Reinforced Concrete Structure Tutorial

RC4 – Two Span Reinforced Concrete Slab Example

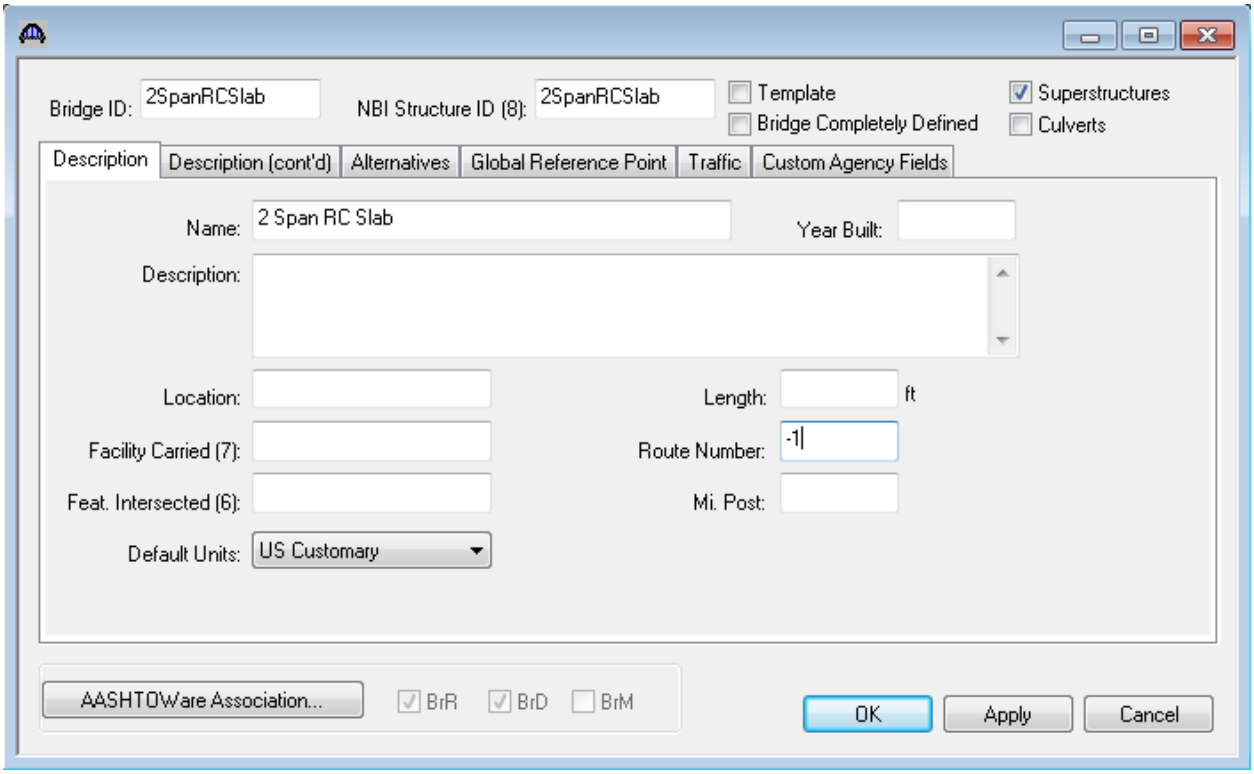
BrR and BrD Training

RC4 – Two Span Reinforced Concrete Slab Example

Topics Covered

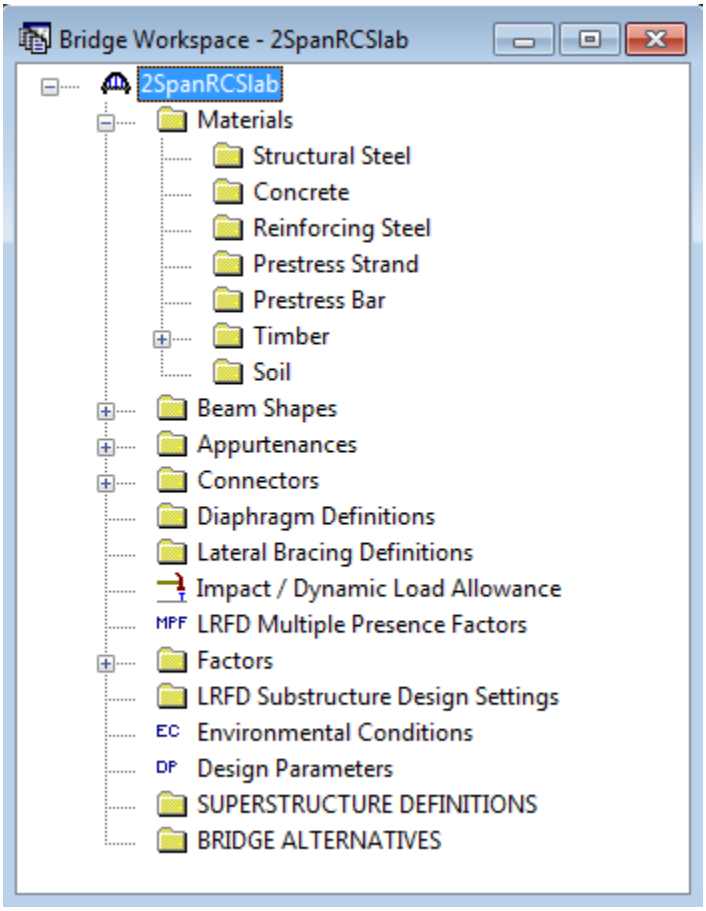
- Reinforced concrete slab input as girderline.
- Cross section based input.
- Slab depth varies parabolically over the pier.

From the Bridge Explorer create a new bridge and enter the following description data:



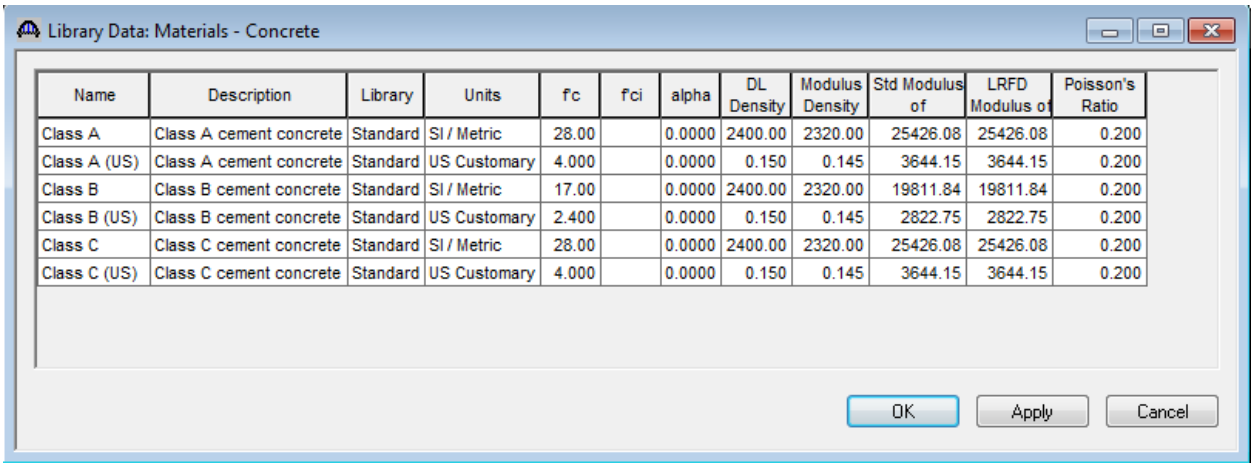
Close the window by clicking Ok. This saves the data to memory and closes the window.

To enter the materials to be used by members of the bridge, click on the ⊞ to expand the tree for Materials. 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).

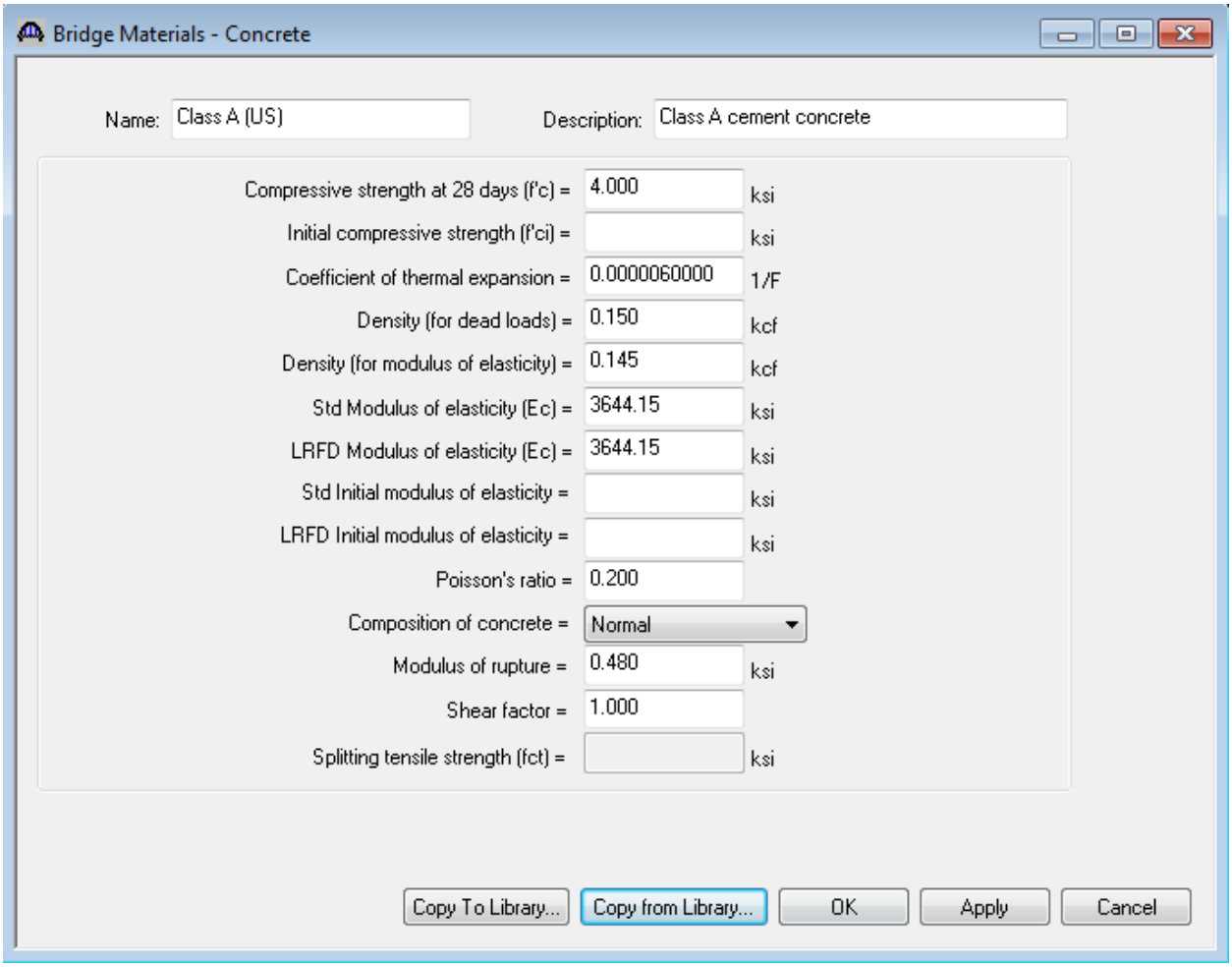
Add the concrete material by selecting from the Concrete Materials Library by clicking the Copy from Library button. The following window opens:



Name	Description	Library	Units	f'c	f'ci	alpha	DL Density	Modulus Density	Std Modulus of	LRFD Modulus of	Poisson's Ratio
Class A	Class A cement concrete	Standard	SI / Metric	28.00		0.0000	2400.00	2320.00	25426.08	25426.08	0.200
Class A (US)	Class A cement concrete	Standard	US Customary	4.000		0.0000	0.150	0.145	3644.15	3644.15	0.200
Class B	Class B cement concrete	Standard	SI / Metric	17.00		0.0000	2400.00	2320.00	19811.84	19811.84	0.200
Class B (US)	Class B cement concrete	Standard	US Customary	2.400		0.0000	0.150	0.145	2822.75	2822.75	0.200
Class C	Class C cement concrete	Standard	SI / Metric	28.00		0.0000	2400.00	2320.00	25426.08	25426.08	0.200
Class C (US)	Class C cement concrete	Standard	US Customary	4.000		0.0000	0.150	0.145	3644.15	3644.15	0.200

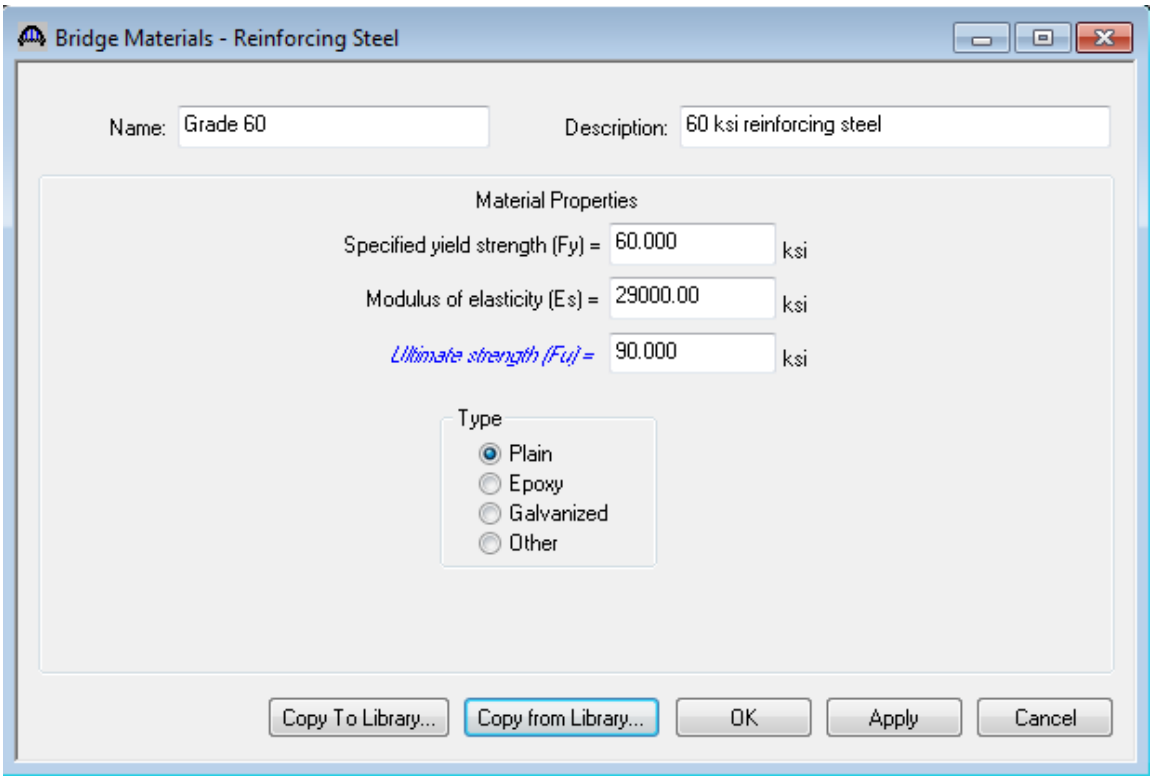
Select the Class A (US) material and click Ok.

The selected material properties are copied to the Bridge Materials – Concrete window as shown below.



Click Ok to save the data to memory and close the window.

Add the following reinforcement steel in the same manner.



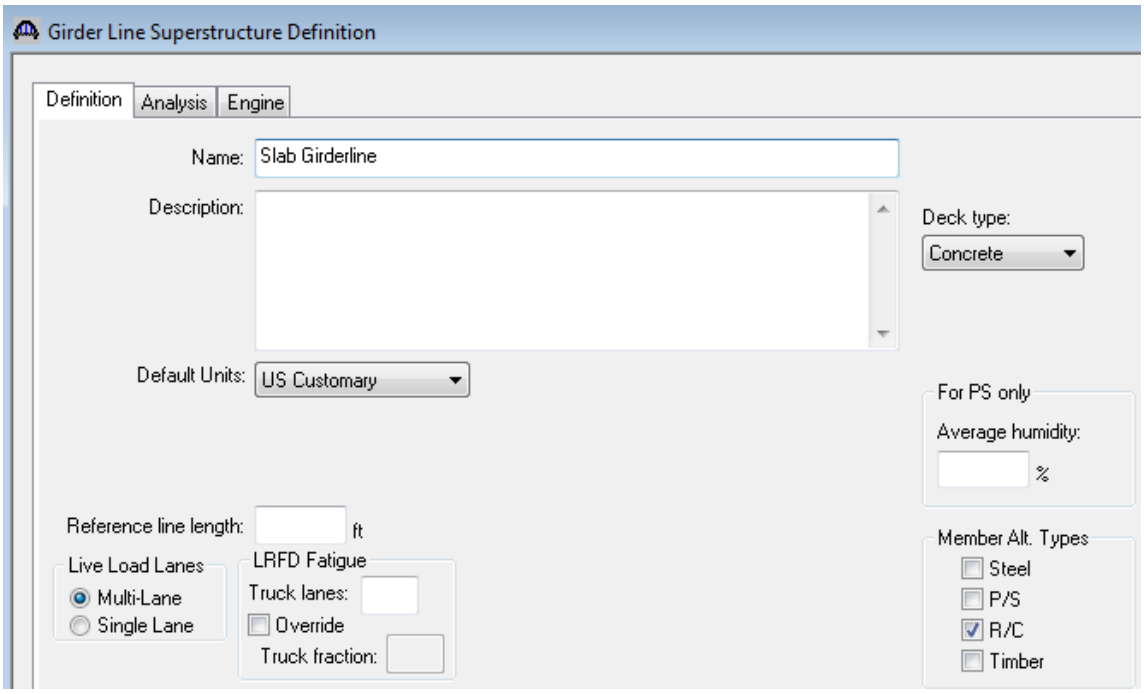
We do not need to define any beam shapes since we are using a reinforced concrete slab. The slab will be entered later as a cross section.

Reinforced concrete slab could be entered as Girderline Structure Definitions in BrR/BrD. Since we will not be defining a Structure Typical Section for a girderline structure, we do not need to define any appurtenances. The dead load due to the appurtenances will be entered later as member loads.

The default impact factors, standard LRFD and LFD factors will be used so we will skip to Structure Definition. Bridge Alternatives will be added after we enter the Structure Definition.

Double click on SUPERSTRUCTURE DEFINITIONS (or click on SUPERSTRUCTURE DEFINITIONS and select File/New from the menu or right mouse click on SUPERSTRUCTURE DEFINITIONS and select New from the popup menu) to create a new structure definition.

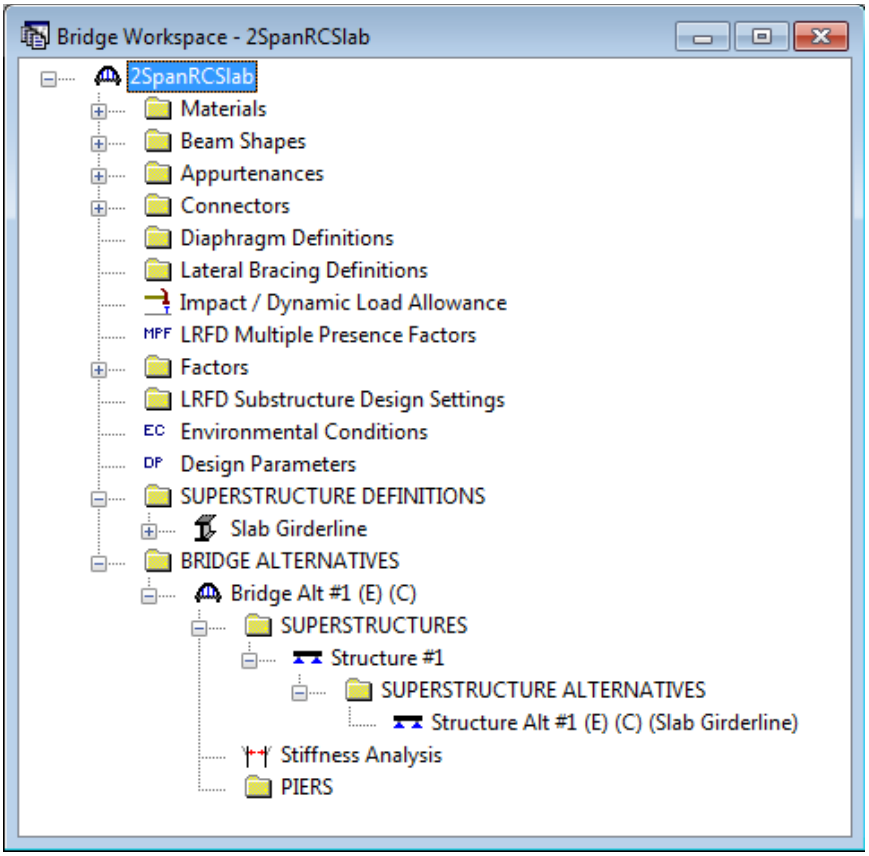
Select Girder Line Superstructure, click Ok and the Structure Definition window will open. Enter the appropriate data as shown below:



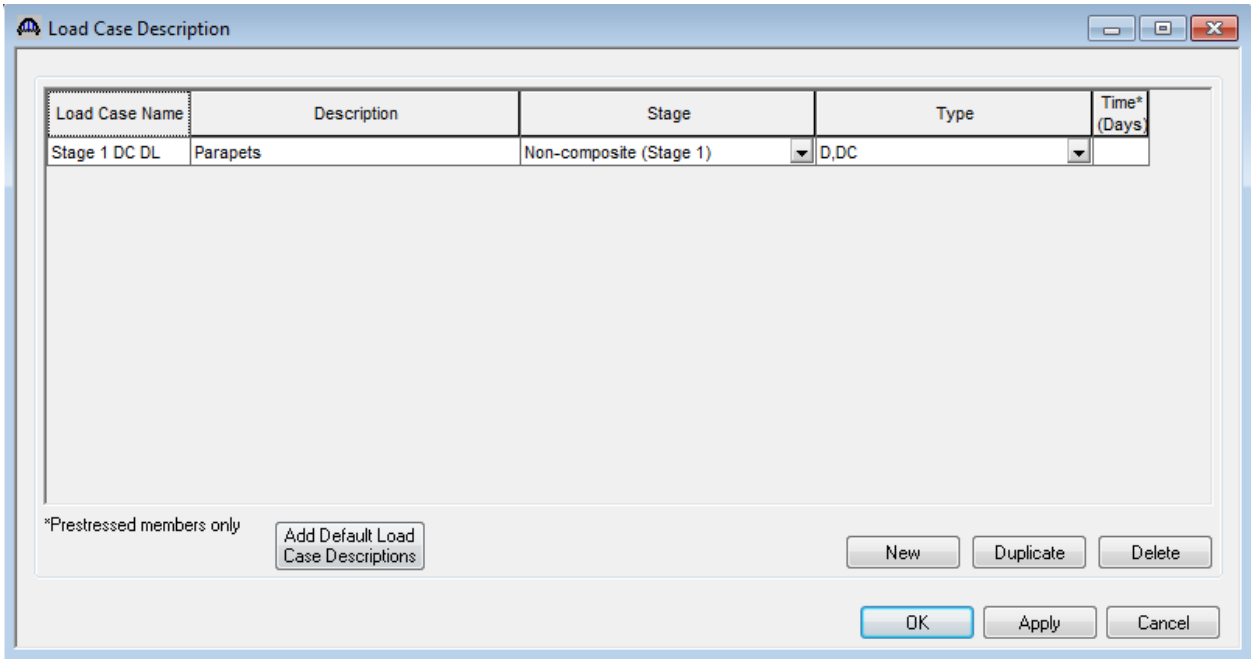
Click on Ok to save the data to memory and close the window.

We now go back to the Bridge Alternatives and create a new Bridge Alternative, a new Structure, and a new Structure Alternative as we did previously.

The partially expanded Bridge Workspace tree is shown below:



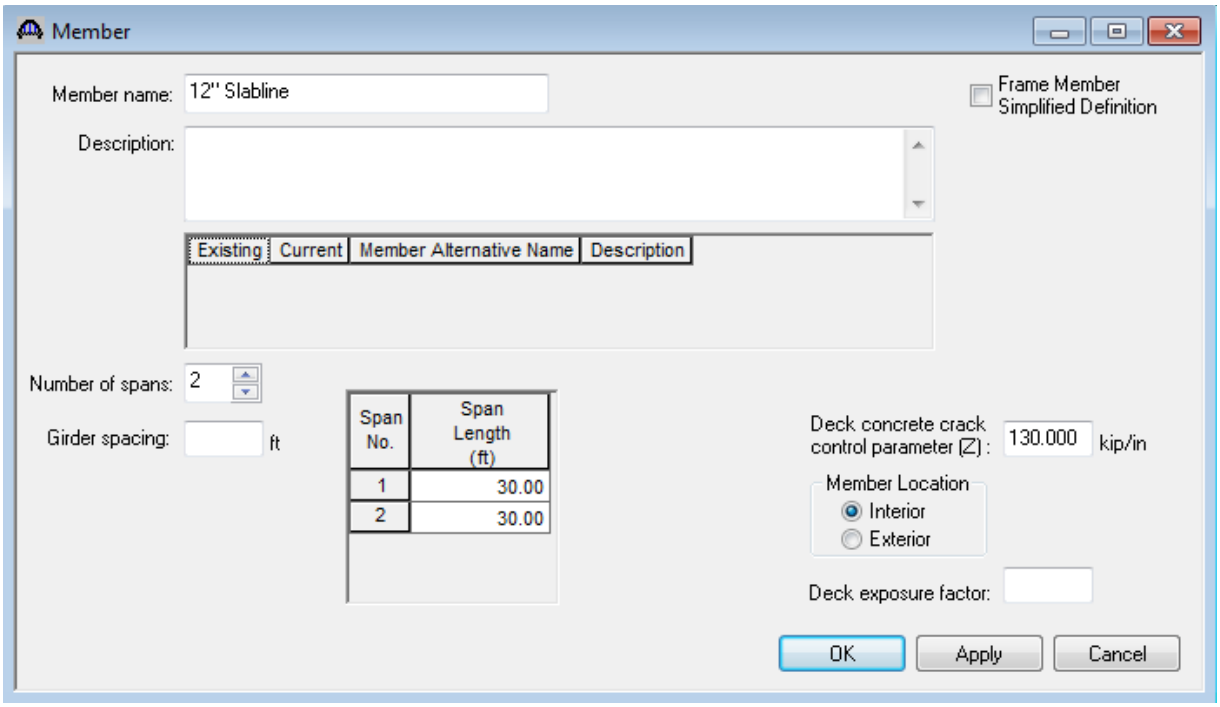
Click Load Case Description to define the dead load cases. The completed Load Case Description window is shown below.



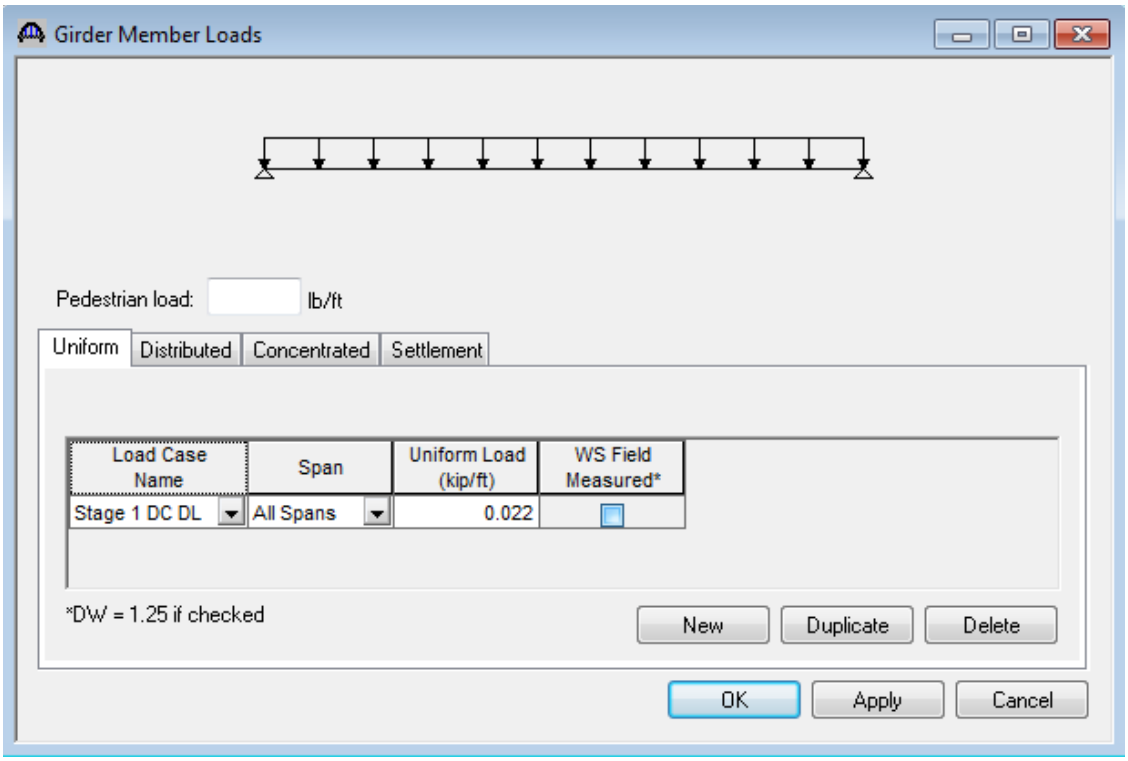
Describing a member:

Open the Member window by double clicking on Member in tree. Fill in the window with the following information. If we press F1 while this window is active, the Help topic for the Member window will be displayed. This help topic tells us that girder spacing and member location are not required for a slab member so we will not enter any data for those items.

The first Member Alternative that we create will automatically be assigned as the Existing and Current Member alternative for this Member.

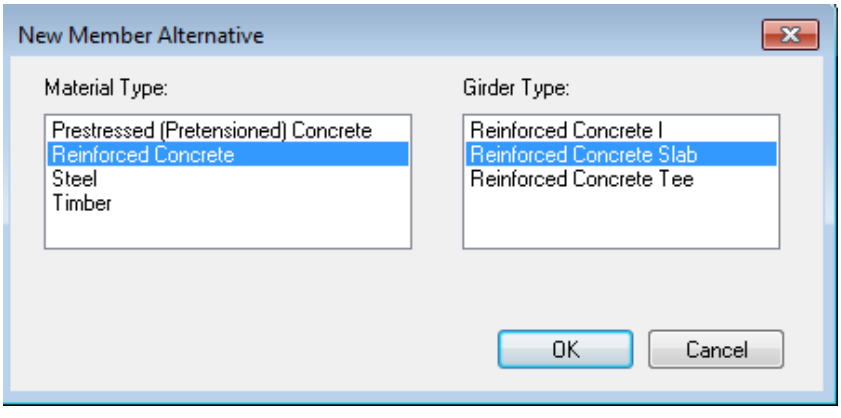


Double-click Member Loads to open the Member Loads window. This structure has 2 parapets each weighing 300 lb/ft. We are defining a 12" wide strip of slab as our member, and the bridge cross section has a width of 27 ft. So the parapet load applied to this member will be (2*300 lb/ft)*1'/27' = 22 lb/ft.



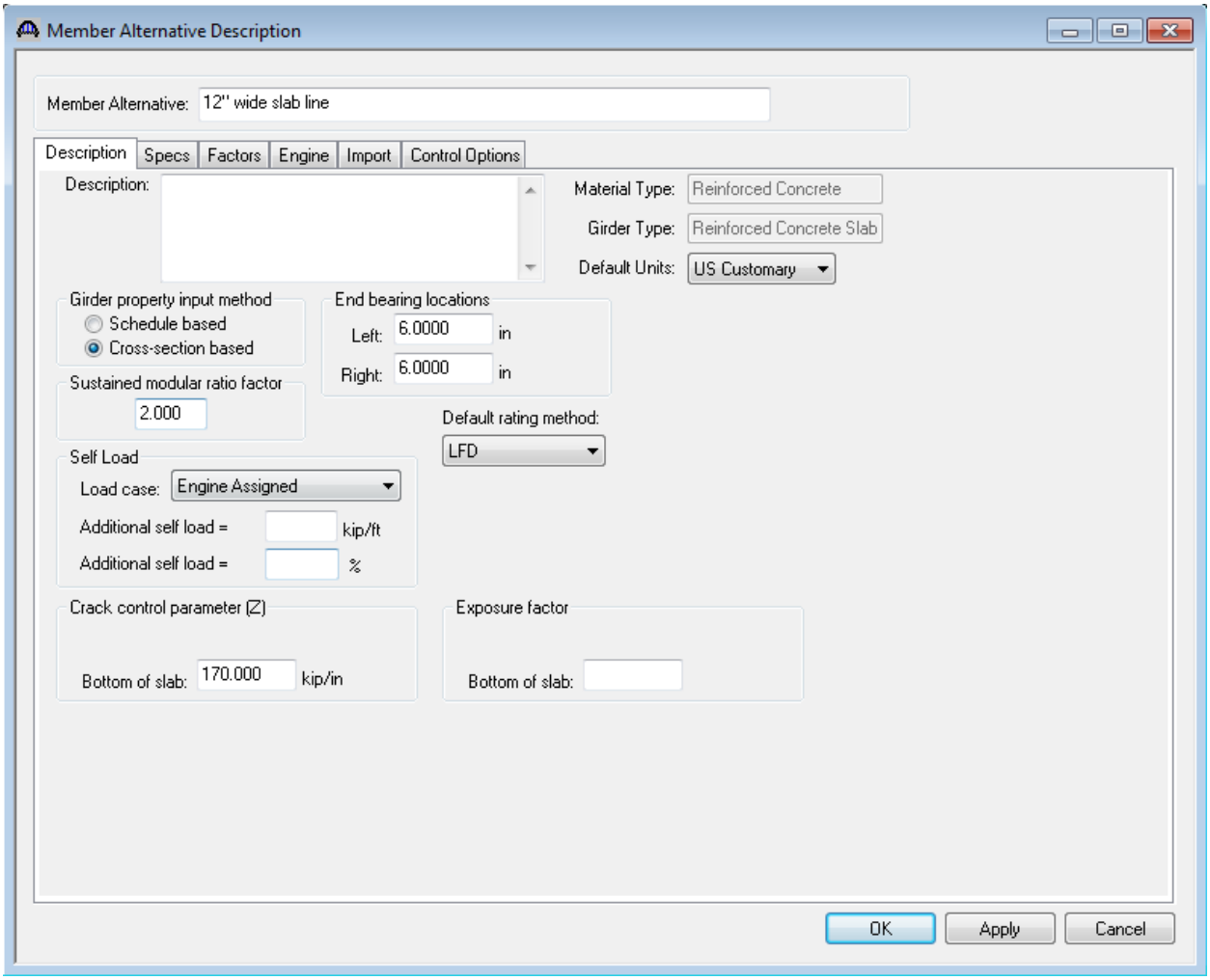
Defining a Member Alternative:

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 Slab for the Girder Type.

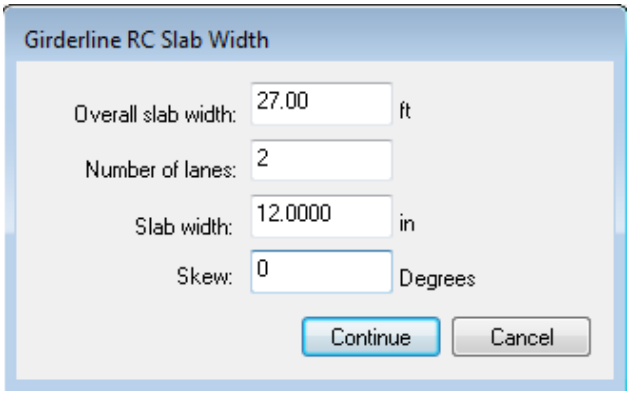


Click Ok to close the dialog and create a new member alternative.

The Member Alternative Description window will open. Enter the appropriate data as shown below. The Cross-section based Girder property input method is the only input method available for a reinforced concrete beam. AASHTO Article 3.24.4 states that concrete slabs designed in accordance with AASHTO Article 3.24.3 shall be considered satisfactory in bond and shear so we will select the LFD Ignore shear checkbox under the Shear computation method.

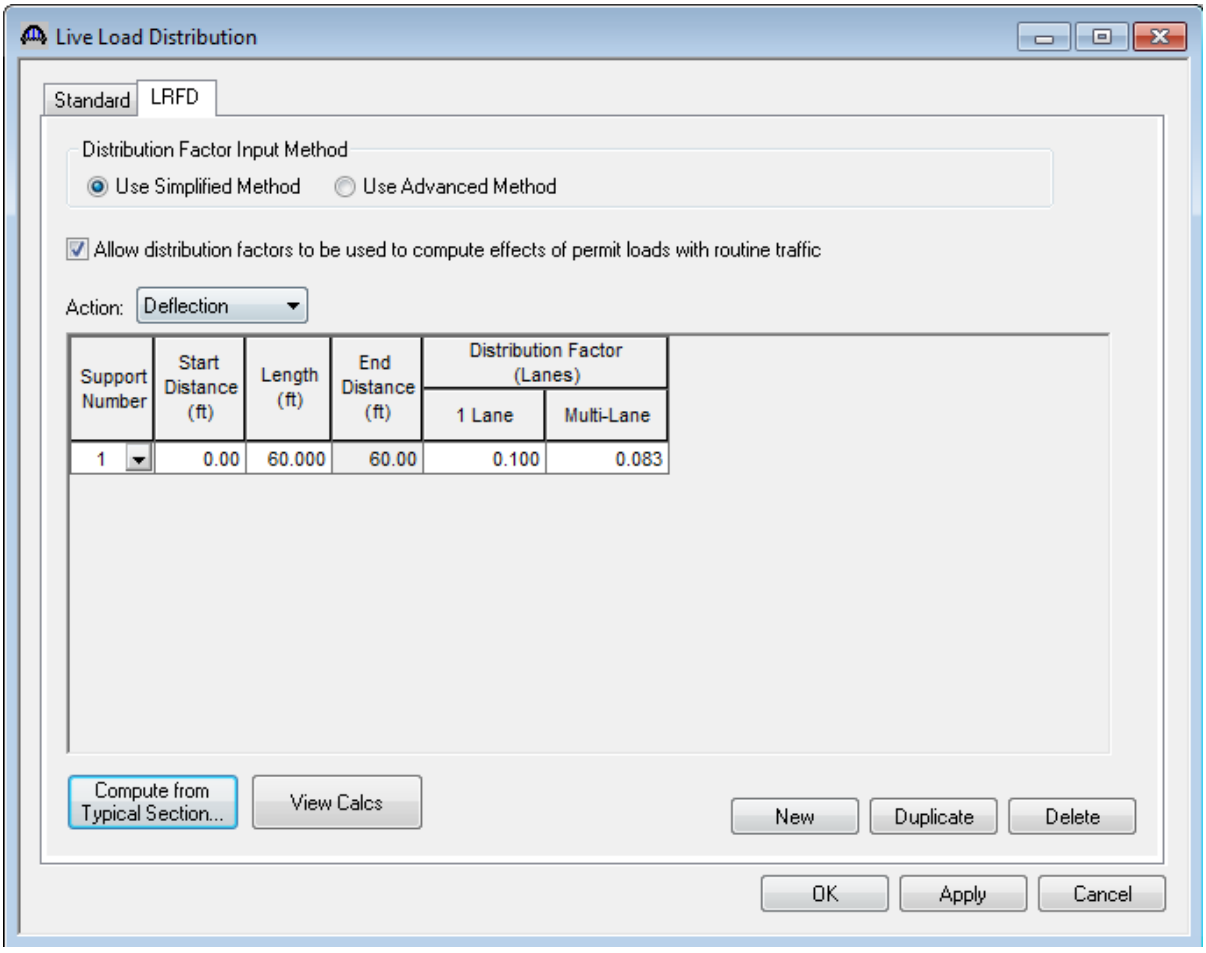


We can now enter the live load distribution factors for this member. Open Live Load Distribution window, LRFD tab. Click Compute from Typical Section button, enter values as below in the pop up window.

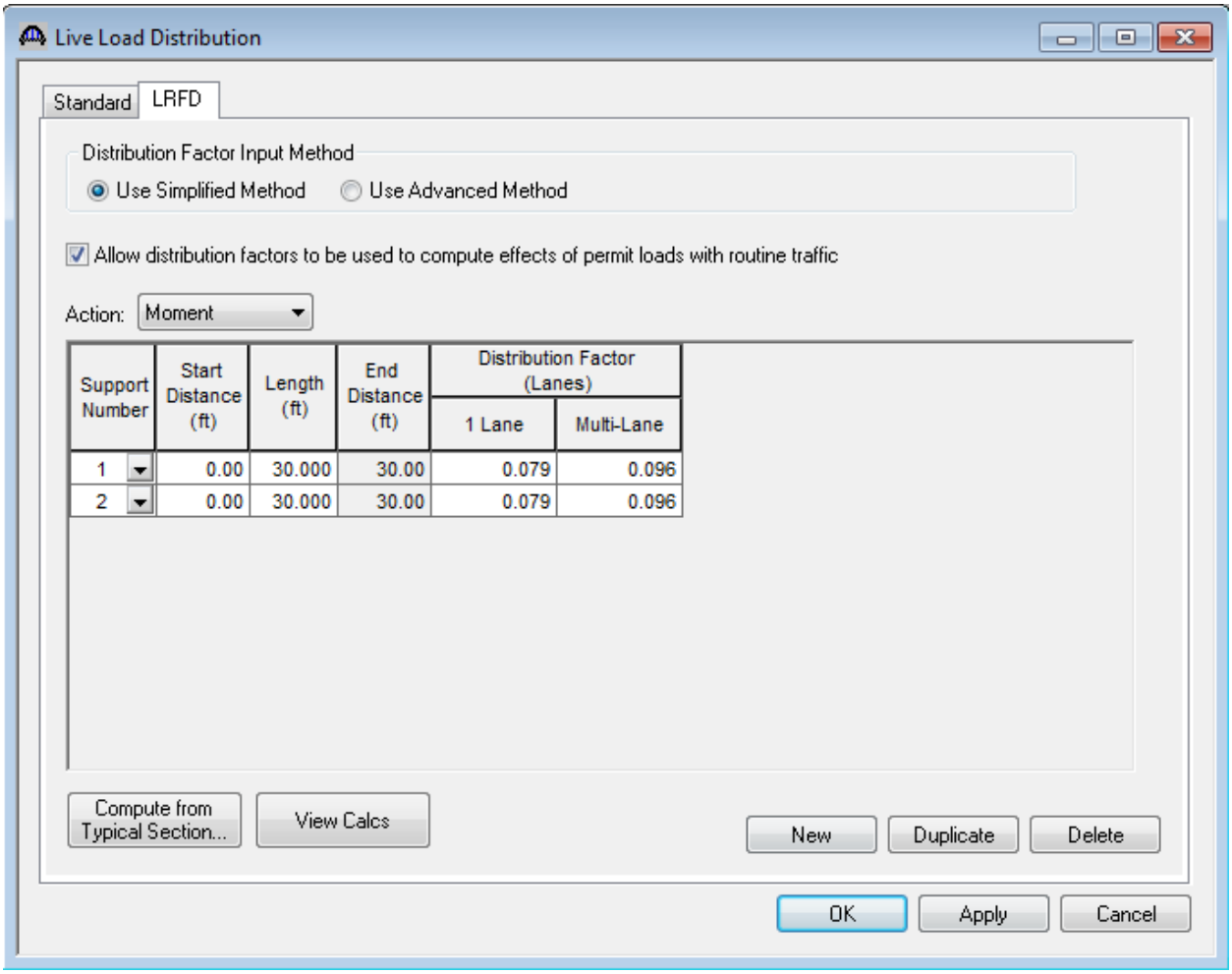


Click Continue button, BrR will compute LRFD live load distribution factors, click OK to close the analysis window. Live load distribution factors will be calculated as below.

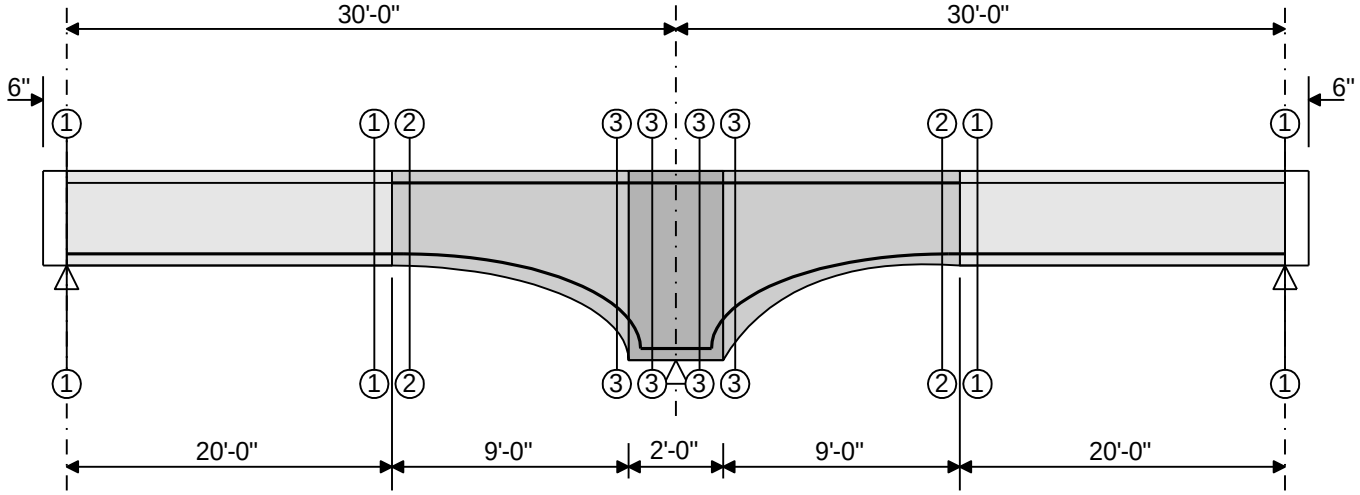
Deflection distribution factors.

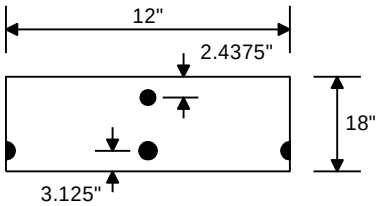


Moment and shear have the same following distribution factors.

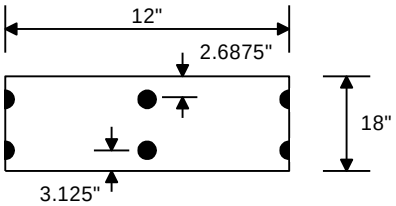


We can now create a new cross section by double-clicking on Cross Section in the tree. This member contains three cross sections as illustrated below. The completed Cross Section windows follow.

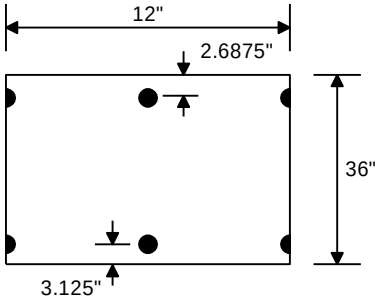




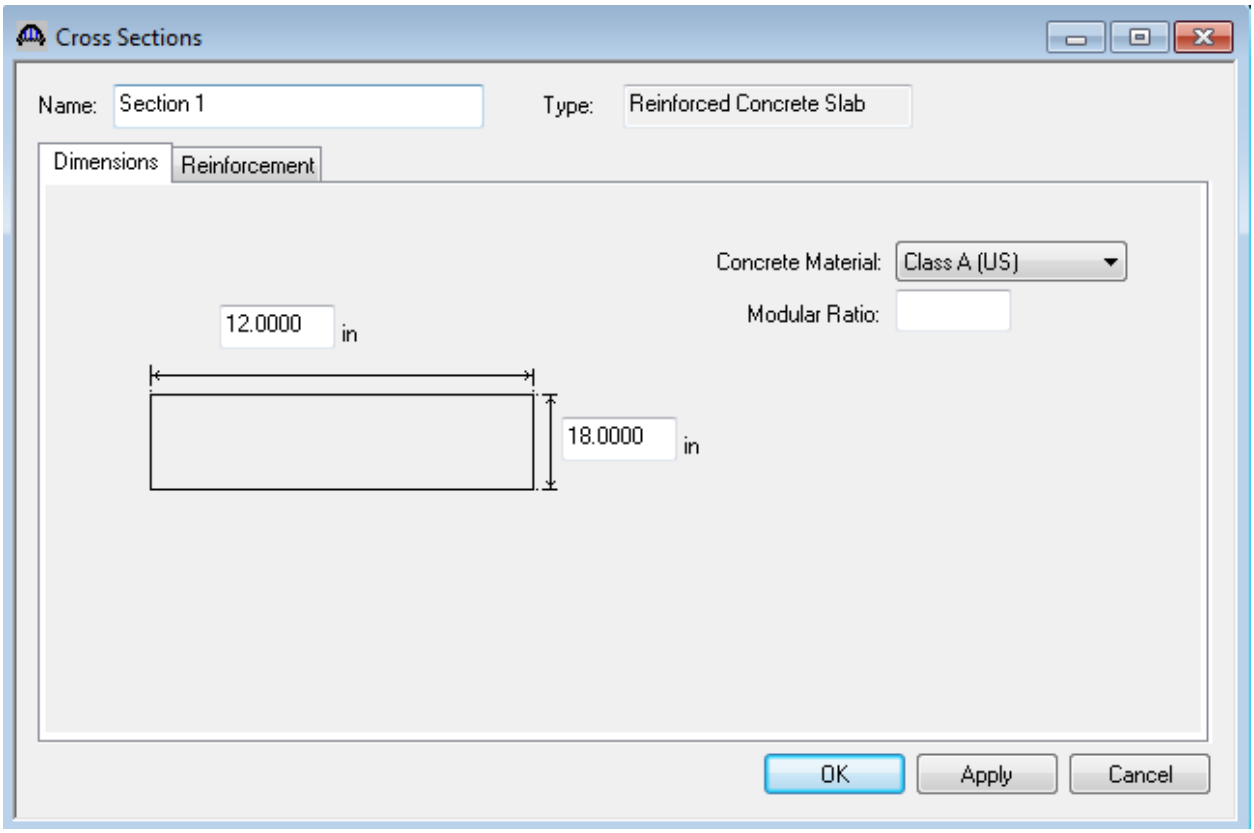
Section 1

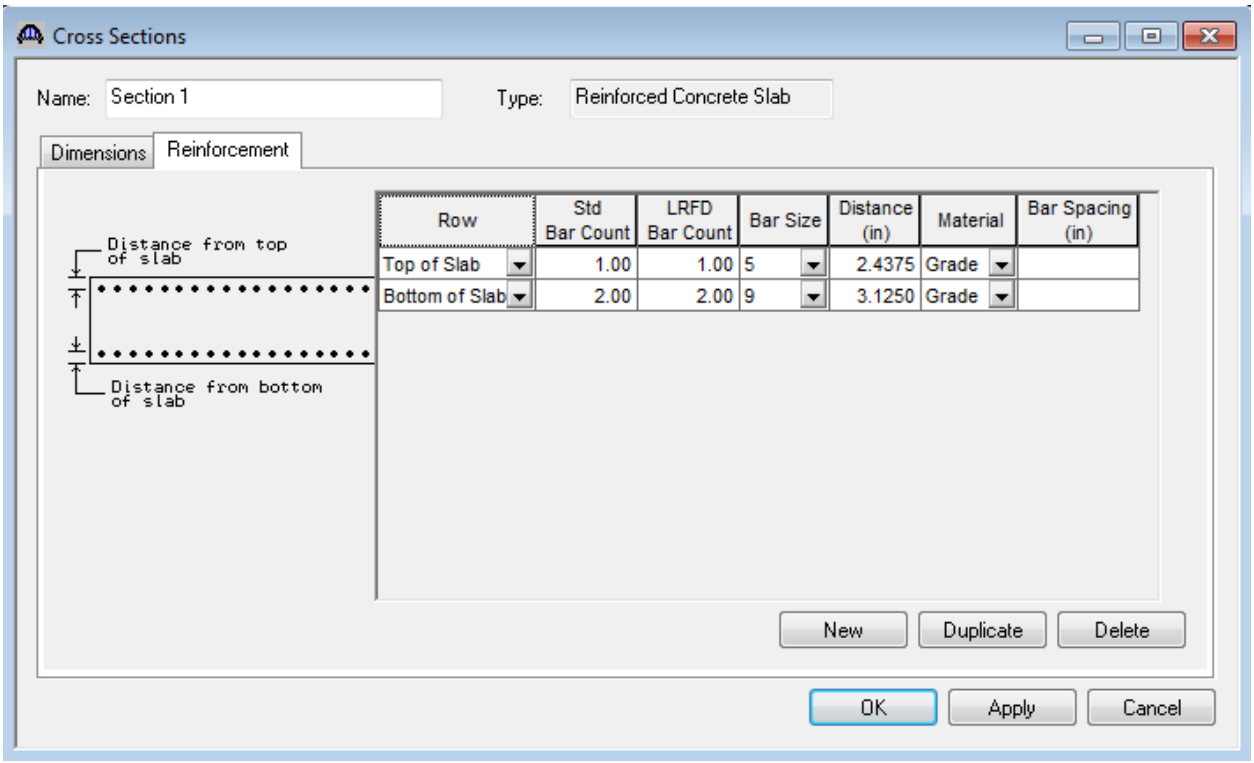


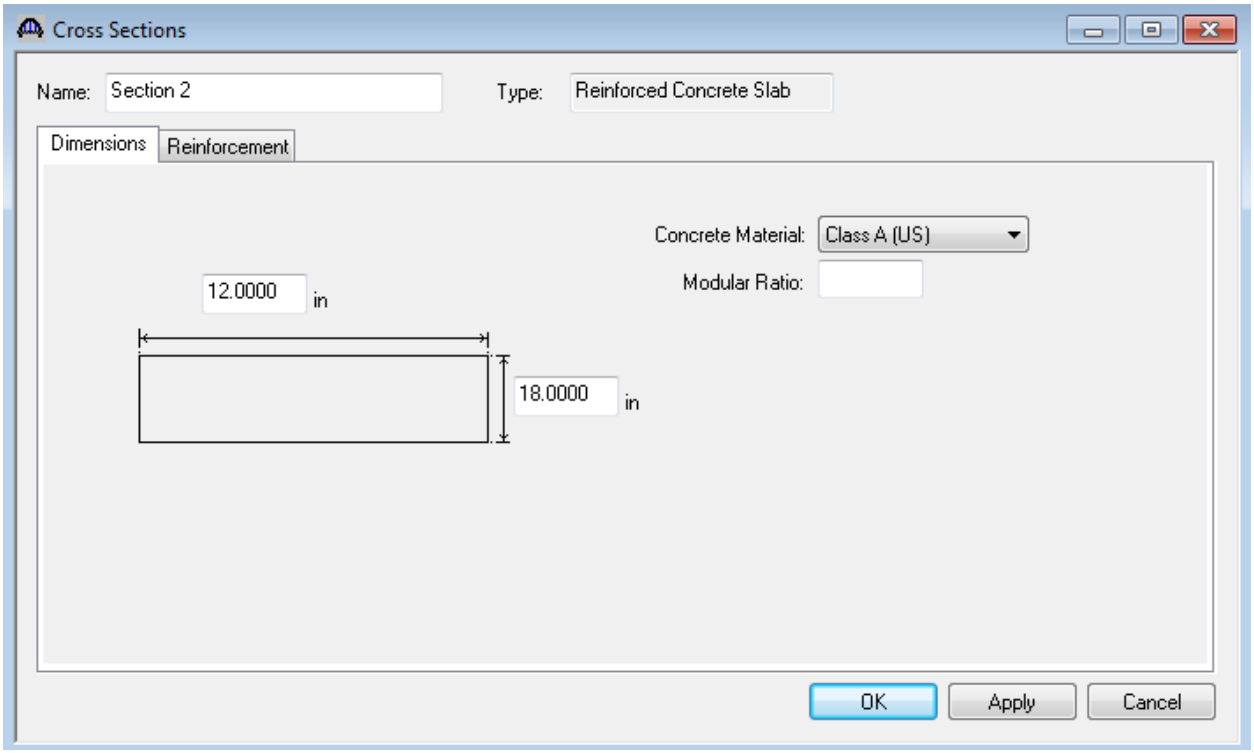
Section 2

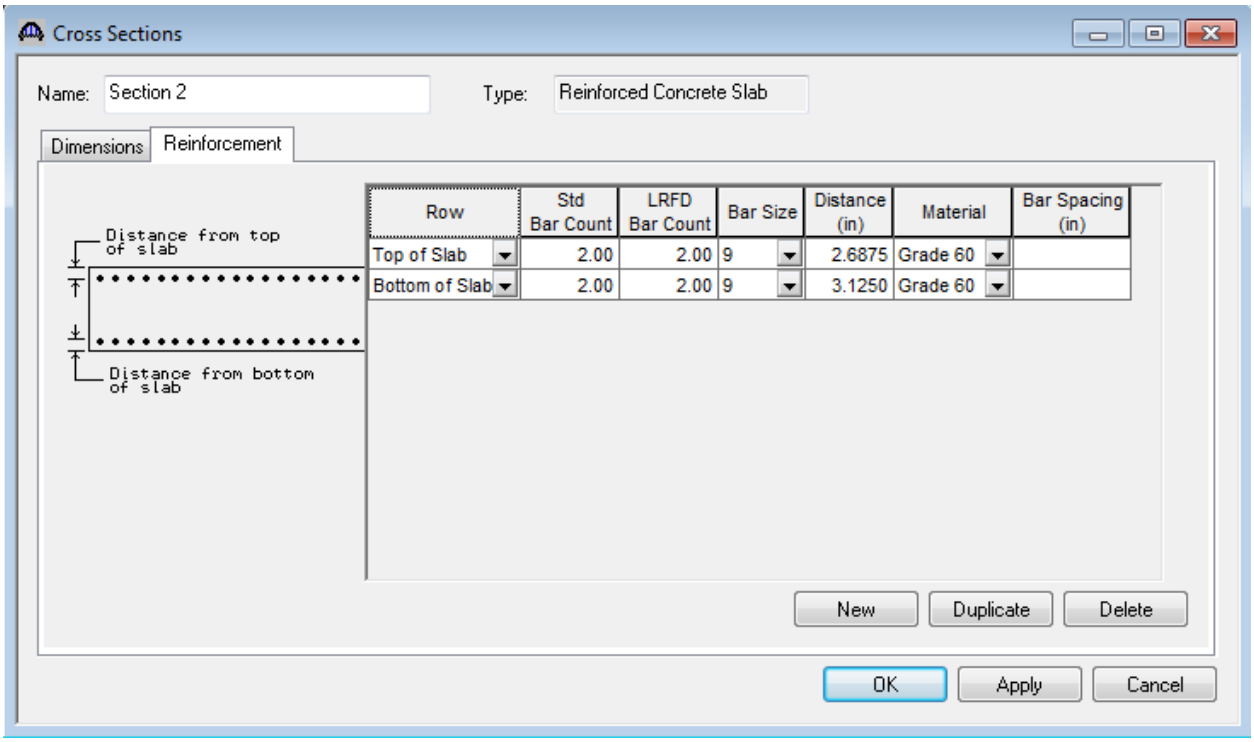


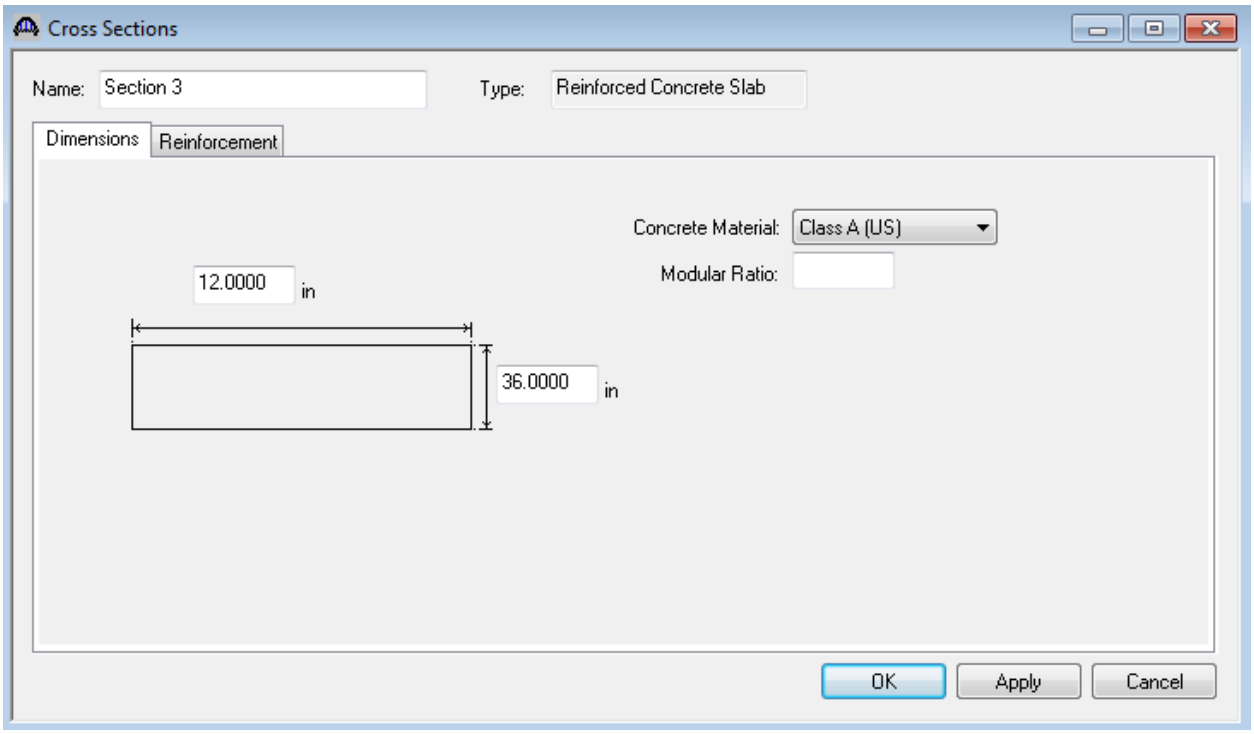
Section 3

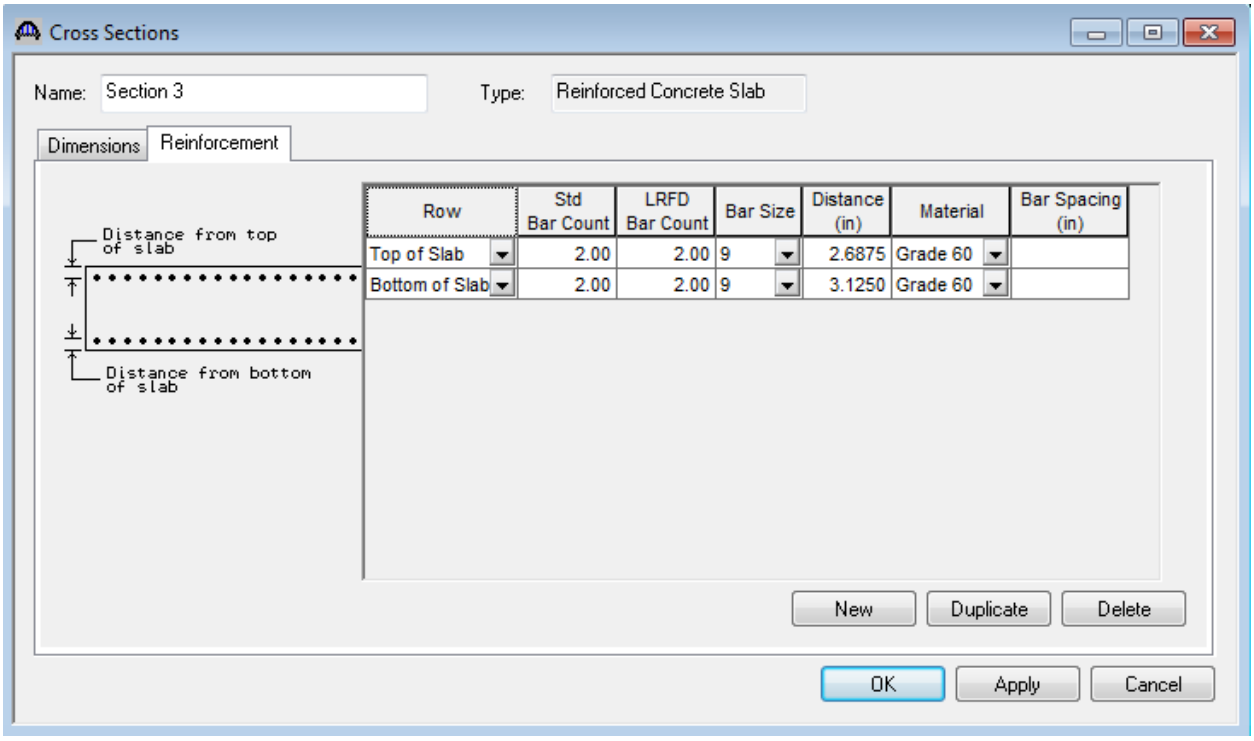

Cross Sections
Name: Section 1
Type: Reinforced Concrete Slab
Dimensions
Reinforcement
Concrete Material: Class A (US)
Modular Ratio:
12.0000 in
18.0000 in
OK
Apply
Cancel


Cross Sections
Name: Section 1
Type: Reinforced Concrete Slab
Dimensions
Reinforcement
Distance from top of slab
Distance from bottom of slab
Row
Std Bar Count
LRFD Bar Count
Bar Size
Distance (in)
Material
Bar Spacing (in)
Top of Slab 1.00 1.00 5 2.4375 Grade
Bottom of Slab 2.00 2.00 9 3.1250 Grade
New
Duplicate
Delete
OK
Apply
Cancel

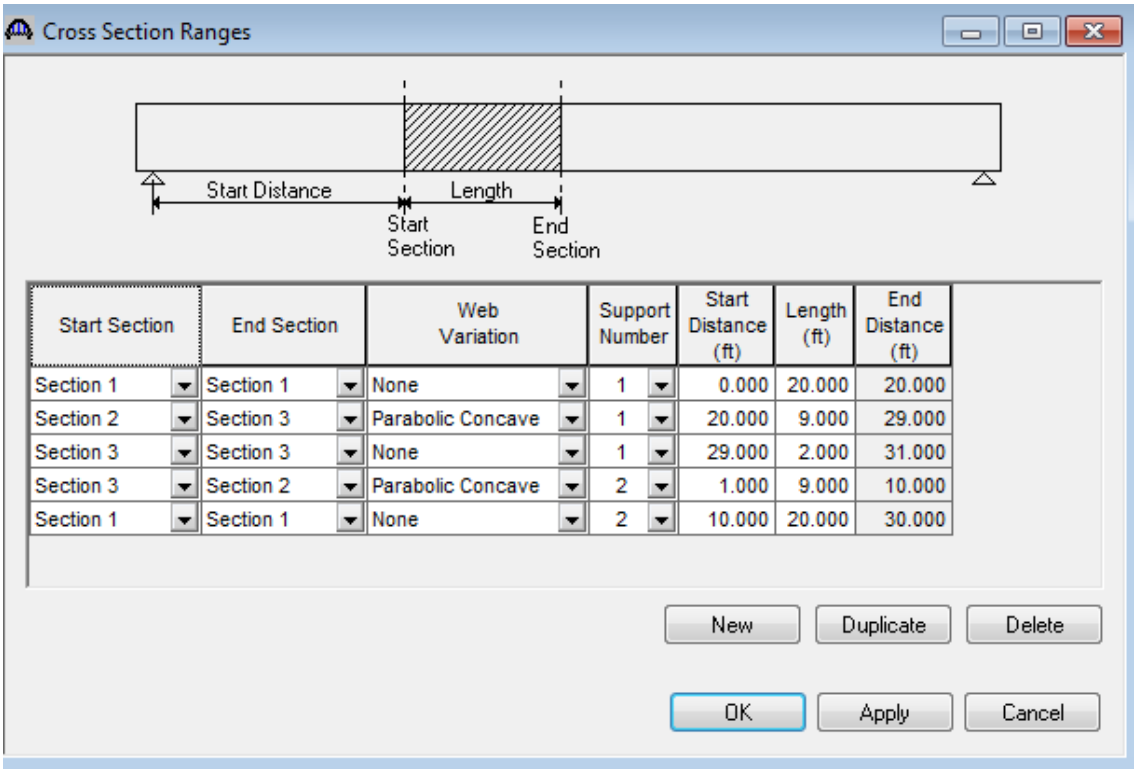

Cross Sections
Name: Section 2
Type: Reinforced Concrete Slab
Dimensions
Reinforcement
Concrete Material: Class A (US)
Modular Ratio:
12.0000 in
18.0000 in
OK
Apply
Cancel


Cross Sections
Name: Section 2
Type: Reinforced Concrete Slab
Dimensions
Reinforcement
Distance from top of slab
Distance from bottom of slab
Row
Std Bar Count
LRFD Bar Count
Bar Size
Distance (in)
Material
Bar Spacing (in)
Top of Slab 2.00 2.00 9 2.6875 Grade 60
Bottom of Slab 2.00 2.00 9 3.1250 Grade 60
New
Duplicate
Delete
OK
Apply
Cancel


Cross Sections
Name: Section 3
Type: Reinforced Concrete Slab
Dimensions
Reinforcement
Concrete Material: Class A (US)
Modular Ratio:
12.0000 in
36.0000 in
OK
Apply
Cancel


Cross Sections
Name: Section 3
Type: Reinforced Concrete Slab
Dimensions
Reinforcement
Distance from top of slab
Distance from bottom of slab
Row
Std Bar Count
LRFD Bar Count
Bar Size
Distance (in)
Material
Bar Spacing (in)
Top of Slab 2.00 2.00 9 2.6875 Grade 60
Bottom of Slab 2.00 2.00 9 3.1250 Grade 60
New
Duplicate
Delete
OK
Apply
Cancel

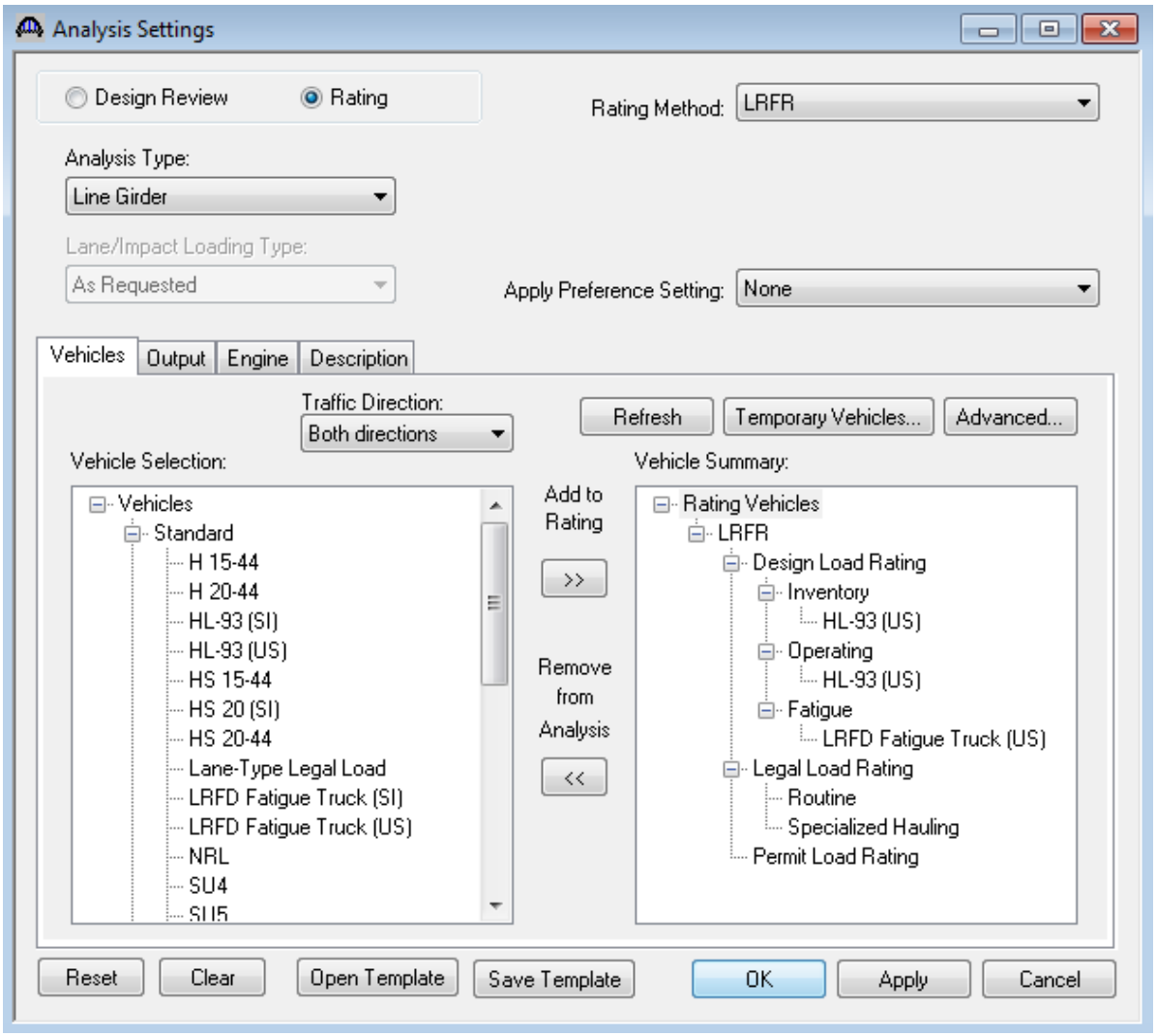
The cross sections are now applied over the length of the member using the Cross Section Ranges window as shown below:



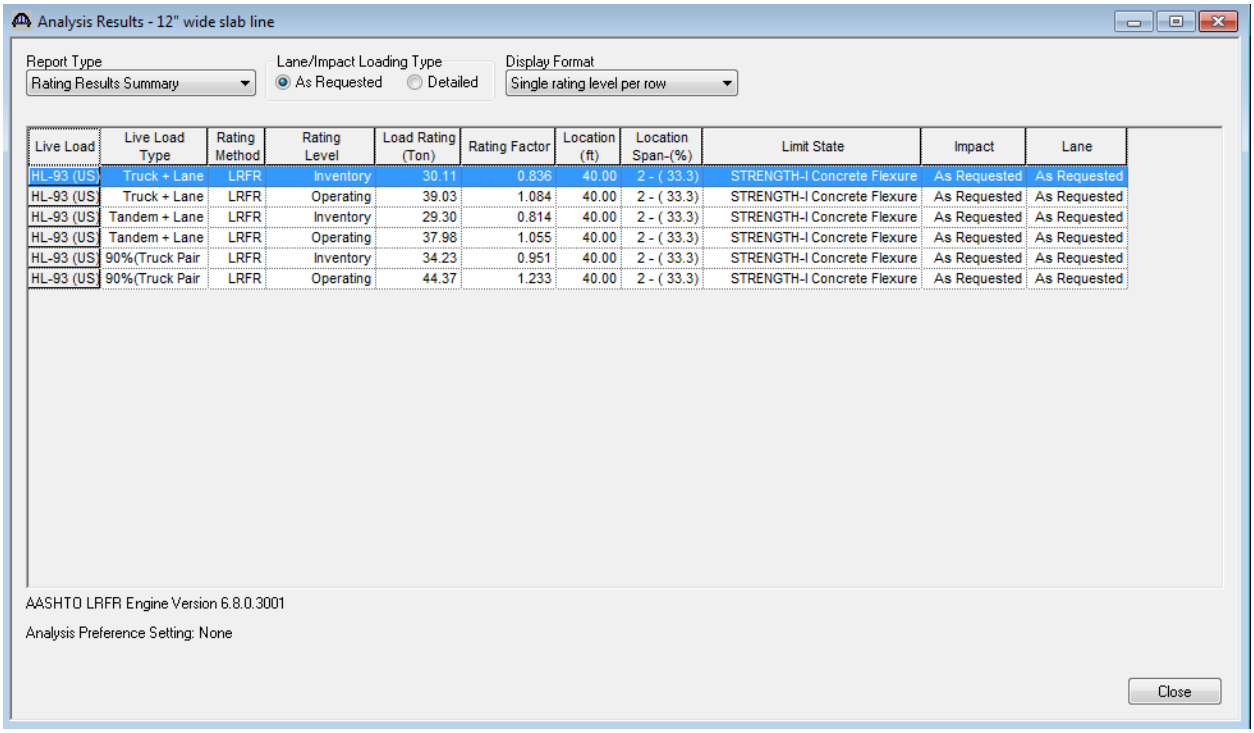
Shear Reinforcement Ranges and Bracing Ranges are not applicable to this member so we will not enter any data in these windows. We also do not need to define any Points of Interest since we will not be overriding any information we have entered.

The description of this structure is complete.

The member alternative can now be analyzed. To perform LRFR rating, select the View Analysis Settings button on the toolbar to open the window shown below. Click Open Template button and select the LRFR Design Load Rating to be used in the rating and click Ok.

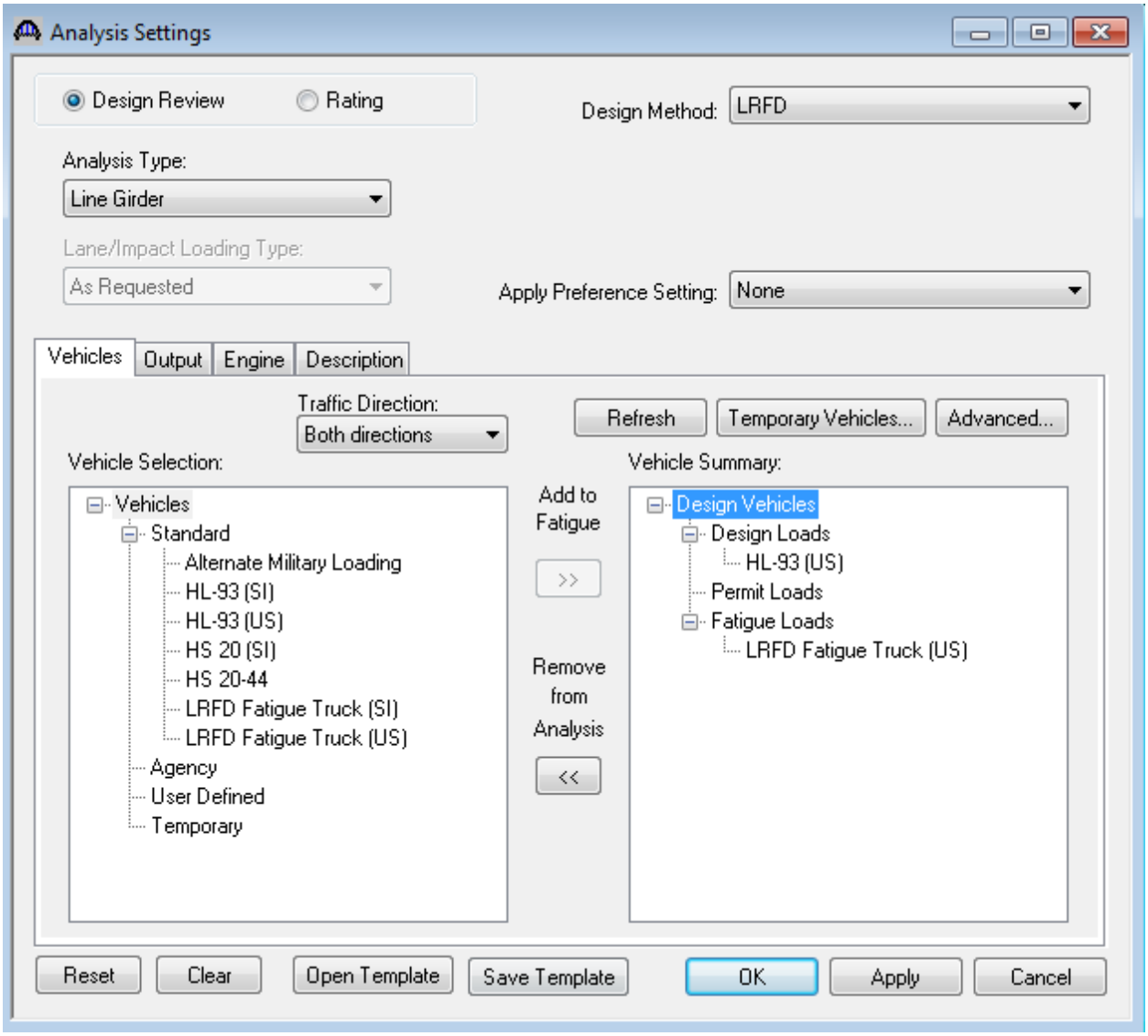


Next click the Analyze button on the toolbar to perform the rating. When the rating is finished you can review the results by clicking the View analysis Report on the toolbar. The window shown below will open.

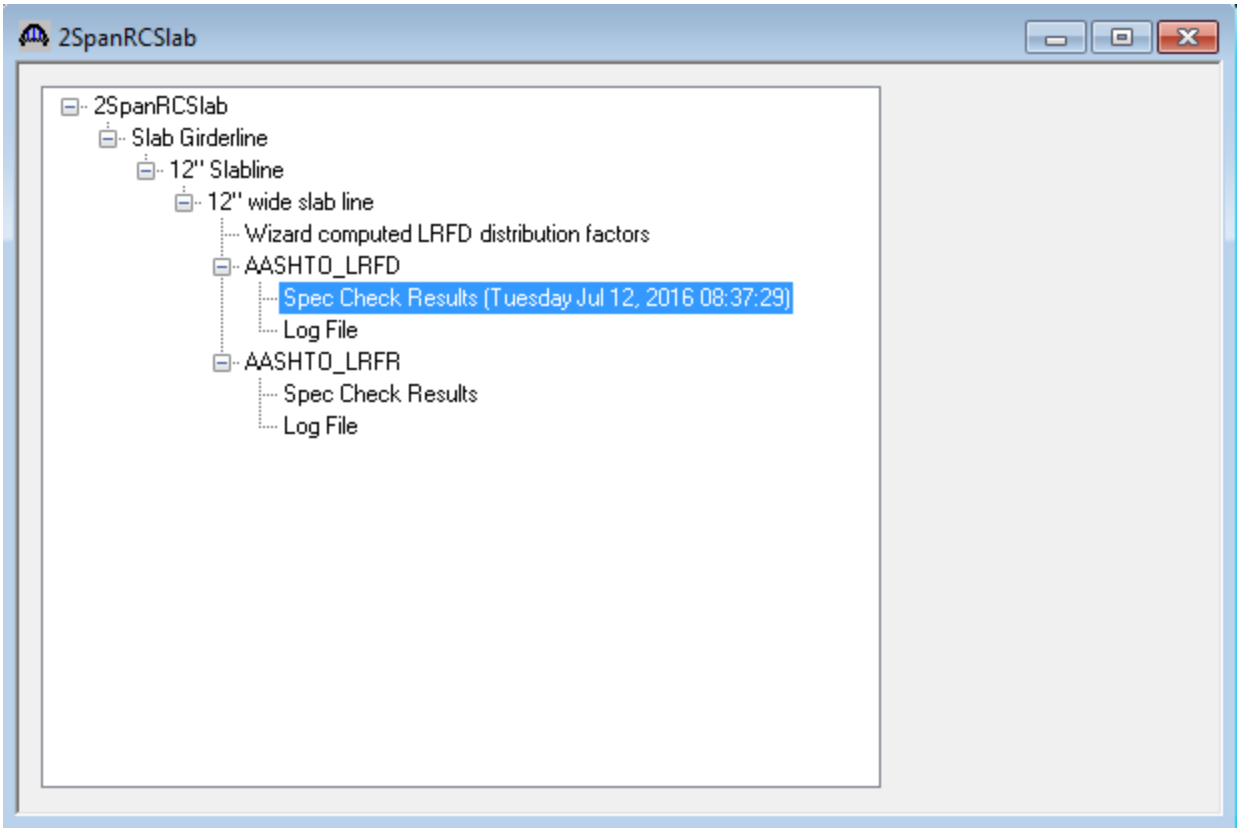


Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Location (ft)	Location Span-(%)	Limit State	Impact	Lane
HL-93 (US)	Truck + Lane	LRFR	Inventory	30.11	0.836	40.00	2 - (33.3)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	39.03	1.084	40.00	2 - (33.3)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	29.30	0.814	40.00	2 - (33.3)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	37.98	1.055	40.00	2 - (33.3)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	90%(Truck Pair	LRFR	Inventory	34.23	0.951	40.00	2 - (33.3)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	90%(Truck Pair	LRFR	Operating	44.37	1.233	40.00	2 - (33.3)	STRENGTH-I Concrete Flexure	As Requested	As Requested

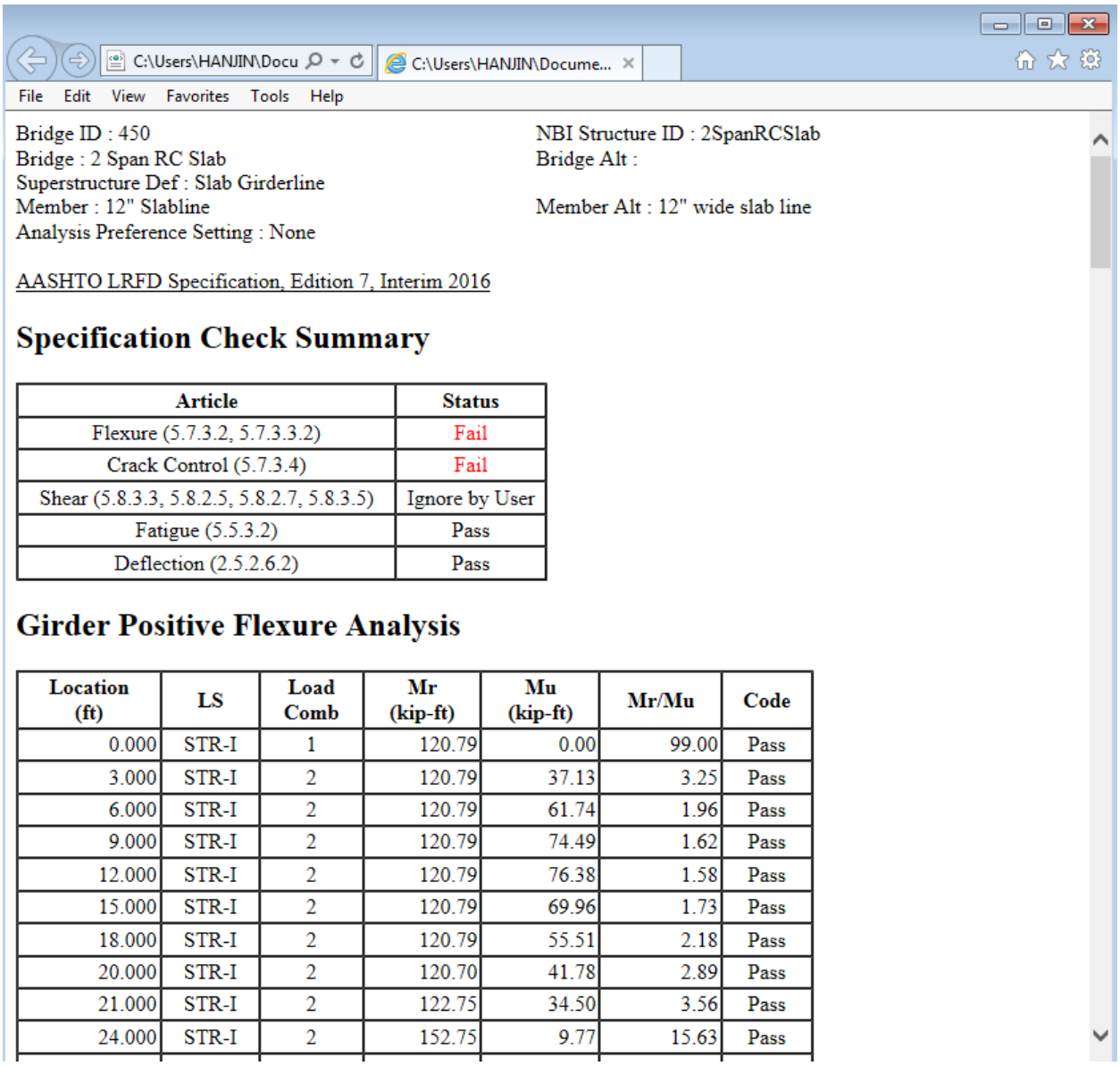
An LRFD design review of this girder for HL93 loading can be performed by BrD LRFD. To do LRFD design review, enter the Analysis Settings window as shown below:



BrD LRFD analysis will generate a spec check results file. Click  on tool bar to open the following window.



To view the spec check results, double click the Spec Check Results in this window.



Bridge ID : 450
Bridge : 2 Span RC Slab
Superstructure Def : Slab Girderline
Member : 12" Slabline
Analysis Preference Setting : None

NBI Structure ID : 2SpanRCSlab
Bridge Alt :

Member Alt : 12" wide slab line

AASHTO LRFD Specification, Edition 7, Interim 2016

Specification Check Summary

Article	Status
Flexure (5.7.3.2, 5.7.3.3.2)	Fail
Crack Control (5.7.3.4)	Fail
Shear (5.8.3.3, 5.8.2.5, 5.8.2.7, 5.8.3.5)	Ignore by User
Fatigue (5.5.3.2)	Pass
Deflection (2.5.2.6.2)	Pass

Girder Positive Flexure Analysis

Location (ft)	LS	Load Comb	Mr (kip-ft)	Mu (kip-ft)	Mr/Mu	Code
0.000	STR-I	1	120.79	0.00	99.00	Pass
3.000	STR-I	2	120.79	37.13	3.25	Pass
6.000	STR-I	2	120.79	61.74	1.96	Pass
9.000	STR-I	2	120.79	74.49	1.62	Pass
12.000	STR-I	2	120.79	76.38	1.58	Pass
15.000	STR-I	2	120.79	69.96	1.73	Pass
18.000	STR-I	2	120.79	55.51	2.18	Pass
20.000	STR-I	2	120.70	41.78	2.89	Pass
21.000	STR-I	2	122.75	34.50	3.56	Pass
24.000	STR-I	2	152.75	9.77	15.63	Pass