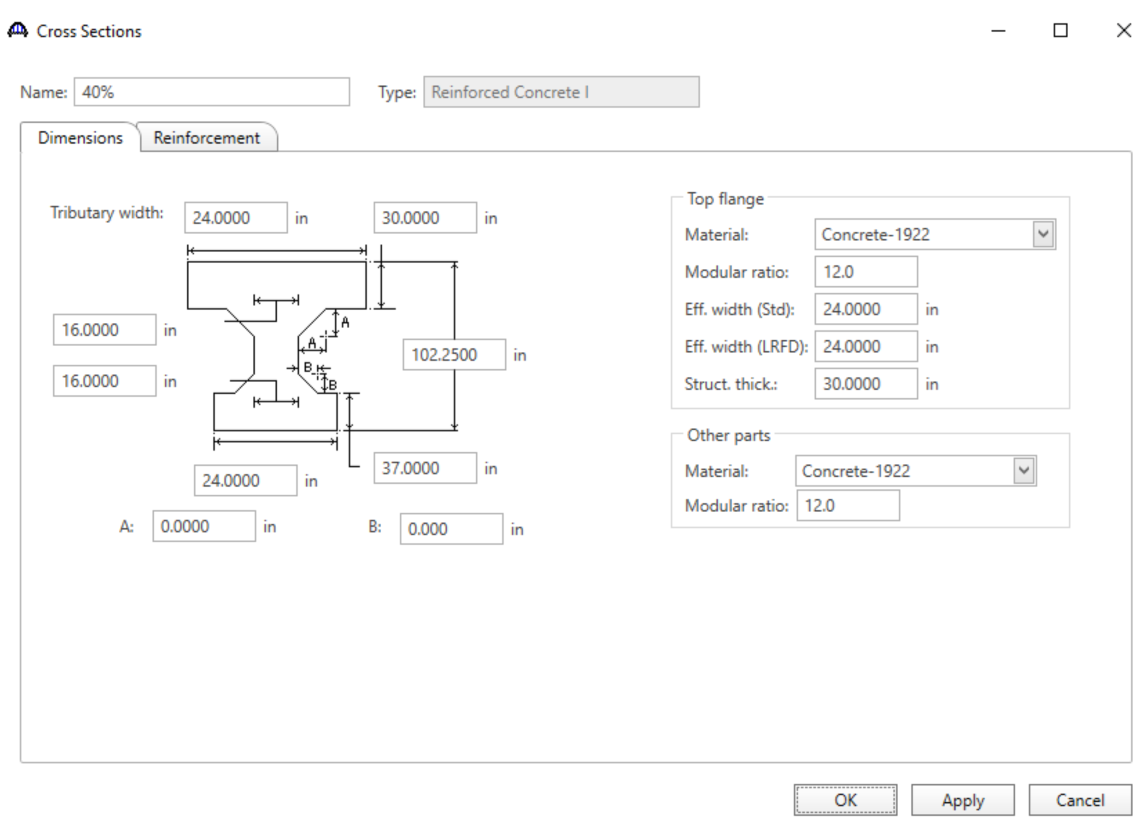

Cross Sections
Name: 10%
Type: Reinforced Concrete I
Dimensions
Reinforcement
Distance from top of beam
Distance from bottom of beam
Row | Std bar count | LRFD bar count | Bar size | Distance (in) | Material | Bar spacing (in)
Bottom of Gir... | 5.00 | 5.00 | 11 | 4.0000 | Structural or unkn | 4.0000
Bottom of Gir... | 5.00 | 5.00 | 11 | 8.0000 | Structural or unkn | 4.0000
Bottom of Gir... | 1.00 | 1.00 | 11 | 12.0000 | Structural or unkn | 4.0000
Bottom of Gir... | 2.00 | 2.00 | 11 | 56.0000 | Structural or unkn | 16.0000
Bottom of Gir... | 2.00 | 2.00 | 11 | 70.0000 | Structural or unkn | 8.0000
Top of Girder | 2.00 | 2.00 | 4 | 4.0000 | Structural or unkn | 8.0000
New
Duplicate
Delete
OK
Apply
Cancel

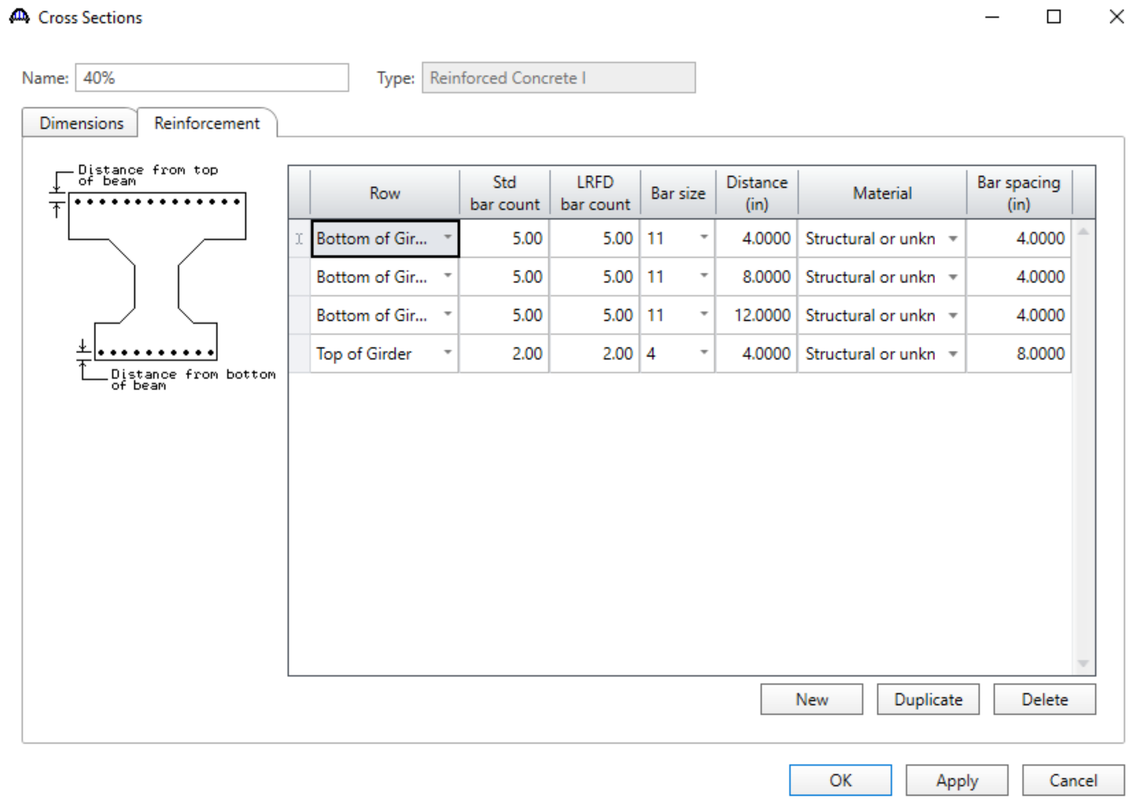

Cross Sections
Name: 20%
Type: Reinforced Concrete I
Dimensions
Reinforcement
Tributary width: 24.0000 in
33.3750 in
16.0000 in
16.0000 in
86.7500 in
24.0000 in
37.0000 in
A: 0.0000 in
B: 0.000 in
Top flange
Material: Concrete-1922
Modular ratio: 12.0
Eff. width (Std): 24.0000 in
Eff. width (LRFD): 24.0000 in
Struct. thick.: 30.0000 in
Other parts
Material: Concrete-1922
Modular ratio: 12.0
OK
Apply
Cancel

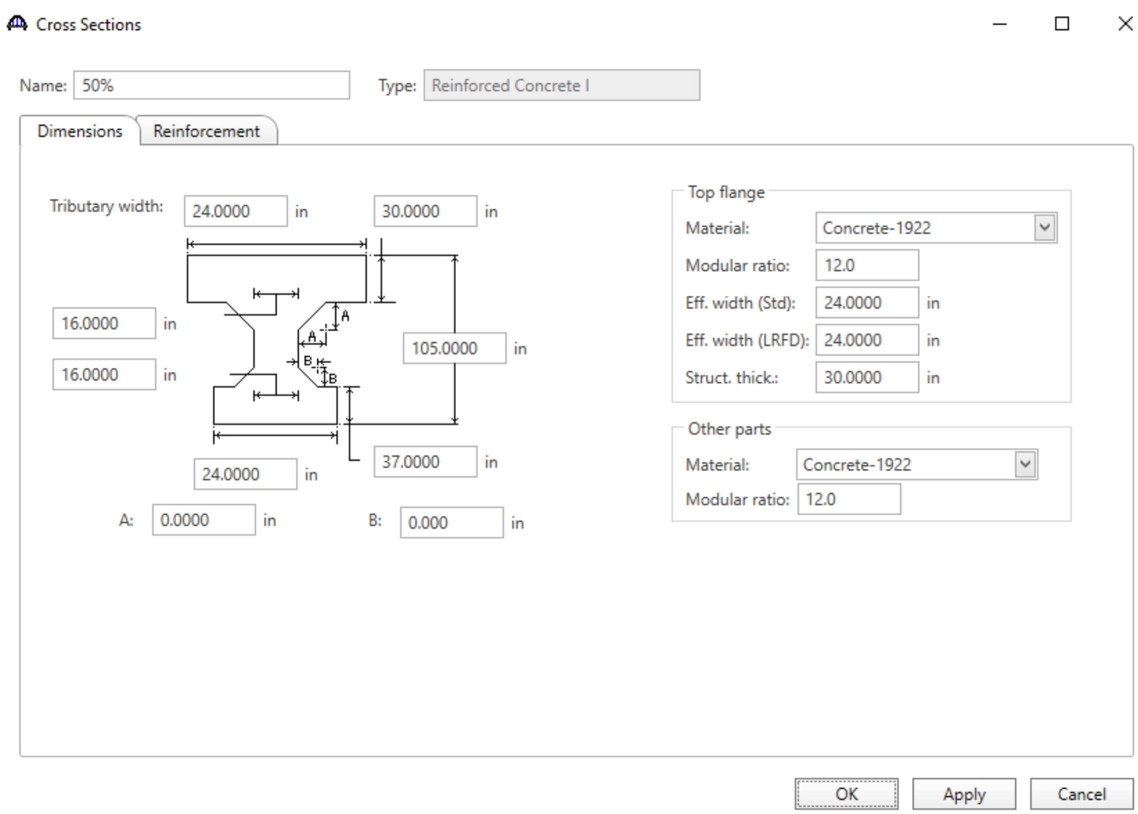

Cross Sections
Name: 20%
Type: Reinforced Concrete I
Dimensions
Reinforcement
Distance from top of beam
Distance from bottom of beam
Row | Std bar count | LRFD bar count | Bar size | Distance (in) | Material | Bar spacing (in)
Bottom of Gir... | 5.00 | 5.00 | 11 | 4.0000 | Structural or unkn | 4.0000
Bottom of Gir... | 5.00 | 5.00 | 11 | 8.0000 | Structural or unkn | 4.0000
Bottom of Gir... | 1.00 | 1.00 | 11 | 12.0000 | Structural or unkn | 4.0000
Bottom of Gir... | 2.00 | 2.00 | 11 | 12.0000 | Structural or unkn | 16.0000
Bottom of Gir... | 2.00 | 2.00 | 11 | 44.0000 | Structural or unkn | 8.0000
Top of Girder | 2.00 | 2.00 | 4 | 4.0000 | Structural or unkn | 8.0000
New
Duplicate
Delete
OK
Apply
Cancel

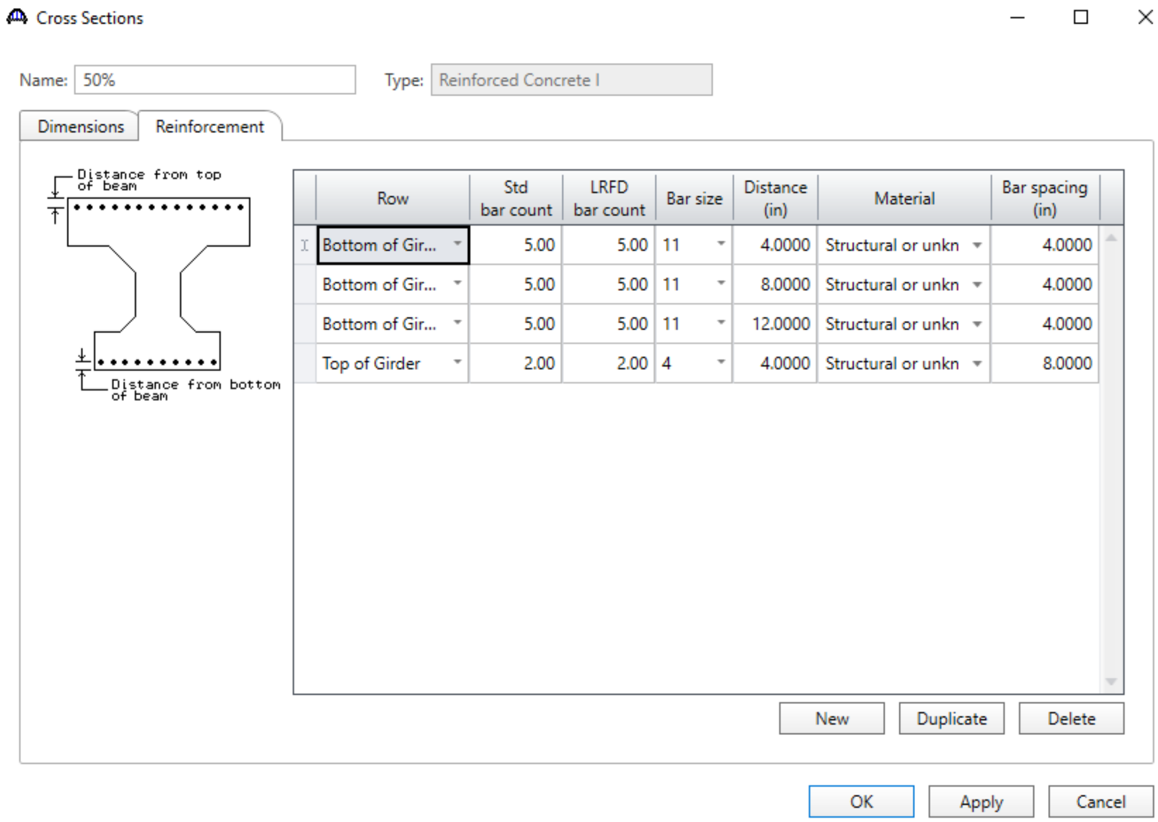

Cross Sections
Name: 30%
Type: Reinforced Concrete I
Dimensions
Reinforcement
Tributary width: 24.0000 in
30.0000 in
16.0000 in
16.0000 in
94.1250 in
24.0000 in
37.0000 in
A: 0.0000 in
B: 0.000 in
Top flange
Material: Concrete-1922
Modular ratio: 12.0
Eff. width (Std): 24.0000 in
Eff. width (LRFD): 24.0000 in
Struct. thick.: 30.0000 in
Other parts
Material: Concrete-1922
Modular ratio: 12.0
OK
Apply
Cancel


Cross Sections
Name: 30%
Type: Reinforced Concrete I
Dimensions
Reinforcement
Distance from top of beam
Distance from bottom of beam
Row
Std bar count
LRFD bar count
Bar size
Distance (in)
Material
Bar spacing (in)
Bottom of Gir... 5.00 5.00 11 4.0000 Structural or unkn 4.0000
Bottom of Gir... 5.00 5.00 11 8.0000 Structural or unkn 4.0000
Bottom of Gir... 5.00 5.00 11 12.0000 Structural or unkn 4.0000
Top of Girder 2.00 2.00 4 4.0000 Structural or unkn 8.0000
New
Duplicate
Delete
OK
Apply
Cancel

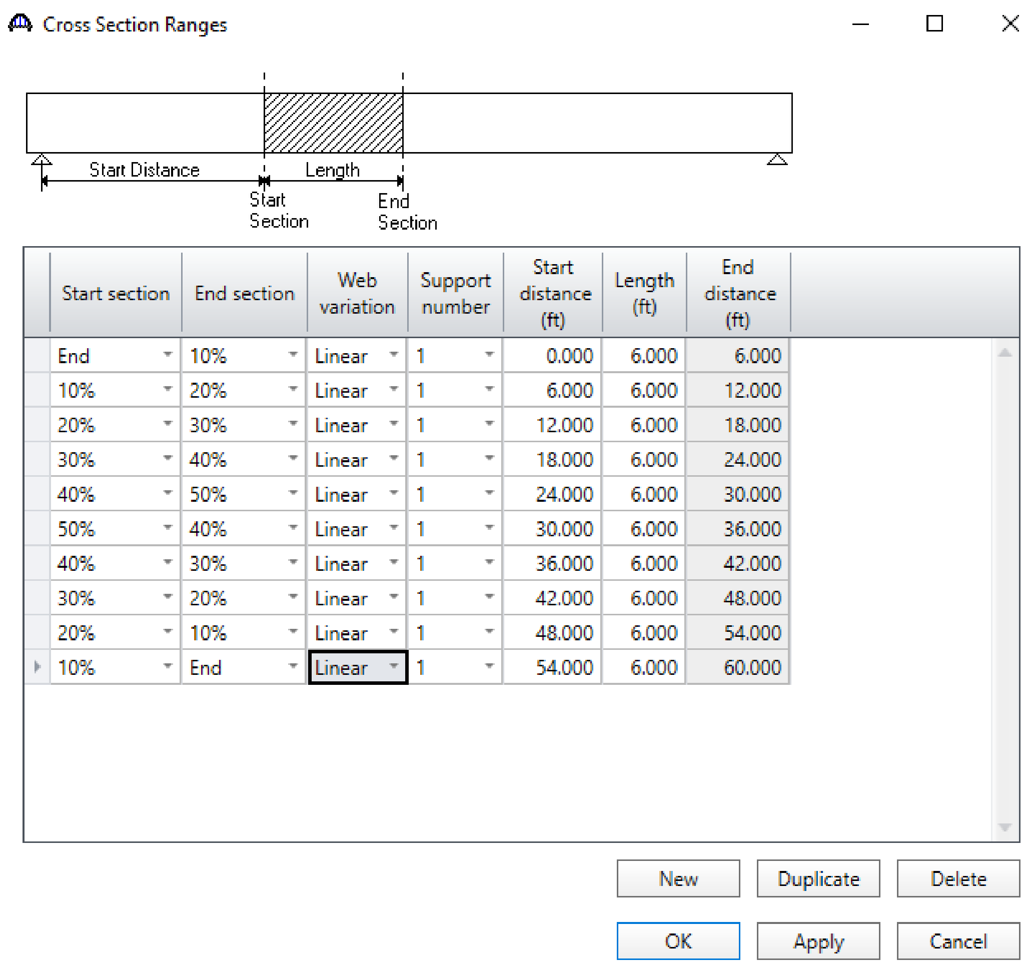

Cross Sections
Name: 40%
Type: Reinforced Concrete I
Dimensions
Reinforcement
Tributary width: 24.0000 in
30.0000 in
16.0000 in
16.0000 in
102.2500 in
24.0000 in
37.0000 in
A: 0.0000 in
B: 0.000 in
Top flange
Material: Concrete-1922
Modular ratio: 12.0
Eff. width (Std): 24.0000 in
Eff. width (LRFD): 24.0000 in
Struct. thick.: 30.0000 in
Other parts
Material: Concrete-1922
Modular ratio: 12.0
OK
Apply
Cancel


Cross Sections
Name: 40%
Type: Reinforced Concrete I
Dimensions
Reinforcement
Distance from top of beam
Distance from bottom of beam
Row | Std bar count | LRFD bar count | Bar size | Distance (in) | Material | Bar spacing (in)
Bottom of Gir... | 5.00 | 5.00 | 11 | 4.0000 | Structural or unkn | 4.0000
Bottom of Gir... | 5.00 | 5.00 | 11 | 8.0000 | Structural or unkn | 4.0000
Bottom of Gir... | 5.00 | 5.00 | 11 | 12.0000 | Structural or unkn | 4.0000
Top of Girder | 2.00 | 2.00 | 4 | 4.0000 | Structural or unkn | 8.0000
New
Duplicate
Delete
OK
Apply
Cancel


Cross Sections
Name: 50%
Type: Reinforced Concrete I
Dimensions
Reinforcement
Tributary width: 24.0000 in
30.0000 in
16.0000 in
16.0000 in
105.0000 in
24.0000 in
37.0000 in
A: 0.0000 in
B: 0.000 in
Top flange
Material: Concrete-1922
Modular ratio: 12.0
Eff. width (Std): 24.0000 in
Eff. width (LRFD): 24.0000 in
Struct. thick.: 30.0000 in
Other parts
Material: Concrete-1922
Modular ratio: 12.0
OK
Apply
Cancel


Cross Sections
Name: 50%
Type: Reinforced Concrete I
Dimensions
Reinforcement
Distance from top of beam
Distance from bottom of beam
Row
Std bar count
LRFD bar count
Bar size
Distance (in)
Material
Bar spacing (in)
Bottom of Gir... 5.00 5.00 11 4.0000 Structural or unkn 4.0000
Bottom of Gir... 5.00 5.00 11 8.0000 Structural or unkn 4.0000
Bottom of Gir... 5.00 5.00 11 12.0000 Structural or unkn 4.0000
Top of Girder 2.00 2.00 4 4.0000 Structural or unkn 8.0000
New
Duplicate
Delete
OK
Apply
Cancel

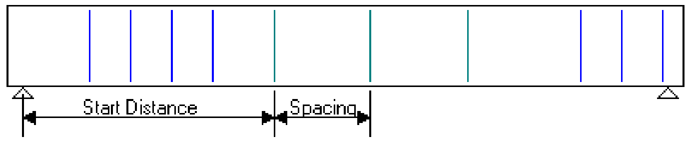
Now that the cross sections have been entered we must assign them to the appropriate locations along the beam. Open the **Cross Section Ranges** window. The cross sections were identified for the end of the beam and then every 6 feet along the bridge length (10th points). Starting with the end of the beam select the start and end cross sections and then corresponding length between these sections. This model can be further refined with more cross section descriptions and shorter length between cross sections.



Start section	End section	Web variation	Support number	Start distance (ft)	Length (ft)	End distance (ft)
End	10%	Linear	1	0.000	6.000	6.000
10%	20%	Linear	1	6.000	6.000	12.000
20%	30%	Linear	1	12.000	6.000	18.000
30%	40%	Linear	1	18.000	6.000	24.000
40%	50%	Linear	1	24.000	6.000	30.000
50%	40%	Linear	1	30.000	6.000	36.000
40%	30%	Linear	1	36.000	6.000	42.000
30%	20%	Linear	1	42.000	6.000	48.000
20%	10%	Linear	1	48.000	6.000	54.000
10%	End	Linear	1	54.000	6.000	60.000

Open the **Shear Reinforcement Ranges** window and define the location and spacing of shear reinforcement as determined from the plans.

RC Shear Reinforcement Ranges

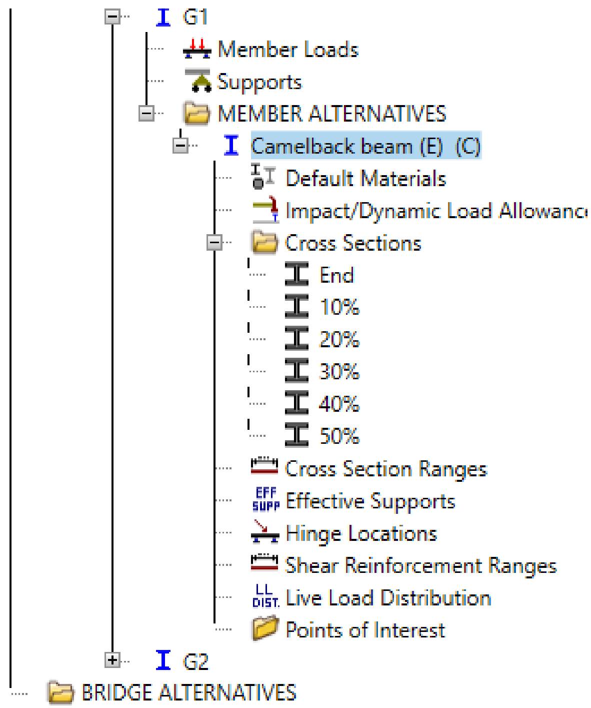


Name	Support number	Start distance (ft)	Number of spaces	Spacing (in)	Length (ft)	End distance (ft)
shear stirrups	1	2.33	1	0.0000	0.00	2.33
shear stirrups	1	2.33	6	8.0000	4.00	6.33
shear stirrups	1	6.33	5	10.0000	4.17	10.50
shear stirrups	1	10.49	6	12.0000	6.00	16.49
shear stirrups	1	16.49	3	36.0000	9.00	25.49
shear stirrups	1	20.99	3	30.0000	7.50	28.49
shear stirrups	1	28.49	1	36.0000	3.00	31.49
shear stirrups	1	31.49	3	30.0000	7.50	38.99
shear stirrups	1	38.99	3	18.0000	4.50	43.49
shear stirrups	1	43.49	6	12.0000	6.00	49.49
shear stirrups	1	49.49	5	10.0000	4.17	53.66
shear stirrups	1	53.66	6	8.0000	4.00	57.66

Stirrup wizard... New Duplicate Delete

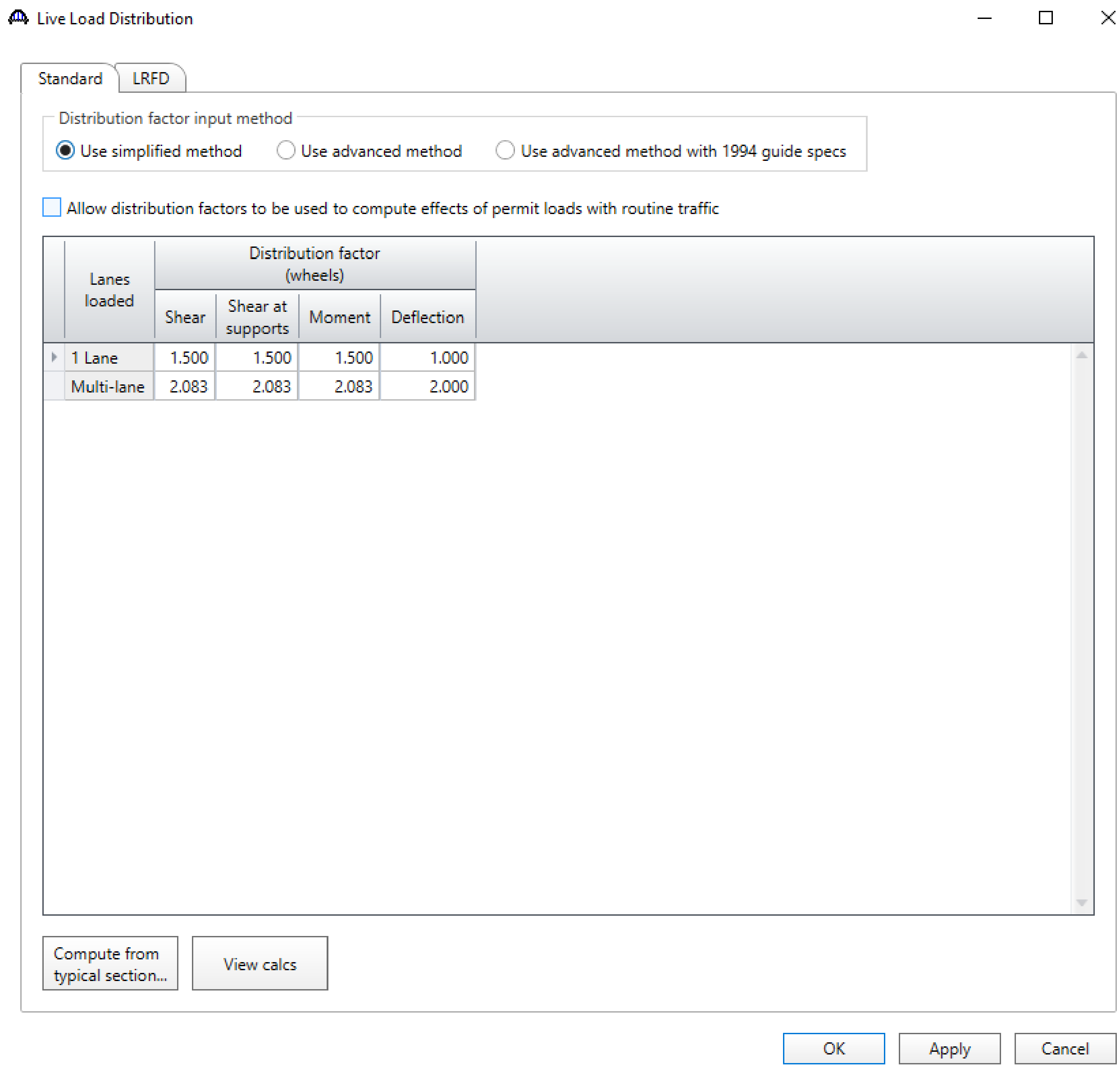
OK Apply Cancel

Next, copy G1 to G2. Do this by right clicking on ***camelback beam (E)(C)***, select copy, then right click on **MEMBER ALTERNATIVES** under G2 and select paste.



Now that all beams within the span have been defined we are able to go back to windows within the bridge tree that will require updating.

The **Live Load Distribution** window for both G1 and G2 needs to be updated, select **Compute from Typical Section**.

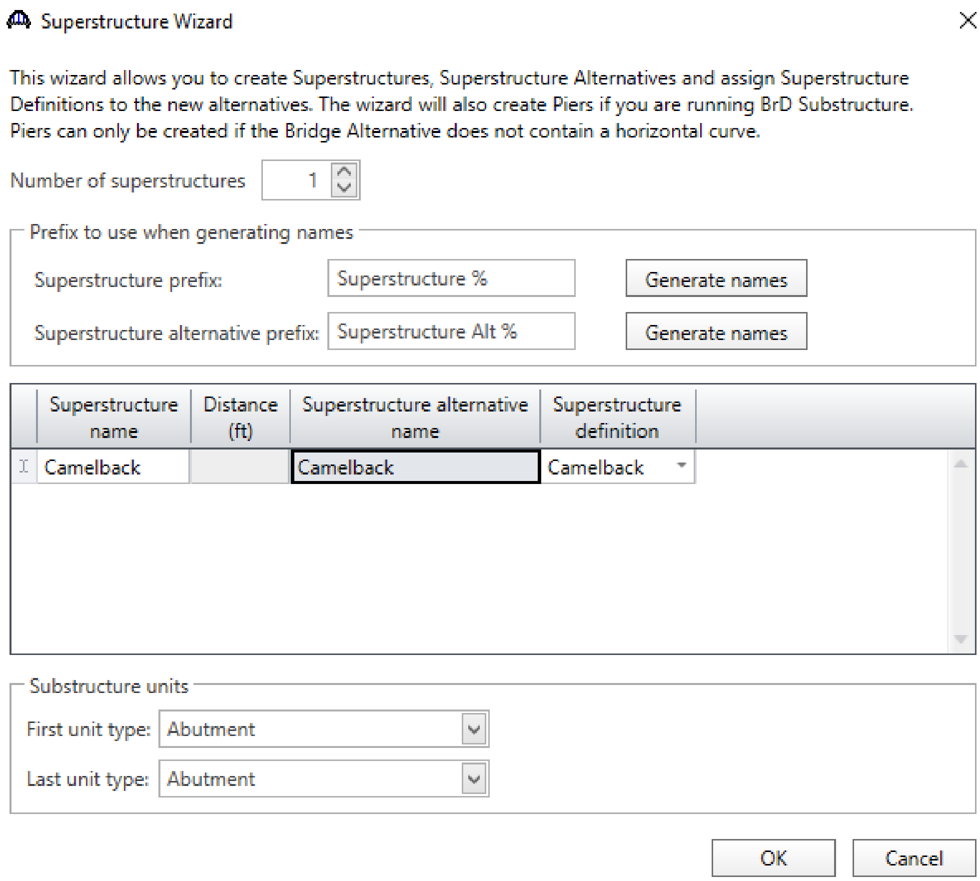


Bridge Alternatives

Now that the superstructure definitions are modeled, Bridge Alternatives must be created. This makes it possible to rate the entire bridge at one time and also perform batch processes in the Bridge Explorer workspace, which is important for permitting issues.

For load rating, there will typically be only one Bridge Alternative. Another Bridge Alternative could be created for a proposed bridge or rehabilitation project, but only one bridge alternative should be existing/current at a time. Each superstructure that was entered above now needs its own definition in the Bridge Alternative. Select the superstructure wizard. Enter the number of superstructures. Enter the superstructure and superstructure alternative names and then select the superstructure definition that you want to link to each alternative.

The bridge alternative portion of the tree may be created manually by double-clicking on each branch and assigning the necessary bridge components to each branch as shown above (**Superstructure Wizard…** button may be selected to aid in this process). Double-click **BRIDGE ALTERNATIVES** and enter the Alternative Name, then select the **Superstructure Wizard…** button and enter the data shown in the window below.

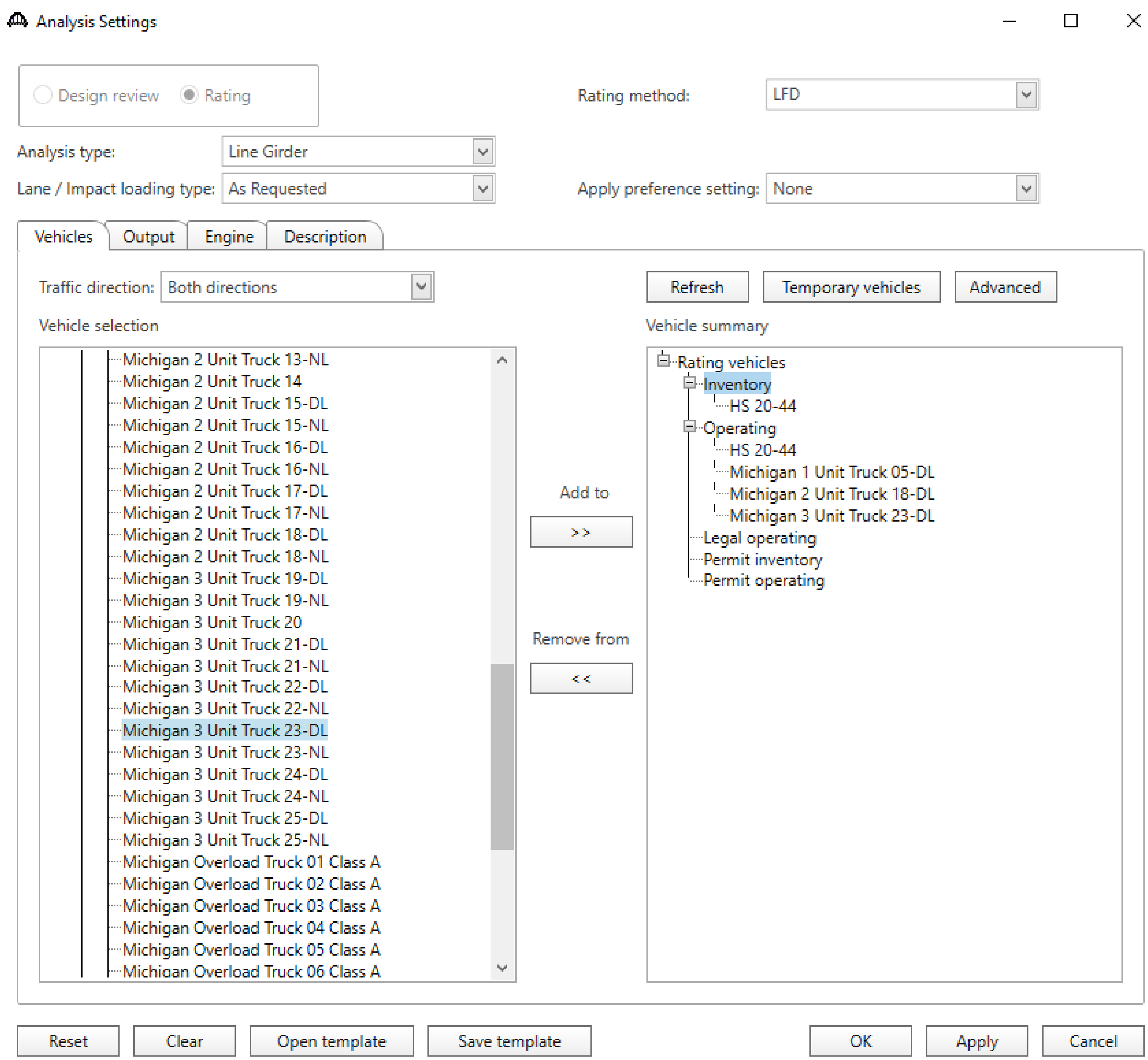


Click **Finish** to close the Superstructure Wizard and **OK** to save the Bridge Alternative data to memory and close the window.

Analysis

Vehicle Selection

From the *Bridge* menu, select *Analysis Settings* and load the following vehicles into the rating column:

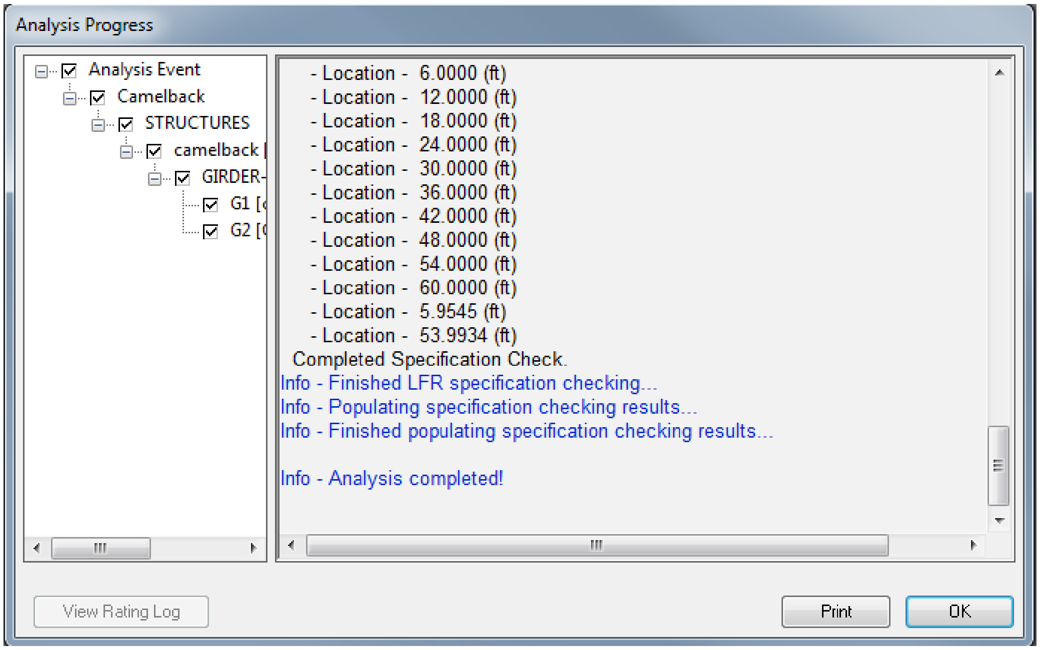


Select **OK**

Note: MDOT trucks 5-DL, 18-DL and 23-DL are used in this analysis as they are the commonly controlling 1-unit, 2-unit and 3-unit trucks, respectively. The load rating engineer should evaluate the list of legal vehicles to determine whether others may control and include them in the analysis if necessary. In addition, if posting is required, all legal loads must be analyzed to determine the lowest tonnage for each vehicle category.

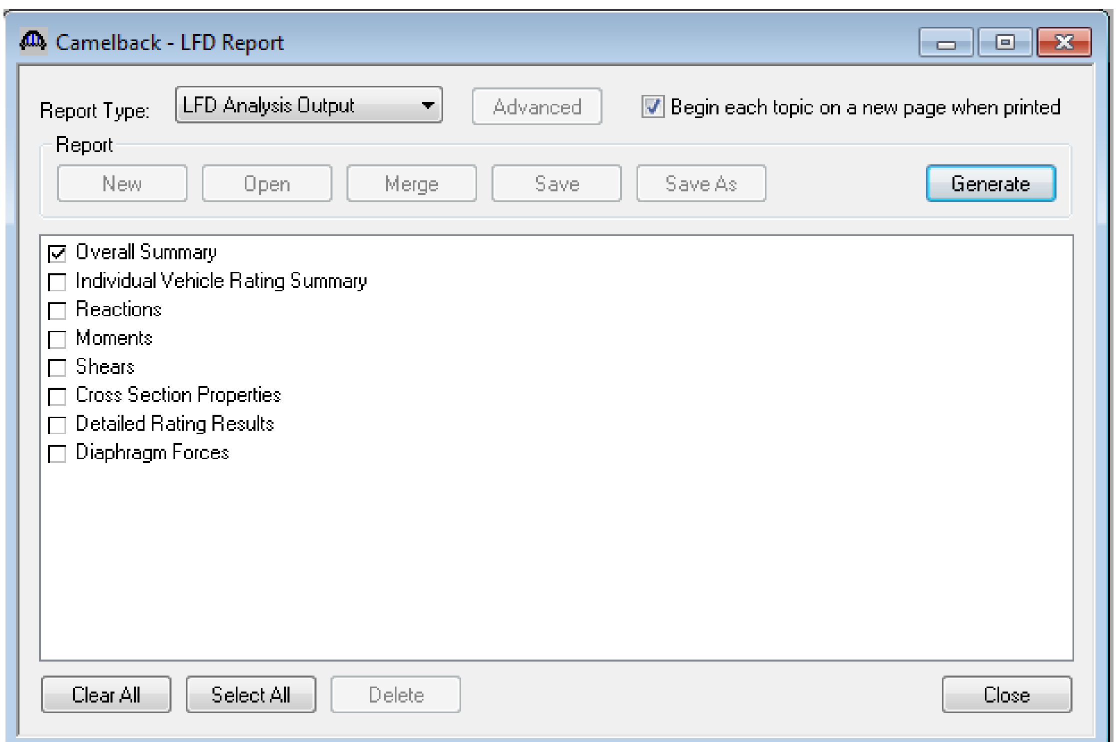
Analysis

Go to *Bridge/Analyze*. You will be informed regarding progress and completion of the analysis.



Reporting

Results of the analysis may be viewed using the *Report Tool* located within the *Bridge* menu.



Select **Generate**.

Bridge Name: Sample of a Camelback Bridge Load Rating
NBI Structure ID: camelback1
Bridge ID: camelback1

Analyzed By: BrR
Analyze Date: Monday, September 13, 2016 12:58:35
Analysis Engine: AASHTO LFR Engine Version 7.0.3001
Analysis Preference Setting: None

Report By: brr
Report Date: Monday, September 13, 2021 13:00:09

Structure Definition Name: camelback
Member Name: G1
Member Alternative Name: camelback beam

Load Factor Rating Summary

Live Load		Rating Factor	Controls	Capacity (Ton)	Span	Location (ft)	Percent	Impact	Lane
HS 20-44	Inventory	0.836	Design Shear - Concrete	30.11	1	60.00	100.0	As Requested	As Requested
HS 20-44	Operating	1.397	Design Shear - Concrete	50.28	1	60.00	100.0	As Requested	As Requested
Michigan 1 Unit Truck 05-DL	Operating	1.334	Design Shear - Concrete	56.04	1	60.00	100.0	As Requested	As Requested
Michigan 2 Unit Truck 18-DL	Operating	0.901	Design Shear - Concrete	69.38	1	60.00	100.0	As Requested	As Requested
Michigan 3 Unit Truck 23-DL	Operating	0.962	Design Shear - Concrete	74.10	1	60.00	100.0	As Requested	As Requested

Note:
"N/A" indicates not applicable
"**" indicates not available

Bridge Name: Sample of a Camelback Bridge Load Rating
NBI Structure ID: camelback1
Bridge ID: camelback1

Analyzed By: BrR
Analyze Date: Monday, September 13, 2016 12:58:35
Analysis Engine: AASHTO LFR Engine Version 7.0.3001
Analysis Preference Setting: None

Report By: brr
Report Date: Monday, September 13, 2021 13:00:09

Structure Definition Name: camelback
Member Name: G2
Member Alternative Name: Copy of camelback beam

Load Factor Rating Summary

Live Load		Rating Factor	Controls	Capacity (Ton)	Span	Location (ft)	Percent	Impact	Lane
HS 20-44	Inventory	0.836	Design Shear - Concrete	30.11	1	60.00	100.0	As Requested	As Requested
HS 20-44	Operating	1.397	Design Shear - Concrete	50.28	1	60.00	100.0	As Requested	As Requested
Michigan 1 Unit Truck 05-DL	Operating	1.334	Design Shear - Concrete	56.04	1	60.00	100.0	As Requested	As Requested
Michigan 2 Unit Truck 18-DL	Operating	0.901	Design Shear - Concrete	69.38	1	60.00	100.0	As Requested	As Requested
Michigan 3 Unit Truck 23-DL	Operating	0.962	Design Shear - Concrete	74.10	1	60.00	100.0	As Requested	As Requested

Note:
"N/A" indicates not applicable
"**" indicates not available