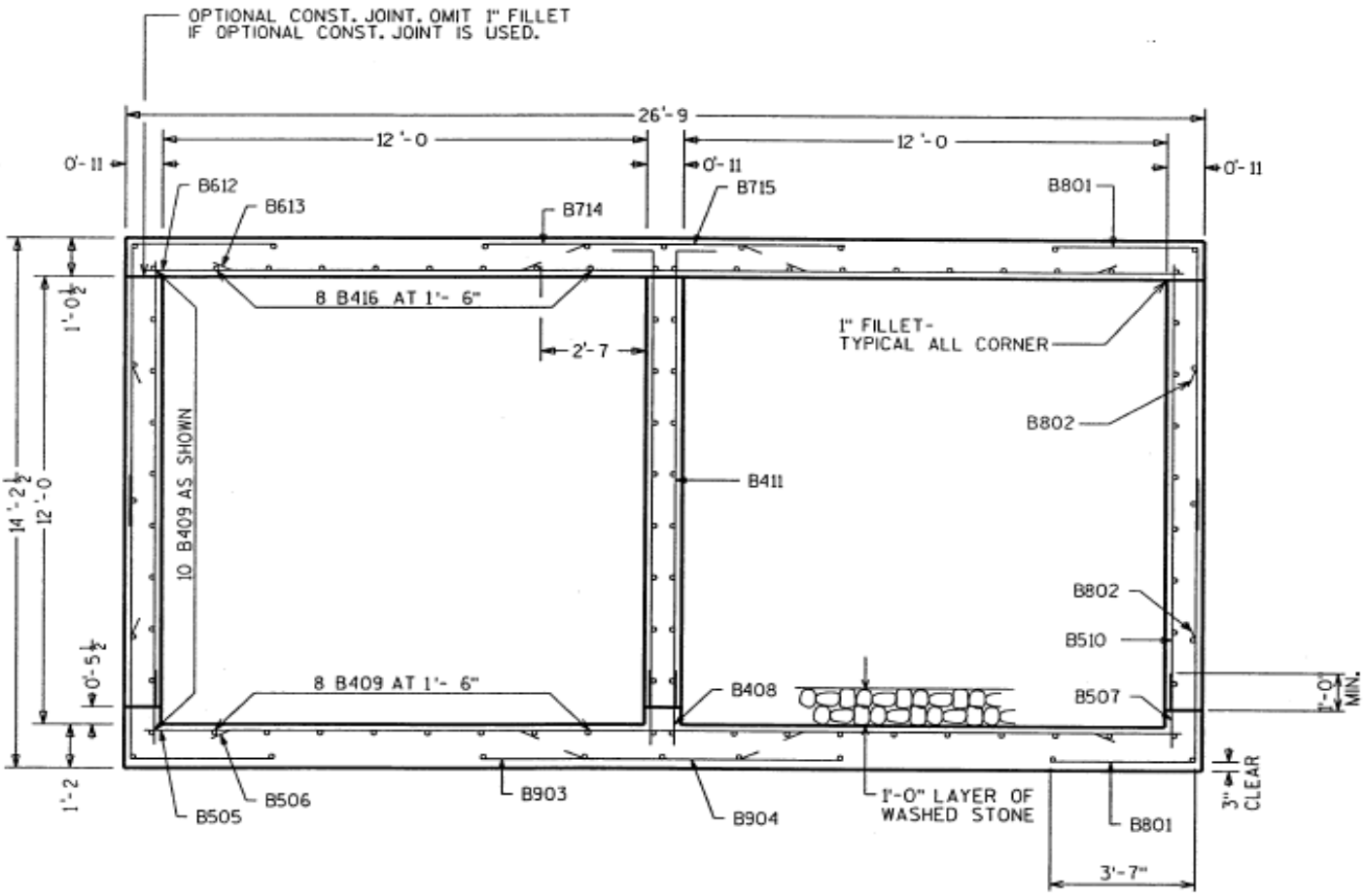
# *CVT1 – Culvert Tutorial*

## *CVT1 – Two Cell RC Box Culvert Example (and Culvert Design Tool)*

# CVT1 – Two Cell RC Box Culvert Example (and Culvert Design Tool)

## Topics Covered

- Enter culvert description
- Perform AASHTO Culvert LRFR analysis and review results
- Culvert Design Tool




TYPICAL SECTION THRU BOX

ALL LONGITUDINAL BARS NOT IDENTIFIED ARE B409 AS SHOWN.

## BILL OF BARS

THE FIRST OR FIRST AND SECOND DIGIT OF THE MARK SIGNIFIES THE BAR SIZE.
THE DIMENSION IN THE BENT COLUMN IS THE OUT TO OUT HORIZONTAL LEG OF A "L" SHAPED BAR.

| | MARK | NUMBER REQ'D. | LENGTH | BENT | CUTTING DIAG. | LOCATION |
|---|---|---|---|---|---|---|
| ⚠ | B801 | 416 | 11 -2 | 3-7 | NO | CORNERS |
| ⚠ | B802 | 400 | 7-4 | 3-7 | NO | CORNERS |
| ⚠ | B903 | 76 | 9-0 | NO | NO | BOTTOM SLAB TRANS. |
| ⚠ | B904 | 72 | 4-10 | NO | NO | BOTTOM SLAB TRANS. |
| ⚠ | B505 | 124 | 25-10 | NO | NO | BOTTOM SLAB TRANS. |
| ⚠ | B506 | 240 | 8-2 | NO | NO | BOTTOM SLAB TRANS. |
| | B507 | 296 | 2-0 | NO | NO | WALLS-DOWELS VERT. |
| | B408 | 136 | 2-0 | NO | NO | WALLS-DOWELS VERT. |
| | B409 | 320 | 33-0 | NO | NO | TOP&BOTTOM SLAB & WALL |
| | B510 | 296 | 12 -4 | NO | NO | WALLS VERT. |
| | B411 | 136 | 13 -4 | 1-0 | NO | WALLS VERT. |
| ⚠ | B612 | 84 | 25-10 | NO | NO | TOP SLAB TRANS. |
| ⚠ | B613 | 160 | 8-2 | NO | NO | TOP SLAB TRANS. |
| ⚠ | B714 | 116 | 9-0 | NO | NO | TOP SLAB TRANS. |
| ⚠ | B715 | 112 | 4-10 | NO | NO | TOP SLAB TRANS. |
| | B416 | 64 | 33-0 | NO | NO | TOP SLAB LONGIT. |
| | B417 | 4 | 26-4 | NO | NO | HEADERS HORIZ. |
| | B318 | 72 | 3-1 | YES | NO | HEADER STIRRUPS VERT. |
| | B519 | 267 | 4-0 | NO | NO | VERT.CONST.JOINT |
| | | | | | | |
| | | | | | | |

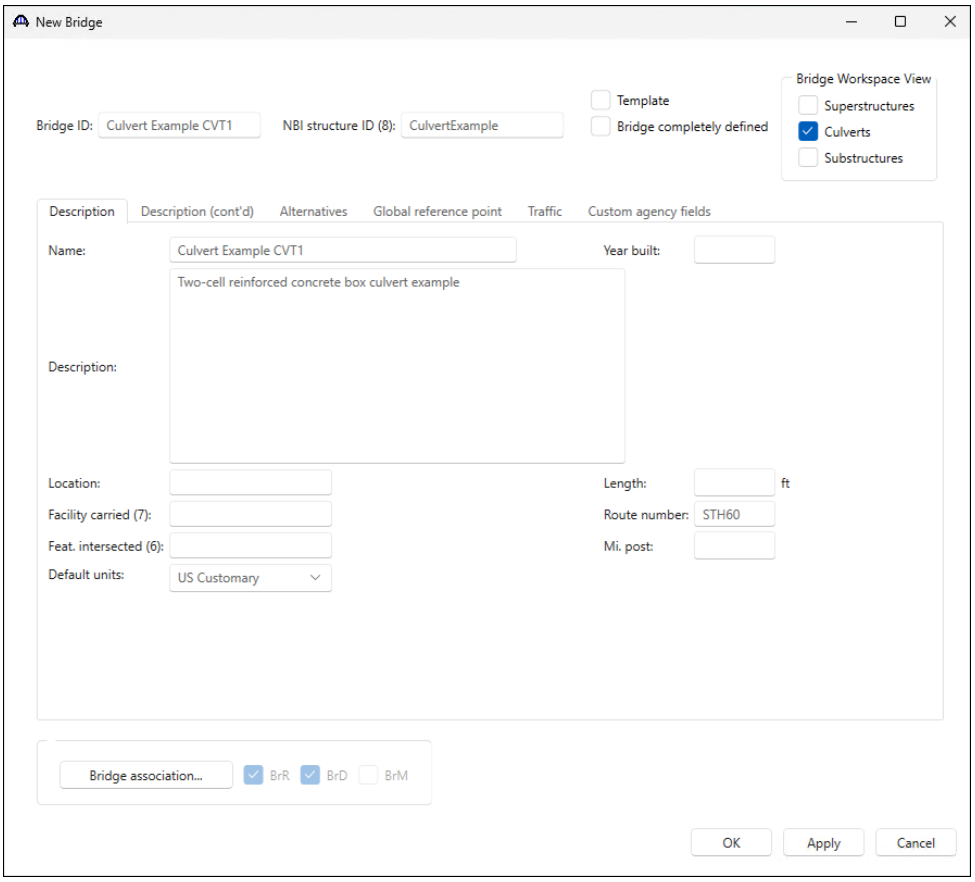
⚠ B801 BARS MAY BE SUBSTITUTED FOR B802 BARS
B903 BARS MAY BE SUBSTITUTED FOR B904 BARS
B505 BARS MAY BE SUBSTITUTED FOR PAIRS OF B506 BARS
B612 BARS MAY BE SUBSTITUTED FOR PAIRS OF B613 BARS
B714 BARS MAY BE SUBSTITUTED FOR B715 BARS.

Material Properties:

- Culvert concrete – Class A, f'c = 3.5 ksi
- Reinforcing steel – Grade 60, Fy = 60 ksi
- Soil – 120 pcf, $\phi$ = 30 deg

## Enter culvert description

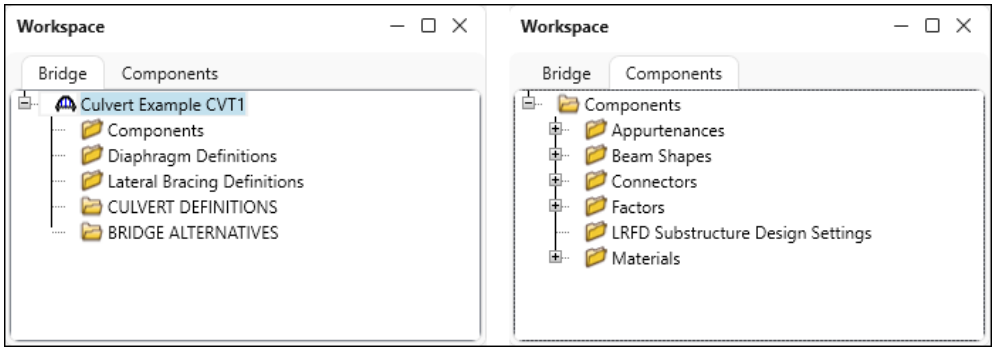
From the **Bridge Explorer** create a **new bridge** and enter the following description data.




The **Superstructures** and **Culverts** checkboxes specify the types of structures the bridge contains. These checkboxes filter what to display in the **Bridge Workspace** tree.

Close the window by clicking **OK**.

After the bridge is created, the **Bridge Workspace** tree and **Components** tree are as shown below.

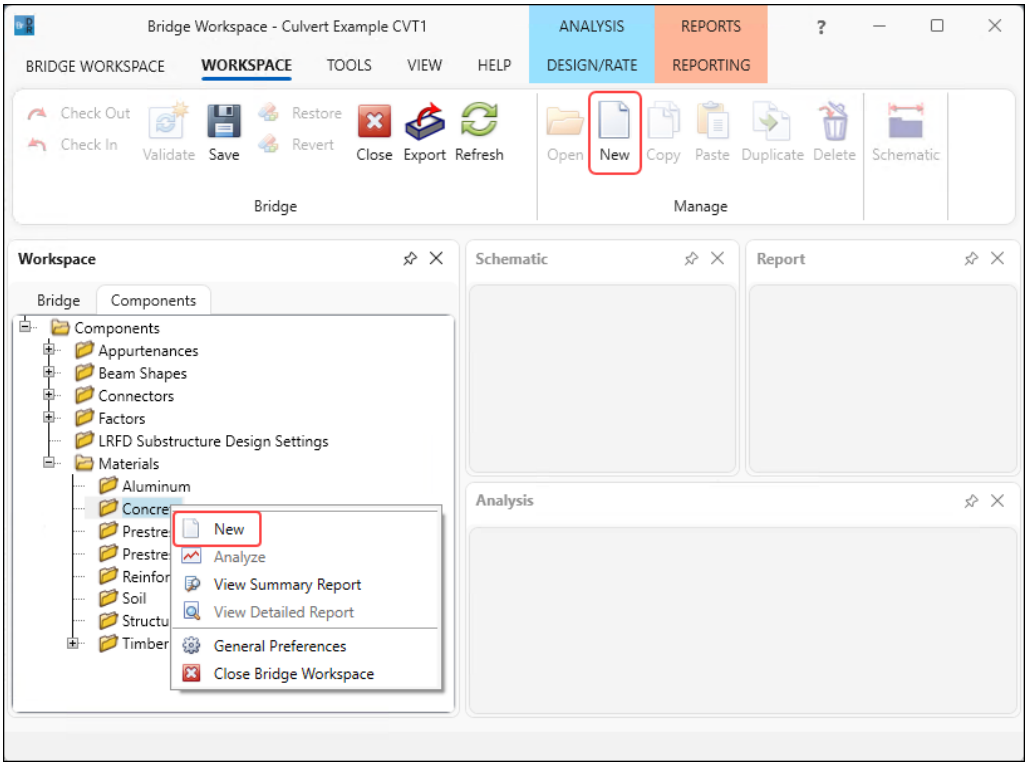


The **Bridge Workspace** tree is organized according to the definition of a bridge with data shared by many of the bridge components shown in the **Components** tab. A bridge can be described by working from top to bottom within the tree.

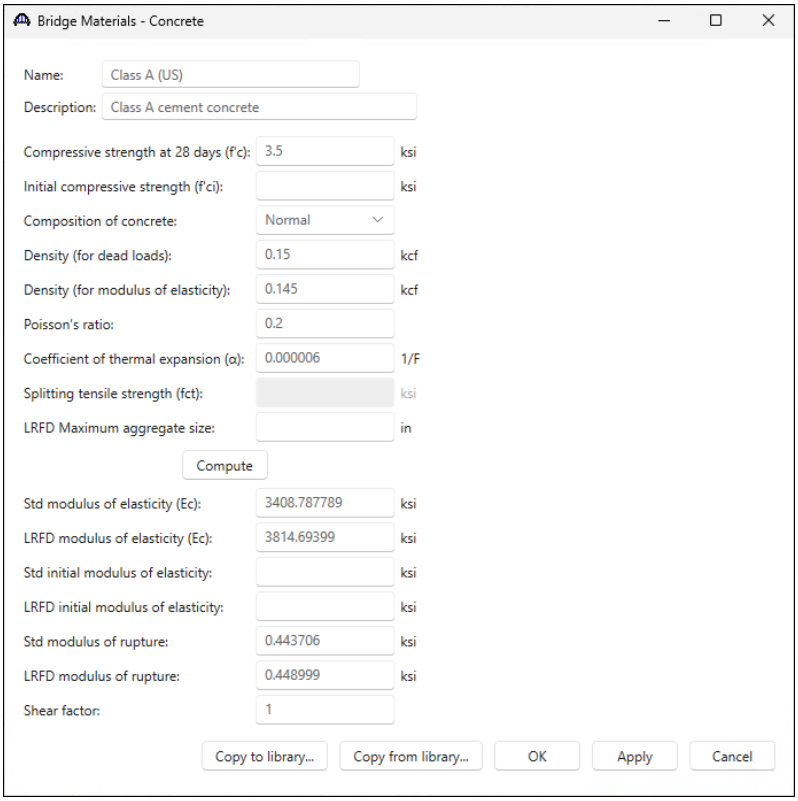
## Bridge Materials

To enter the materials for the culvert, in the **Components** tab, expand the tree for **Materials**.

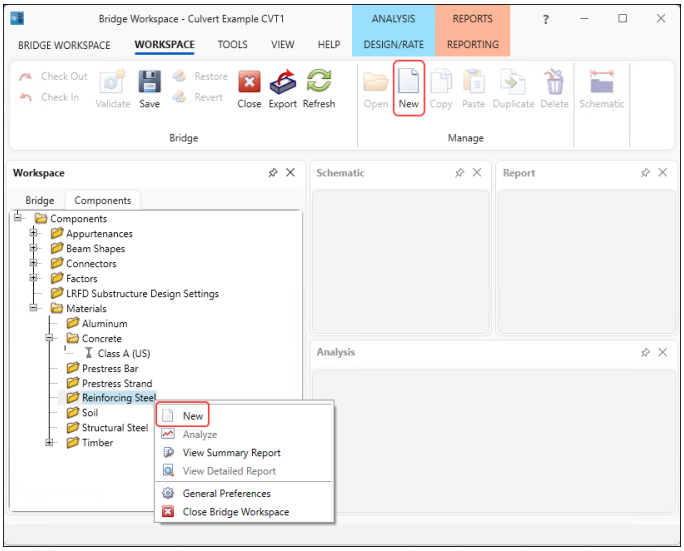
To add a concrete material, double-click on the **Concrete** folder in the **Components tab** (or select **Concrete** and click on the **New** button from the **Manage** group of the **WORKSPACE** ribbon or right click and select **New**) to create a new concrete material as shown below.



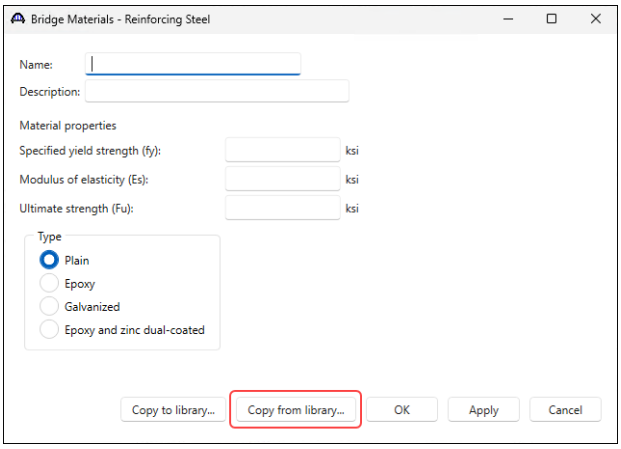
On the **Bridge Materials**-Concrete window, enter the values shown above the **Compute** button and click the **Compute** button to calculate the remaining values (**Class A(US)** in the library is slightly different from the values shown below).

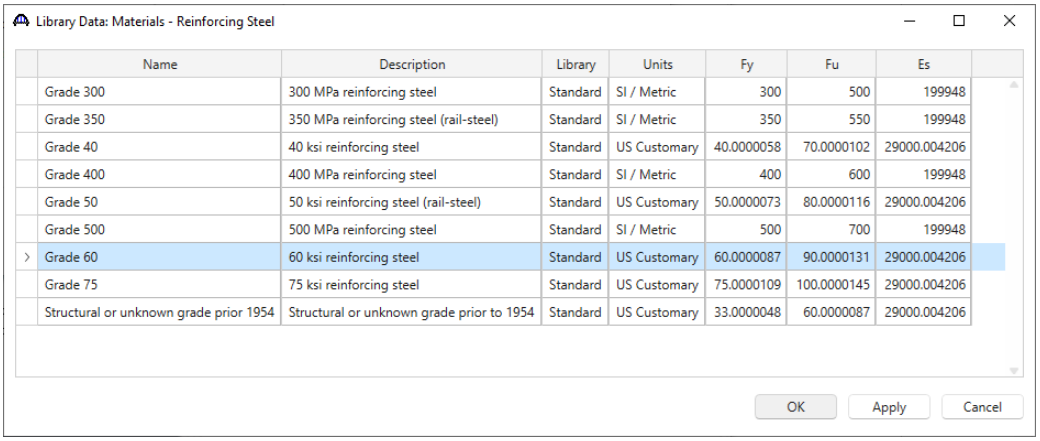



To add a reinforcing steel material, double-click on the **Reinforcing Steel** folder in the **Components** tab (or select **Reinforcing Steel** and click on the **New** button from the **Manage** group of the **WORKSPACE** ribbon or right click and select **New**) to create a new reinforcing steel material as shown below.

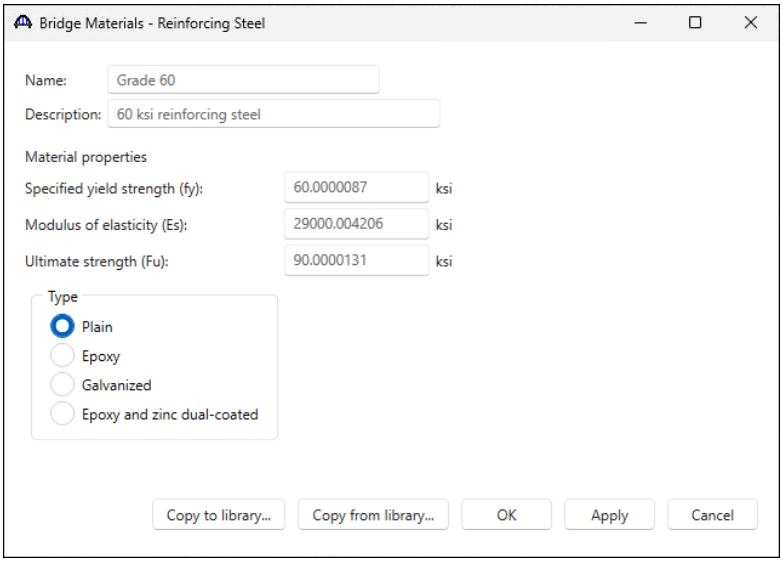


On the **Bridge Materials-Reinforcing Steel** window, **click** on the **Copy from library…** button and copy the **Grade 60** reinforcing steel to be used in the bridge as shown below.



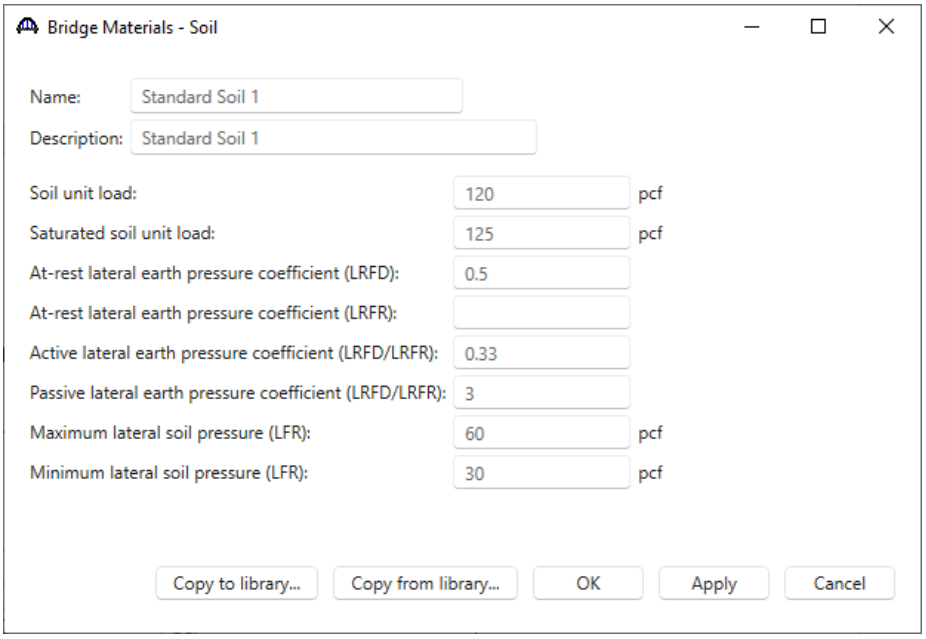




The **Bridge Materials – Reinforcing Steel** window will be updated with material information as shown below.



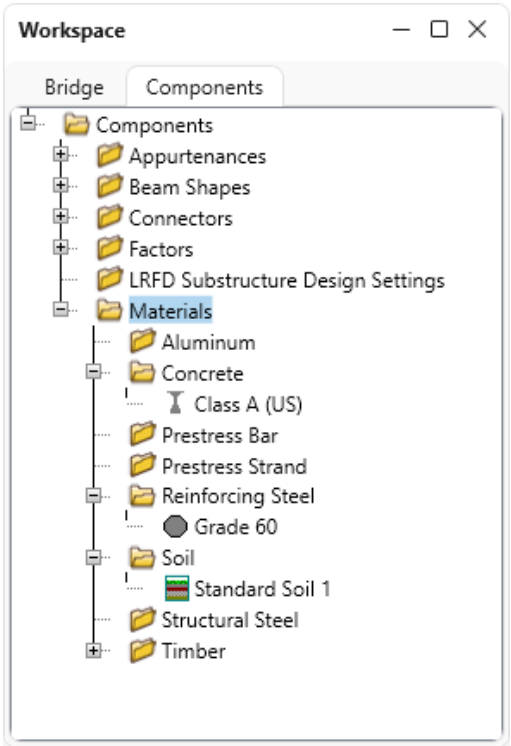

Click **OK** to add the reinforcing steel material and close the window.

Similarly, add a new soil material by copying the **Standard Soil 1** from the library. The **Bridge Materials – Soil** window with material information updated is shown below.



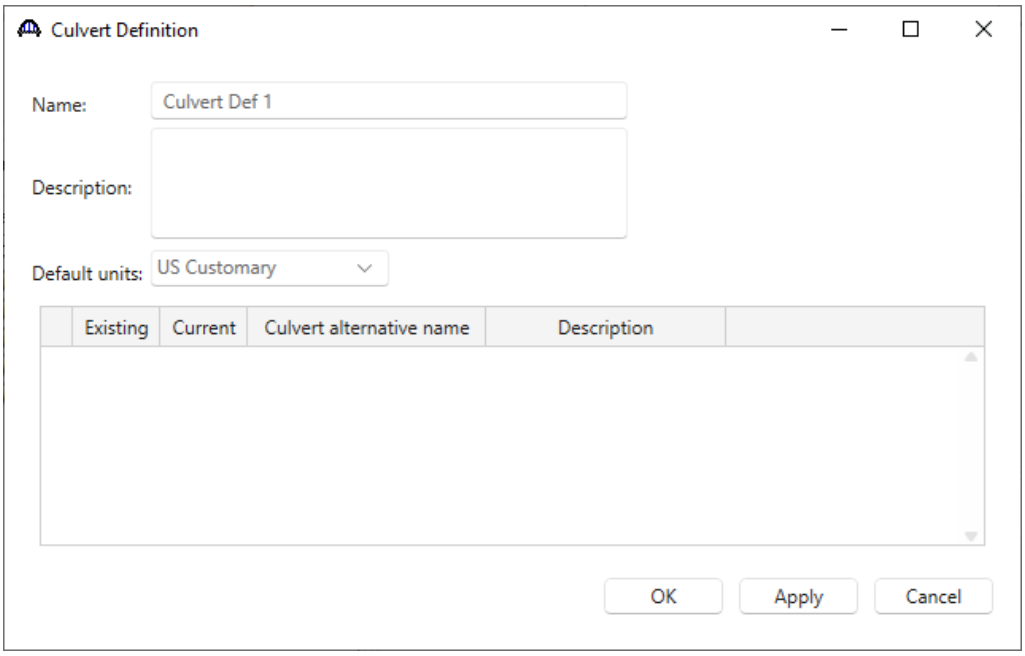

Click **OK** to add the soil material and close the window.

The **Components** tree updated with the three materials to be used by the culvert is shown below.



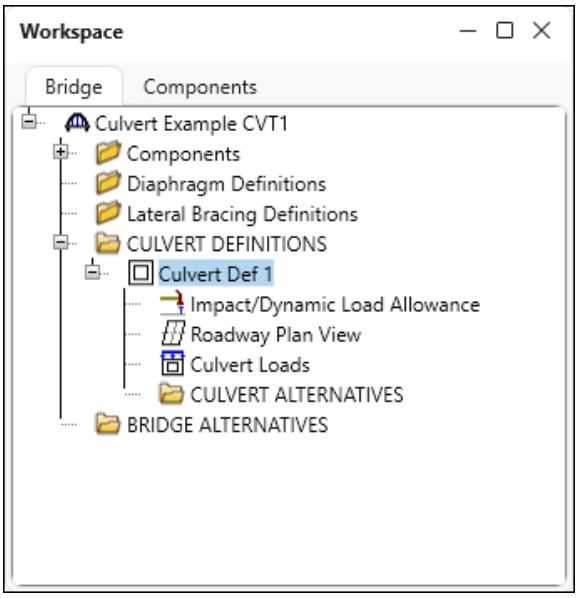
## Culvert Definition

Navigate to the **Bridge** tab of the **Bridge Workspace**. Double click on the **CULVERT DEFINITIONS** folder to create a new culvert definition. Enter the Culvert Definition **Name** as show below. The first Culvert Alternative added will automatically be assigned as the **Existing** and **Current** Culvert Alternative for this Culvert Definition.



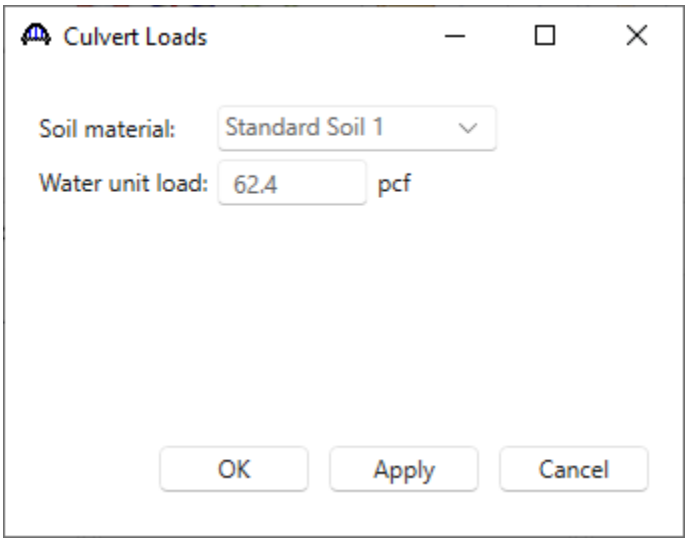

Click **OK** to apply the data and close the window.

Click on the + button of the newly added culvert definition to expand the culvert definition tree as shown below.



### Culvert Loads

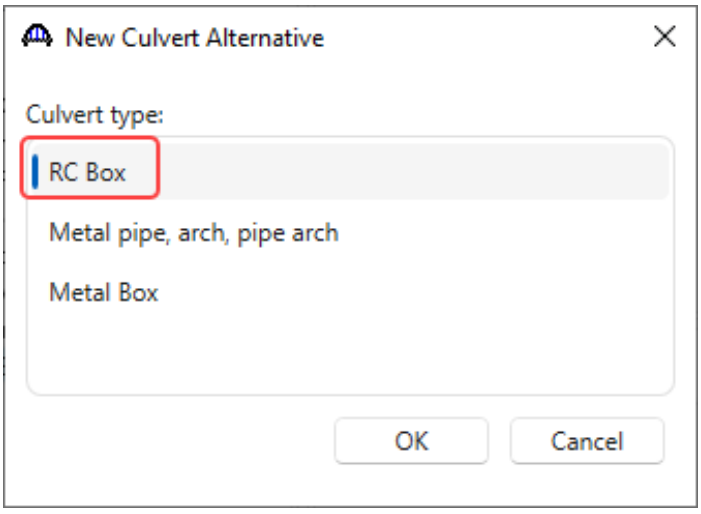
Double-click on the **Culvert Loads** node to open the **Culvert Loads** window. For this example, the default values specified in this window will be used. No change is required.



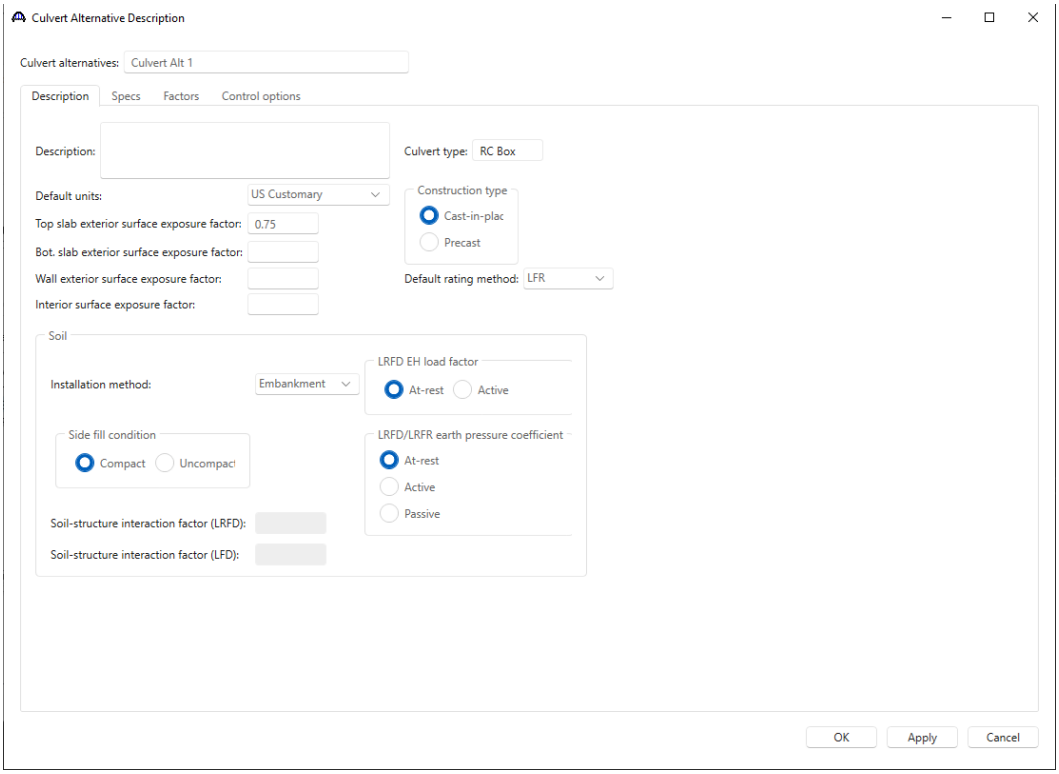

Click **OK** to close the window.

### Culvert Alternative

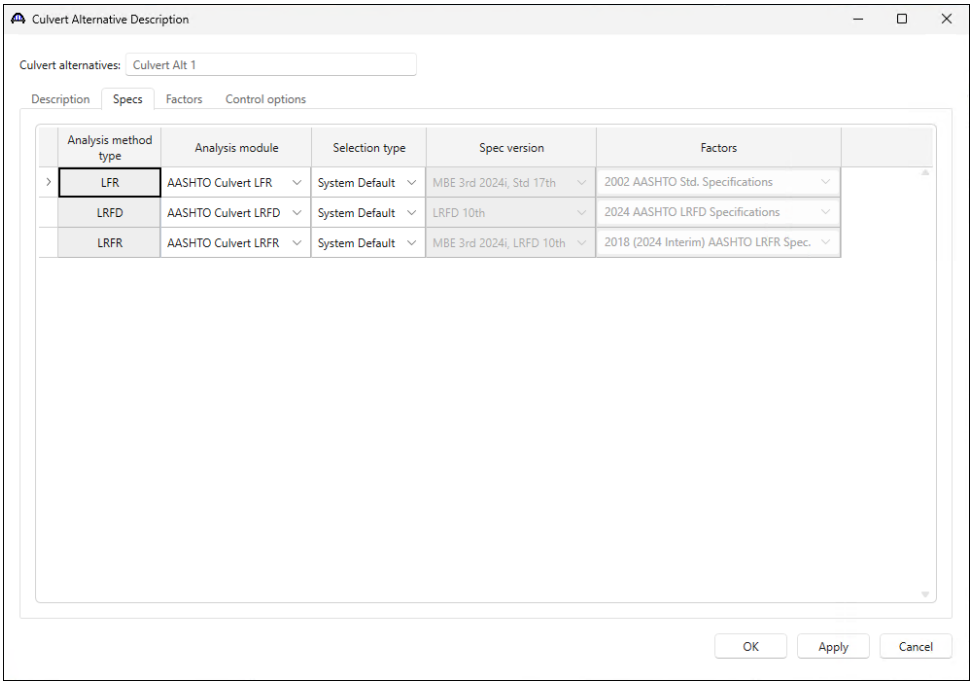
Double-click on the **CULVERT ALTERNATIVES** folder to create a new culvert alternative for **Culvert Def 1**. Select **RC Box** in the **New Culvert Alternative** window and click **OK** to open the **Culvert Alternative Description** window as shown below.



In the **Culvert Alternative Description** window, enter the data as shown below.

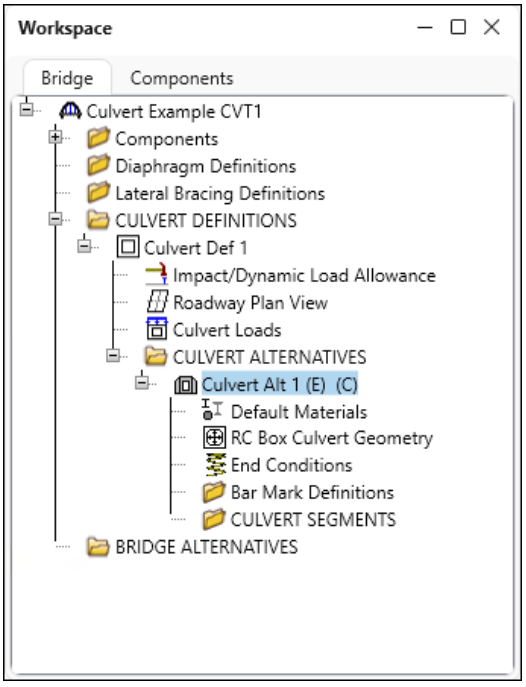


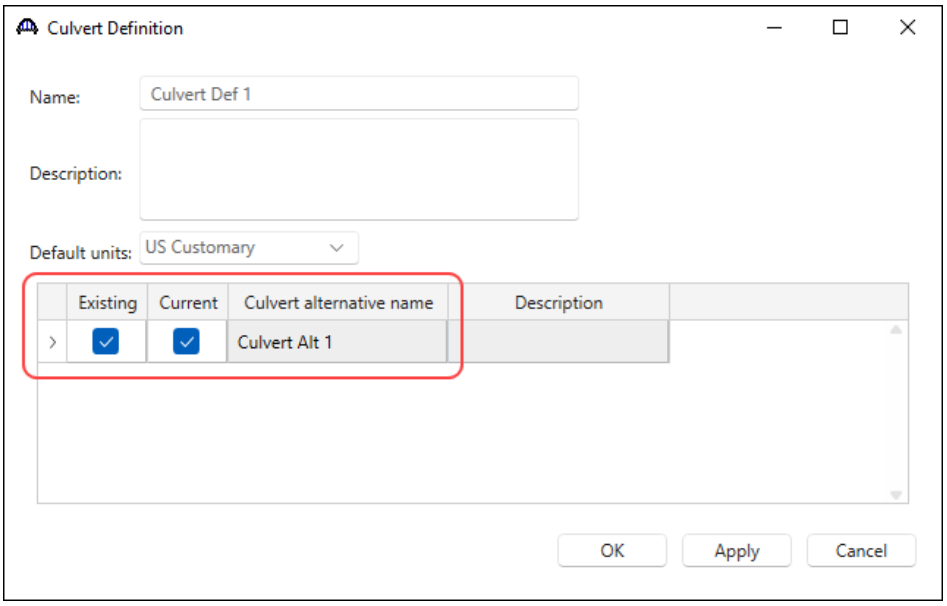

Navigate to the **Specs** tab of this window. **AASHTO Culvert LRFR** is selected as the analysis module for **LRFR** analysis.




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

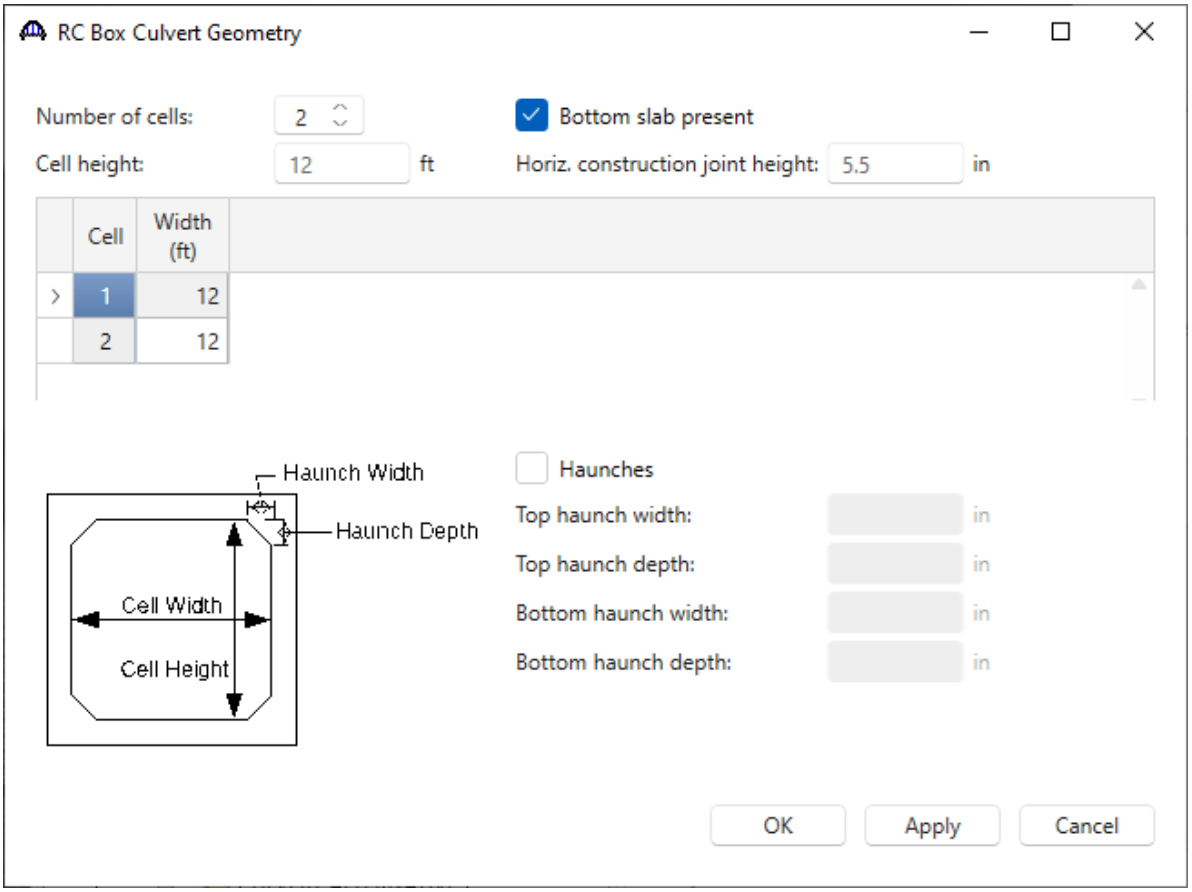
The expanded tree for **Culvert Alt 1** is shown below. Note that the **Culvert Alt 1** is automatically assigned as the **Existing** and **Current** alternative shown by the **(E)** and **(C)** in the name. This culvert alternative is also updated as **Existing** and **Current** alternative in the **Culvert Definition** window as shown below.



## RC Box Culvert Geometry

Double-click on the **RC Box Culvert Geometry** node in the **Bridge Workspace** tree. Enter the data as shown below.

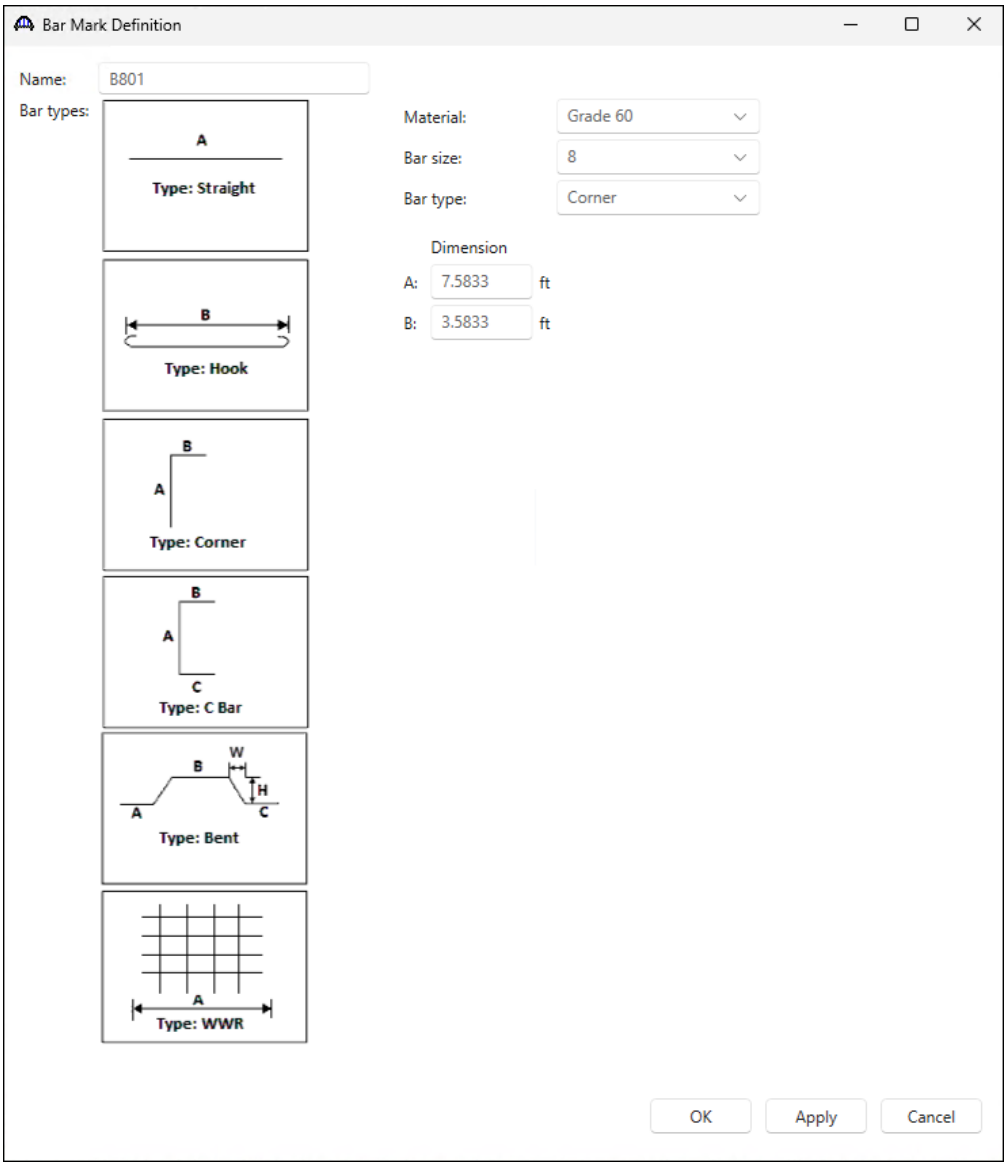



Click **OK** to apply the data and close the window.

## Bar Mark Definitions

Double-click on the **Bar Mark Definitions** folder in the **Bridge Workspace** tree to create a new bar mark definition for **Culvert Alt 1**. Enter the data for B801 as shown below.

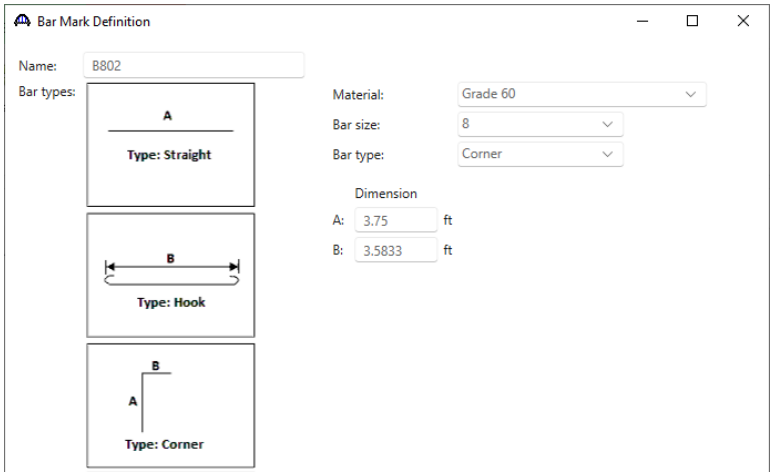
| MARK | NUMBER REQ'D. | LENGTH | BENT | CUTTING DIAG. | LOCATION |
|---|---|---|---|---|---|
| B801 | 416 | 11 -2 | 3-7 | NO | CORNERS |



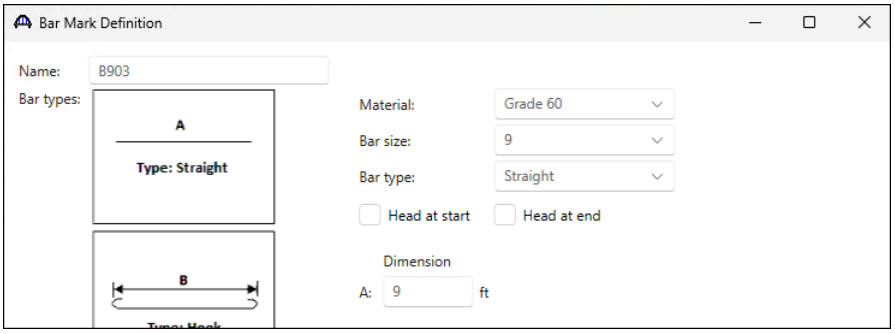

Click **OK** to apply the data and close the window.

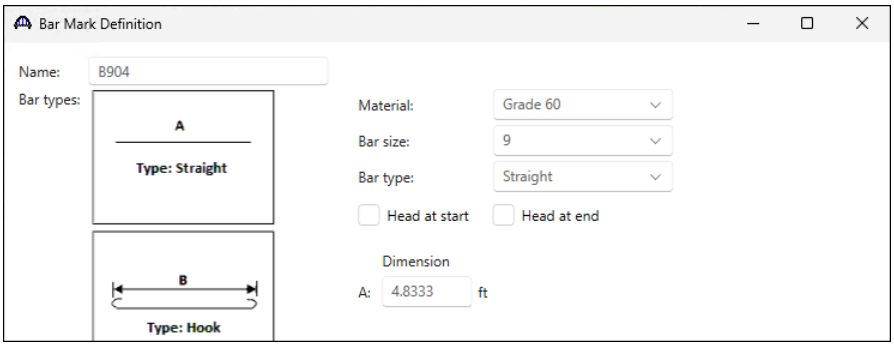
Repeat this process and add the following transverse bar mark definitions.

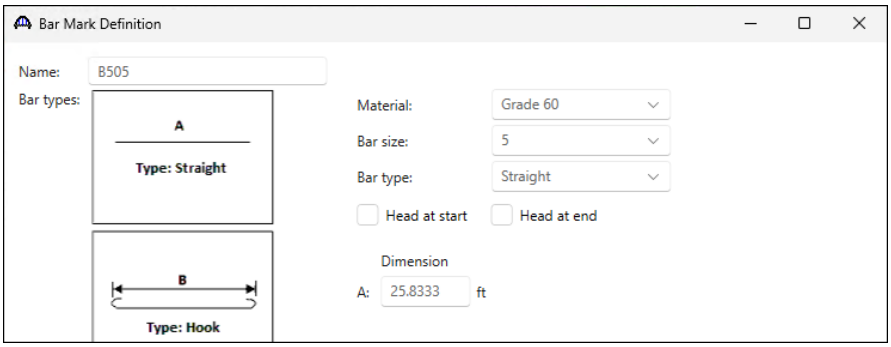
| MARK | NUMBER REQ'D. | LENGTH | BENT | CUTTING DIAG. | LOCATION |
|---|---|---|---|---|---|
| B802 | 400 | 7-4 | 3-7 | NO | CORNERS |

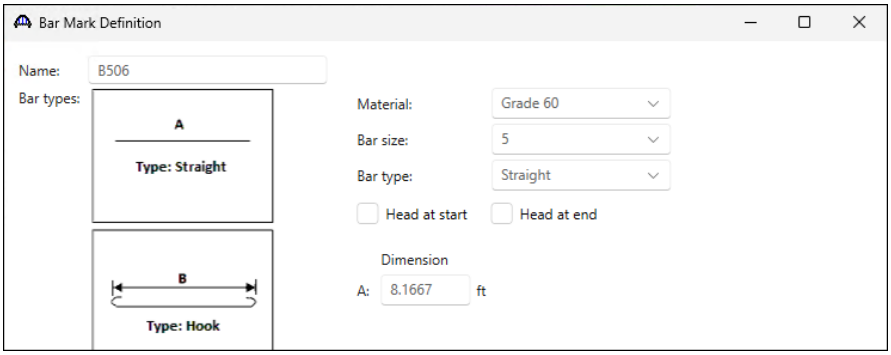


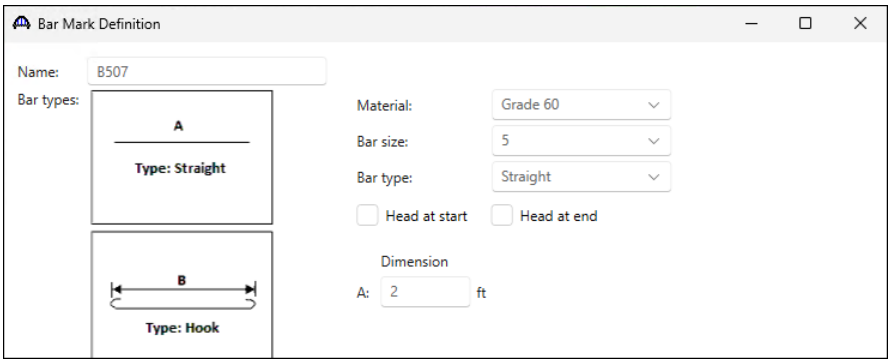

| MARK | NUMBER REQ'D. | LENGTH | BENT | CUTTING DIAG. | LOCATION |
|---|---|---|---|---|---|
| B903 | 76 | 9-0 | NO | NO | BOTTOM SLAB TRANS. |
| B904 | 72 | 4-10 | NO | NO | BOTTOM SLAB TRANS. |
| B505 | 124 | 25-10 | NO | NO | BOTTOM SLAB TRANS. |
| B506 | 240 | 8-2 | NO | NO | BOTTOM SLAB TRANS. |
| B507 | 296 | 2-0 | NO | NO | WALLS-DOWELS VERT. |
| B408 | 136 | 2-0 | NO | NO | WALLS-DOWELS VERT. |
| B510 | 296 | 12-4 | NO | NO | WALLS VERT. |
| B411 | 136 | 13-4 | 1-0 | NO | WALLS VERT. |
| B612 | 84 | 25-10 | NO | NO | TOP SLAB TRANS. |
| B613 | 160 | 8-2 | NO | NO | TOP SLAB TRANS. |
| B714 | 116 | 9-0 | NO | NO | TOP SLAB TRANS. |
| B715 | 112 | 4-10 | NO | NO | TOP SLAB TRANS. |

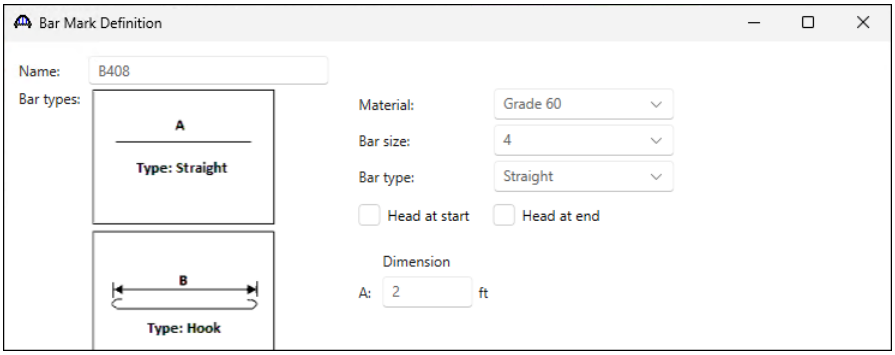


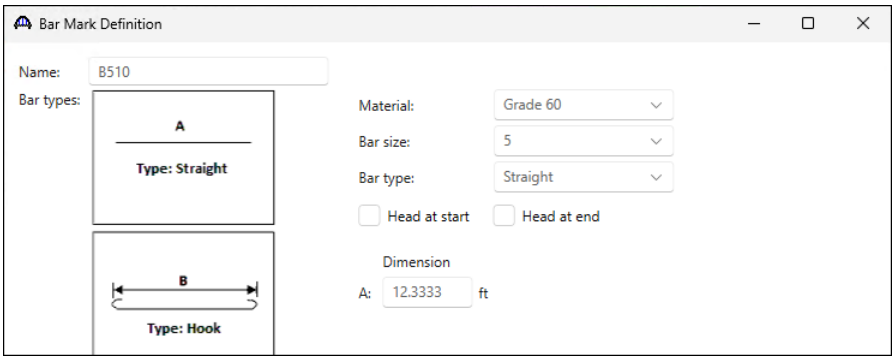

Bar Mark Definition
Name: B904
Bar types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 9
Bar type: Straight
Head at start
Head at end
Dimension
A: 4.8333 ft

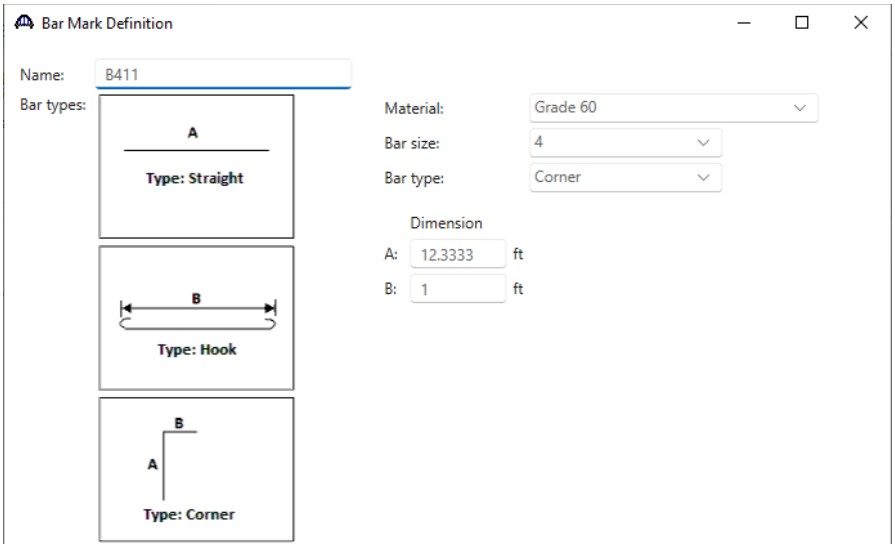

Bar Mark Definition
Name: B505
Bar types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 5
Bar type: Straight
Head at start
Head at end
Dimension
A: 25.8333 ft

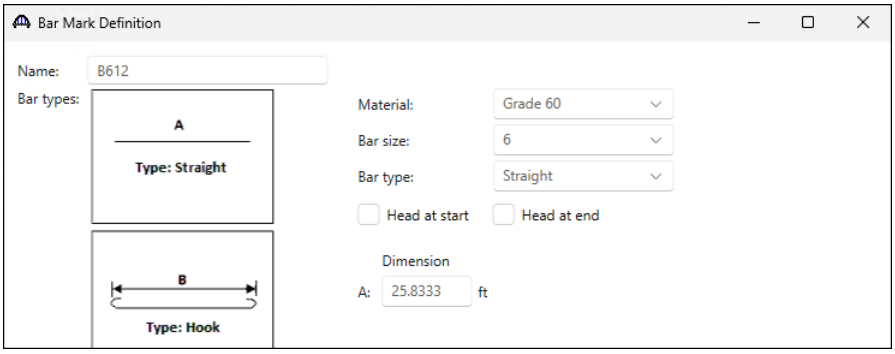

Bar Mark Definition
Name: B506
Bar types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 5
Bar type: Straight
Head at start
Head at end
Dimension
A: 8.1667 ft

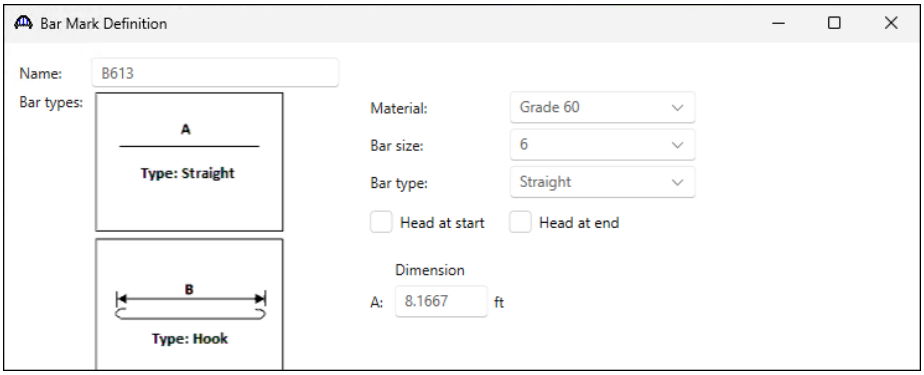

Bar Mark Definition
Name: B507
Bar types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 5
Bar type: Straight
Head at start
Head at end
Dimension
A: 2 ft

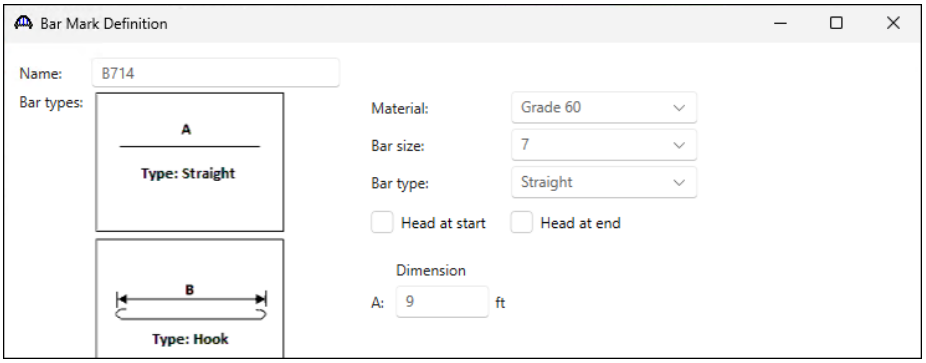

Bar Mark Definition
Name: B408
Bar types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 4
Bar type: Straight
Head at start
Head at end
Dimension
A: 2 ft

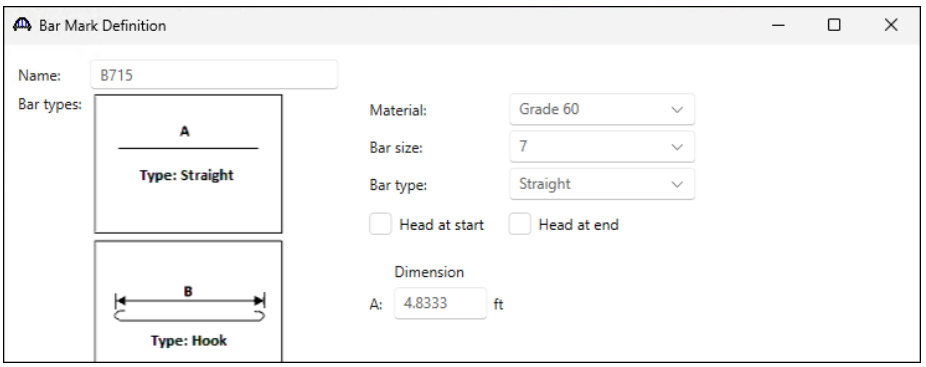

Bar Mark Definition
Name: B510
Bar types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 5
Bar type: Straight
Head at start
Head at end
Dimension
A: 12.3333 ft


Bar Mark Definition
Name: B411
Bar types:
A
Type: Straight
B
Type: Hook
B
A
Type: Corner
Material: Grade 60
Bar size: 4
Bar type: Corner
Dimension
A: 12.3333 ft
B: 1 ft


Bar Mark Definition
Name: B612
Bar types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 6
Bar type: Straight
Head at start
Head at end
Dimension
A: 25.8333 ft

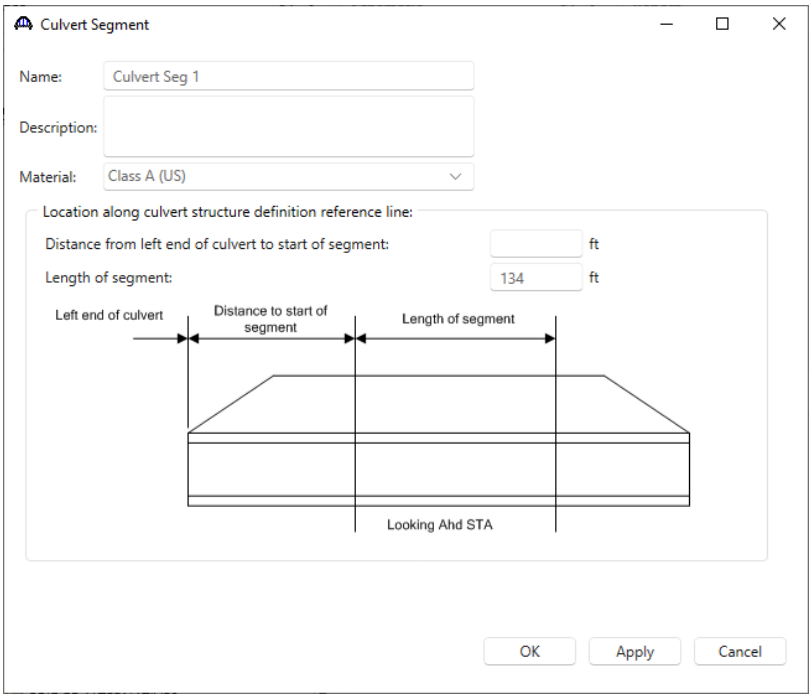

Bar Mark Definition
Name:
B613
Bar types:
A
Type: Straight
B
Type: Hook
Material:
Grade 60
Bar size:
6
Bar type:
Straight
Head at start
Head at end
Dimension
A:
8.1667
ft


Bar Mark Definition
Name:
B714
Bar types:
A
Type: Straight
B
Type: Hook
Material:
Grade 60
Bar size:
7
Bar type:
Straight
Head at start
Head at end
Dimension
A:
9
ft


Bar Mark Definition
Name:
B715
Bar types:
A
Type: Straight
B
Type: Hook
Material:
Grade 60
Bar size:
7
Bar type:
Straight
Head at start
Head at end
Dimension
A:
4.8333
ft

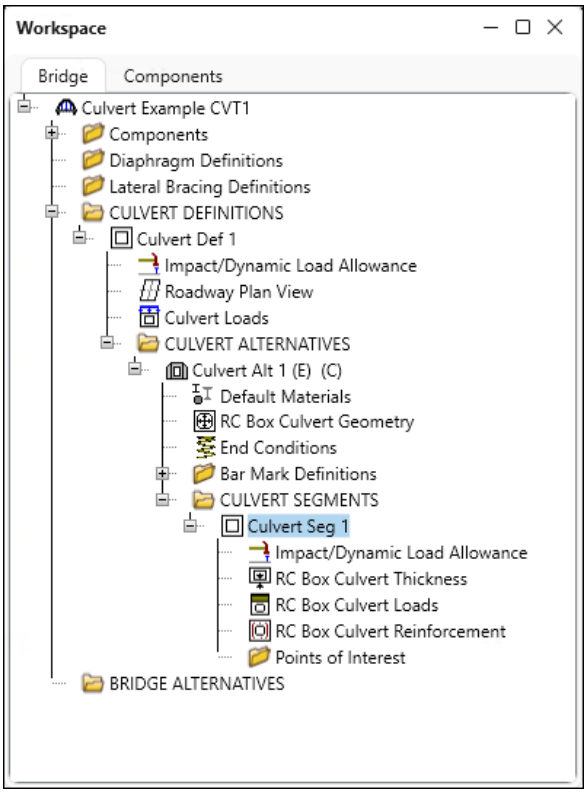
## Culvert Segments

Double-click on the **CULVERT SEGMENTS** folder to create a new culvert segment for **Culvert Alt 1**. A culvert alternative may have one or more culvert segments. Enter the data as show below.



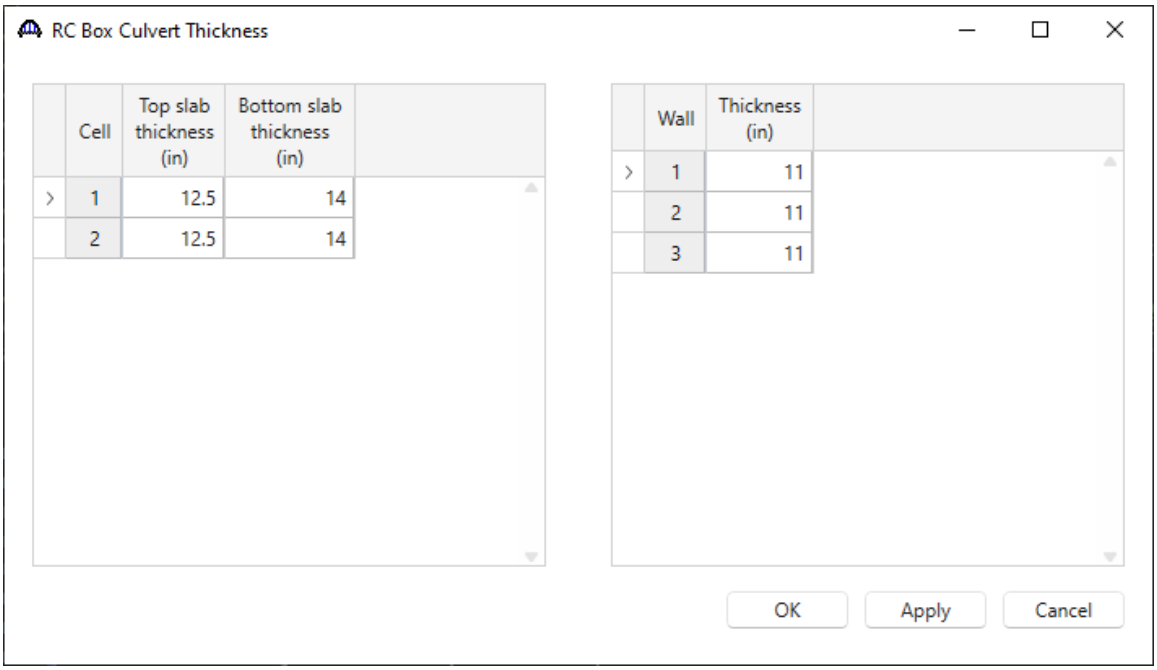

Click **OK** to create a new culvert segment and close the window.

The expanded tree for **Culvert Seg 1** is shown below.



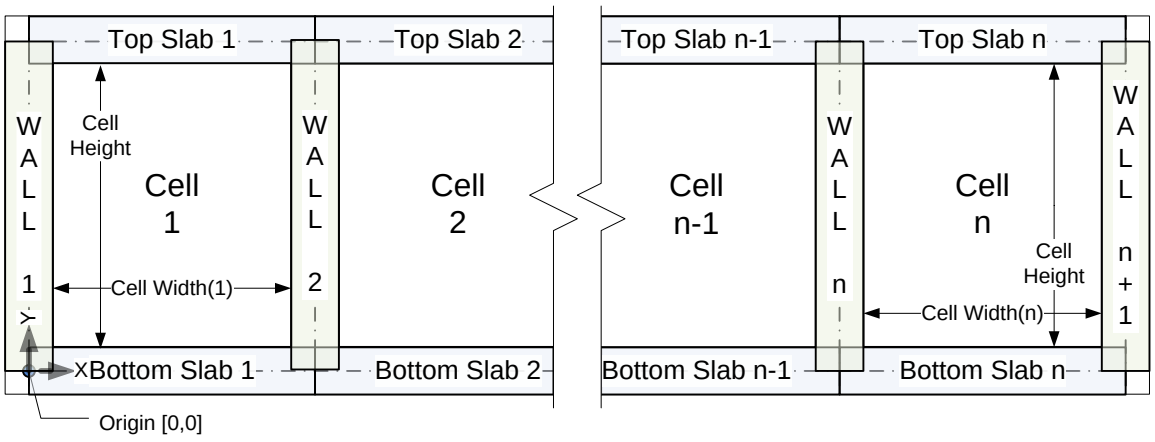
### RC Box Culvert Thickness

Double-click on the **RC Box Culvert Thickness** node in the **Bridge Workspace** tree. Enter the slab and wall thicknesses as shown below.



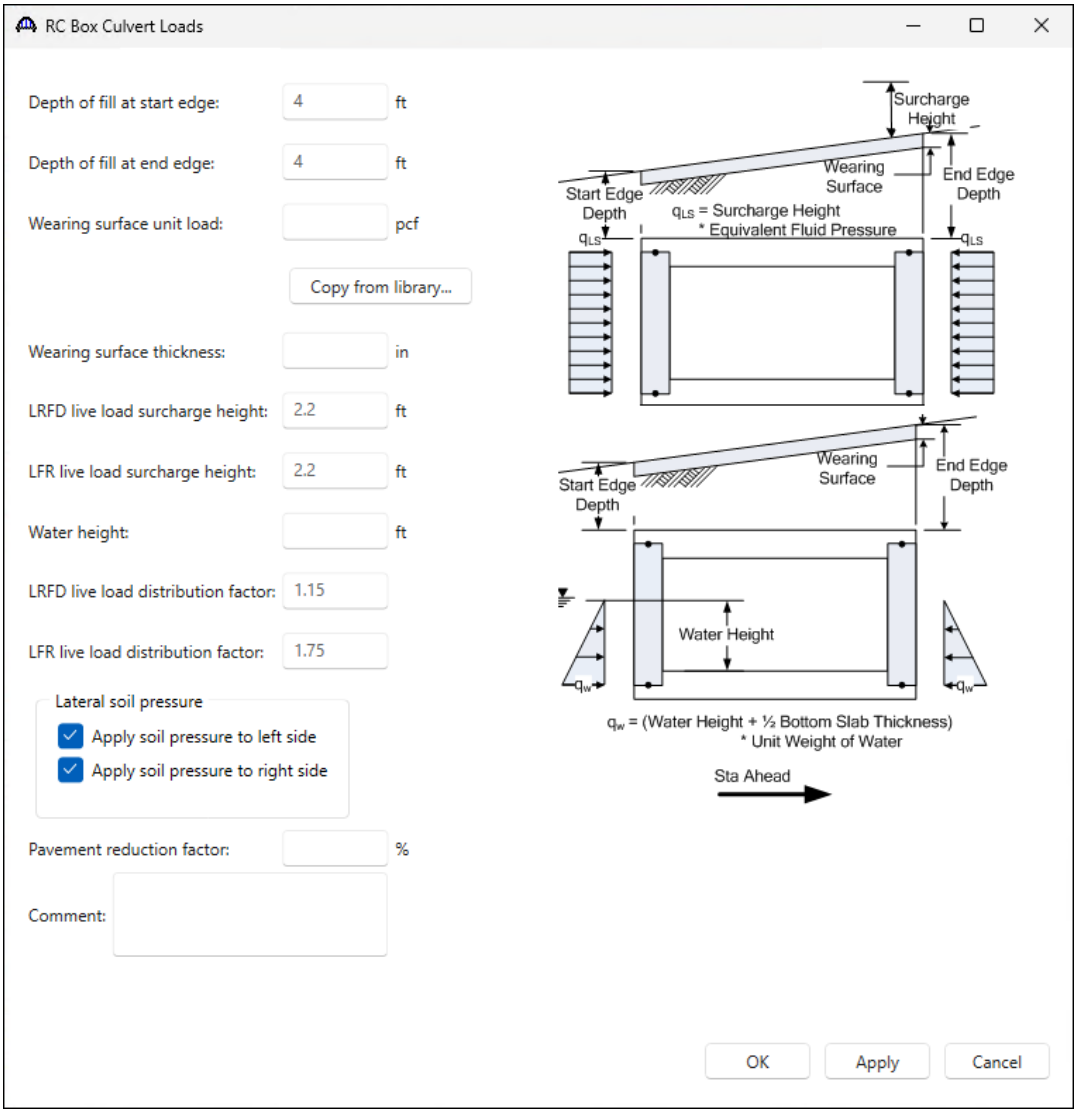

Click **OK** to apply the data and close the window.

The following shows the components for a box culvert with n cells.



## RC Box Culvert Loads

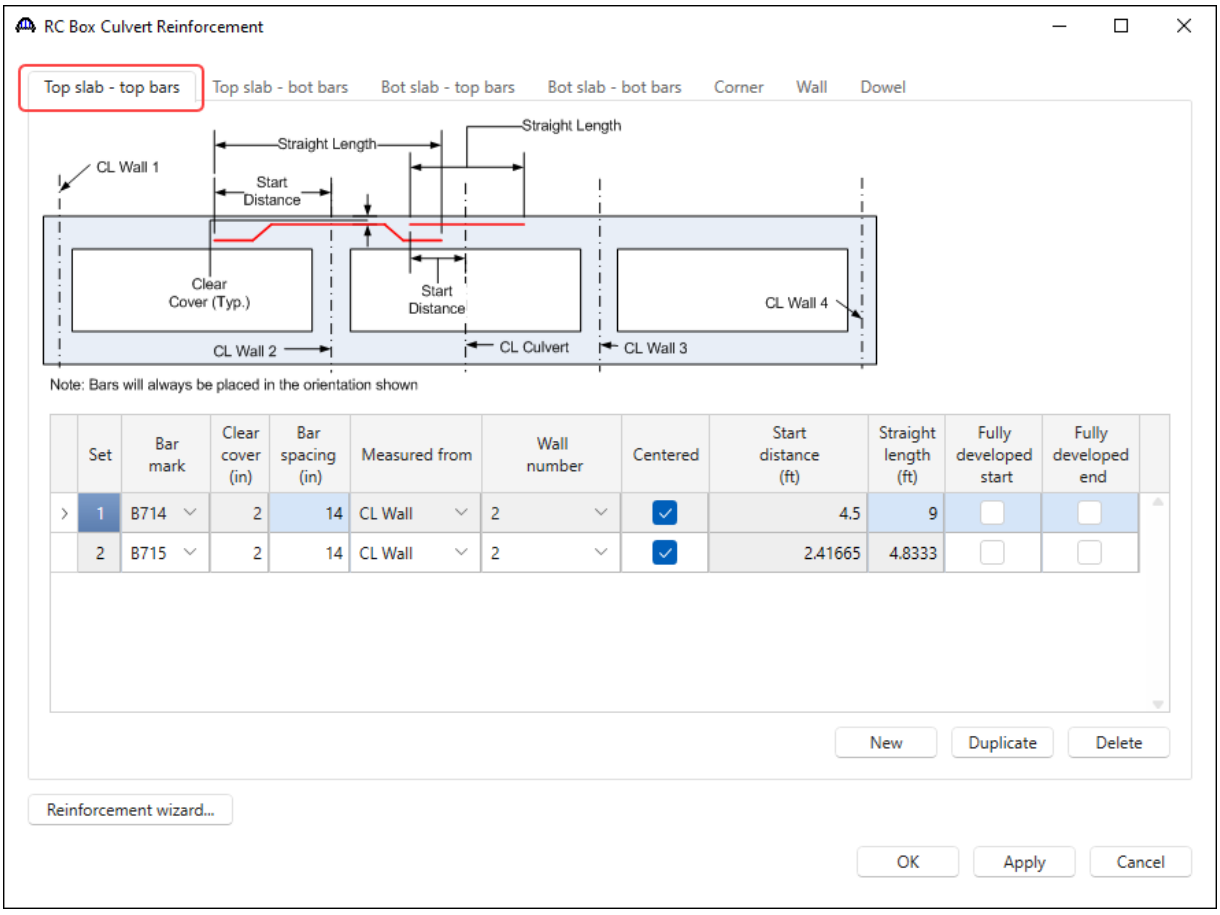
Double-click on **RC Box Culvert Loads** in the **Bridge Workspace** tree. Enter the culvert loads for **Culvert Seg 1** as shown below. Select the checkboxes under **Lateral soil pressure** shown below to apply soil pressure to both sides of the culvert. These checkboxes are provided to allow for the case where a culvert is widened by placing another culvert directly next to it so that side does not have lateral earth pressure.




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

## RC Box Culvert Reinforcement

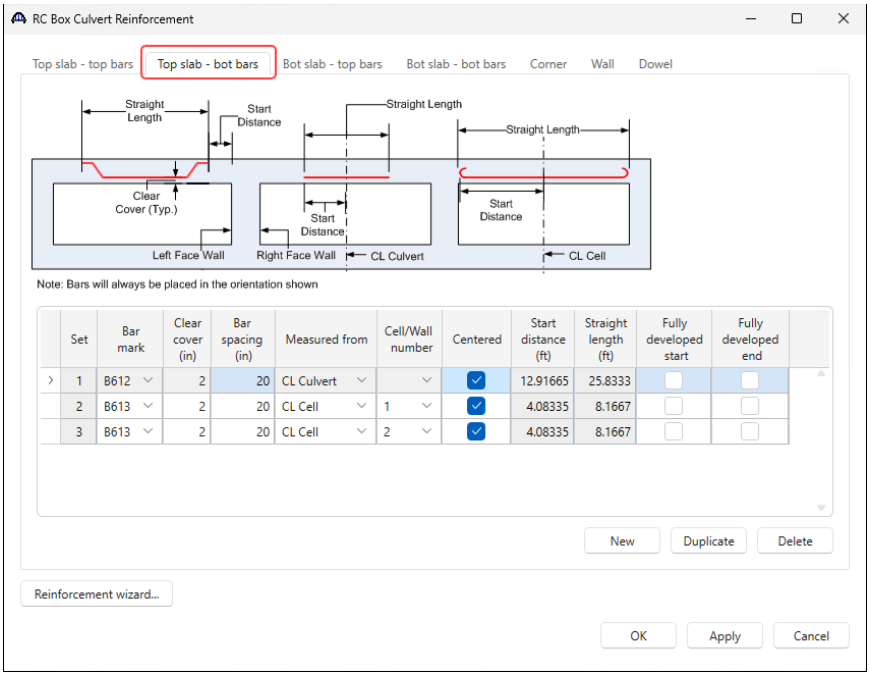
Double-click on the **RC Box Culvert Reinforcement** node in the **Bridge Workspace** tree. Enter the reinforcement data as shown below for each location.




*Note: If a bent bar is selected in this tab, the clear cover is measured from the top of the top slab to the middle section of the bar (section B in the Bar Mark Definition), and the bar will be oriented as shown in the Schematic.*

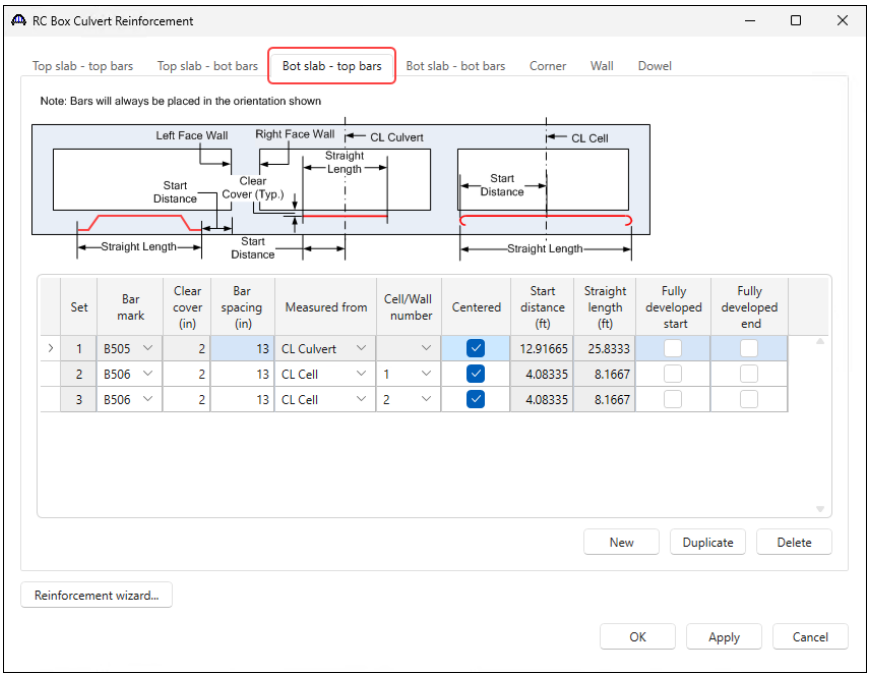
Click **Apply** to apply the data and not close the window.

Navigate to the **Top slab - bot bars** tab to add more reinforcement details.

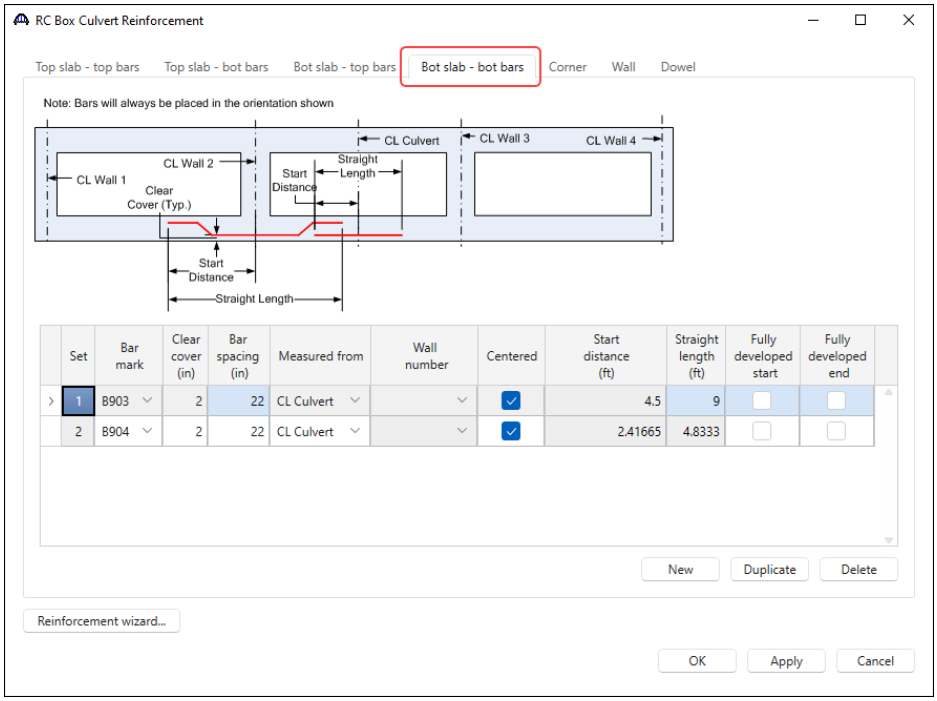



*Note: If a bent bar is selected in this tab, the clear cover is measured from the bottom of the top slab to the middle section of the bar (section B in the Bar Mark Definition), and the bar will be oriented as shown in the Schematic.*

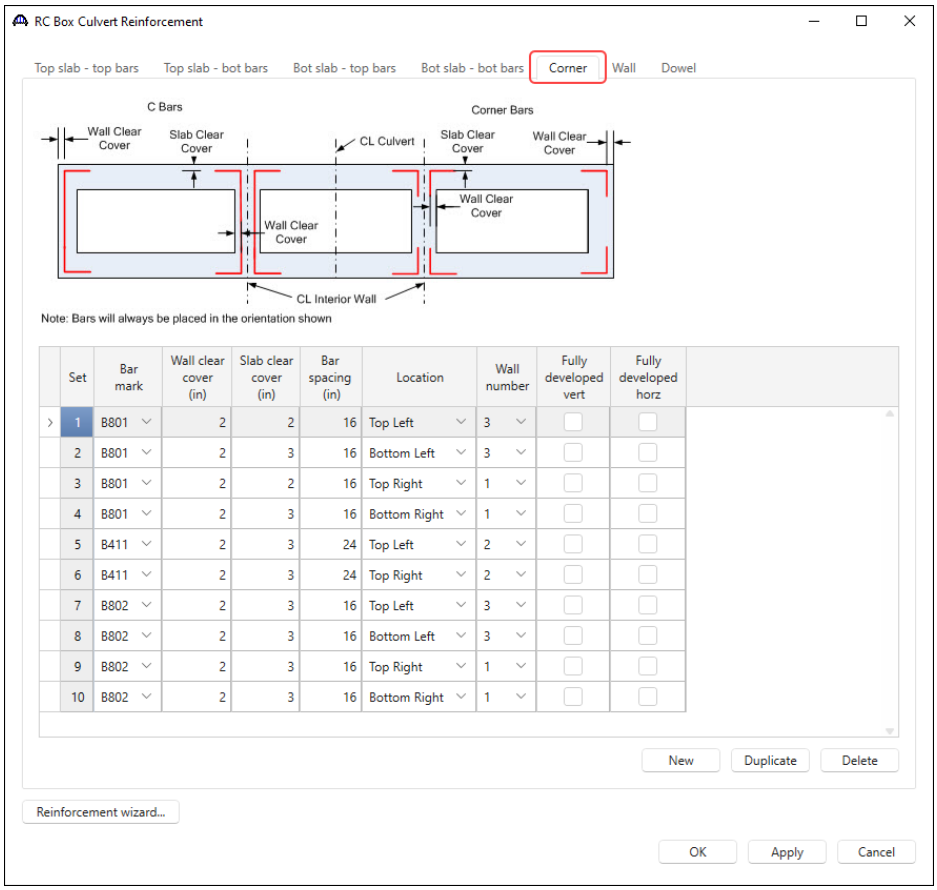
Similarly, add reinforcement in each location as shown below.

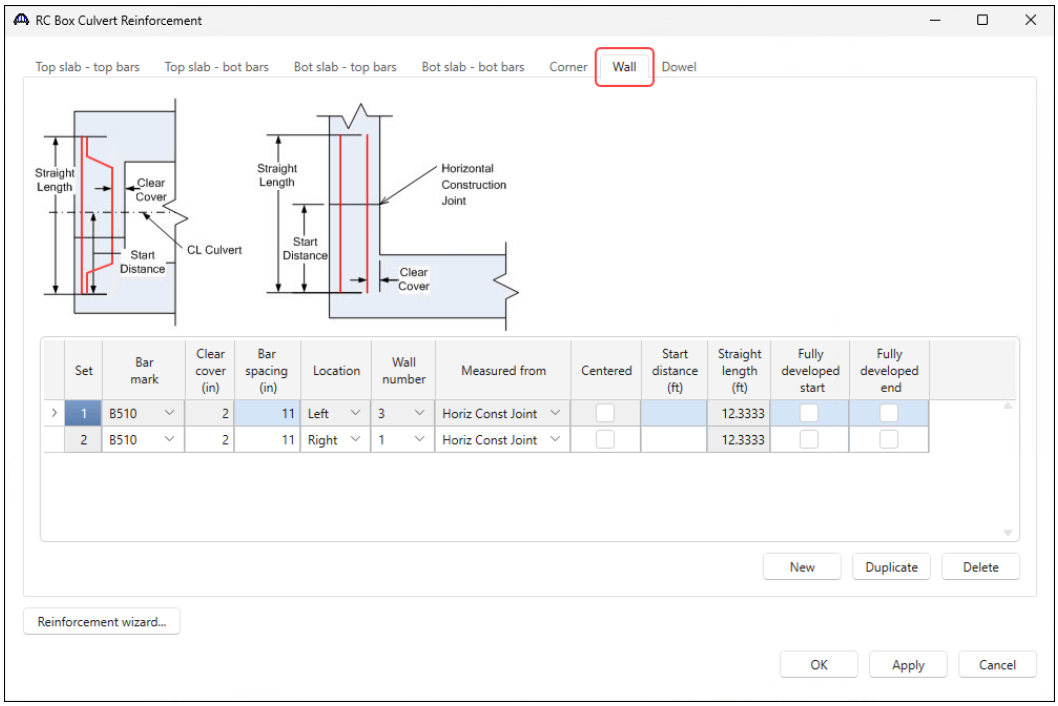



*Note: If a bent bar is selected in this tab, the clear cover is measured from the top of the bottom slab to the middle section of the bar (section B in the Bar Mark Definition), and the bar will be oriented as shown in the Schematic.*

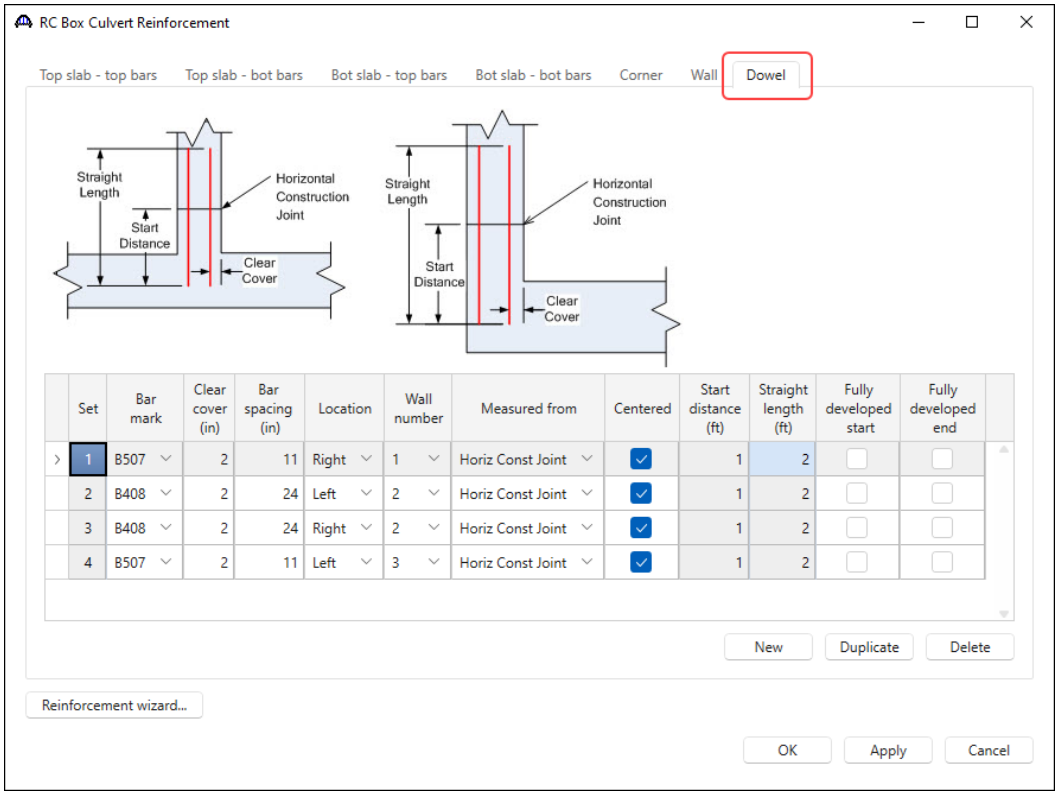



*Note: If a bent bar is selected in this tab, the clear cover is measured from the bottom of the bottom slab to the middle sectionn of the bar (section B in the Bar Mark Definition), and the bar will be oriented as shown in the Schematic.*



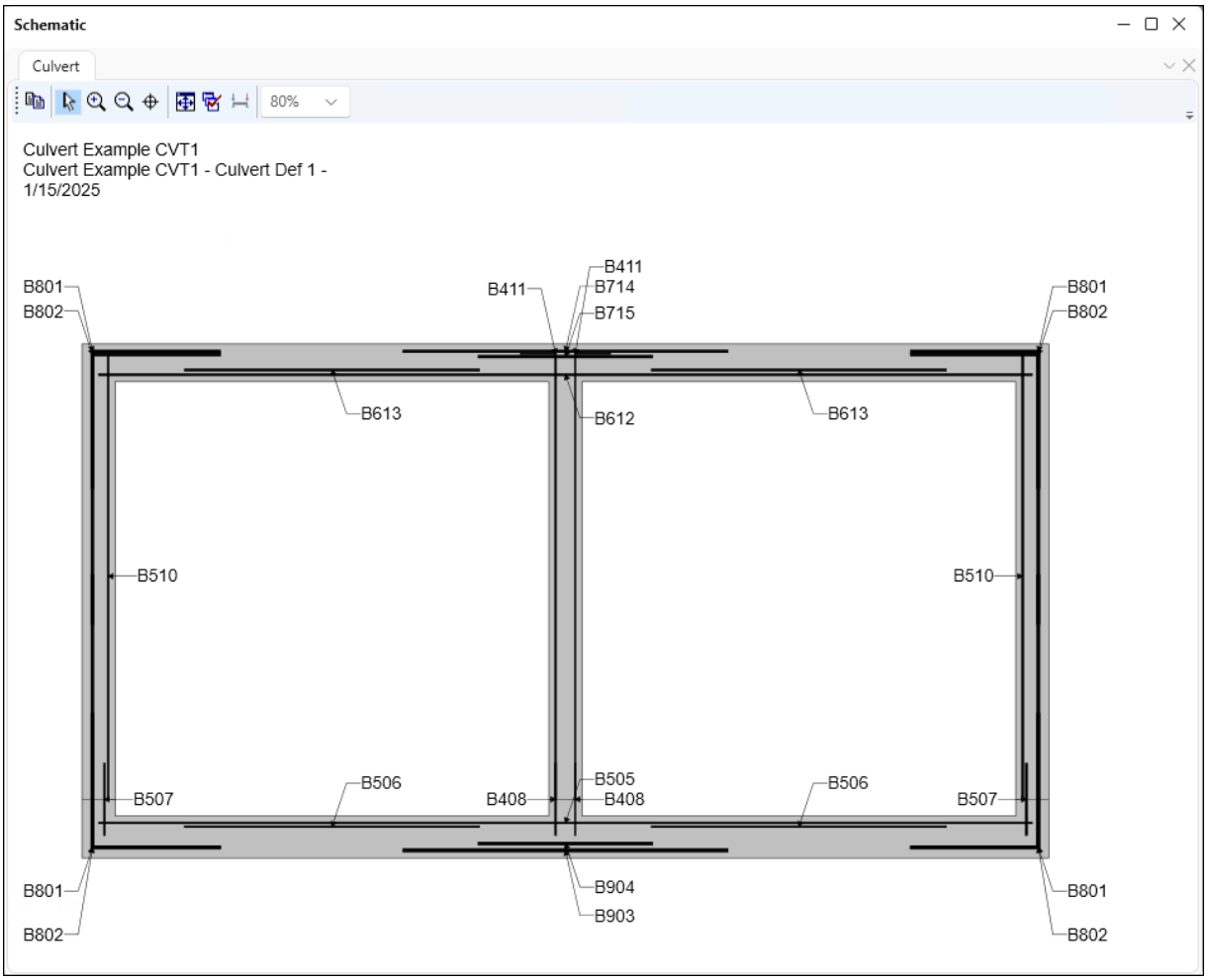



*Note: If a bent bar is selected in this tab, the clear cover is measured from face of the wall that is selected under "Location" to the middle section of the bar (section B in the Bar Mark Definition). The bar will be oriented with the middle section of the bar towards the face of the wall selected under "Location".*



### Schematic – RC Box Culvert Reinforcement

Click on **RC Box Culvert Reinforcement** and select **Schematic** from the **WORKSPACE** ribbon (or right click and select **Schematic** from the drop down menu) to view the schematic showing reinforcement details for this bridge.

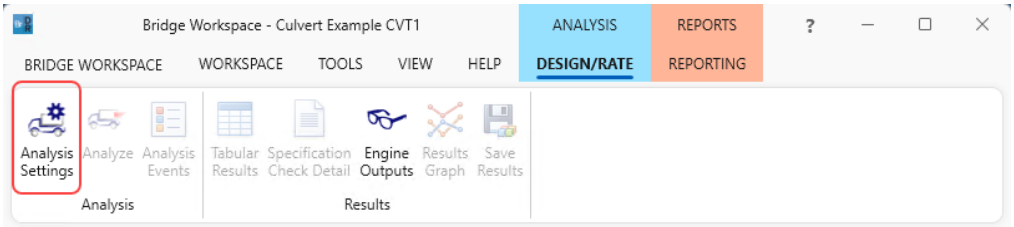



The description of the two-cell reinforced concrete box culvert is complete.

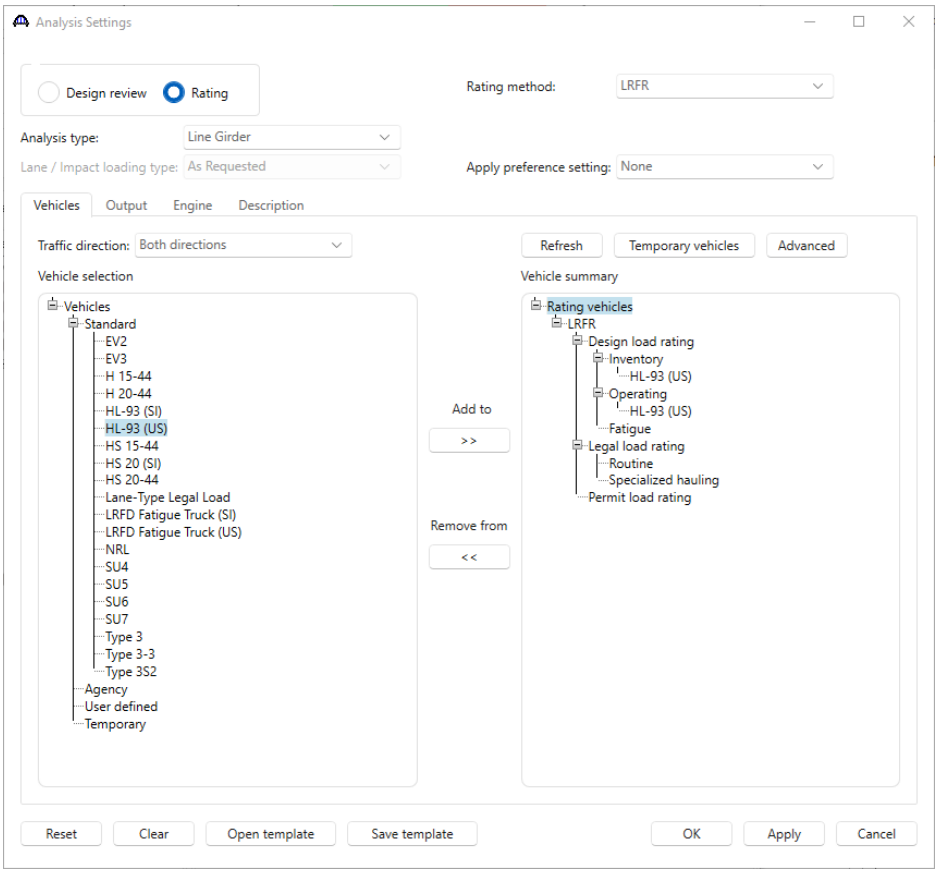
## Perform AASHTO Culvert LRFR analysis and review results.

### LRFR Analysis

To perform an LRFR Design Load Rating, click the **Analysis Settings** button from the **Analysis** group of the **DESIGN/RATE** ribbon.

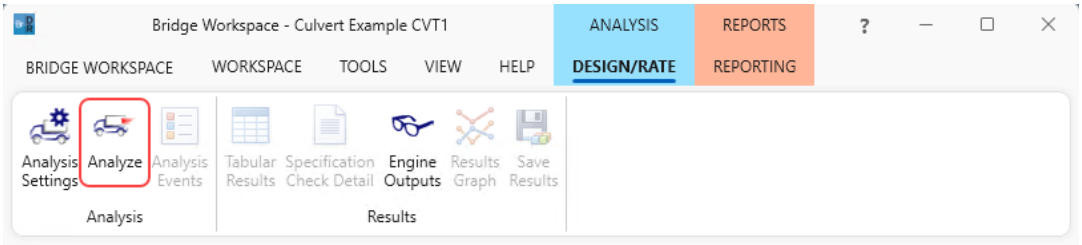



Apply the analysis settings as shown below.



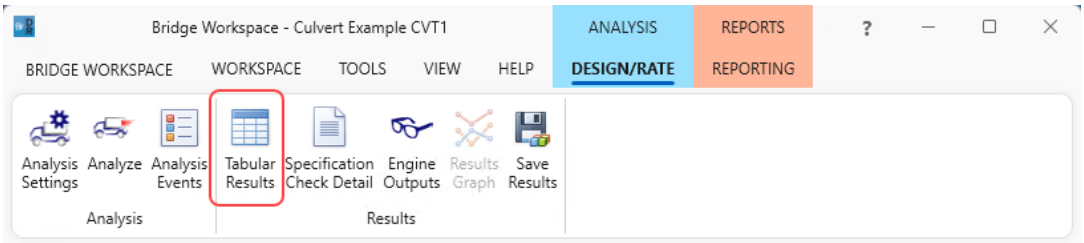

Click **OK** to apply the data and close the window.

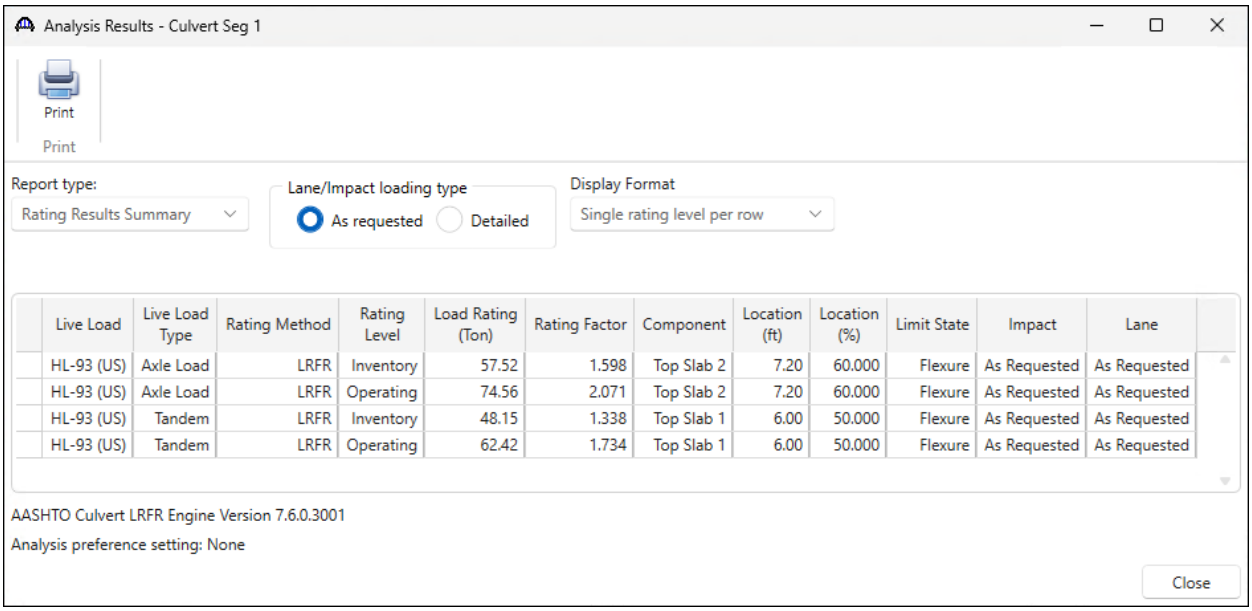
With **Culvert Seg 1** selected in the **Bridge Workspace** tree, click the **Analyze** button from the **Analysis** group of the **DESIGN/RATE** ribbon to start the rating process.




## Tabular Results

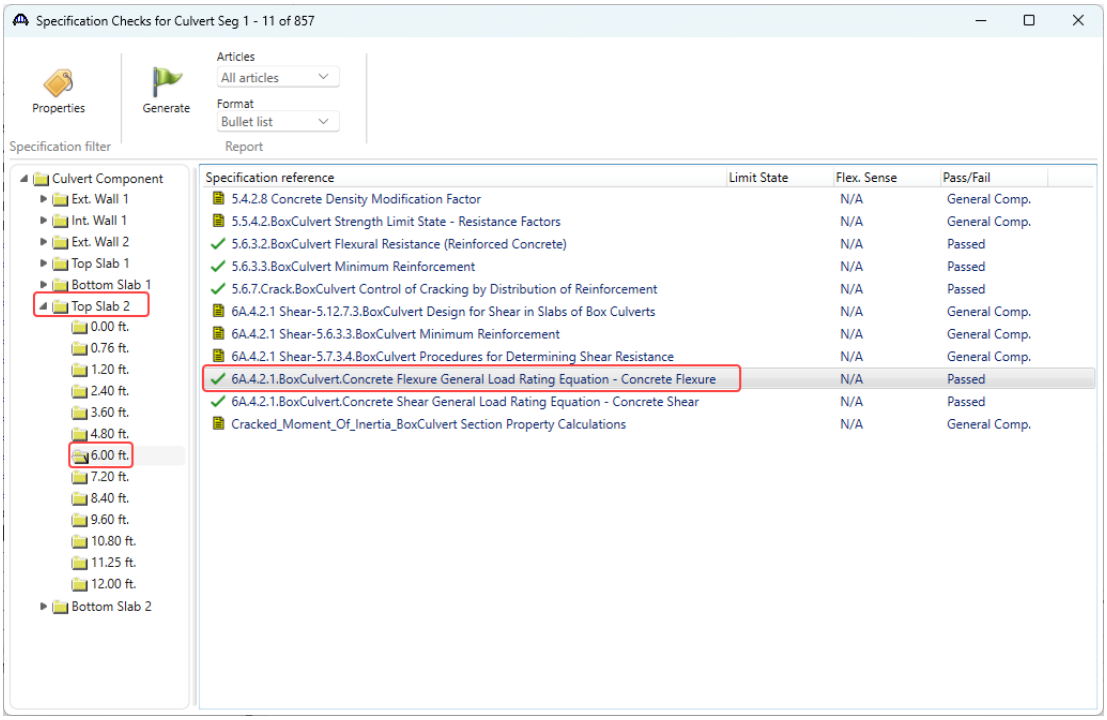
When the rating is finished, results can be reviewed by clicking the **Tabular Results** button from the **Results** group of the **DESIGN/RATE** ribbon. The window shown below will open.



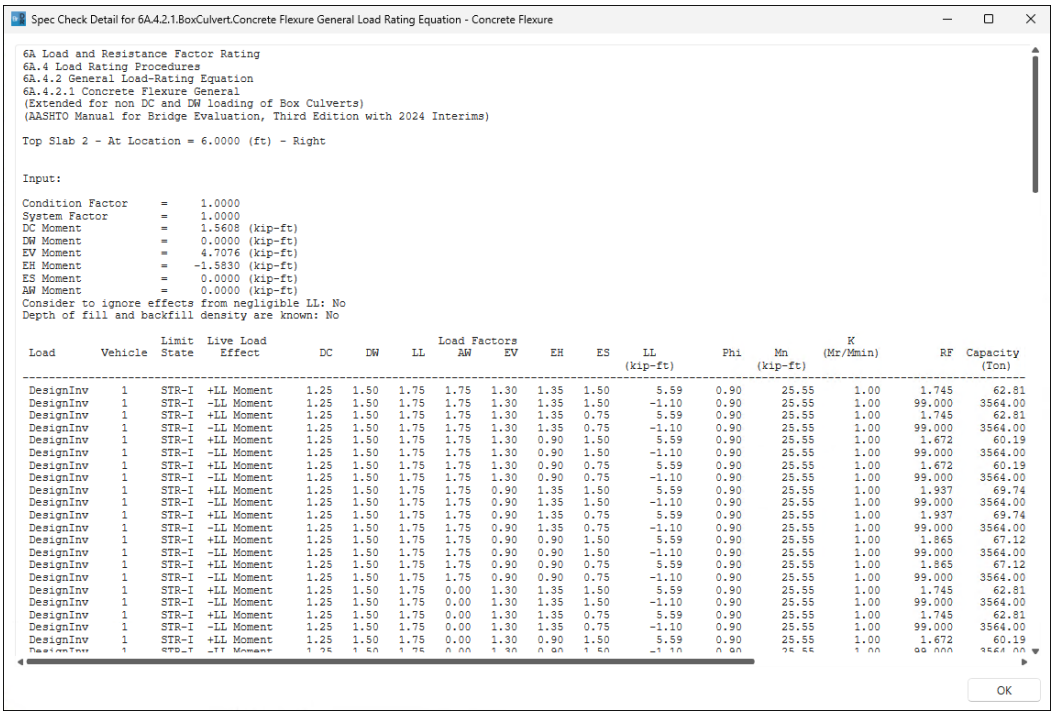



## Specification Check Detail

To review detailed rating results at the controlling location, click the **Specification Check Detail** button in the ribbon to open the **Specification** window. Expand the tree for **Top Slab 2** and select the **6.00 ft.** folder.

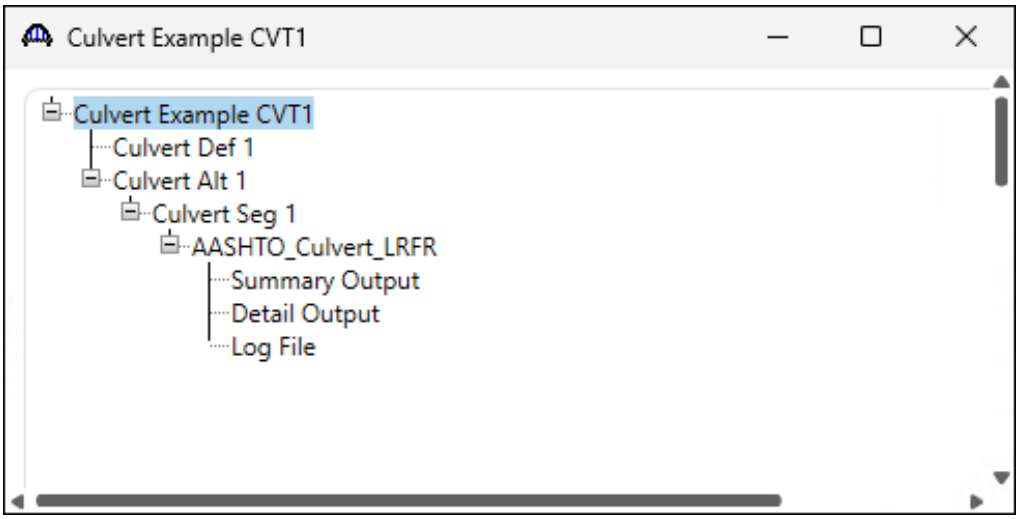



Double-click on the **6A.4.2.1 BoxCulvert Concrete Flexure General Load Rating Equation - Concrete Flexure** specification reference to open the **Spec Check Detail** window.



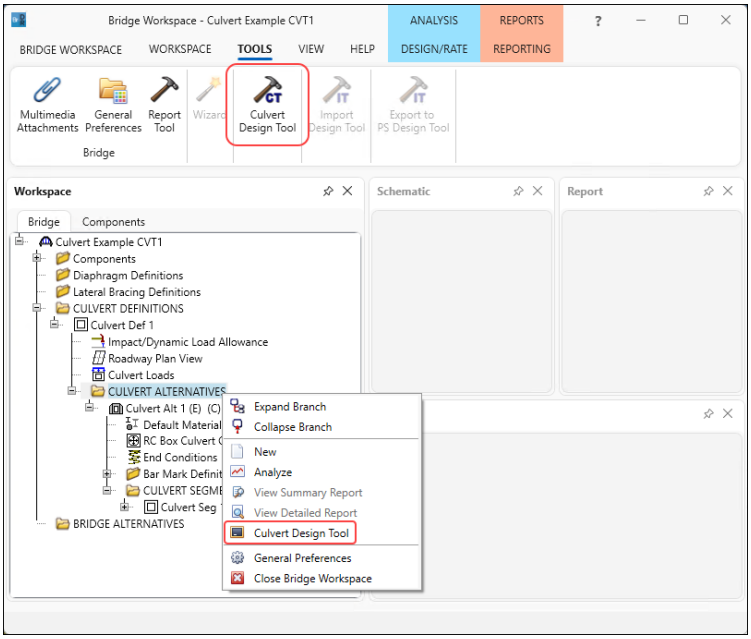
### Engine Outputs

To review engine outputs, select the **Engine Outputs** button in the ribbon. Double-clicking on the **Summary Output** or **Detail Output** will open the engine output file in a separate window.

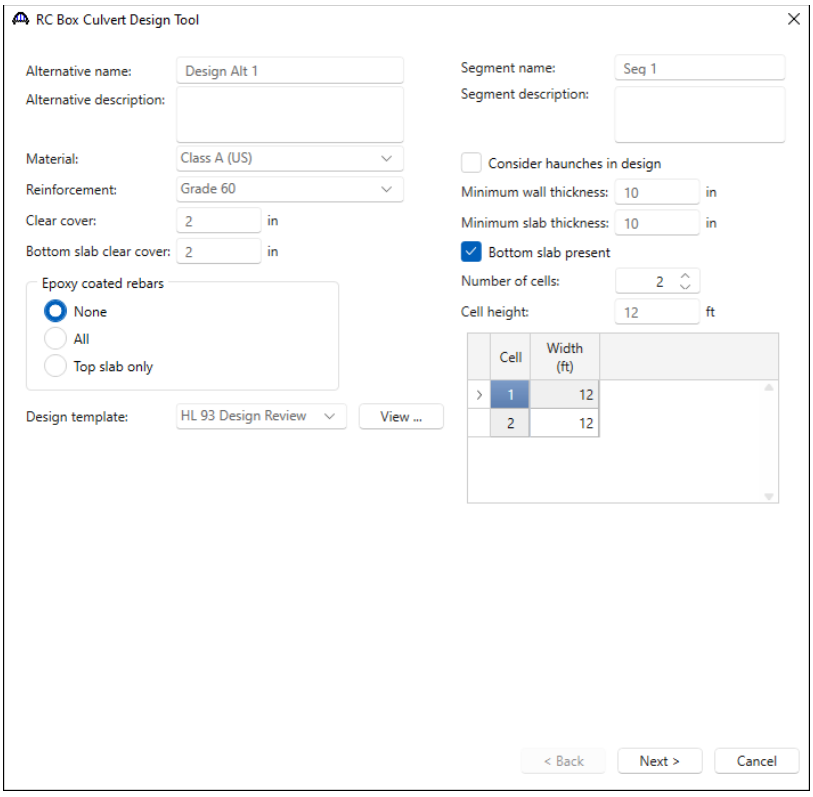


## Culvert Design Tool

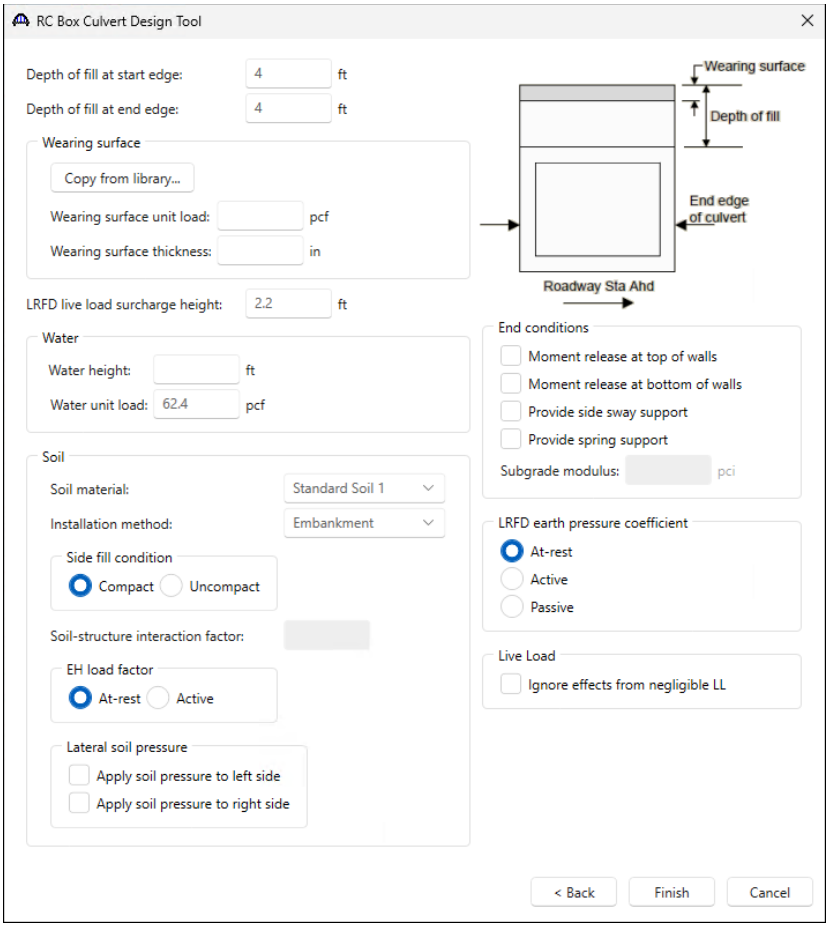
Select the **CULVERT ALTERNATIVES** folder in the **Bridge Workspace** tree. Click the **Culvert Design Tool** button in the **TOOLS** ribbon (or right click and select **Culvert Design Tool**) to open the **RC Box Culvert Design Tool** as shown below.



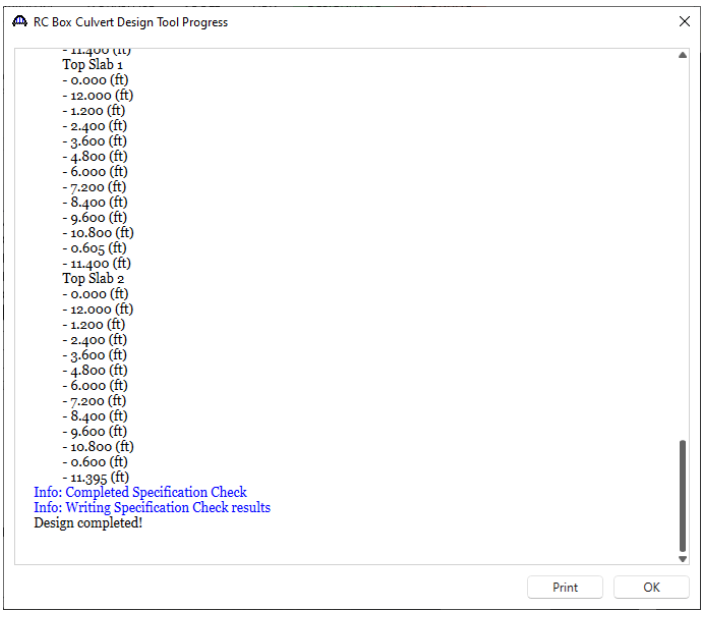

Enter the data as shown below and click the **Next** button.



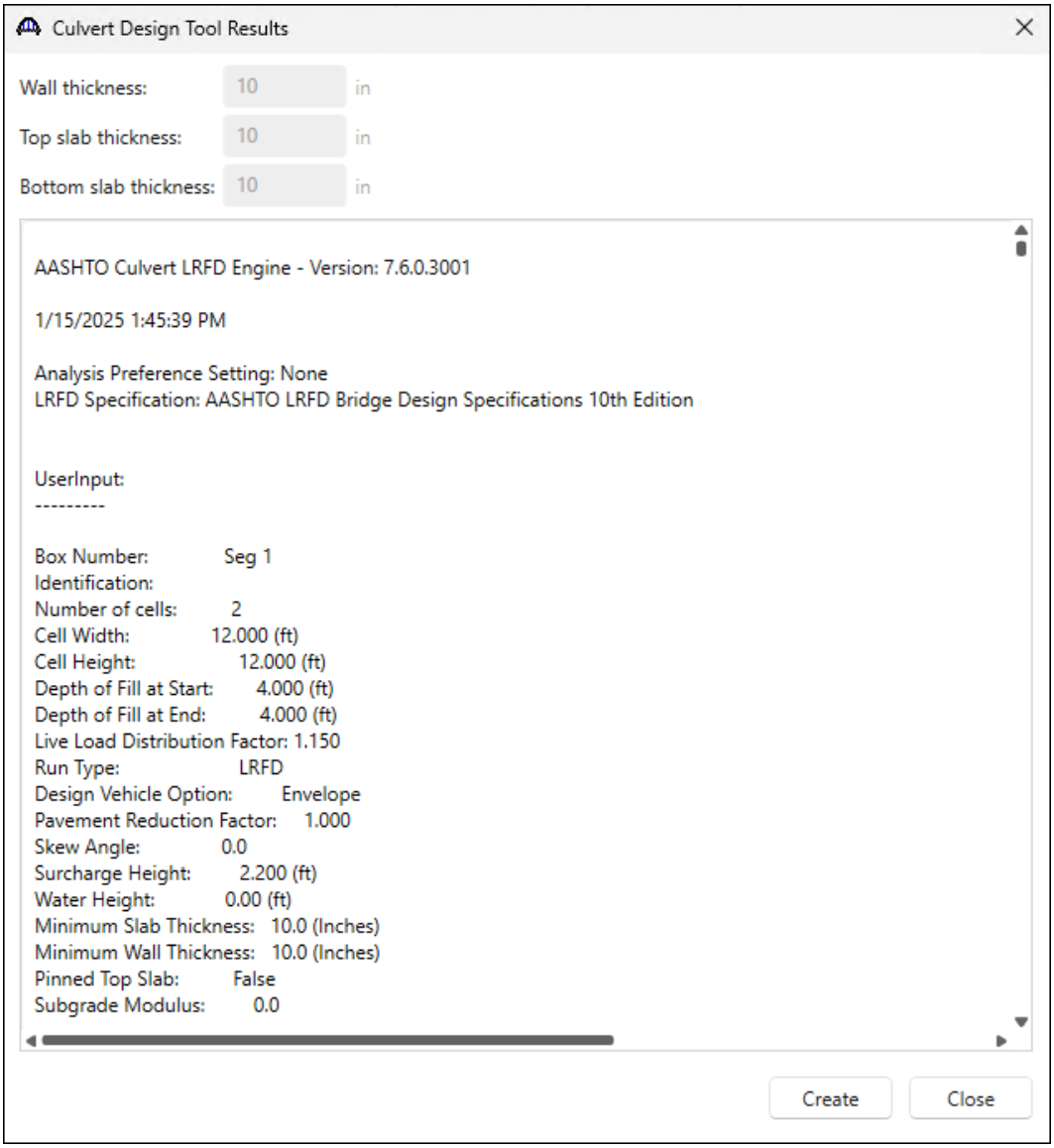
Enter the data as shown below.



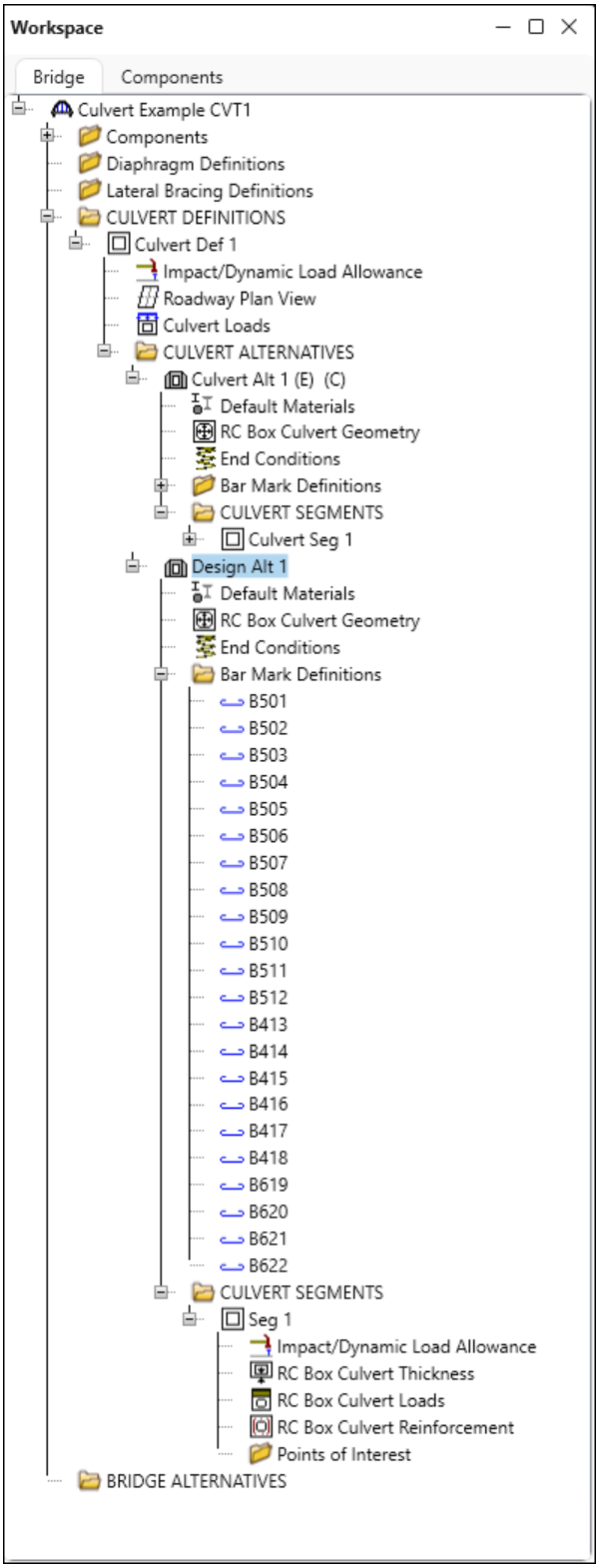

Click **Finish** to start the design process. Click **OK** to close the **RC Box Culvert Design Tool Progress** window after the design is completed.



The **Culvert Design Tool Results** window is shown below. Click **Create** to accept the design and click **Close** to close the window.



The **Bridge Workspace tree** with the **Design Alt 1** is shown below.



## Schematic - RC Box Culvert Reinforcement

Select the **RC Box Culvert Reinforcement** node under **Design Alt 1** in the **Bridge Workspace** tree. Click the **Schematic** button from the **WORKSPACE** ribbon (or right click and select **Schematic**) to review the reinforcement data.