

*AASHTOWare BrDR 7.5.0*

---

*Reinforced Concrete Structure Tutorial*  
*RC4 – Two Span Reinforced Concrete Slab Example*

# RC4 – Two Span RC Concrete Slab

BrDR Training

## RC4 – Two Span Reinforced Concrete Slab Example

### Topics Covered

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

### Reinforced concrete slab input as girder line

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

2SpanRCSlab

Bridge ID: 2SpanRCSlab NBI structure ID (8): 2SpanRCSlab

Template  Superstructures  
 Bridge completely defined  Culverts  
 Substructures

Description Description (cont'd) Alternatives Global reference point Traffic Custom agency fields

Name: 2 Span RC Slab Year built:

Description:

Location:  Length:  ft

Facility carried (7):  Route number: -1

Feat. intersected (6):  Mi. post:

Default units: US Customary

Bridge association...  BrR  BrD  BrM

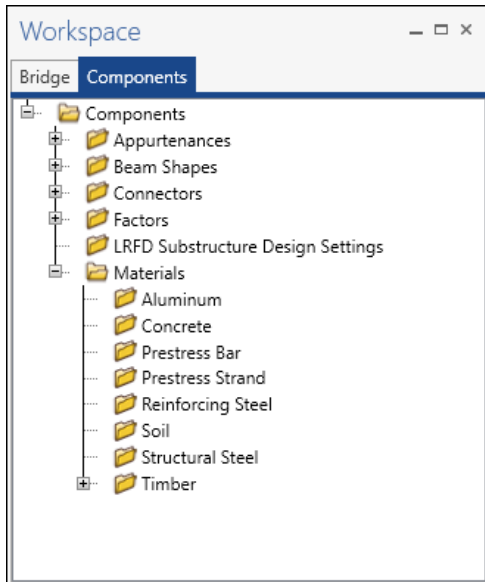
OK Apply Cancel

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

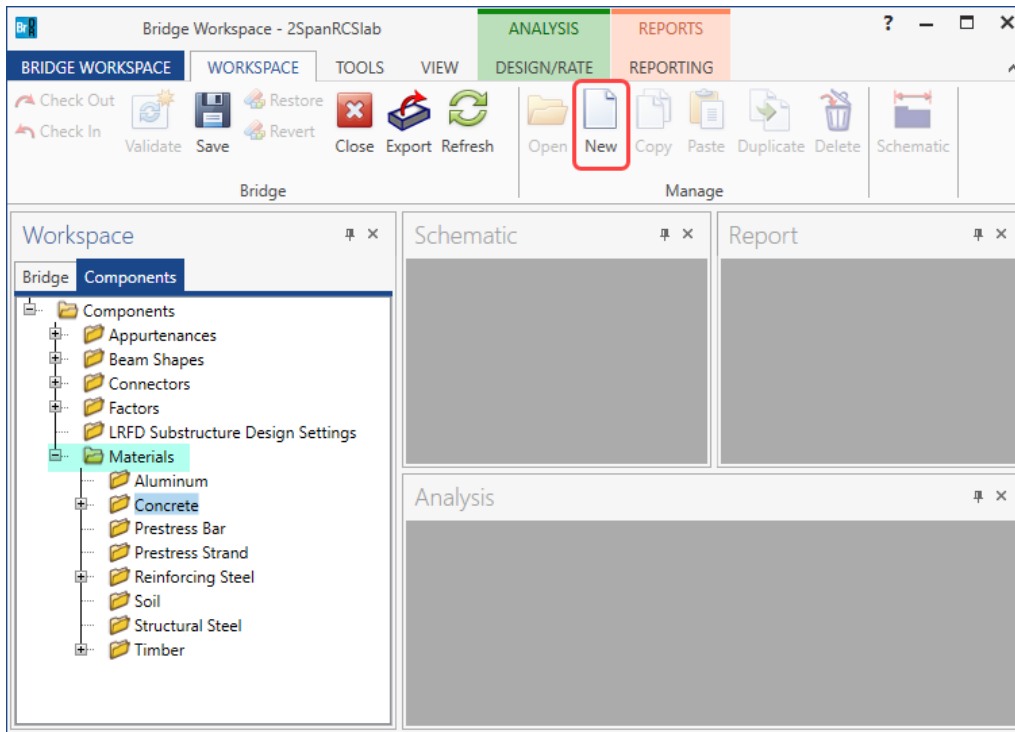
## RC4 – Two Span RC Concrete Slab

### Bridge Components

To enter the materials to be used by members of the bridge, go to the **Components** tab of the Bridge Workspace, and click on **+** 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 **New** from the **Manage** group of the **WORKSPACE** ribbon (or right mouse click on Concrete and select **New**).



## RC4 – Two Span RC Concrete Slab

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 <sub>c</sub>	f <sub>ci</sub>	alpha	DL density	Modulus density	Std modulus of elasticity	LRFD modulus of elasticity	Poisson's ratio	Modulus of rupture
Class A	Class A cement concrete	Standard	SI / Metric	28.00		0.0000108000	2400.00	2320.00	25426.08	27730.36	0.200	3.33
▶ Class A (US)	Class A cement concrete	Standard	US Customary	4.000		0.0000060000	0.150	0.145	3644.15	3986.55	0.200	0.480
Class B	Class B cement concrete	Standard	SI / Metric	17.00		0.0000108000	2400.00	2320.00	19811.84	23520.23	0.200	2.60
Class B (US)	Class B cement concrete	Standard	US Customary	2.400		0.0000060000	0.150	0.145	2822.75	3368.12	0.200	0.372
Class C	Class C cement concrete	Standard	SI / Metric	28.00		0.0000108000	2400.00	2320.00	25426.08	27730.36	0.200	3.33
Class C (US)	Class C cement concrete	Standard	US Customary	4.000		0.0000060000	0.150	0.145	3644.15	3986.55	0.200	0.480

Select the **Class A (US)** material and click **OK**.

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

Bridge Materials - Concrete

Name:

Description:

Compressive strength at 28 days (f<sub>c</sub>):  ksi

Initial compressive strength (f<sub>ci</sub>):  ksi

Composition of concrete:

Density (for dead loads):  kcf

Density (for modulus of elasticity):  kcf

Poisson's ratio:

Coefficient of thermal expansion (α):  1/F

Splitting tensile strength (f<sub>ct</sub>):  ksi

LRFD Maximum aggregate size:  in

Std modulus of elasticity (E<sub>c</sub>):  ksi

LRFD modulus of elasticity (E<sub>c</sub>):  ksi

Std initial modulus of elasticity:  ksi

LRFD initial modulus of elasticity:  ksi

Std modulus of rupture:  ksi

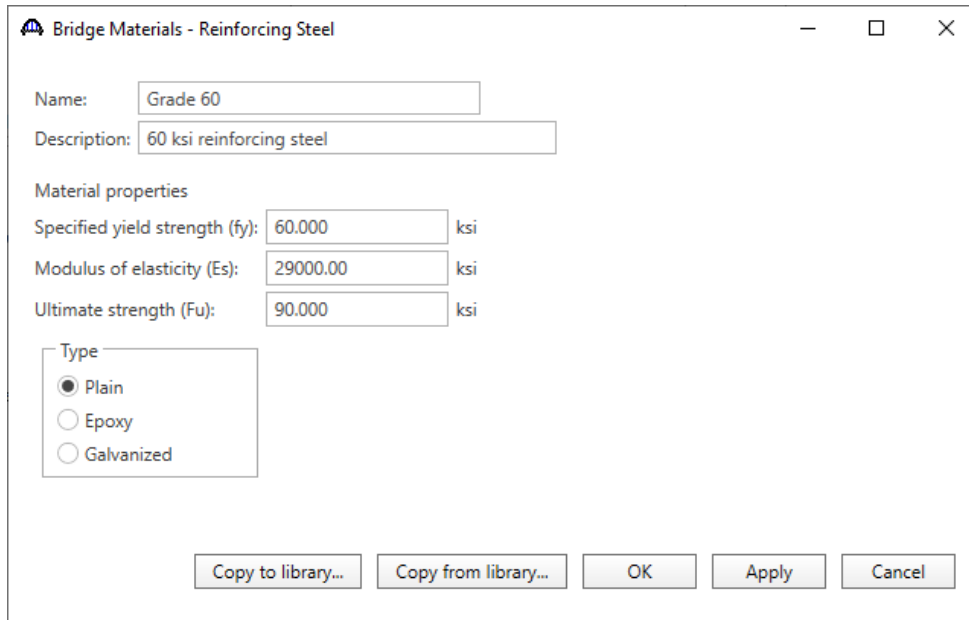
LRFD modulus of rupture:  ksi

Shear factor:

Click **OK** to apply the data and close the window.

## RC4 – Two Span RC Concrete Slab

Add the following **Reinforcement Steel (Grade 60)** in the same manner.



Bridge Materials - Reinforcing Steel

Name:

Description:

Material properties

Specified yield strength (fy):  ksi

Modulus of elasticity (Es):  ksi

Ultimate strength (Fu):  ksi

Type

Plain

Epoxy

Galvanized

Since this example is a reinforced concrete slab, beam shapes need not be defined. The slab will be entered later as a cross section.

The reinforced concrete slab will be entered as **Girder line Structure Definition** in BrDR. Since a Structure Typical Section is not defined for girder line structures, appurtenances are not defined. The dead load due to the appurtenances will be entered later as member loads.

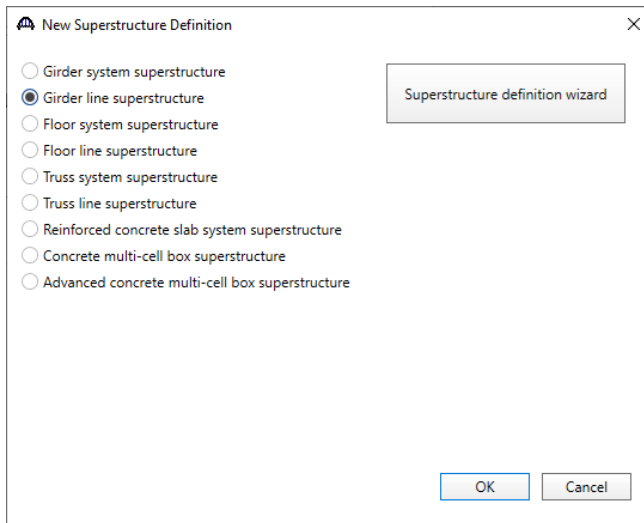
The default impact factors for LRFD and LFD will be used, so the next step will be to define a Superstructure. Bridge Alternatives will be added after a superstructure is defined.

## RC4 – Two Span RC Concrete Slab

### Superstructure Definition

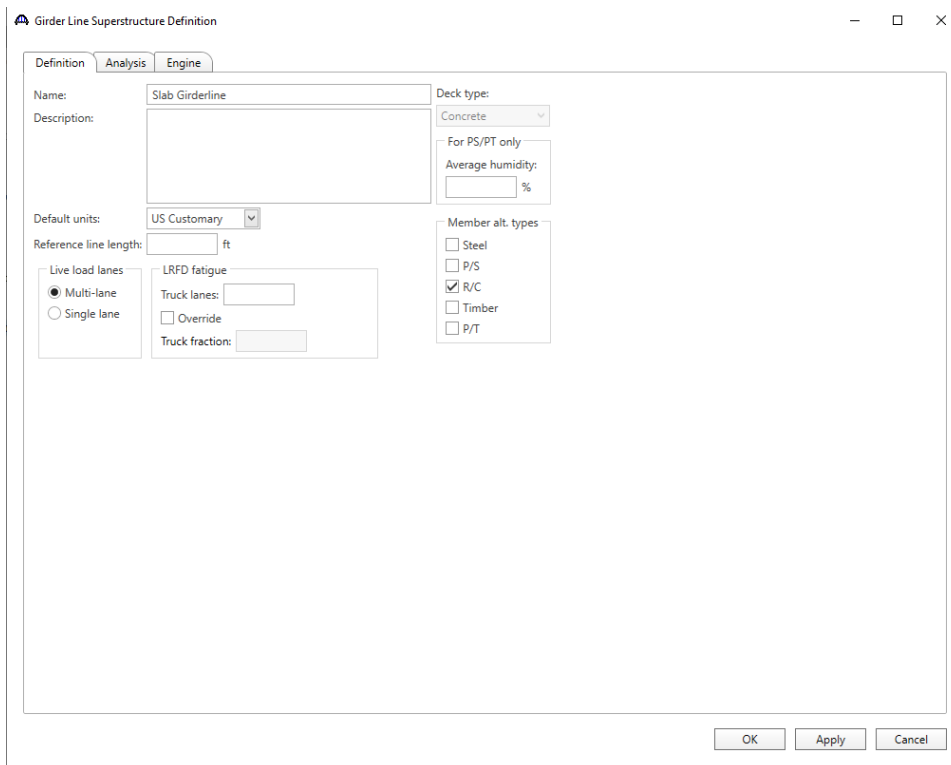
Double click on **SUPERSTRUCTURE DEFINITIONS** or click on **SUPERSTRUCTURE DEFINITIONS** and select **New** from the **Manage** group of the **Workspace** ribbon (or right mouse click on **SUPERSTRUCTURE DEFINITIONS** and select **New** from the pop up menu) to create a new structure definition.

Select **Girder line Superstructure** from the **New Superstructure Definition** window, click **OK** to open the **Girder Line Superstructure Definition** window. Enter the data as shown below.



The dialog box titled "New Superstructure Definition" contains a list of radio button options for selecting a superstructure type. The "Girder line superstructure" option is selected. A "Superstructure definition wizard" button is positioned to the right of the list. At the bottom of the dialog are "OK" and "Cancel" buttons.

- Girder system superstructure
- Girder line superstructure
- Floor system superstructure
- Floor line superstructure
- Truss system superstructure
- Truss line superstructure
- Reinforced concrete slab system superstructure
- Concrete multi-cell box superstructure
- Advanced concrete multi-cell box superstructure



The "Girder Line Superstructure Definition" dialog box has three tabs: "Definition", "Analysis", and "Engine". The "Definition" tab is active. It contains the following fields and options:

- Name:** Slab Girderline
- Description:** (empty text area)
- Deck type:** Concrete (dropdown menu)
- For PS/PT only:** (checkbox, unchecked)
- Average humidity:** (input field, empty) %
- Default units:** US Customary (dropdown menu)
- Reference line length:** (input field, empty) ft
- Live load lanes:** Multi-lane (selected), Single lane (unchecked)
- LRFD fatigue:** Truck lanes: (input field, empty), Override: (checkbox, unchecked), Truck fraction: (input field, empty)
- Member alt. types:** Steel (checkbox, unchecked), P/S (checkbox, unchecked), R/C (checkbox, checked), Timber (checkbox, unchecked), P/T (checkbox, unchecked)

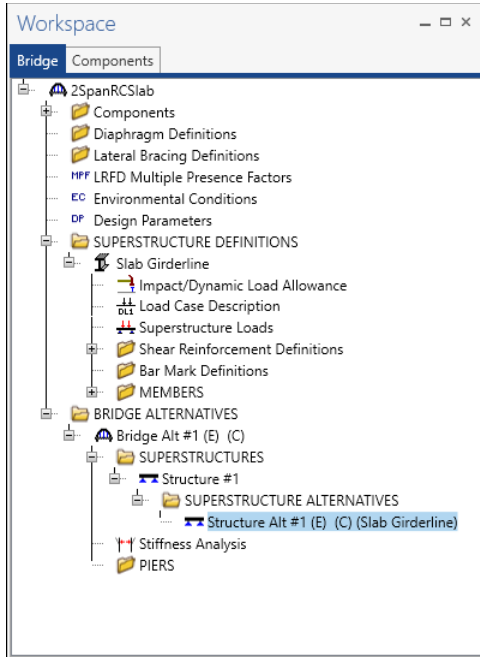
Buttons at the bottom: "OK", "Apply", "Cancel".

Click **OK** to apply the data and close the window.

## RC4 – Two Span RC Concrete Slab

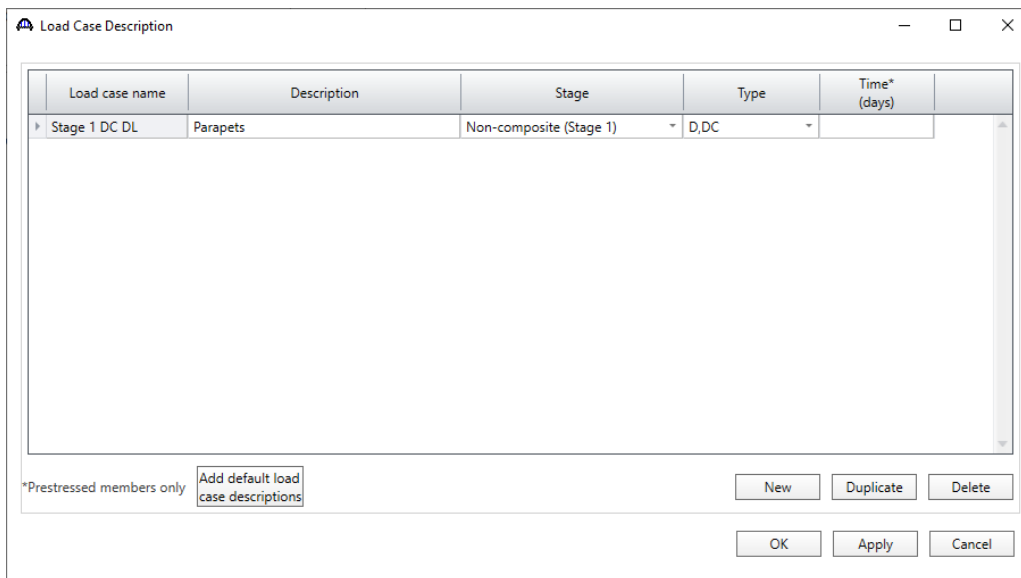
Navigate to the **Bridge Alternatives** node in the **Bridge Workspace** tree and create a new **Bridge Alternative**, a new **Structure**, and a new **Structure Alternative** as shown in **STL1 tutorial**.

The partially expanded **Bridge Workspace** tree is shown below:



### Load Case Description

Double click on the **Load Case Description** node in the Bridge Workspace tree to open the **Load Case Description** window and define the dead load cases as shown below. The completed **Load Case Description** window is shown below.

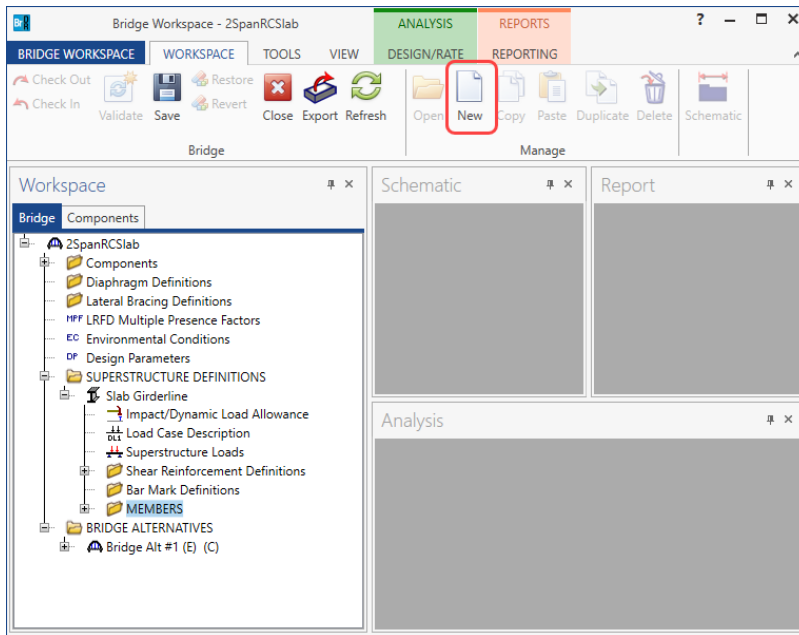


Click **OK** to apply the data and close the window.

## RC4 – Two Span RC Concrete Slab

### Member

Open the **Member** window by selecting **Member** in **Bridge Workspace** tree and click on **New** from the **Manage** tab of the **WORKSPACE** ribbon (or by double clicking on **Member** in bridge workspace tree).



Fill in the window with the following information. If F1 is pressed while this window is active, the Help topic for the Member window will be displayed. This **Help** topic describes that girder spacing, and member location are not required for a slab member, therefore no data will be entered for those items.

The first Member Alternative created will automatically be assigned as the **Existing** and **Current** Member alternative for this Member.

Existing	Current	Member alternative name	Description

Click **OK** to apply the data and close the window.

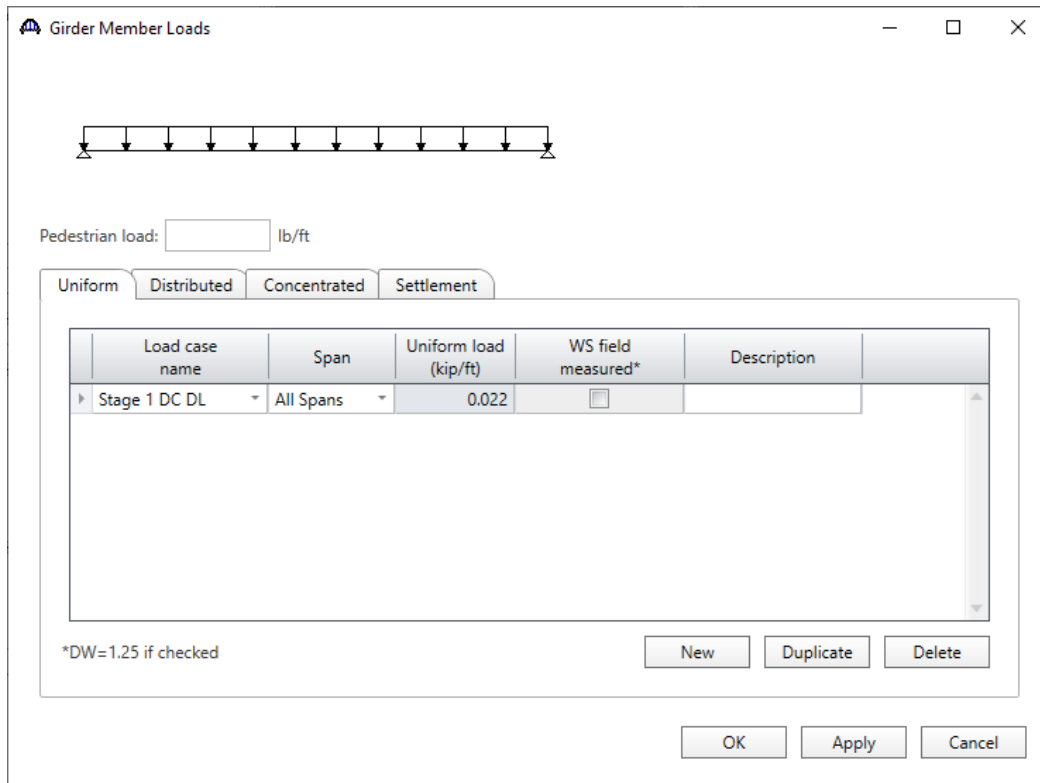


## RC4 – Two Span RC Concrete Slab

### Member Loads

Expand **12” Slabline** in the **Bridge Workspace** tree and double click on **Member Loads** to open the **Girder Member Loads** window. This structure has 2 parapets each weighing 300 lb/ft. A 12” wide strip of slab is defined as the member, and the bridge cross section has a width of 27 ft. So, the parapet load applied to this member will be  $(2 * 300 \text{ lb/ft}) * 1' / 27' = 22 \text{ lb/ft}$ .

Click **New** to add a row in **Uniform** tab of this window and enter the data as shown below:



The screenshot shows the "Girder Member Loads" window. At the top, there is a diagram of a horizontal line with downward-pointing arrows representing a uniform load. Below the diagram is a text input field labeled "Pedestrian load:" followed by a small empty box and the unit "lb/ft".

Below the input field are four tabs: "Uniform", "Distributed", "Concentrated", and "Settlement". The "Uniform" tab is selected.

Under the "Uniform" tab is a table with the following columns: "Load case name", "Span", "Uniform load (kip/ft)", "WS field measured\*", and "Description".

Load case name	Span	Uniform load (kip/ft)	WS field measured*	Description
Stage 1 DC DL	All Spans	0.022	<input type="checkbox"/>	

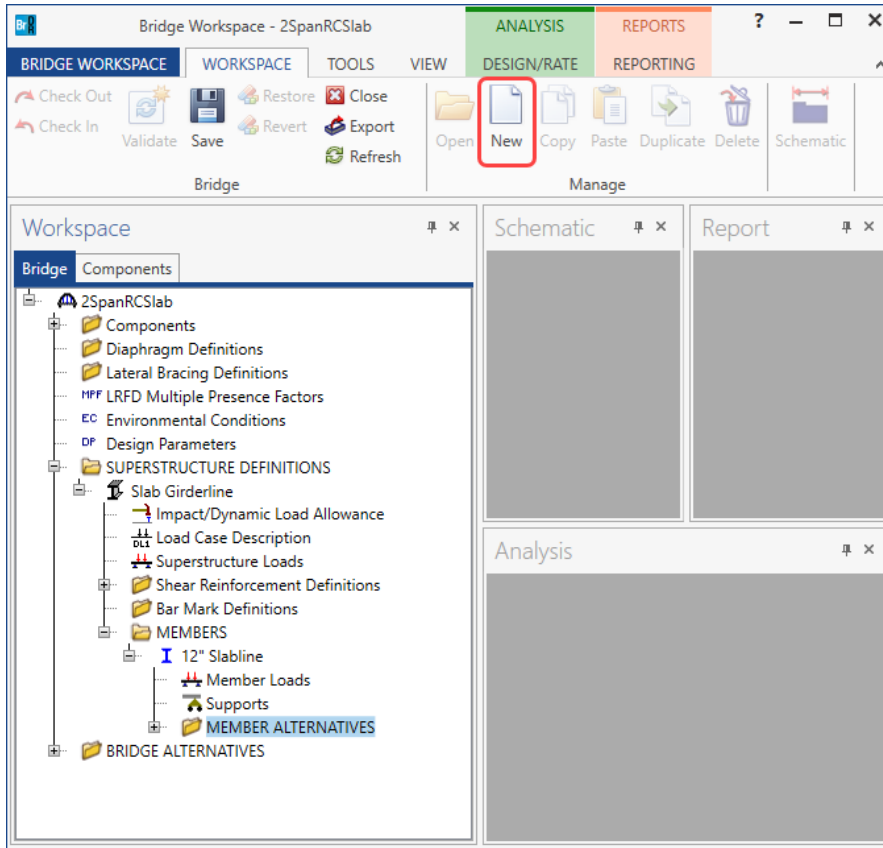
Below the table, there is a note: "\*DW=1.25 if checked". To the right of the table are three buttons: "New", "Duplicate", and "Delete". At the bottom of the window are three buttons: "OK", "Apply", and "Cancel".

Click **OK** to apply the data and close the window.

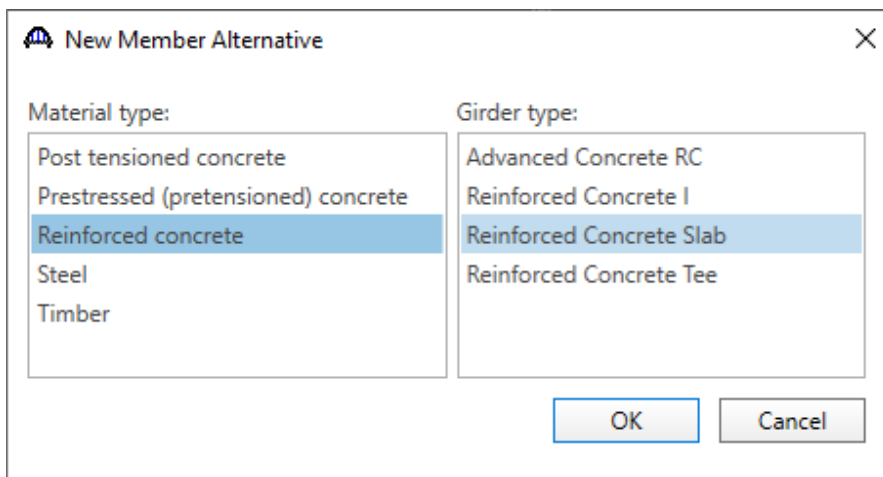
## RC4 – Two Span RC Concrete Slab

### Member Alternative

Select **MEMBER ALTERNATIVES** in the **Bridge Workspace** tree and click on **New** from the **Manage** group of the **WORKSPACE** ribbon (or double-click **MEMBER ALTERNATIVES** in the tree) to create a new alternative.



The New Member Alternative window shown below will open. Select **Reinforced Concrete** for the **Material type**, **Reinforced Concrete Slab** for the **Girder type** and click **OK**.



## RC4 – Two Span RC Concrete Slab

The **Member Alternative Description** window will open. Enter the data as shown below.

Member alternative: 12" wide slab line

Description | Specs | Factors | Engine | Import | Control options

Description:

Material type: Reinforced Concrete  
Girder type: Reinforced Concrete Slab  
Modeling type: Open Girder  
Default units: US Customary

Girder property input method:  
 Schedule based  
 Cross-section based

End bearing locations:  
Left: 6.0000 in  
Right: 6.0000 in

Sustained modular ratio factor:  
2.000

Self load:  
Load case: Engine Assigned  
Additional self load:  kip/ft  
Additional self load:  %

Default rating method: LFR

Crack control parameter (Z):  
Bottom of beam: 170.000 kip/in

Exposure factor:  
Bottom of beam:

OK Apply Cancel

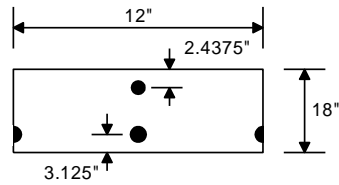
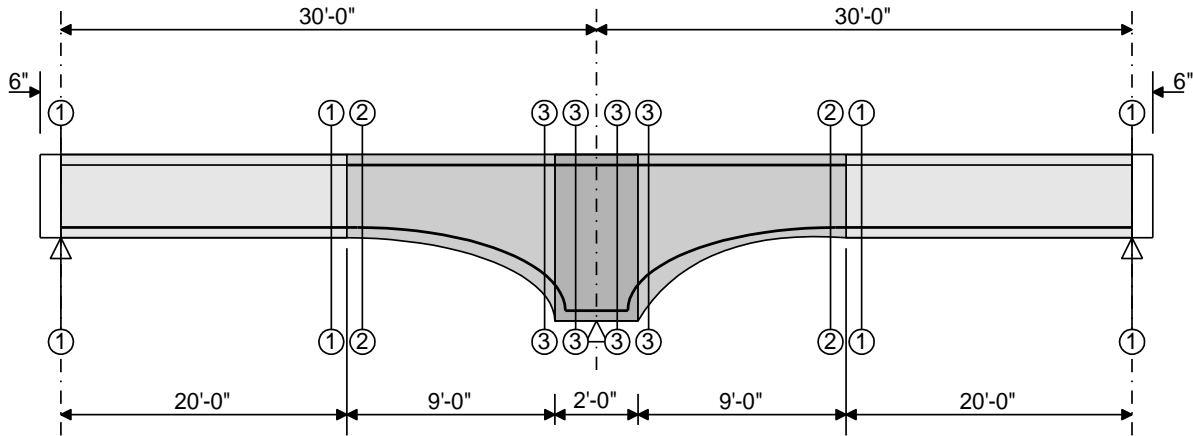
Click **OK** to apply the data and close the window.

# RC4 – Two Span RC Concrete Slab

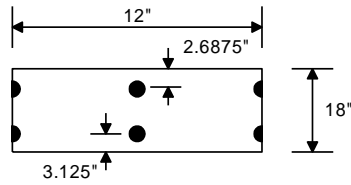
## Cross section based input

### Cross Sections

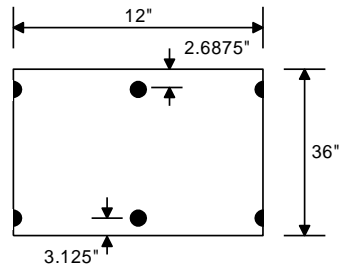
Expand **12" wide slab line (E) (C)** member alternative on the **Bridge workspace** tree and double click on **Cross Sections** to open the **Cross Sections** window and create a new cross section. This member contains three cross sections as illustrated below.



Section 1



Section 2



Section 3

# RC4 – Two Span RC Concrete Slab

Enter each cross-section **Dimensions** and **Reinforcement** data as shown below:

## Section 1

Concrete material: Class A (US)  
Modular ratio:

12.0000 in  
18.0000 in

OK Apply Cancel

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 60	
Bottom of Slab	2.00	2.00	9	3.1250	Grade 60	

New Duplicate Delete

OK Apply Cancel

# RC4 – Two Span RC Concrete Slab

## Section 2:

**Cross Sections**

Name:  Type:

Dimensions Reinforcement

Concrete material:

Modular ratio:

12.0000 in

18.0000 in

OK Apply Cancel

**Cross Sections**

Name:  Type:

Dimensions Reinforcement

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

# RC4 – Two Span RC Concrete Slab

## Section 3:

**Cross Sections**

Name:  Type:

Dimensions Reinforcement

Concrete material:    
 Modular ratio:

12.0000 in  
36.0000 in

**Cross Sections**

Name:  Type:

Dimensions Reinforcement

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	

## RC4 – Two Span RC Concrete Slab

Slab depth varies parabolically over the pier

### Cross Section Ranges

Double click on the **Cross Section Ranges** in the **Bridge Workspace** tree to open the **Cross Section Ranges** window. Apply the cross sections over the length of the member as shown below:

Start section	End section	Web variation	Support number	Start distance (ft)	Length (ft)	End distance (ft)
Section 1	Section 1	None	1	0.000	20.000	20.000
Section 2	Section 3	Parabolic Concave	1	20.000	9.000	29.000
Section 3	Section 3	None	1	29.000	2.000	31.000
Section 3	Section 2	Parabolic Concave	2	1.000	9.000	10.000
Section 3	Section 3	None	2	10.000	20.000	30.000

Click **OK** to apply the data and close the window.

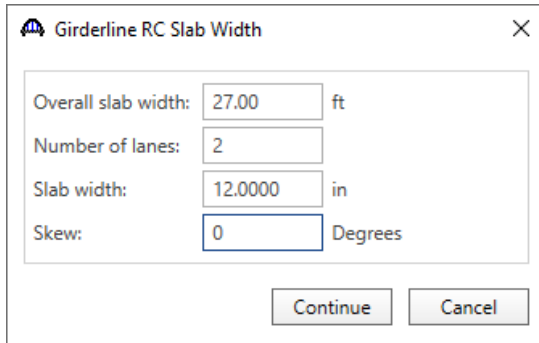
**Shear Reinforcement Ranges** and **Bracing Ranges** are not applicable to this member so no data will be entered in these windows. There is no requirement to define any **points of interest** since none of the information entered will be overridden in this example.



## RC4 – Two Span RC Concrete Slab

### Live Load Distribution

Open the **Live Load Distribution** window from the **Bridge Workspace** tree and go to the **LRFD** tab. Click the **Compute from typical section...** button, enter values as shown below in the pop-up window.



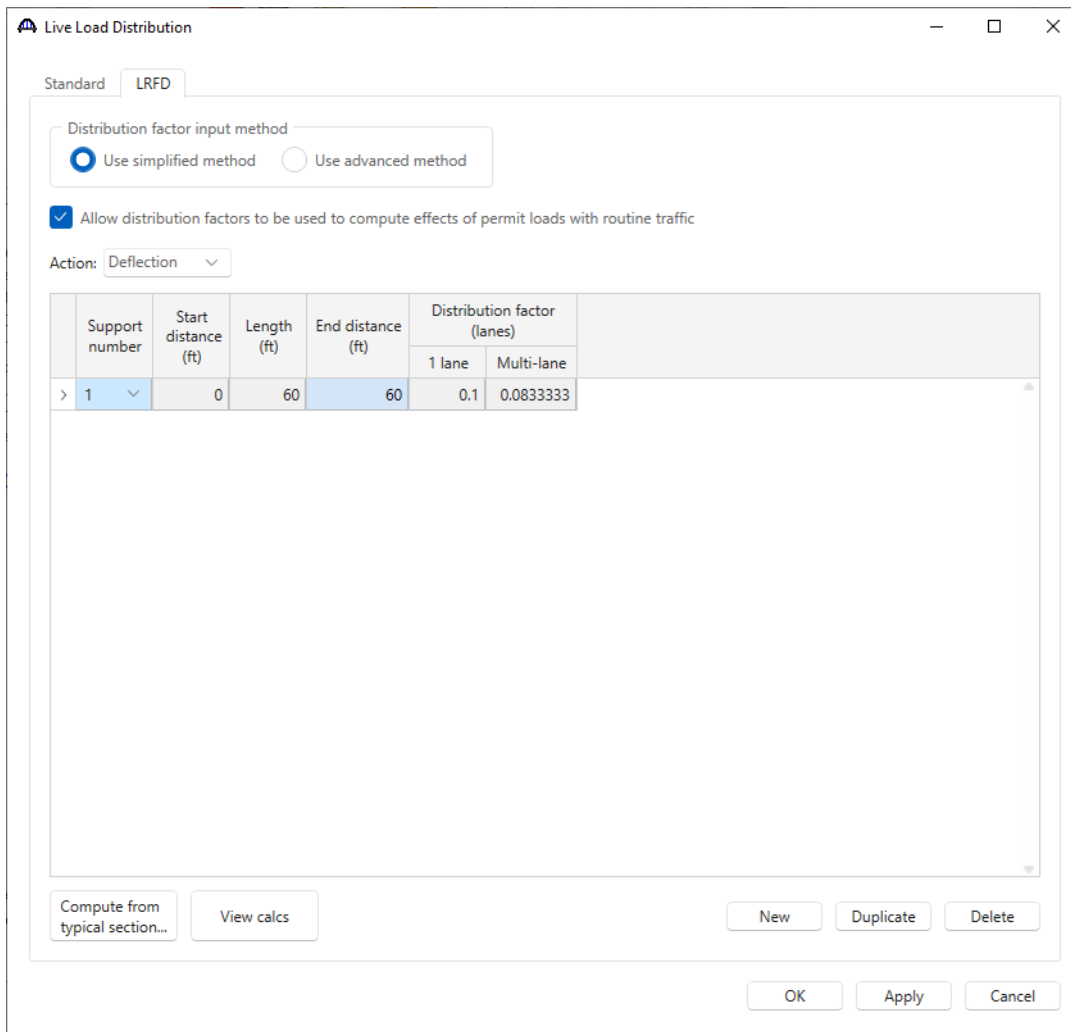
The dialog box titled "Girderline RC Slab Width" contains the following input fields:

- Overall slab width: 27.00 ft
- Number of lanes: 2
- Slab width: 12.0000 in
- Skew: 0 Degrees

Buttons: Continue, Cancel

Click **Continue** to compute the live load distribution factors. Once the Analysis is complete, click the **OK** button in the **LRFD Distribution Factor** Progress window to apply these factors in the Live Load Distribution window.

Deflection distribution factors:



The "Live Load Distribution" window is shown with the "LRFD" tab selected. The "Distribution factor input method" is set to "Use simplified method". The checkbox "Allow distribution factors to be used to compute effects of permit loads with routine traffic" is checked. The "Action" is set to "Deflection".

	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Distribution factor (lanes)	
					1 lane	Multi-lane
>	1	0	60	60	0.1	0.0833333

Buttons: Compute from typical section..., View calcs, New, Duplicate, Delete, OK, Apply, Cancel

# RC4 – Two Span RC Concrete Slab

Moment and shear have the same distribution factors (moment is shown below).

Standard | **LRFD**

Distribution factor input method  
 Use simplified method  Use advanced method

Allow distribution factors to be used to compute effects of permit loads with routine traffic

Action: **Moment** ▾

	Support number	Start distance (ft)	Length (ft)	End distance (ft)	Distribution factor (lanes)	
					1 lane	Multi-lane
	1 ▾	0	30	30	0.0787906	0.096013
	2 ▾	0	30	30	0.0787906	0.096013

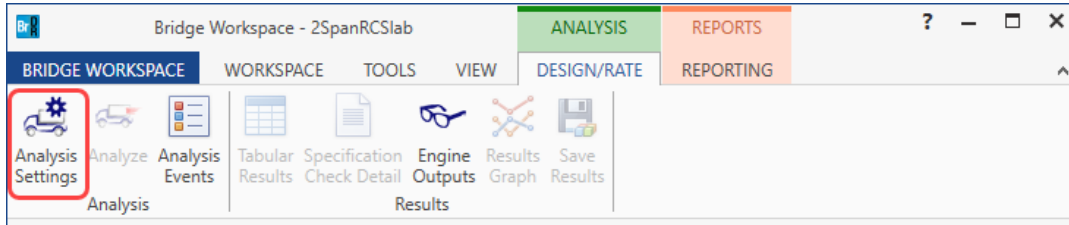
Compute from typical section... | View calcs | New | Duplicate | Delete | OK | Apply | Cancel

The member alternative can now be analyzed.

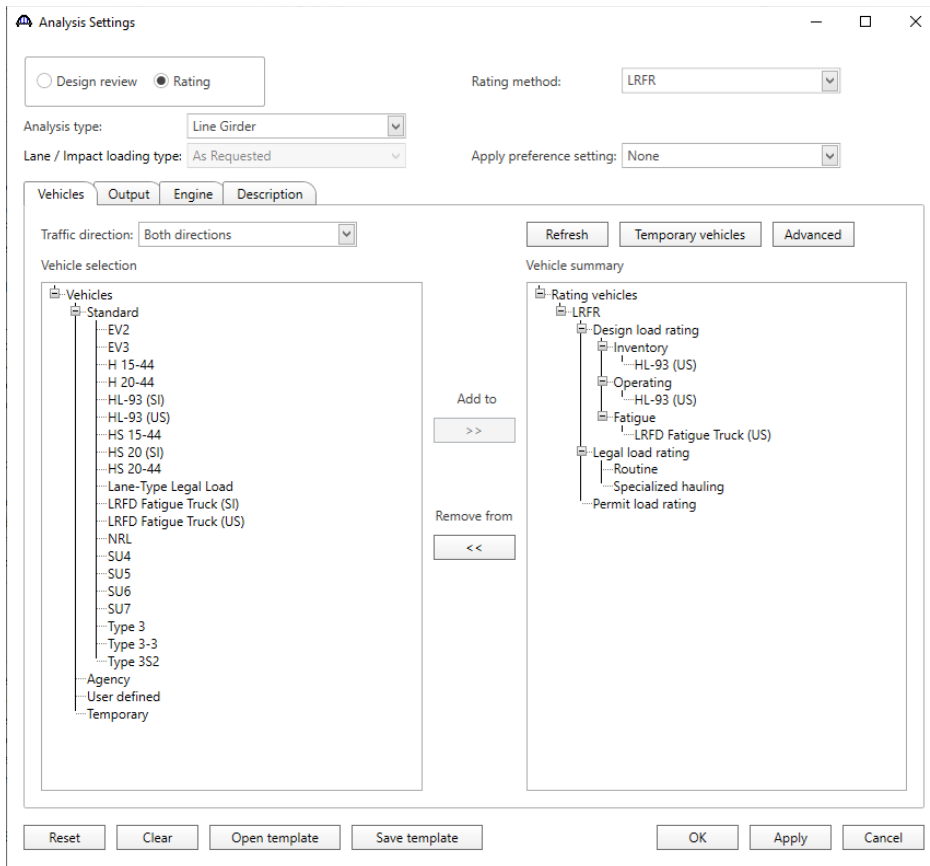
## RC4 – Two Span RC Concrete Slab

### LRFR Rating

To perform an **LRFR** rating, click the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon which opens the **Analysis Settings** window.

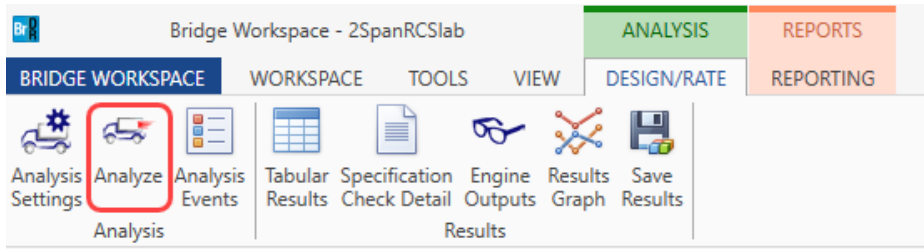


Click the **Open template** button and select the **LRFR Design Load Rating** to be used in the rating and click **OK**. The **Analysis Settings** will be as shown below.



# RC4 – Two Span RC Concrete Slab

Next click the **Analyze** button on the **DESIGN/RATE** ribbon to perform the rating.



## Tabular Results

When the rating is finished you can review the results by clicking the **Tabular Results** button on the **Results** group of the **DESIGN/RATE** ribbon. The window shown below will open.

Analysis Results - 12" wide slab line

Print

Report type: Rating Results Summary

Lane/Impact loading type:  As requested  Detailed

Display Format: Single rating level per row

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	57.85	1.607	20.00	1 - (66.7)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Truck + Lane	LRFR	Operating	74.99	2.083	20.00	1 - (66.7)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Inventory	116.52	3.237	36.00	2 - (20.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	90%(Truck Pair + Lane)	LRFR	Operating	151.05	4.196	36.00	2 - (20.0)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Inventory	56.17	1.560	20.00	1 - (66.7)	STRENGTH-I Concrete Flexure	As Requested	As Requested
HL-93 (US)	Tandem + Lane	LRFR	Operating	72.82	2.023	20.00	1 - (66.7)	STRENGTH-I Concrete Flexure	As Requested	As Requested

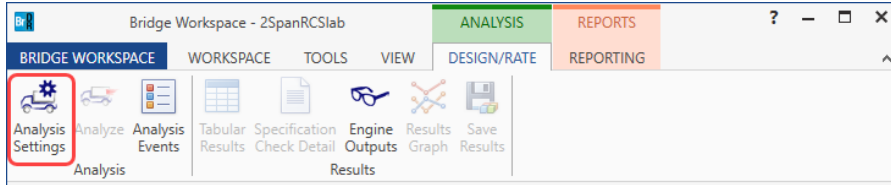
AASHTO LRFR Engine Version 7.5.0.3001  
Analysis preference setting: None

Close

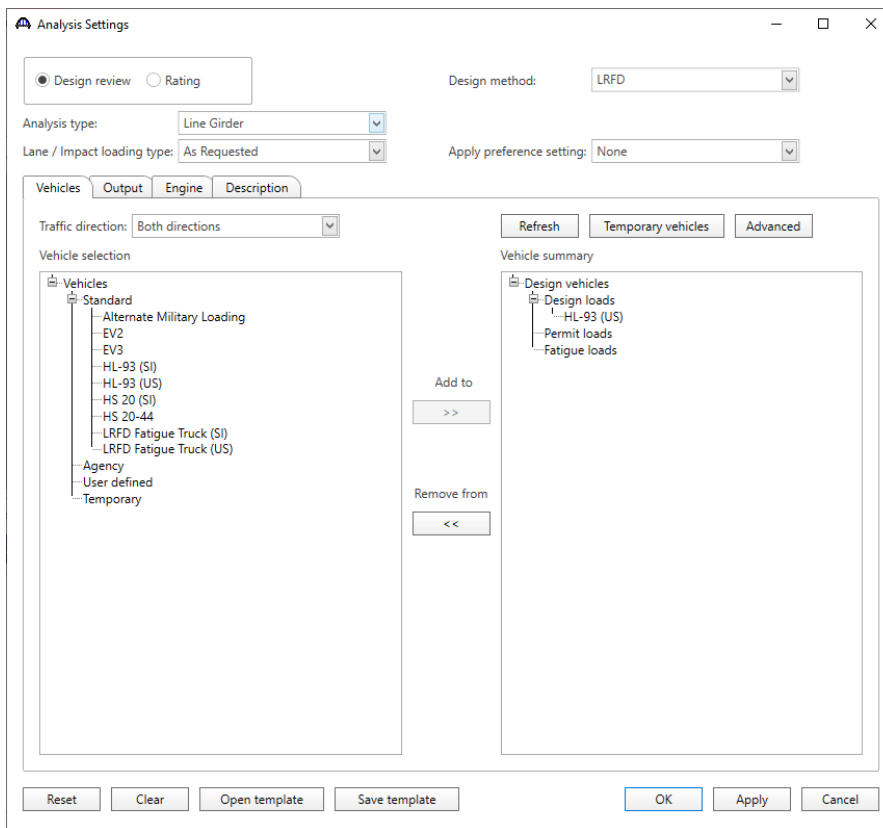
## RC4 – Two Span RC Concrete Slab

### LRFD Design Review

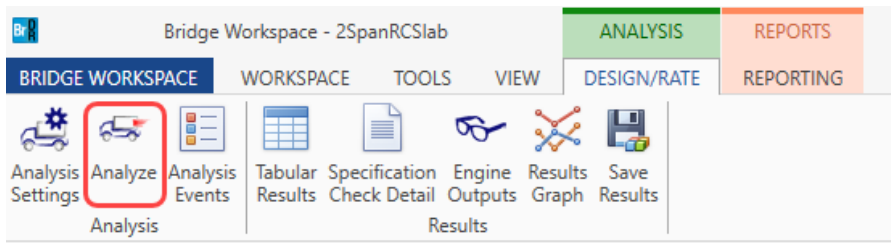
To perform an LRFD design review, click the **Analysis Settings** button on the **Analysis** group of the **DESIGN/RATE** ribbon which opens the **Analysis Settings** window. Note: The **Design review** option is only available if you have a license for the BrD software.



Select the vehicles to be used in the analysis as shown below and click **OK**.




Next click the **Analyze** button on the ribbon to perform the analysis.

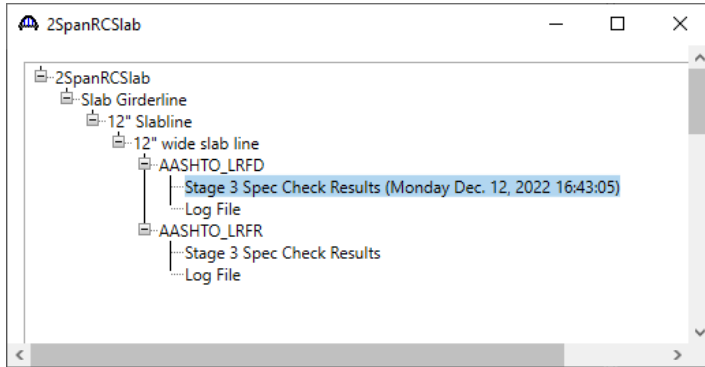


# RC4 – Two Span RC Concrete Slab

## Engine Outputs

The BrDR LRFD analysis will generate a spec check results file. Click the **Engine Outputs** button  on the **Results** group of the **DESIGN/RATE** ribbon to open the following window.

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



The spec check results file will be displayed as shown below.

Bridge ID : 2SpanRCSlab      NBI Structure ID : 2SpanRCSlab  
 Bridge : 2 Span RC Slab      Bridge Alt :  
 Superstructure Def : Slab Girderline  
 Member : 12" Slabline      Member Alt : 12" wide slab line  
 Analysis Preference Setting :

AASHTO LRFD Specification, Edition 9, Interim 0

### Specification Check Summary

Article	Status
Flexure (5.6.3.2, 5.6.3.3)	Pass
Crack Control (5.6.7)	Pass
Shear (5.7.3.3, 5.7.2.5, 5.7.2.6, 5.7.3.5)	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)	Design Ratio Mr/Mu	Code
0.000	STR-I	1	120.79	0.00	99.000	Pass
3.000	STR-I	2	120.79	36.25	3.332	Pass
6.000	STR-I	2	120.79	59.41	2.033	Pass
9.000	STR-I	2	120.79	70.33	1.718	Pass
12.000	STR-I	2	120.79	70.27	1.719	Pass
15.000	STR-I	2	120.79	62.50	1.933	Pass
18.000	STR-I	2	120.79	46.13	2.618	Pass
20.000	STR-I	2	120.70	31.68	3.810	Pass
21.000	STR-I	2	122.75	24.19	5.074	Pass
24.000	FAT-I	4	152.75	8.62	17.723	Pass
27.000	FAT-I	4	218.66	4.40	49.650	Pass
30.000	FAT-I	4	202.70	1.51	99.000	Pass